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Small Fishes of the River Padma Near Rajshahi and Their Utilization in the Preparation of Fish Meal and Fish Protein Concentrate (Fpc)

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SMALL FISHES OF THE RIVER PADMA NEAR RAJSHAHI AND THEIR UTILIZATION IN THE PREPARATION OF FISH MEAL AND FISH PROTEIN CONCENTRATE (FPC)

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DEDICATED

TO

My Beloved Husband

Dr. Md. Abdur Rashid

My Only Affectionate Daughter

Redwana Farbin Farbi

And

My Other Family Members

DECLARATION

I do hereby declare that the research work entitled "SMALL FISHES OF THE RIVER PADMA NEAR RAJSHAHI AND THEIR UTILIZATION IN THE PREPARATION OF FISH MEAL AND FISH PROTEIN CONCENTRATE (FPC)" submitted to the Department of Zoology, Faculty of Life and Earth Science, University of Rajshahi for the Degree of Doctor of Philosophy is the result of my own investigation. The thesis or part of it has not been submitted to any other university or institution for any degree or prize.

22.12.12

Dated : December, 2012

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CERTIFICATE

This is to certify that that the thesis entitled "SMALL FISHES OF THE RIVER PADMA NEAR RAJSHAHI AND THEIR UTILIZATION IN THE PREPARATION OF FISH MEAL AND FISH PROTEIN CONCENTRATE (FPC)" submitted for the degree of **Ph. D.** is an original research work of Sarmin Akther, of the Department of Zoology, University of Rajshahi, Bangladesh.

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ABSTRACT

The small indigenous fishes (SIF) are the great source of protein, fat, minerals and micro nutrients. The present research provides information about the small indigenous fishes of the river Padda (Padma) and their preservation, preparation and utilization of FPC made of fast food as fish powder and biochemical analyses of fishmeal of these fishes. The study was carried out during the period from July 2008 to June 2011. The specimens were collected by multiple spot visits to the river bank of Rajshahi City and their adjacent areas and different fish markets.

A total of five species of fishes and a group of mixed fishes under 5 families and 5 orders such *Glossogobius giuris*, *Colisa fasciata, Puntius ticto, Eutropiichthyes vacha*, *Corica soborna* and some mixed fishes (*Chanda nama*, *Chanda ranga*, *Amblypharyngodon mola*, *Mastacembelus pancalus*, *Xenentodon cancila*) were selected to determine the flesh production, preparation and preservation of powder, utilization, acceptability, biochemical analyses and fishmeal preparation of fish powder and fast food products made by powder of the small fishes.

Total length, total weight, after dressing weight, waste weight and weight after dressing and washing were recorded. The percentage of edible portion compared to their wastes were also determined. The highest percentage of weight after dressing and washing was found for *Corica soborna* 97.54% and the lowest in mixed fishes 72.34%. Among the six experimental fishes the highest percentage of waste product was 27.66% in mixed fishes and 2.5% was the lowest in *Corica soborna*.

Five different species and a group of mixed fishes were used for preparation of powder (FPC). Preservation of all these fishes were in powdered form which were sun dried or oven dried. Sun drying is easy a process and can be used in large scale. But quality of the oven dried fishes was better. The fish powder remains in good condition for 7-9 months at normal room temperature, but in -18°C the powder was in good condition throughout the year. Highest quantity of powder from 1 kg of fish was obtained in case of *Corica soborna* 25.80% and the lowest 11.72% in *Glossogobius giuris*.

Biochemical analyses of the selected six small fishes (protein, fat, moisture, minerals such as calcium, phosphorous, iron) were done. The maximum calcium content was

found as 2.53% in *Puntius ticto* and minimum was 1.66% in *Glossogobius giuris*. Maximum phosphorous content was 2.93% in *Colisa fasciata* and minimum was 1.85% in mixed fishes (*Chanda nama*, *Chanda ranga*, *Amblypharyngodon mola*, *Mastacembelus pancalus*, *Xenentodon cancila*). Maximum iron content was found as 32.00 mg/100g in mixed fishes and minimum in *Puntius ticto* as 20.25 mg/100g. The maximum moisture content was found in *Glossogobius giuris* (14.28%) and minimum in *Corica soborna* fishes (12.05%). Maximum protein was found in *Glossogobius giuris* (73.32%) and minimum in *Colisa fasciata* (57.76%). Maximum fat content was found in *Corica soborna* (23.63%) and minimum in *Eutropiichthyes vacha* 1.29%.

Different fast food items such as fish soup, fish cutlet, fish toast, fish burger, fish stick kabab, fish ball noodles, fish parota, fish papadom, fish pakora were prepared by the six experimental fishes. The consumers' remarks and acceptances towards the taste, flavour and colour of different fish fast food items in relation to occupation such as teachers, students, doctors, house wives and others were also observed.

The majority of different professionals gave their opinion as good and tasty of all the fast food products. These included fish soup (45%), fish cutlet (47%), fish toast (46%), fish burger (50%), fish stick kabab (45%), fish ball with noodles (41%), fish parota (47%), fish pakora (39%) and fish papadom (39%).

The cost of production and profit of the products were assessed. Among all the fast food products fish burger was of the highest production cost (Tk. 25.00). But on the consumers' remarks basis the highest cost was of fish soup (Tk. 21.5) and the lowest production cost was in fish papadom Tk. 10.50 and Tk. 14.7 in fish cutlet.

The present work also gives an information on how to make fishmeal with the head, fin, viscera and other waste parts of the fishes and their utilization.

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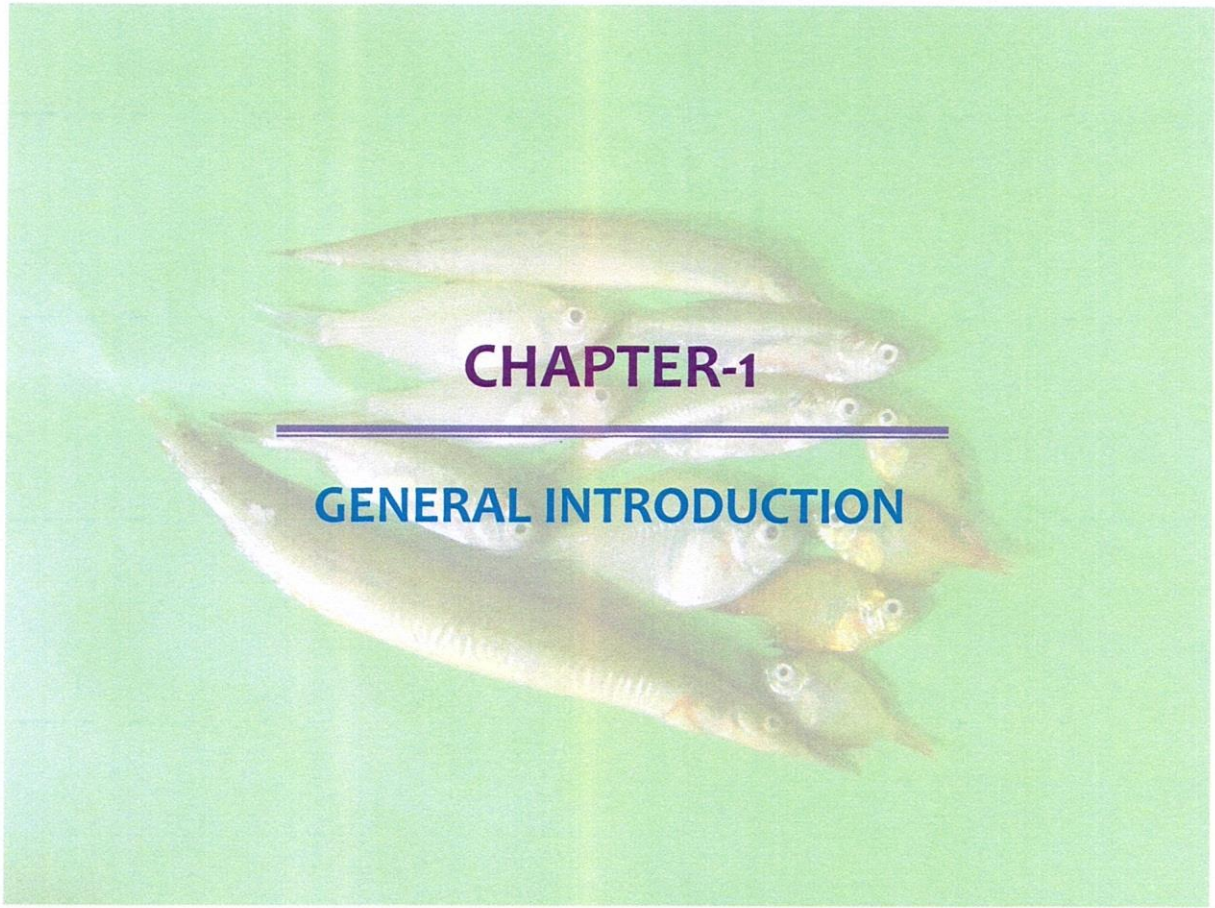


CHAPTER-1

GENERAL INTRODUCTION

Chapter One

GENERAL INTRODUCTION

Bangladesh, one of the largest deltas of the world is criss crossed by innumerable rivers and rivulets and has a great fishery potential (Rahman, 1994). Riverine fishing areas comprise nearly one fifth of the entire fishing area of 4.9 million hectares of the country (Huq *et al.*, 1986). Capture fisheries in the rivers and their adjacent floodplains in the form of common property and open access resources constitute a vital component of the agro ecosystem of rural Bangladesh (Sadeque, 1990), Bangladesh is endowed with about 230 rivers and it is estimated that the total length of about 24,140 km of these rivers, criss-cross the country and eventually flow down to the Bay of Bengal (BBS, 1991).

Fisheries sector (freshwater, brackish water and marine) have been gradually higher position in the developing economy of Bangladesh since last three years (Shafi, 2003). This sector plays a vital role in the national economy regarding employment generation, animal protein supply, foreign currency earning and poverty alleviation and economic development. According to the report of DoF (2011), the fisheries sector is contributing 2.73% of the total export earning and 4.43% to the GDP. About 15 million people are directly or indirectly employed in this sector and labour employment is increasing approximately to 3.5% annually. In the year 2010-2011, the total production of fishes was 30.62 lakh mt. (DoF, 2011).

In Bangladesh, only 6 percent of the daily food intake is animal food of which fish accounts for about 50% (Thislted *et al.*, 1997). Fish is one of the most popular and well known foods among all categories of people in Bangladesh. Fish protein is a high class protein which is easily digestible and nutritionally enriched in comparison with other animal protein (Mazid, 2005). Approximately 80% of the animal protein comes from fish flesh, because of poor production and high price rate of egg and meat in Bangladesh (Rubbi *et al.*, 1987).

About 85-90% of fish protein is digestible and contains all the essential dietary amino acids (Nilson, 1946). About 5% of total protein comes from fishes as food in the world. Muscle of fish is largely composed of proteins of the globulin and albumin classes, and internal organs and the muscles also contain all the vitamins of B-complex (Guha, 1962). Fish liver, apart from its content of vitamins A, D and E, is also a good source of B vitamins (Balachandran, 2001). Fish oils are the richest known source of vitamins A and D, and generally contain a high proportion of polyunsaturated fatty acids, which plays an important role in reducing the cholesterol level in the human blood (Rao *et al.*, 1977). Fish is a good source of fluoride and iodine, which is needed for the development of the strong teeth and the prevention of goiter in man (Andrew, 2001). Fish is a source of polyunsaturated fatty acid (PUFA) known to be beneficial in preventing cardiovascular disease, breast and colon cancer, psoriasis etc. (Hasan, 2001).

The Padda river (Padma, the Bangladesh portion of the Ganges) plays an important role in the fisheries of Bangladesh. In every year large amount of fishes are caught from this river. Large quantities of carp fry are caught from numerous breeding grounds of this river (DoF, 1996). There are 265 species of fishes under 154 genera and 55 families in the inland waters of Bangladesh (Rahman, 2005). Over 150 species have been considered as SIF (Amin *et al.*, 2009). Islam and Hossain (1983) provided an account of 110 species of fishes of the river Padda (Padma) near Rajshahi. Bhuiyan *et al.* (1992) listed 133 species inhabiting the freshwaters of Rajshahi district. Hossain and Haque (2005) enlisted 134 species in the river Padda near Rajshahi. A total of 57 SIF were recorded belonging to 23 families and 11 orders in the river Padma. The most abundant family and order were found as Cyprinidae (28.07% SIF) and Cypriniformes (35.09% SIF) respectively (Samad *et al.*, 2010). In the riverine water the maximum number of species was recorded in the Padda river.

Protein deficiency is a major problem of a large number of children as well as adults of Bangladesh. In Bangladesh 40 percent of households have income that is considered to be below the poverty line and a substantial portion of these poor

households suffer from food deficiency and malnutrition (BBS, 2009). According to DoF (2011), the contribution of fisheries sector to animal protein supply is 58%, where per capita annual fish demand is 20.44 kg and per capita annual fish intake is 18.94 kg. Fishes are the only source where one can get all essential amino acids. Moreover most important omega-3 fatty acid is found in fishes (Watson, 2003). Fish as a source of protein is high in polysaturated fatty acids, omega-3 is important in lowering harmful blood cholesterol (LDL and VLDL) levels and increase the level of helpful necessary cholesterol HDL (Haque, 2010). The staple foods of Bangalis are rice and fishes, together which make a complete and nutritious diet.

The small indigenous fishes (SIF) of Bangladesh are generally considered to be those which grow to a length of approximately 5-25 cm or 9 inches at maturity (Felts *et al.*, 1996). Detailed biological information of these fishes is not presently available except few publications as stated by Hossain and Afroze (1991). Small fishes have short life cycle and can grow in all types of inland waterbodies. Small fishes are caught using a variety of gears made of synthetic / cotton fibres or nylon thread mosquito nets, different types of bamboo traps, even with bare hand after dewatering of smaller waterbodies. Because of overfishing and reduced waterbodies a number of small fishes are now under the threat of extinction. In Bangladesh 143 freshwater fish species are categorized as small indigenous fishes (SIF). In the past, these fishes were abundant in the rivers but at present natural and man made catastrophes caused degradation of these valuable small fish species and threatened to extinction (Islam, 2009). Some are already on the verge of extinction. So, there is presently an urgent need to conserve and to increase the production of the small fishes through proper management of rivers of Bangladesh. Side by side these species should be introduced in the farming systems of the country.

Most of our people prefer the large sized fishes, though Hossain *et al.* (1999) reported that percentage of edible flesh was higher in small sized fishes than in

large sized fishes. Even the bones of some small fishes are consumed for an important source of calcium. Analysis of small fish species showed that they contain a large amount of micro nutrients and minerals, which can play an important role in the elimination of malnutrition in Bangladesh (Ahmed *et al.*, 1997; Thilsted *et al.*, 1997; Hossain *et al.* 1997; Saha, 2003; Wahab *et al.*, 2003 and Faculty of Fisheries, BAU, 2008). Many small fishes are palatable but at peak season these fishes along with other small fishes fail to fetch a satisfactory market price. These fishes can be utilized by preparing some food products (low or high protein) which can be stored in preservative, refrigerator or even in the kitchen shelf for a long time.

Small fishes have a high nutritional value in terms of protein, micronutrients, vitamins and minerals not commonly available in other foods (Ross *et al.*, 2003). These fishes are cooked with vegetables and a little oil and eaten whole, leading to greater food diversity in diet. Cooked fishes can also be more equally distributed among the household members. While in case of big fishes the adult males get a larger share compared to the other members. During shopping, to women, small fish are the second choice after fruit, if they have enough money at hand (Deb and Haque, 2011).

Some small fishes, for example mola (*Amblypharyngodon mola*), dhela (*Osteobrama cotio*) and kaski (*Corica soborna*), have very high contents of vitamin A. As the smaller fishes are consumed whole, with all organs and bones, they contain usually larger quantities of calcium, as well as iron and zinc (Hossain, 1997 and Hossain *et al.*, 2003). Nearly 70% people of the population have physiological iodine deficiency, 47% already have goiter and about 5,00,000 people are cretin (Yusuf *et al.*, 1993). Deficiency of riboflavin, vitamin C, zinc, calcium and some other micro nutrients are also common in Bangladesh.

In Bangladesh anemia and vitamin A deficiency have remained unchanged problem during the last three decades and persists as to be the major public health problem (Ahmed, 1999, 2000).

Role of small indigenous fishes (SIF)

Fish is the primary source of animal protein in the diet of most people of Bangladesh (DoF, 2005). Fresh and dried fish is a very popular food item. Fishes contribute about 9% of total protein consumption and 63% of the per capita animal protein intake in the daily diet of the people (DoF, 2010). Fish protein is said to be healthier and cholesterol free. Fish protein contains all the essential amino acids in right proportion and is called complete protein needed for the proper growth and development of human body (Hossain, 1996). Though it is well accepted that fish is a good source of animal protein, but their role as a source of vitamins and minerals is often overlooked in the developing countries (Roos *et al*., 2007).

In tropical climate fishes spoil within hours at ambient temperature because of the presence of bacteria on the body surface of the fishes.

Sun drying is one of the most important low cost methods of fish preservation and the product plays an important role particularly in providing nutrients to the people of all classes of Bangladesh. The demands for dried and dehydrated fish as an export item is increasing day by day. According to the FRSS (2012), the quantity of exported dry fish from Bangladesh was in 2004-2005, 272 metric tons which valued 3.71 crore taka and in 2010-2011 it was 623.25 metric tons worth 5.57 crore taka. Dried fishes are the most important source of protein. The total harvest can be used as food for human consumption (FPC) and waste products can also be used as fish feed/poultry feed (as fish meal).

During sun drying about 50% of the dried fish products are wasted (30% during drying and 20% during subsequent storage in high humid and high temperature condition), in the subtropical countries like Bangladesh (Doe, 1985). The major problem associated with the sun drying of fishes are infestation of the products by the fly and insect larvae during drying and their subsequent storage.

The present work deals with the small fishes of the river Padda and their surrounding area. The study mainly deals with a checklist of small fishes in the

river Padda and their preservation, preparation, utilization and biochemical analysis of FPC small fishes and fast food products. Some works have been done on the flesh contents of different species of fishes (Hossain *et al.*, 1999; Mookherjee and Basu, 1946; Sultana *et al.*, 2011). However, the authors did not give any suggestion or any method for proper utilization to provide maximum nutrient after consumption. The present work also deals with group weight and weight after dressing and washing, estimation of edible portion, use for human consumption and preparation of some fast food of the dust of small fishes.

The role of fishes specially small fishes in the diet of the rural poor in Bangladesh was reviewed by Hossain and Afroze (1991), Bhuiyan (1997) mentioned that among the fishery communities the small fishes occupy an important position in the popular food items. The amount of fishes eaten by the very poor about 69% is the small fishes (darkina, puti, kachki, taki, guchi) (Barman *et al.*, 2011). In a country having a population suffering from malnutrition and protein deficiency such fish species may have positive steps regarding the improvement of the national health.

The people of Bangladesh tremendously suffer from malnutrition and struggle hard to attain sufficiency in this field. It is necessary to do proper utilization of small fishes which support to increase the production of protein rich food. Small fishes consumed along with bones are widely believed to be the excellent sources for calcium and phosphorous. These small indigenous fishes are cheaper access to the supply of essential nutrients in our diet.

Nutrient contribution from SIF

Food consumption surveys in rural Bangladesh have shown that SIF provide the main source of animal protein on the rural Bangladesh diet. SIF are also important source of vitamin-A, calcium and iron. Comparative studies show that the nutritional significance of SIF is higher than compared to larger fishes. Many SIF are eaten whole with bones and heads and thus contribute to add calcium, phosphorous and vitamins to the diet of Bangladeshi people.

Table 1.1. Nutritional value of some small indigenous fishes (SIF).

Nutritional value of SIF	Author(s)
Sharpunti, punti, chela, kholisha, pabda, tengra etc. contain high quantities of protein, vitamin, iron and minerals.	INFS (1977)
Mola is the rich source of vitamin-A.	Ahmed (1981)
Mola weighing 1-3 g contains about 8 mg retinol and 12 mg dehydroretional per 100 mg of edible tissue. Dhela weighing about 3 g contains about 22 mg retinol and 31 mg dehydroretional per 100 mg of edible tissue.	Zafri and Ahmed (1981)
Mola and dhela contain high quantities of vitamin-A, which can prevent xeropthalmia in growing children.	Alam (1985)
Kaski and mola are rich source of calcium.	Rahman (1982)
Mola, dhela, chela and kholisha have high protein, vitamin and mineral contents.	Banu *et al.* (1985)
Mola, darkina and baim contain vitamin-A in sufficient quantity and can help prevent night blindness in children.	Sirajuddin (1986)
Small fishes have a high nutritional value in terms of protein, vitamins and minerals, that are not commonly available in other foods of Bangladesh.	Afroze *et al.* (1997)
Small fishes contain large amounts of calcium and also iron and zinc. Mola, dhela, darkina and kaski contain large amounts of vitamin-A.	Thilsted *et al.* (1997)
SIF are a good source of protein and minerals. SIF contain more calcium and phosphorous than big fish.	Hossain *et al.* (1999)

(Source: Wahab, 2003).

Number of small indigenous fishes (SIF)

Once this region (north-west region) had an abundance of small fishes including koi, singi, magur, punti, sharpunti, mola, kholisha, baim, taki, tengra, gulsha tengra, pabda, kakila, bata, raikhor and many others. They were readily available in all the habitats of this region. Because of overfishing, indiscriminate use of insecticides and pesticides and unavailability of sufficient waters and siltation and the Farraka dam in the rivers the population of these fishes has been drastically reduced.

In Bangladesh, 143 species of small fishes are listed. Many of these are also included in the list of cultured fishes. In polyculture of carp fishes and small fishes, small fish do not decrease the production of carp fishes. The total production it will be increase which will give additional supplement to the earn and amount of fish intake (Roos *et al.* 2002, Wahab *et al.*, 2008 and Kunda *et al.*, 2009). The number would be much higher if all small fish species of estuarine origin migrating into the rivers, floodplains were included. But in Rajshahi region (Northwest region) about 50-57 small indigenous fish species (SIFS) are available.

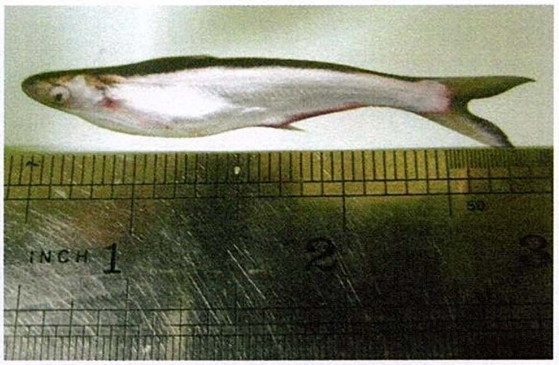
Table 1.2. List of experimental small fishes, their characters and classification.

Species no.	Classification	Local name	Morphological characters
1.	**Class:** Osteichthyes **Order:** Perciformes **Family:** Gobiidae **Genus:** *Glossogobius* **Species:** *G. giuris* (Hamilton, 1822)	Bele	Mouth subcutaneous and oblique. Teeth in both jaws are arranged in several rows. No barbel, and lateral line. Anterior portion of the body cylindrical and posterior compressed, it is elongated and covered with etenoid scales, becoming cycloid in the head. Pectoral fin elongated and caudal fin rounded. Colour variable generally cream colour light black marking on the head.
2.	**Class:** Osteichthyes **Order:** Perciformes **Family:** Anabantidae **Genus:** *Colisa* **Species:** *C. fasciata* (Bloch and Schneider, 1801)	Khalisha Kholisha	Mouth small, dorsal and abdominal profile equally convex, dorsal pointed, pelvics consists of a single filiform, caudal square or may be rounded. Lateral line interrupted. Scale present, spiny dorsal greenish or bluish above, dirty white below. Orange backwardly directed oblique bands descend from back of abdomen.
3.	**Class:** Osteichthyes **Order:** Cypriniformes **Family:** Cyprinidae **Genus:** *Puntius* **Species:** *P. ticto* (Hamilton-Buchanan, 1822)	Tit punti	Body strongly compressed, elevated, mouth small, terminal, barbels absent, lateral line incomplete, dorsal fin long, pectoral long. Silvery with two black spots. During breeding season (May to October) flanks turn red.
4.	**Class:** Osteichthyes **Order:** Siluriformes **Family:** Schilbeidae **Genus:** *Eutropiichthyes* **Species:** *E. vacha* (Hamilton, 1822)	Bacha	Body compressed, dorsal and ventral profiles about equally convex, snout compressed, pointed, mouth large, 4 pairs of barbels, dorsal and pectoral spine weak. Silvery grayish along the back, pectorals, dorsal and caudal black edged.
5.	**Class:** Osteichthyes **Order:** Clupeiformes **Family:** Clupeidae **Genus:** *Corica* **Species:** *C. soborna* (Hamilton, 1822)	Kachki	Elongated, moderately compressed, abdominal profile more convex than that of dorsal. No scute before origin of pectoral origin of dorsal nearer to caudal base than to tip of snout. Pectoral as long as head excluding snout. Pelvics originate behind vertical from posterior base of dorsal, caudal forked. Silvery with a lateral band.
6.	Mixed fishes (*Chanda nama*, *Chanda ranga*, *Amblypharyngodon mola*, *Mastacembelus pancalus*, *Xenentodon cancila*)	Nama chanda, ranga chanda, mola, guchi, kakila	-

a

b

c



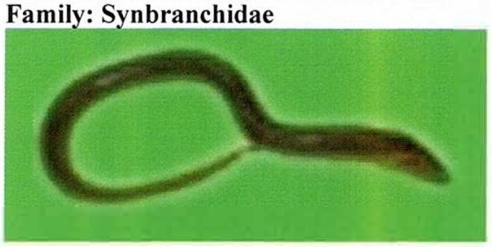
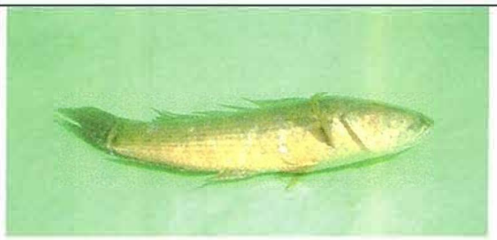
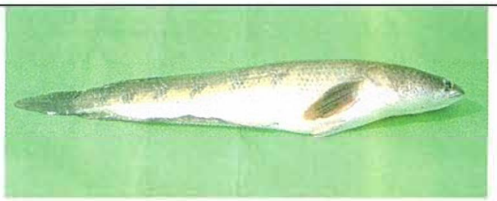
d

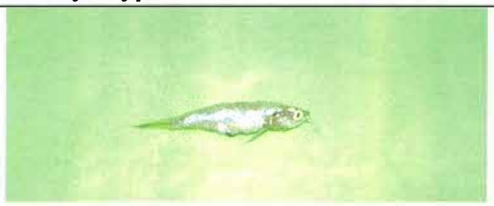
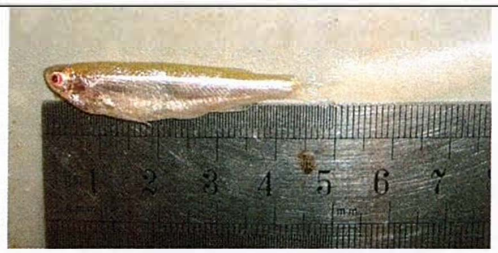
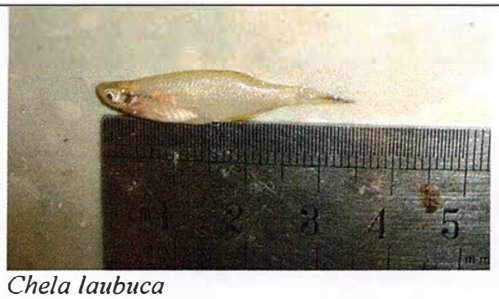
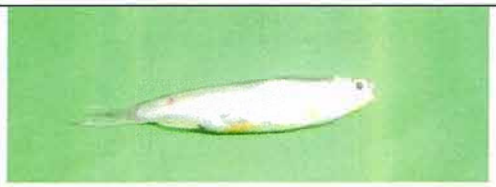
e

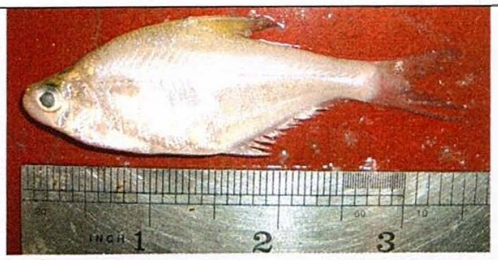
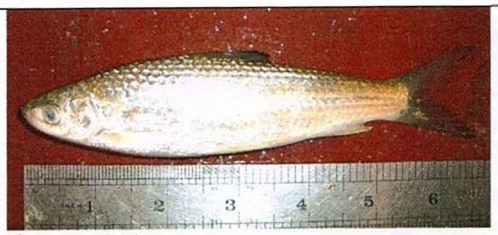
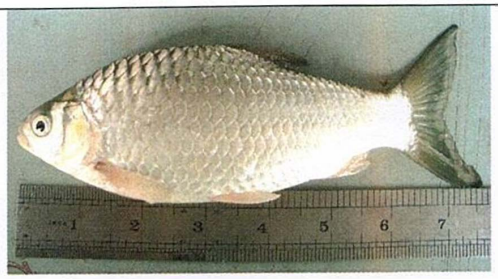
f

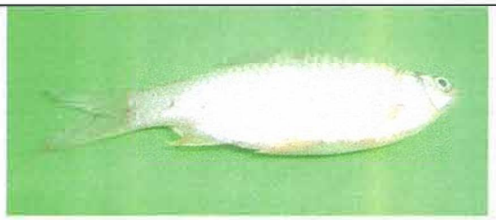
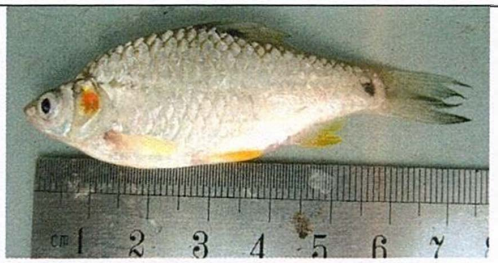
Plate 1.1: Photographs of the experimental fishes (a. *G. giuris*; b. *C. fasciata*; c. *P. ticto*; d. *E. vacha*; e. *C. soborna* and f. group of mixed fishes

Table 1.3. A checklist of the small fishes of the river Padda near Rajshahi.

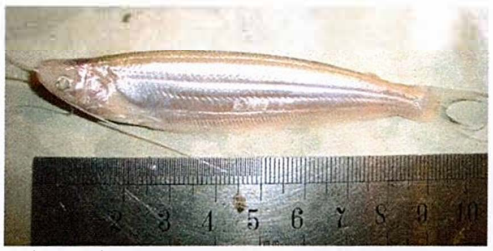
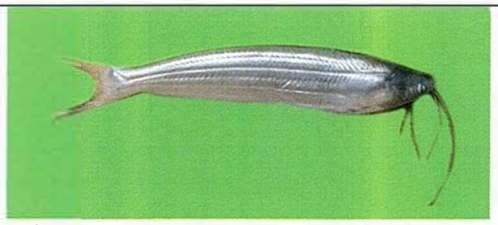
Sl. No.	Scientific Name	Local Name	Availability
1	**Family: Belonidae**  *Xenentodon cancila*	Kakila	VC
2	**Family: Synbranchidae**  *Monopterus cuchia*	Kuchia	C
	Family: Channidae		
3	 *Channa punctatus*	Taki, Lata	C
4	 *Channa orientalis*	Cheng	R
5	 *Channa marulius*	Gojar	R
6	 *Channa gachua*	Cheng	R

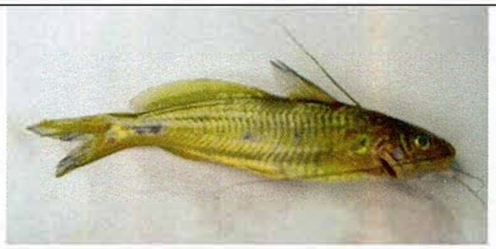
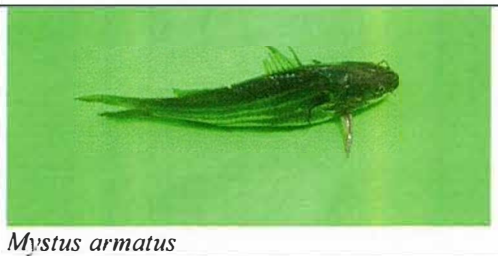
Sl. No.	Scientific Name	Local Name	Availability
7	**Family: Cyprinidae**		
	 *Esomus danricus*	Darkina	C
8	 *Chela cachius*	Chep Chela	C
9	 *Chela laubuca*	Kash Khaira	R
10	 *Aspidoparia morar*	Morari	C
11	 *Aspidoparia jaya*	Jaya	VC
12	 *Rasbora rasbora*	Darkina, Leazza Darkina	R

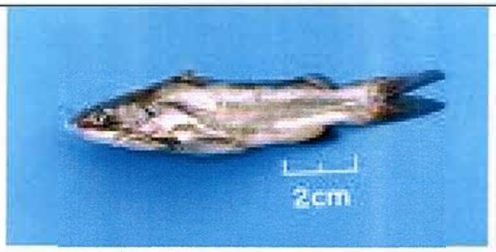
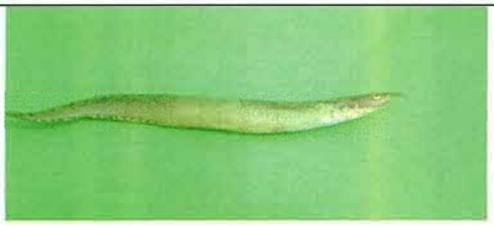
Sl. No.	Scientific Name	Local Name	Availability
13	 *Amblypharyngodon mola*	Mola, Moya, Mourula	VC
14	 *Rohtee cotio*	Keti, Chela, Dhela	C
15	 *Labeo bata*	Bata, Bhangan bata	R
16	 *Cirrhina reba*	Raik, Tatkini, Bata, Raikhor	VR
17	 *Puntius sarana*	Sarputi	VR
18	 *Puntius chola*	Chala punti	VC

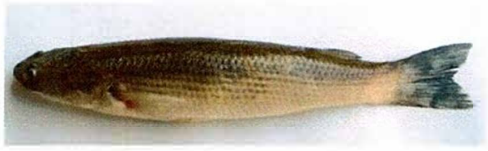
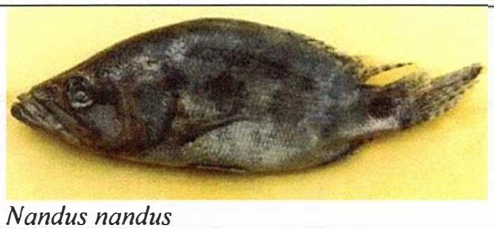
Sl. No.	Scientific Name	Local Name	Availability
19	 *Puntius phutunio*	Phutani punti	C
20	 *Puntius conchonius*	Kanchan punti	VC
21	 *Puntius ticto*	Tit punti	VC
22	 *Puntius sophore*	Jat punti	VC
23	 *Puntius terio*	Teri punti, Gili punti	R
24	 *Someleptes gongota*	Pahari gutum	R

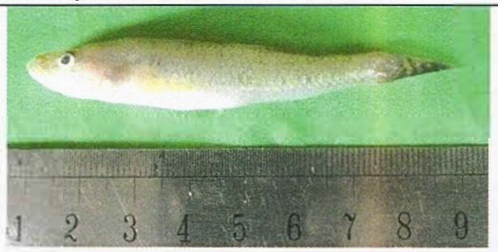
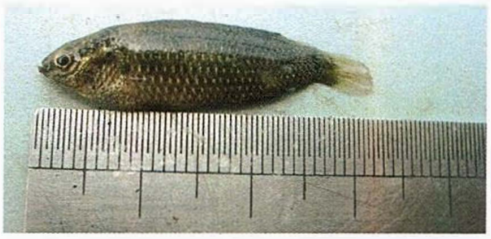
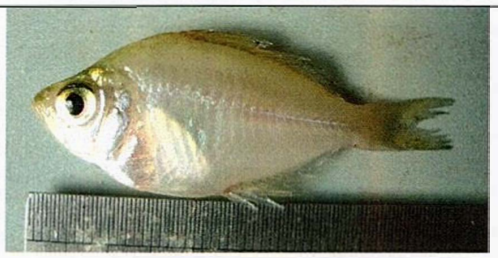
Sl. No.	Scientific Name	Local Name	Availability
25	 *Botia dario*	Rani	C
26	 *Botia lohachata*	Rani, Putul, Beti	VR
27	 *Lepidocephalus guntea*	Gutum, Puiya	C
	Family: Clariidae		
28	 *Clarias batrachus*	Magur	VC
	Family: Siluridae		
29	 *Ompok bimaculatus*	Kani Pabda, Boali Pabda	VC
30	*Ompok pabda* 	Modhu Pabda	VC

Sl. No.	Scientific Name	Local Name	Availability
	Family: Heteropneustidae		
31	 *Heteropneustes fossilis*	Shing	C
	Family: Schilbeidae		
32	 *Ailia coila*	Kajuli, Baspata	R
33	 *Ailia punctata*	Kajuli, Baspata	C
34	 *Pseudeutopius atherinoides*	Batashi	R
35	 *Eutropiichthys vacha*	Bacha	C
36	 *Clupisoma murius*	Muri Bacha	R

Sl. No.	Scientific Name	Local Name	Availability
37	 *Clupisoma garua*	Ghaura	C
	Family: Bagridae		
38	 *Mystus cavasius*	Golsha, Golsha Tengra	VC
39	 *Mystus bleekeri*	Golsha, Golsha Tengra	VC
40	 *Mystus tengara*	Bajari Tengra, Ghuitta Tengra	VC
41	 *Mystus vittatus*	Tengra	VC
42	 *Mystus armatus*	Tengra	VC

Sl. No.	Scientific Name	Local Name	Availability
43	 *Mystus gulio*	Nuna Tengra	C
44	 *Gagata youssoufi*	Gang Tengra	VC
45	 *Gudusia chapra*	Chapila	VC
46	 *Corica soborna*	Kachki	VC
	Family: Mastacembelidae		
47	 *Macrognathus aculeatus*	Tara Baim	VC
48	 *Mastacembelus armatus*	Sal Baim	VC

Sl. No.	Scientific Name	Local Name	Availability
49	 *Mastacembelus pancalus*	Pancal	VC
	Family: Mugilidae		
50	 *Rhinomugil corsula*	Khorsula	C
	Family: Anabantidae		
51	 *Colisa sota*	Boicha, Chuna Kholisha	R
52	 *Colisa fasciata*	Kholisha	VC
53	 *Anabas testudineus*	Koi	VC
	Family: Nandidae		
54	 *Nandus nandus*	Meni	R

Sl. No.	Scientific Name	Local Name	Availability
	Family: Gobidae		
55	 *Glossogobius giuris*	Bele	C
56	**Family: Pristolepidae**		
	 *Badis badis*	Napit	R
57	**Family: Centropomidae**		
	 *Chanda ranga*	Ranga Chanda	VC
58	 *Chanda nama*	Chanda	C
59	 *Chanda beculis*	Chanda	C

C = common; VC = very common, R = rare, VR = very rare

(Personal observation and communication)

The present work consists of seven chapters which are designed as follows-

Chapter One – General Introduction and review of literature.

Chapter Two – Flesh production from some small indigenous fishes.

Chapter Three – Preparation, preservation and utilization of fish protein concentrate (FPC) made of small indigenous fishes.

Chapter Four – Biochemical analysis of powder (FPC) of SIF.

Chapter Five – Acceptability of FPC made of different fast food products of small fishes.

Chapter Six – Preparation of fish meal (FM) and their utilization.

Chapter Seven – Summary and conclusion.

Description of study area

The present study was conducted in the river Padda on the bank side of the river and Rajshahi City Corporation (Kasiadanga to Binodpur) adjacent to the area. The study was extended from western border of Kasiadanga to eastern border of Binodpur (Fig. 1.1).

The Padda (the Bangladesh portion of the Ganges) is the lower part of the Ganges enters Bangladesh from India through the Rajshahi district (Latitude 24°22' N; longitude 88°35'E). The Padda meets with another river the Jamuna near Aricha and finally meets with the Meghna river near Chandpur and adopts the name "Meghna" before falling into the Bay of Bengal.

The Padda is an important spawning and feeding ground for riverine fish species of southwestern Bangladesh. In the Padda river, Cypriniformes is the largest family represented by 86 species belonging to 43 genera (Hossain and Haque, 2005). Previously, Islam and Hossain (1983) enlisted 110 fish species in the Padda river near Rajshahi; Bhuiyan *et al.* (1992) published a checklist of the fishes of Rajshahi having 133 species of small fishes. Samad *et al.* (2010) reported to availability of small indigenous fish species of the river Padma.

The experimental species were collected from different fish landing centres of the Padda near Rajshahi e.g., Bulonpur, Shaheb bazar, Panchoboti, Katakhali and Binodpur.

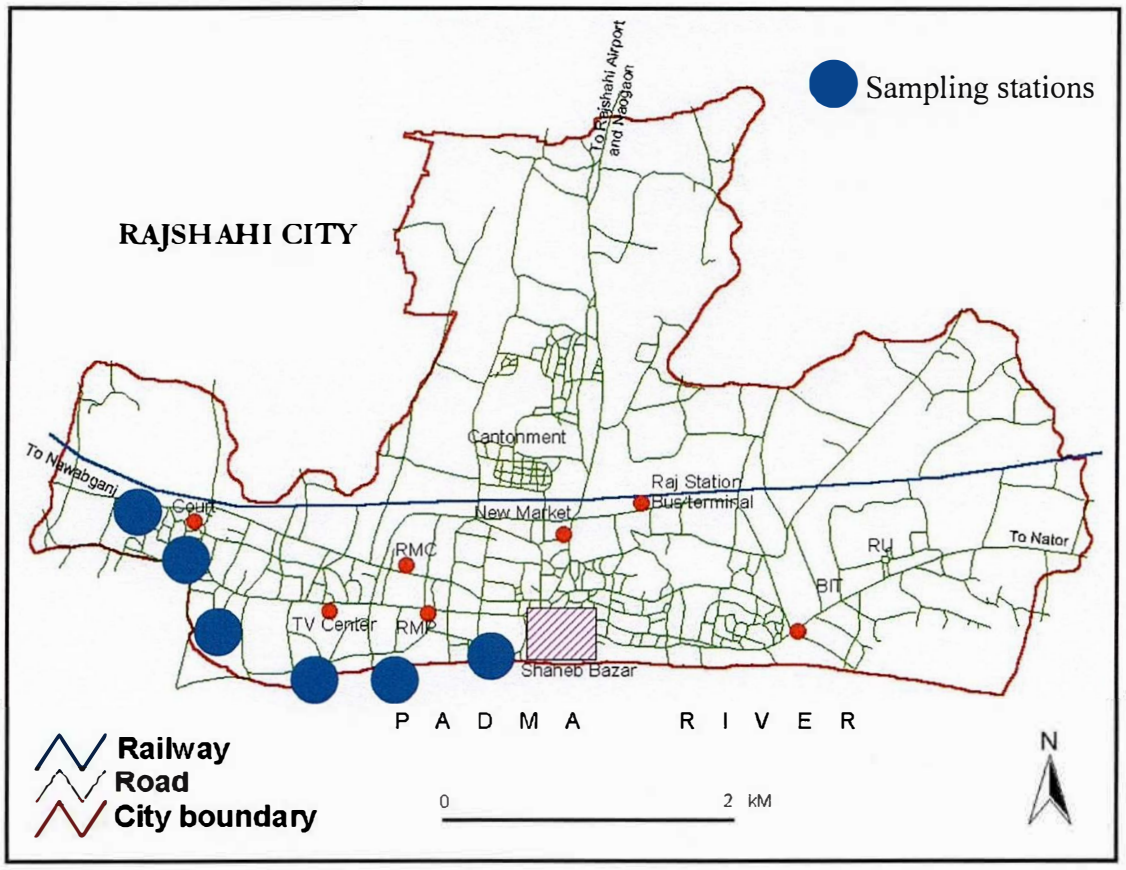


Fig. 1.1. Map of the sampling areas.

OBJECTIVES OF THE WORK

The objectives of the present works include:

- To provide a check list of available small fish species of the river Padda (Padma).
- To study the edible flesh production after dressing and washing of each experimental fish species.
- To find the proper preservation methods of some small fishes.
- To explore the utilization of the small fishes.
- Preparation of different fast food items (FPC) with small fishes.
- To assess the chemical composition of the species (*Glossogobius giuris*; *Colisa fasciata*; *Puntius ticto*; *Eutropiichthyes vacha*, *Corica soborna* and some mixed small fishes (*Chanda nama*, *C. ranga*, *Amblypharyngodon mola*, *Mastacembelus pancalus*, *Xenentodon cancila*) of powdered condition of the fishes.
- To know the food value, utilization and acceptability of fast food items of the fishes.
- To assess the preparation of fish meal and its utilization.

REVIEW OF LITERATURE

This chapter provides a selected review of literature of the past researches on the river Padda near Rajshahi and related works. A short number of researches have been done in this sector. Islam and Hossain (1983) provided an account of 110 species of fishes of the river Padda near Rajshahi. Bhuiyan *et al.* (1992) listed 133 species inhabiting the freshwaters of Rajshahi district. Hossain and Haque (2005) enlisted 134 species in the river Padma. Samad *et al.* (2010) reported 57 small indigenous fishes in the river Padma near Rajshahi.

Considerable numbers of works have been done on flesh contents of different species of fishes by some authors such as Mookherjee and Basu, 1946; Hossain *et al.*, 1999, Wahab *et al.*, 2003; Kunda *et al.*, 2009; Heilporn *et al.*, 2010; Sultana *et al.*, 2011 etc. But they have not shown how to utilize the small fishes.

Many works have been done on the preservation and utilization technique of fishes. These are Aref *et al.* (1964, 1965), Rubbi *et al.* (1978) Ahmed *et al.* (1979), Bhuiyan *et al.* (1990); Moore (1990), Hossain (1992), Martin (1994), Hossain *et al.* (1994), Kamal *et al.* (2000), Nowsad (2003), Haq (2005), Mansur (2005), Islam *et al.* (2006), Rabbane *et al.* (2006), Heilporn *et al.* (2010), Huang *et al.* (2010) etc.

Sun drying of fishes is one of the most old and traditional method for fish processing and preservation used by both skilled and unskilled personnel. Sun drying of fishes is a simple method and the processed fish product may be utilized throughout the year if proper way of storage and marketing can be maintained.

The present attempt has been made to know how to utilize, specially preserve and prepare the fast food items of small fishes for our rural people and the loss in term of percentage after dressing and washing the products which are used for human consumption and prepare of fishmeal by wastes of fish for poultry.

The majority of Bangladeshi people are suffering from protein deficiency and majority of them are suffering from protein energy (PEM) deficit. The main cause of various human diseases is due to deficiency of nutrient content of food.

Nutritional studies have proved that fish proteins rank in the same class as chicken protein and are superior to beef protein, milk and egg albumin.

Fishes play a very important role in nutrition supply for people. Scientists believe that better health of the people can be ensured quickly and economically through greater production of fishes (Borgstrom, 1961).

Fish flesh contains up to 80% water and oil, 15-25% protein, 1-2% mineral and 2% other constituents (CSIR-1962, India). Another report from FAO (1991) revealed that fishes contain 72% water, 19% protein, 8% oil, 0.15% calcium, 0.25% phosphorous and 0.10% vitamins A, B, C and D. Reports also show that iron, calcium and phosphorous are present in readily available from with 30-40% of the available iron occurring as a nucleoprotein complex. Many other mineral constituents were also reported to be present in fish muscle.

Nabi and Hossain (1990) reported that the flesh of *Macrognathus aculeatus* contains up to 80% water oil, 12.36-18.28% protein, 1.65-5.46% fats, 0.96-2.05% carbohydrates, 1.97 to 4.59% ash, 1-2% mineral.

Felts *et al.* (1996) reported that small indigenous fishes are a valuable and easily available source of food rich in protein, oil and minerals. It is important in the diet of rural poor in Bangladesh.

Hossain and Afroze (1991) reviewed the role of small fishes in the diet of the rural poor in Bangladesh. Small fishes are mostly non-culturable in our country but it provides food and nutrition.

Thilsted *et al.* (1997) also reported that many nutrients such as vitamin A and C, iron, calcium, zinc and iodine are not found in rice and have to be obtained from other sources. Small fishes play a vital role which contributes to the diet of the rural poor in Bangladesh where more than 30,000 children become blind every year from due to vitamin A deficiency, one million suffer from night blindness and about 50-70 percent of women and children die within a few months of the blinding episodes (Cohen, 1989). Small fishes which are less than 10 cm in length and usually eaten whole with the organs and bones, contain large amount of

calcium and possibly iron and zinc. Many of the small fishes are caught in rivers and natural water bodies. Small fishes eaten frequently in small amounts and is more equally distributed among family members than big fishes of which men get the large share.

Hossain *et al.* (1999) reported that percentage of edible flesh is higher in small sized fishes than in large sized fishes. The authors showed that flesh weight after dressing was high in mola fish (67.76%) compared to the carps (62.57% for rui, 58.62% for catla and 57.51% for mrigel).

FRSS (2000-2001) reported the production of the river Padma as 136 thousand from upper Padma near Kushtia district. The reports are also available on the total landing of the lower Padma river as 112, 1484, 454, 451, 40, 189, 667 metric tons from Dhaka, Faridpur, Rajbari, Manikgonj, Munshigonj, Sariatpur respectively.

Roos *et al.* (2007) described the vitamin A, calcium, iron and zinc contents from the commonly consumed fish species of Bangladesh. Very high content of vitamin A (500-1500 µg RE/100g raw edible parts) in Dhela (*Osteobrama cotio cotio*), Darkina (*Esomus danricus*), mola and chanda (*C. baculis*) (Roos *et al.*, 2003). Even sun dried fishes contain up to 60-80% protein (Hoq, 2004).

Sultana *et al.* (2011) reported that flesh weight after dressing was high in *C. soborna* as 97.76% and the lowest in *C. fasciata* as 57.4%. Highest quantity of powder from of fish was obtained in case of the mixed species as 24.61% and the lowest in *O. bacaila* which was 20.52%.

Biochemical analysis of the small fishes

The major component of fish fillet is water. In general, the body composition of fishes depends on age, sex, seasons and diet (Love, 1970; Philips *et al.*, 1996). It was suggested that changes in body components during starvation are dependent upon water temperature, reproductive status and age (Afroze *et al.*, 1997).

Fish flesh contains four basic ingredients in varying proportion such as water, protein, fat, ash and other important nutrients substances like minerals and vitamins

(Stansby, 1962). Generally fish protein tends to be higher in lysine and lower in tryptophan contents than meat.

CSIR (1962) reported that fish flesh contains up to 80% water, 15-25% protein, 1-2% mineral.

Guha (1962) worked on fish nutrition as human food and fish which supply high class protein compared to other animal sources.

Stansby (1962) reported the proximate composition of the flesh contents for the edible portion of different fishes which showed a wide range of variation as moisture 28-90%, protein 6-28%, fat 0.2-64% and ash 0.4-1.5%.

A large number of workers such as Saha and Guha (1940), Jacobs (1958), Jacquot (1961), Khuda *et al.* (1962, 1964), Jafri *et al.* (1964), Adhikari and Noor (1967), Zafri and Ahmed (1980), Rahman *et al.* (1982), Anderson *et al.* (1982), Ahmed and Hassan (1983), Rubbi *et al.* (1987), Mollah (1987), Nabi and Hossain (1990), Banu *et al.* (1991), Thilsted *et al.* (1997), Hossain *et al.* (1999), Iwata *et al.* (2000), Rahman *et al.* (2003 and 2004), Islam *et al.* (2003), Islam and Joadder (2005), Naser *et al.* (2007), Sultana *et al.* (2011) etc. worked on the biochemical composition of different fish species in different point of view.

Fish oil has generally unsaturated fatty acids than animal fats. Since polyunsaturated fatty acids are beneficial in keeping down the cholesterol level of blood. Fish and fish oil are particularly useful in their regard (Guha, 1962).

Jafri and Khawaja (1968) determined the chemical composition and nutritional value of some small indigenous fishes (SIF). The frequency of changes in the composition of biochemical constituents of any organism vary with the variation of the environmental changes. Small fishes often are easily digestible and contain protein, fat, vitamin, calcium, phosphorous and some other minerals which are needed for human body (Sultana *et al.*, 1997). Every 100g fish contains 14-18 g of protein (Islam, 2007).

Hardy and Keay (1972) classified fishes on the basis of fat contents into lean fishes (less than 0.5% fat), semi fat fishes (less than 2% fat) and fatty fishes (more than 2% fat).

Banu *et al.* (1985) estimated the protein, riboflavin and iron contents of 17 species of small indigenous freshwater fishes and one species of prawn.

Al-Habib (1990) estimated the protein content of six freshwater fishes and he observed that these fishes contained 11-16.75% protein.

Nabi and Hossain (1990) observed that the chemical composition of caloric content of *Macrognathus aculeatus* and found protein was 1.65-5.46%.

Sultana *et al.* (1997) reported that small fishes often are easily digestible and contain protein, fat, vitamin, calcium, phosphorous and some other minerals which are needed for human body.

Islam *et al.* (2003) observed protein content of *Cirrhina reba* as 19.74% in male and 18.89% in female.

Hoq (2004) reported that sun dried fishes contain up to 60-80% protein.

Islam and Joadder (2005) found the average protein content of female *Glossogobius giuris* as 14.61% lower than the male which was 15.23%.

Musa and Bhuiyan (2006) reported that moisture (72.94%), protein (16.67%), lipid (6.12%), ash (2.53%), while carbohydrate content was 1.63% in fresh *Mystus bleekeri*.

Sultana *et al.* (2011) reported that highest percentage of protein content was found in mixed species (72.45%) and lowest in *Chanda ranga* (52.65%), fat content was highest (23%) in mixed species and lowest (12.66%) in *Corica soborna*. Calcium 1.34% in *Mystus vittatus* highest and lowest 0.80% in mixed small fishes, highest phosphorous was found in *C. ranga* (2.90%) and lowest (1.72%) in *C. soborna*. Maximum amount of iron was found in mixed species (45.20/100g) and the lowest (16.85 mg/100g) in *Clupisoma atherinoides*.

Acceptability of FPC of different fast food products

Consumers' acceptances, remarks etc. are the very important factors to introduce any new food products to them. From the present findings it is apparent that an economically viable value-added fish products can be operated in rural areas. Freshwater fishing communities are living in extreme poverty conditions. For alternative income in fishers' family, the poor fishermen and wives of fishers can be trained up in production and marketing activities of such fast fish food products.

Tan *et al.* (1994) conducted researches in the diversification of processing techniques, advances in quality control, hygiene and sanitation management and extension of cool chain distribution system.

SEAFDAC launched many programs in Singapore, Thailand, Philippines and Brunei to utilize the under utilized resources in value-added products (Tan *et al.* 1988).

Prathiarenum *et al.* (1985) and Lazos (1996) produced canned fish ball from freshwater carps and eels and suggested that the freshwater species were more promising than marine species in producing minced products. Fish sausage and ham industry, nowadays use many low cost small pelagic fishes in Japan, in addition to large whale and tuna fishery (Tanikawa, 1985).

The products have continually been upgrading with improved taste and texture compelling with the preference of local people (Ohshima, 1996). The key to the success of these products is the accumulated results of scientific studies on the processing of fish paste products by the Japanese and US researchers (Tanikawa, 1985).

Nowsad *et al.* (1994, 2005) worked on sea food resources availability, utilization and their researches in Bangladesh.

Utilization of fish meal (FM)

Fish meal is a high quality nutritious food which includes high protein, minerals, vitamins and other elements which grow in animal and made of fresh fish or fish wastes or trash fish.

Miller (1970) reported that available amino acid content is present in fish meal.

Windsor (1971) described fish meal as a solid product, ground, that has been obtained by removing the water and some or all the oil from fish or fish waste.

Andrews and Page (1974) also reported that fishmeal being rich in all the dietary essential amino acid.

International Association of Fish Meal Manufactures (IAFMM) 1979 – 1983 has recommended the method of analysis for determination of crude protein, moisture, ash, sand and salt in fishmeal.

Akand *et al.* (1991) fish diets (FM) were formulated to contain 30% protein, 14-17% lipid, 6-10% crude fiber and 31-35% digestible carbohydrate.

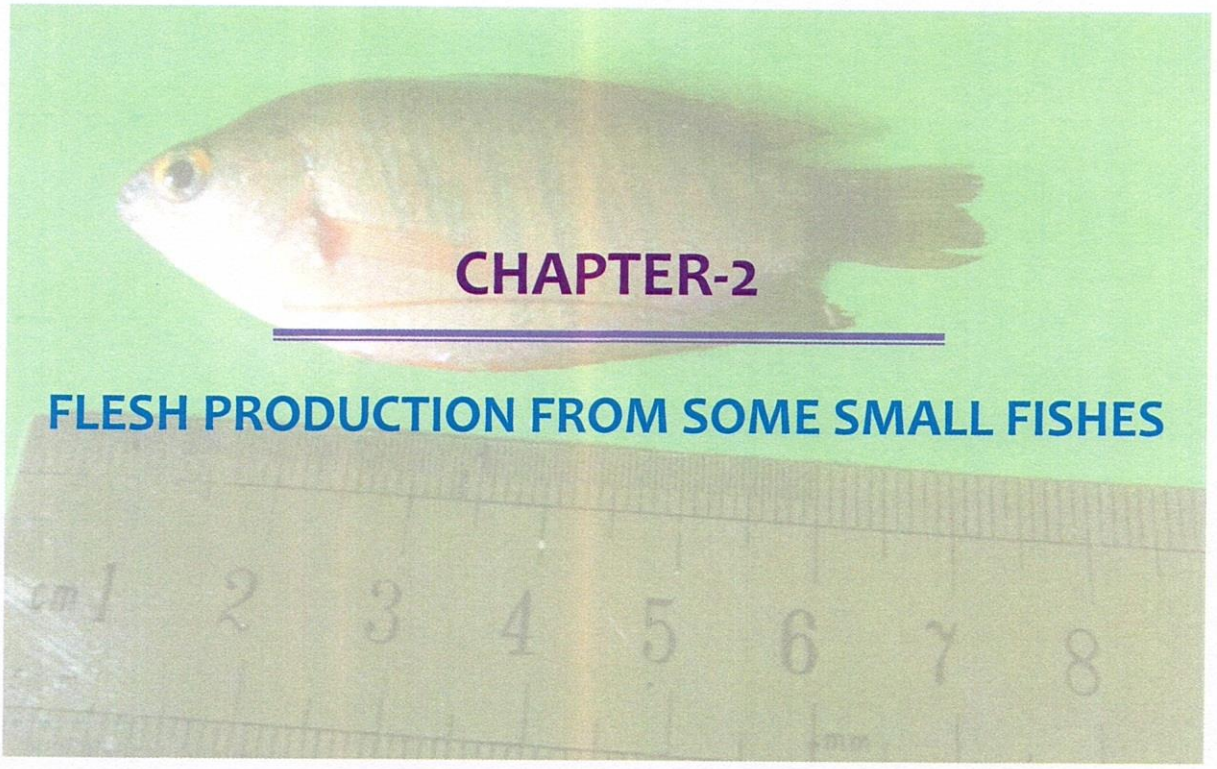
Hasan *et al.* (1997) mentioned that fish meal had been the major source of dietary protein for fish and fry throughout the world but the scarcity and high price limits its utilization as the source of protein in Bangladesh.

Habib *et al.* (2001) use of silkworm pupae as partial replacement of fish meal in the diets of catfishes.

Latif *et al.* (2008) observed that comparative study on the effects of low cost seed cakes and fish meal as dietary source for *Labeo rohita* fingerling.

At present small fishes are not used in fishmeal but in the preparation of high quality fish powder which supplement nutritious food for kids, pregnancy and lactating mother (Matshaw Saptaha, 2012).

So, fish meal is a very important feed for fishes, poultry, cattle and its nutritive value is high.



CHAPTER-2

FLESH PRODUCTION FROM SOME SMALL FISHES

Chapter Two

FLESH PRODUCTION FROM SOME SMALL FISHES

Introduction

In Bangladesh, rice and fish dominate the diet of Bangladeshis to such an extent of the old proverb, 'machhe bhate bangali' which can be translated as 'fish and rice make a Bangali'. This rice and fishes are eaten at least twice daily with small amounts of vegetables, and fish make up the typical meal. About 60% of animal protein consumption comes from fish. Fish consumption is dominated by small indigenous species of fish (SIF). In the national nutrition survey conducted in rural Bangladesh in 1981-1982, average fish intake was 23 g raw fish/person/day, whereas average meat consumption was 5 g/person/day (Ahmed and Hassan, 1983). More recent regional studies have confirmed the importance of fish in the Bangladeshi diet (Hels *et al.*, 2002). Every 100g fish contain 14-18 g of protein (Islam, 2007).

Small fishes are generally eaten with bones, whereas in large fish most or all bones are discarded as plate waste. So, small fishes are an excellent source of calcium. In studies with both humans and rats that the bioavailability of calcium from whole small fishes is as high as that from milk. In humans, the fractional calcium absorption is found to be 24±6% from small fishes and 22±6% from milk (Larsen *et al.*, 2000). The small fishes are captured with simple gears and even children can capture with their hands from water bodies (Alikunhi *et al.*, 1972; Hossain and Afroze, 1991; Hossain, 1994; Felts *et al.*, 1996).

Considerable number of works have been done on flesh contents of different species of fishes by different workers such as CSIR, (1962), Mookherjee and Basu (1946), Hossain and Afroze (1991), Hossain *et al.* (1999). Sultana *et al.* (2011) reported that percentage of edible flesh is higher in small sized fishes compared to large sized fishes.

The present attempt was made to find out the percentage of edible portion of some small fishes after dressing and washing, i.e., the product (%) which are used for human consumption.

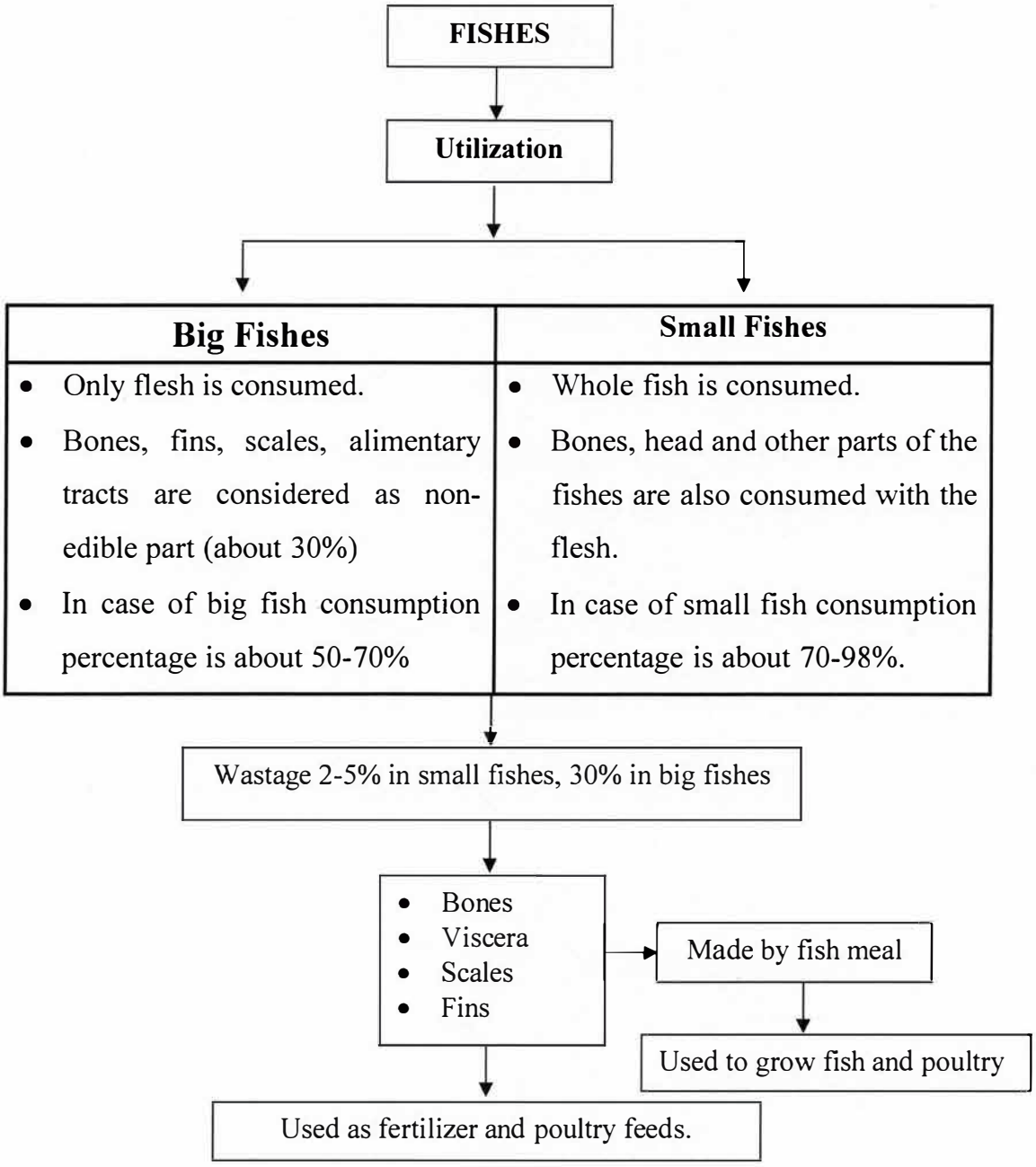


Fig. 2.1. Utilization of big and small fishes

Materials and methods

Sample and data collection

Six samples of *Glossogobius giuris*, *Colisa fasciata, Puntius ticto, Eutropiichthyes vacha*, *Corica soborna* and some mixed fishes (*Chanda nama*, *C. ranga*, *Amblypharyngodon mola*, *Mastacembelus pancalus*, *Xenentodon cancila*) were collected randomly from different fish markets and local landing spots of Rajshahi city. The study was carried out during the period from July 2008 – June 2011. The samples of fishes were collected by multiple spot visits to the river bank of Rajshahi city and adjacent area.

Measurements

Measurement of fishes were taken where there was no damage. Total length (TL) was taken with the help of a centimeter scale. The weight of fresh fish was taken with the help of both pan balance and electronic balance.

The fishes were washed with clean water and the excess water was soaked with kitchen tissue. Firstly, the whole body weight of the samples were recorded. Then the fishes were cut off and the scales were scrapped off. Viscera was removed and the fish was weighted again. Weight of all the wastes (viscera, fins, scales etc.) were taken.

Different measurements

Total length (TL): The lengths from the tip of the snout up to end of the caudal fin of the sample.

Total weight (TW): Total body weight of the sample fishes.

After dressing weight (ADW): Alimentary tract and scales of the fishes were removed then washed with tap water and then weighed.

Wastes weight (WW): Fins, scales, viscera, snout and mouth portion (*Xenentodon cancila*), was cut off and the waste weight was calculated by subtracting the after dressing and washing weight from the total.

Weight after dressing and washing of fish: In order to determine edible portion of the fish, total weight of a group fish was recorded. After dressing, total weight of wastes (scales, fins and viscera) was recorded. Percentage of edible portion was calculated from the following formula-

$$\text{Percentgae of edible portion} = \frac{\text{Total weight of a fish group (g)} - \text{Total weight of roughage (g)}}{\text{Total weight of a fish group (g)}} \times 100$$

Results and Discussion

In table 2.1 the range and mean±SD total length (TL) and total weight (TW), the weight after dressing and washing (ADW) was measured from the group weight. The ADW was found to range from 44.93±0.73 (*E. vacha*, group weight 50g) to 84.15±4.14 (*Colisa fasciata*, group weight 100g).

G. giuris having the maximum mean TL 106.4±18.29 mm, the ratio between the edible and non edible portion was found as 1:0.204 (Table 2.1 and 2.2). The ADW was found to range from 82.99±1.25.

C. fasciata having the maximum mean TL 75.8±10.10 mm, the ratio between the edible and non edible portion was found as 1:0.188 whereas, *P. ticto* same sized fish mean TL = 67.9±16.40mm have the mentioned ratio as 1:0.380 (Table 2.2, Fig. 2.2). After dressing the percentage of edible flesh portion was 84.15 for *C. fasciata* and 72.49 for *P. ticto*.

E. vacha (mean TL = 62.95±13.47mm) is a smaller fish, the ratio between the edible and non edible portion were 1:0.112 and percentage of edible portion was 89.86%.

C. soborna (mean TL = 17.85±5.58mm) is a smaller clupeid fish. The ratio between edible and non edible portion were 1:0.025 and after dressing and washing percentage of edible flesh portion was 97.54% for *C. soborna*.

In mixed fishes having the maximum mean TL 64.6±49.43 mm, the ratio between the edible and non edible portion was found as 1:0.382 (Table 2.1 and 2.2). The ADW was found to range from 72.34±5.08.

Detailed results are shown in Appendix table 1-6

Table 2.1. Total length, total weight and weight after dressing and washing and their mean and standard deviation of 5 species of small fishes and a group of small fishes

Exp. No.	Species (100g)	Total weight of group (g) (N=10)	Range of TL (mm)			Range of TW (g)			Range of ADW (g)		
			Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD
1	*G. giuris*	100	89	140	106.4 ±18.29	2.9	25.2	12.33 ±3.99	81.1	84.5	82.99 ±1.25
2	*C. fasciata*	100	44	90	75.8 ±10.10	5.8	10.8	8.16 ±1.88	79.1	88.4	84.15 ±4.14
3.	*P. ticto*	100	41	102	67.9 ±16.40	1.2	10.9	5.37 ±3.10	64.6	79.0	72.49 ±5.24
4.	*E. vacha*	50	45	80	62.95 ±13.47	0.8	2.3	1.20 ±0.28	43.3	46.0	44.93 ±0.73
5	*C. soborna*	50	12	27	17.85 ±5.58	0.41	1.63	1.03 ±0.64	47.91	49.76	48.77 ±0.61
6	Mixed fishes	100	19	205	64.6 ±49.43	0.20	16.28	3.53 ±4.70	67.8	83.5	72.34 ±5.08

Weight after dressing and washing and waste product in per kg and their ratios are shown in the table 2.2.

Table 2.2. Ratio between weight after dressing and washing weight and waste weight of the species.

Species	Mean TW (g)	Per kg weight of fish		
		Weight after dressing and washing (g)	Weight of waste products (g)	Ratios between weight after dressing and washing and waste product
G. guiris	100	829.90	170.10	1:0.204
C. fasciata	100	841.50	158.50	1:0.188
P. ticto	100	724.90	275.90	1:0.380
E. vacha	100	898.60	101.40	1:0.112
C. soborna	100	975.40	24.60	1:0.025
Mixed fishes	100	723.40	276.60	1:0.382

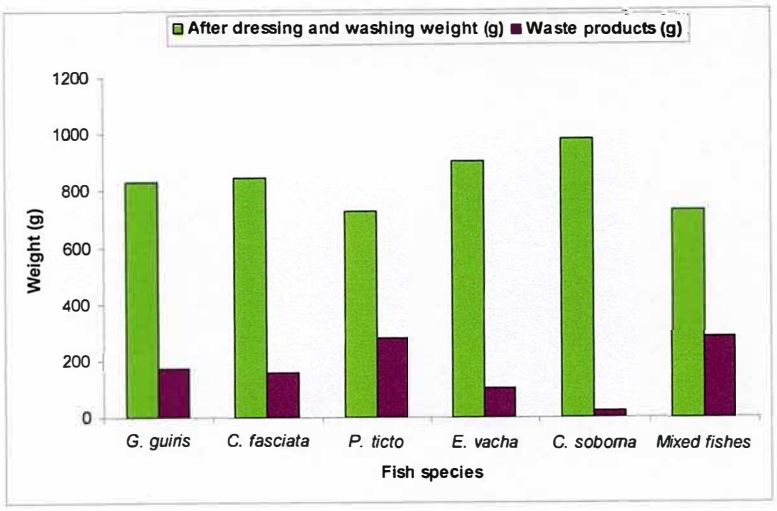


Fig. 2.2. Ratio between weight after dressing and washing and waste weight of six small fish species

Relative percentage of weight after dressing and washing and waste product

Total weight of one group, weight after dressing and washing and waste weight and relative percentage of weight after dressing and washing of 5 species are shown in the table 2.3.

Table 2.3. Relative percentage of weight after dressing and washing (ADW) and waste weight (WW) of each species

Exp. no.	Species	ADW (%)	WW (%)
1	*G. giuris*	82.99	17.01
2	*C. fasciata*	84.15	15.85
3	*P. ticto*	72.49	27.51
4	*E. vacha*	89.86	10.14
5	*C. soborna*	97.54	2.46
6	Mixed fishes	72.34	27.66

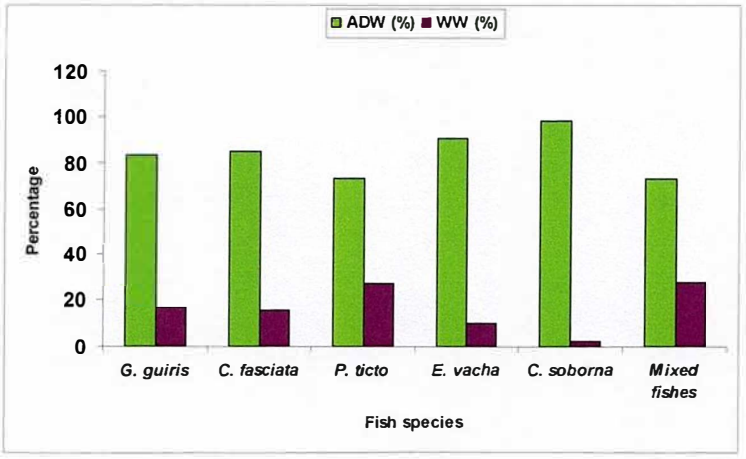


Fig. 2.3. Relative percentage of weight after dressing and washing (ADW) and waste weight (WW) of each species

During the last few years, natural fish stocks have declined due to natural and man made catastrophes, degradation of aquatic environments and the reduction of wetlands and water areas of Bangladesh, resulting in the disappearance of many suitable habitats of floodplains, rivers and brackish water. As a result many of these valuable small indigenous species have been threatened or endangered. Indeed, some are already on the brink of extinction (Hussain *et al.*, 1997; Islam, 2009).

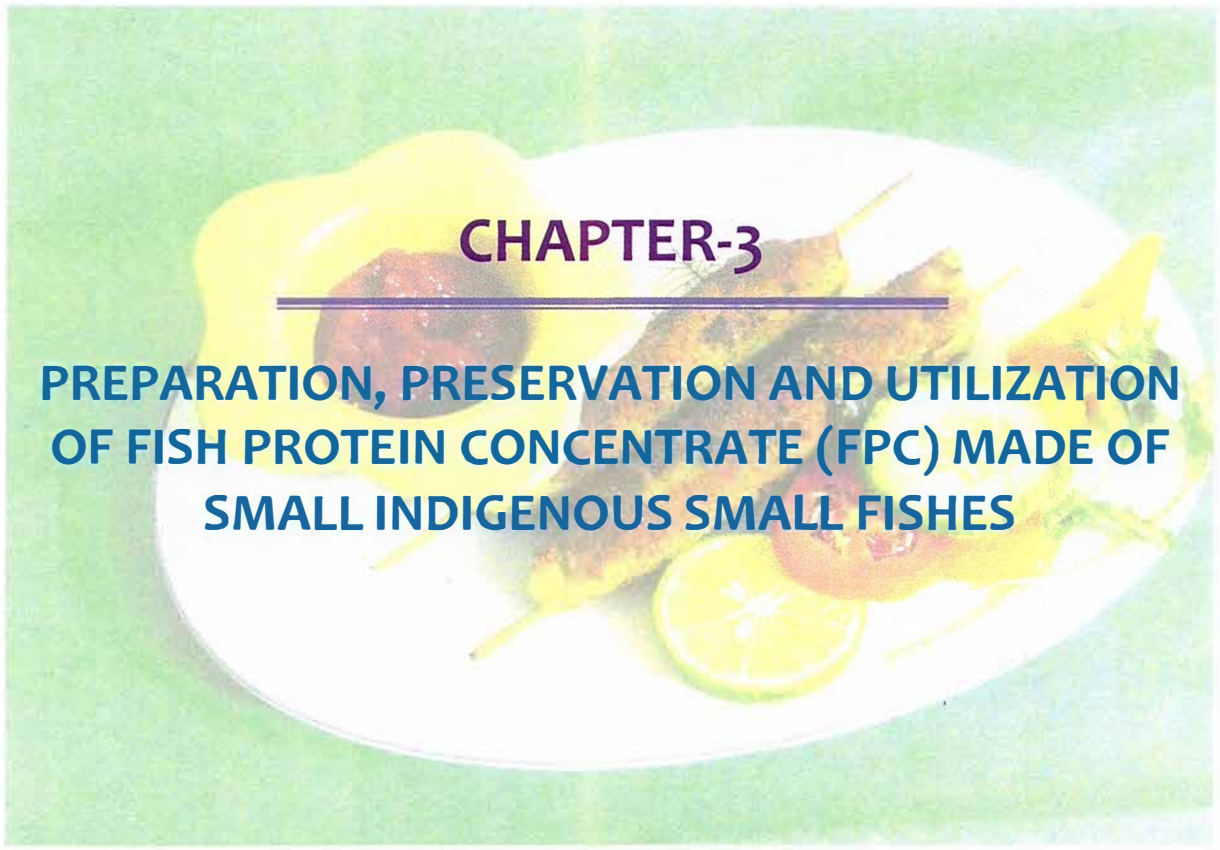
In this research work five economically important species of small fishes and some mixed fishes of 5 families under 5 orders have been taken into consideration. All these fishes are very much popular and more or less acceptable to our local people of all classes. These fishes are caught from the river Padda. The small sized fishes like *Puntius ticto*, *Colisa fasciata*, *Glossogobius giuris* are found in large number during the peak fishing season. Previous studies showed that during peak harvest large quantities of such species are thrown away while the large sized ones are supplied to the far and near markets (Parween *et al.*, 1997).

Small fishes are full of bones, so many people especially urban people dislike and avoid these types of fishes. Besides, cuttings, washing and cooking of small fishes are disturbful to them. Though small fishes are eaten along with bones (e.g., mola, kachki, vacha etc.) these are important dietary sources of calcium. Eyes of the fishes are rich in vitamin A (Roos *et al.*, 2002). For efficient utilization of fish bones as a food, they should be softened (Chie, 1999). Here 6 fish species were selected depending on the consumers', availability and market price. The importance of these small fishes was increased to the consumers of all levels.

The intake of small fishes for vitamins and minerals, the cleaning practice of these fishes became extremely important for the retention of these nutrients. Cleaning practices depend on the fish species size and the organs accumulating the nutrients (Ross *et al.*, 2006). So, the non edible waste portion is not always related with the size of the fish. Normally, the operculum, jaws, fins, viscera, head and the scales are included among the waste. The calcium obtained by eating whole mola fish is

equivalent to the amount of calcium obtained from milk (24±6% mola fish, 22±6% milk) (Larsen *et al.*, 2000), they contain usually larger amounts of calcium as well as iron and zinc (Hossain, 1997 and Hossain *et al.*, 2003).

The report published by Hossain *et al.* (1999); Sultana *et al.* (2011) provides a comparative statement of flesh content and percentage of waste obtained from a number of commercially important fish species. The authors showed that the flesh weight after dressing and washing was high in mola, Kachki, compared to the big fish. The present result could be compared with the mentioned papers and other related published reports, and their relative importance of the small fishes could be established as they contain more edible portion than the large sized fishes contain.



CHAPTER-3

PREPARATION, PRESERVATION AND UTILIZATION OF FISH PROTEIN CONCENTRATE (FPC) MADE OF SMALL INDIGENOUS SMALL FISHES

Chapter Three

PREPARATION, PRESERVATION AND UTILIZATION OF FISH PROTEIN CONCENTRATE (FPC) MADE OF SMALL INDIGENOUS SMALL FISHES

Introduction

Fishes are utilized in 3 categories.

1. Fresh fish (this is common for Bangladeshi people)
2. Dry fish (some are chosen)
3. Fish meal (which are made by wastes of fish i.e., fin, scale, tail, head, viscera etc.)

Fresh fish

Fishes play an important role in the diet of the people of Bangladesh. Fishes and rice are main food of people and have a slogan "mache bhate Bangali".

Dry fish

Fish drying and its use as food were probably first introduced by the Arabian saints and businessmen who are believed to be the pioneer in production and marketing of dry fish in different parts of the world since the Egyptian civilization (Kreuzer, 1974). Now in Bangladesh dry fishes are most popular because same weight of dry fish nutrients are much more than the fresh fish. The dried fish powder is used to make various types of fast foods.

Fish meal

Fish meal is a high quality ingredient in feeds for animals including fish raised by aquaculture, poultry and fertilizer. It is made by wastes of fish such as fins, scales, tails, heads, viscera and spoil fishes.

Fish meal is of two types-

1. Fish Protein concentrate (FPC)
2. Ordinary fish meal (pellet or fish powder)

FPC is of high quality fish meal whereas ordinary fish meal which is used as poultry, livestock or fish feeds is of less quality fish meal.

Fresh and dried fishes are very popular food items in Bangladesh. Fishes are rapidly perishable food stuffs and the small fishes being smaller in size have a tendency to become spoiled more quickly than the larger fishes. In this regard the small fishes spoil quickly and become inedible.

Dried fish is an important source of animal protein. Dried fish is considered as a delicacy in the menu of food from all over the world. In Bangladesh the people of greater Sylhet, Mymensingh, Chittagong, Comilla and Cox's Bazar districts use the dried fishes. Drying is regarded as a traditional and primitive method of fish processing which have already been improved by many fisheries scientists by using polythene tent drier, solar tunnel drier, cabinet drier, rational drying along with low cost open sun drying (Aref *et al.*, 1964). Comparative studies between traditional sun dried and solar tent dried fishes were reported by Monsure *et al.* (1990), Heilporn *et al.* (2010). Fish preservation methods include, (i) different methods of sun drying, (ii) freezing (for longer duration), (iii) icing (for short duration), (iv) fermenting, (v) preparation of dust, pickles and value added food items.

Especially, in the countries where solar energy is abundantly available there sun drying of fish is old method for fish processing. In Bangladesh, fish processing industries mainly processing of shrimps or other high valued commercial fin fishes which are export oriented. During 1996-1997 about 427 metric tons of dried fishes valuing about Tk. 79.2 million and about 561 metric tons of salted fish and Chapa Shutki worth Tk. 138.1 million were exported. However, the production of dried fish is gradually declining (Das and Hossain, 2009).

Moulds, bacteria, infestation by the fly and insect larvae during drying and subsequent storage are the major problems of sun drying of fishes. The principle of fish drying is the removal of moisture using heat energy, either solar or mechanical. Fish drying as a means of preservation has been practiced since time immemorial in Bangladesh and other south-east Asian countries. The basic principle of fish drying is that the activity of the muscle enzyme and microorganisms are reduced to a minimum through drawing out the water content and increase the osmotic process of the fish flesh by drying in a traditional way.

In Bangladesh the households of the artisanal fishermen who are mostly illiterate mainly perform the process of drying of fishes. There are frequent complaints from the consumers about the quality of the products. Lack of proper amenities like proper handling during loading and unloading, time and exposure of the fish to the high environmental temperature and lack of knowledge about scientific and hygienic methods of handling from the time to catch until it is processed into finished products contribute significantly to the loss of quality (Azam *et al.*, 2003).

A large quantity of dried fishes are spoiled each year due to lack of proper drying, preservation and storage facilities particularly during the dull or bad season. Improper handling and processing that lead to spoilage as low quality products impose threats to the public health country wide. Bangladesh loses large quantity of fishes due to spoilage every year and it has been estimated that about 8% of the catch amounting to 4.25 million metric tons never reached the market and are wasted (Rubbi *et al.*, 1978). Actually, dry fish is specially necessary due to shortage of cooking materials at that time. The "trash fishes" are obtainable at cheaper or at no price at all. It is possible to develop a product which can be supplied free during national emergency or can be had at reasonable cost of normal time to almost everyone. Proper sun drying of premium quality fresh fish can minimize the post-harvest loss and reduce the amount of fish spoilage. Under the socio-economic condition of the people of Bangladesh, much fish is preserved by traditional methods of sun drying (Rubbi *et al.*, 1978). For keeping high standard and maintaining good quality of fresh fish and fish products the only effective, easy and acceptable guide line of the FAO-CCRFU should be followed. The FAO-CCRFU code of conduct for responsible fish utilization is yet to be implemented in Bangladesh and there is also no approved code of practice currently in practice for the fresh fish and fish products going for fresh fish and fish products going for domestic consumption (Nowsad, 2005).

Dried fishes can provide nutrition to the local people particularly to the poor section as well as to other classes of the society. It is no longer considered as poor man's fish, and some dried fishes are served in many reputed restaurants and hotels

of Bangladesh. Being a cheapest and most common source of animal protein small fishes need careful handling and processing after its harvesting to consumption. It is not an easy task to preserve fish scientifically as well as to maintain its nutritional value and flavour like the fresh one.

The dried small fishes are used whole or as powder in the cooking. In the present study attempts have been made to utilize such kind of fishes by making powder from their dried condition which is used in preparation of fish fast food items. Dry fish powder is popular and it can be preserved in air tight containers for 6 to 7 months or in refrigerator for a long time (1 year).

The terms fish protein concentrate (FPC) usually refer to fish meal intended for human consumption. High quality fishes are used in making FPC. High quality FPC is used as the protein supplement to poor people who suffer from protein deficiency. In a developing country FPC is being used in relief programmes to improve nutrition.

The production of FPC is within the capacity of the fish meal industry. There are problems as the hygienic requirements naturally conform to those for human food. The fishes should be fresh and the plant should be easy to clean and sterilize after use.

Two types of FPC are produced.

A. With a fat content of less than 0.5%

B. With a fat content of less than 10%

The major problems of using FPC are social rather than technological. FPC type B tastes fishy after production and "fishmeal" FPC type is flavourless.

The present work aims at preparation of FPC and to compare between the weight of sundried and oven dried fishes and to determine the percentage of edible content of these dried fishes and their powder, from the weight of fresh fishes.

Materials and Methods

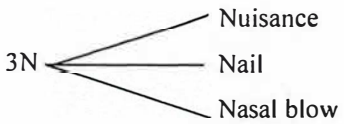
Five different species and a group of mixed small fishes were collected from different spots and landing centres of Rajshahi City during July 2008 to June 2011. All these fishes are caught from river Padda. After collection the specimens were washed and preserved in refrigerator. The species were *Glossogobius giuris*, *Puntius ticto*, *Colisa fasciata*, *Eutropiichthyes vacha*, *Corica soborna* and some mixed fishes (*Chanda nama*, *C. ranga*, *Amblypharyngodon mola*, *Mastacembelus pancalus*, *Xenentodon cancilla*).

Preparation before sun drying

After collection the fishes were washed with tap water then fins, scales, viscera were cleaned and soaked using kitchen tissue paper. Then the weights of a group (50/100g) and individual fresh fishes were taken. The data were recorded separately for each species. After weighing the fresh fishes, they were placed in clean and kept in sun for drying.

Sun drying

Drying involves removal of water from the body of fishes. Sun drying was carried out in the open air using the solar energy to evaporate the water and was carried away by the natural air currents. The specimens were dried for minimum 6-7 days depending on the species and climatic condition. During drying they were kept covered by dense meshed nylon or mosquito net to prevent bird and fly infestation. Special care was given to-



The peak seasons are summer and winter for sun drying and off season is rainy or gloomy weather.

Oven drying

Oven drying was a better method for fish drying. It is better to hygienic and free of atmospheric factors. This method is not feasible for large quantities of drying and

in the rural areas and moreover, it is expensive. But the higher class urban people can dry up fishes at home. It was kept in the oven at 45°C for about 48 hours to remove excess moisture. After the oven drying it was weighted. In this experiment oven drying was done only to compare the dry weight of fishes among these two drying methods.

Parameters during drying

Different parameters for drying method of five small fish species and a group of mixed fishes are shown in Table 3.1.

Table 3.1. Different parameters during drying of the fishes.

Species	Parameters		
	Temperature (°C)	Humidity (%)	Days required to dry up
G. giuris	37-40	78-84	7
C. fasciata	36-39	78-83	5
P. ticto	37-39	77-83	5
E. vacha	36-38	86-90	6
C. soborna	37-38	86-91	3-4
Mixed fishes	36-40	81-87	6

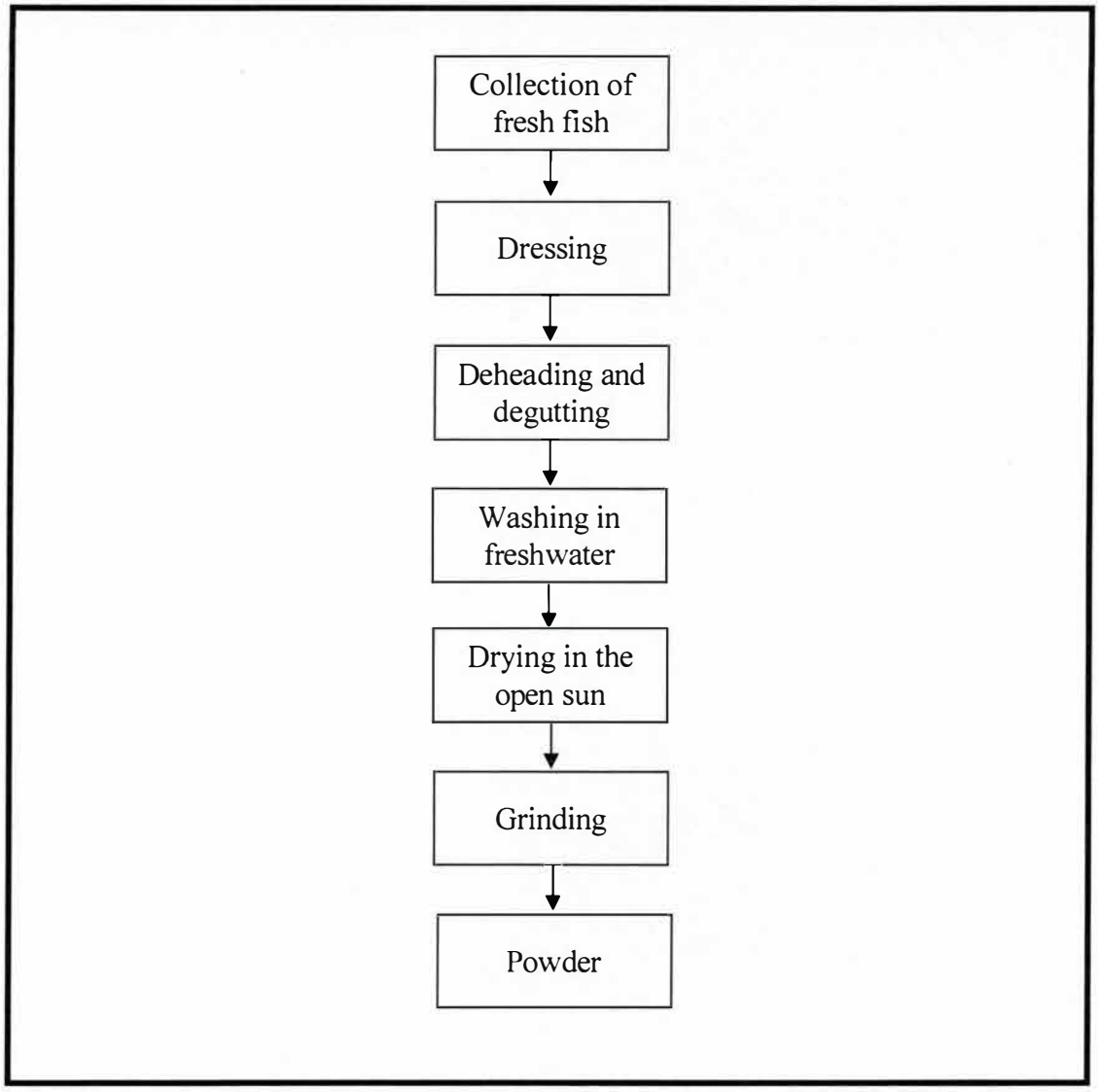


Fig. 3.1. Scheme for processing steps as powder from sun drying fishes.

Preparation of powder from dried fishes

The sun dried fishes or shutki was weighed. Then dry fishes were made to powder with the help of traditional "Shil pata". The powder was sieved by "Chaluni" and again weighed. All these weights were taken with an electronic balance. The powdered fishes were again dried under sun.

Storage of the fish powder

The fish powder was packed in a polythene bag and kept in a plastic container at normal room temperature for 6 or 7 months and then in a refrigerator for 1 year.

Data recorded

The weight of the fishes after sun drying, oven drying and powdering (dust) were recorded as the percentage of the weight of fresh fish and the other processed steps in accordingly. Similarly, the ratio of the weight of different processing steps was calculated with the ratio of the weight of fresh fish and weight of other processed items.

Plate 3.1: Dried small indigenous fishes by sun drying and oven drying method.

Plate 3.2: Weight of fish and fish powder of small indigenous fish (SIF).

Plate 3.3: Dried fish powder in airtight plastic containers and petridishes (fresh condition).

Plate 3.4: Damaged fish and damaged fish powder of small indigenous fishes (SIF).

Results and Discussion

The process and principle of sun drying is expressed by the model (Fig. 3.2).

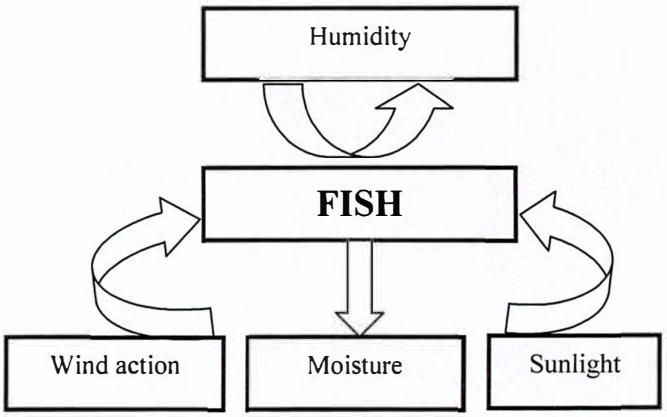


Fig. 3.2. Process of sun drying of fishes (adapted from Nowsad, 2005)

Weight of 10 specimens of each of five small fishes and that of the mixed fishes, and the percentage of sun dried and oven dried fishes to the fresh fish and that of fish powder are presented in Table 3.2.

The average weight of fresh fishes, sun dried fishes, oven dried fishes and powder was found as 379.00, 46.83, 44.93, 43.63 g in *G. giuris*, 396.50, 89.44, 86.88, 84.24 g in *C. fasciata*, 298.00, 56.92, 54.06, 51.87 g in *P. ticto*, 340.00, 82.01, 79.67, 78.14 g in *E. vacha*, 277.00, 71.83, 69.29, 67.14 g in *C. soborna* and 320.00, 83.08, 80.24, 77.83 g in mixed (*C. nama*, *C. ranga*, *A. mola*, *M. pancalus*, *X. cancila*) fishes. Dried fishes are shown in Plate 3.1.

The result shows that minimum and maximum weight of sun dried product (N=10) was obtained as 46.83±15.31 g (*G. giuris*) and 89.44±31.66 g (*C. fasicata*) respectively. The sundried weight of the experimental fishes were found to range from 12.64% (*G. giuris*, initial weight 379.00±142.08 g, N=10) to 28.52% (*C. soborna*, initial weight 277.00±136.89 g, N=10) (Table-3.2).

When these fishes were oven dried, the dry weight was found to range between 44.93±14.65 g (*G. giuris*) and 86.88±31.62 g (*C. fasciata*), which were 12.12% of fresh fish weight and 95.94% of sun dried fish weight and 23.01% of fresh weight and 96.57% of sun dried fish weight respectively (Table 3.2. Detailed results are shown in Appendix tables 7-12.

Table 3.2. Average percentage of powder product from fresh fish, sun-dried fish and oven dried of some small species and mixed fish species (N=10)

Species	Weight of fresh fish (g)	Weight of sun-dried fish (g) and % of fresh fish	Weight of oven dried fish (g) and % of fresh fish and % of sun-dried fish	Weight of powder (g), % of fresh fish, % of sun dried and % of oven dried fish
G. giuris	379±142.08	46.83±15.31 (12.64)	44.93±14.65 (12.12) (95.94)	43.63±14.63 (11.72) (92.86) (96.79)
C. fasciata	396.50±159.68	89.44±31.66 (23.9)	86.88±31.62 (23.01) (96.57)	84.24±31.77 (22.01) (92.84) (96.79)
P. ticto	298±160.73	56.92±27.48 (19.78)	54.06±27.53 (18.42) (93.40)	51.87±27.53 (17.29) (87.70) (93.84)
E. vacha	340±180.72	82.01±44.46 (23.93)	79.67±44.02 (22.89) (95.60)	78.14±43.78 (22.20) (92.65) (96.77)
C. soborna	277±136.89	71.83±25.83 (28.52)	69.29±26.42 (27.00) (95.28)	67.14±26.73 (25.80) (91.42) (95.83)
Mixed fishes	320±144.42	83.08±40.90 (25.06)	80.24±40.65 (23.92) (95.19)	77.83±40.48 (22.94) (91.09) (95.59)

Dried fishes were grouped to produce the powder (dust). Weight of the fish powder was found to range from 43.63±14.63 g (*G. giuris*) to 84.24±31.77g (*C. fasicata*). The powder weight was 11.72%, 92.86% and 96.79% of fresh weight, sun dried weight and oven dried weight in case of *G. giuris* respectively. The powder of *C. soborna* was 25.80% of fresh fish 91.42% of sun dry weight and 95.83% of oven dry weight (Table 3.2).

Doughnut diagram showing the moisture content of sun dried fish, oven dried fish and powder production of six small fishes are shown in the Fig. 3.3-3.8.

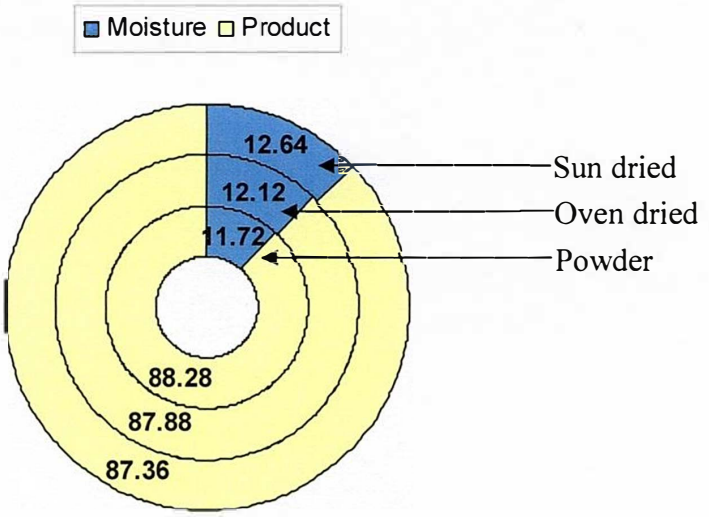


Fig. 3.3. Doughnut diagram showing the moisture content of sun dried fish, oven dried fish and powder production of *G. giuris*

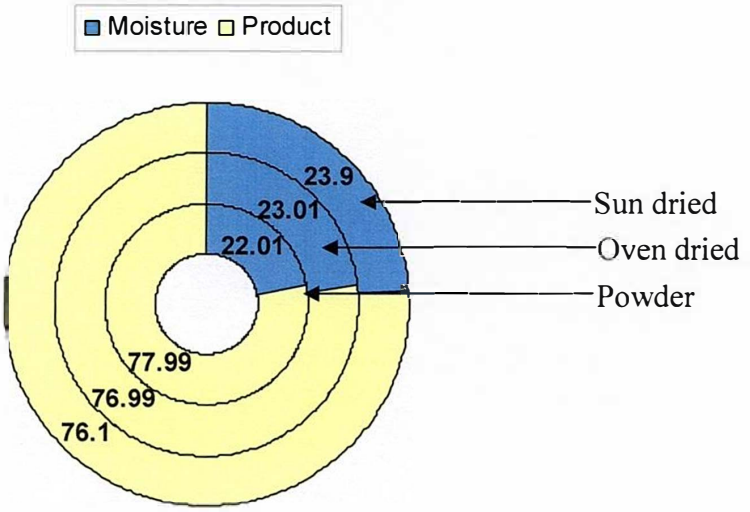


Fig. 3.4. Doughnut diagram showing the moisture content of sun dried fish, oven dried fish and powder production of *C. fasciata*

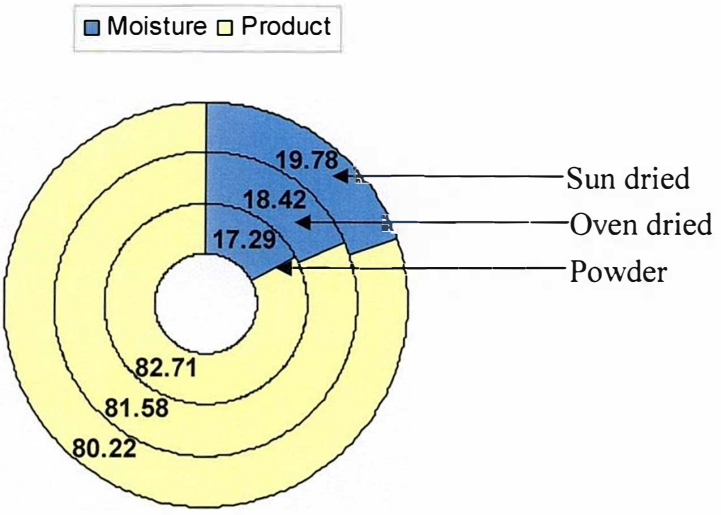


Fig. 3.5. Doughnut diagram showing the moisture content of sun dried fish, oven dried fish and powder production of *P. ticto.*

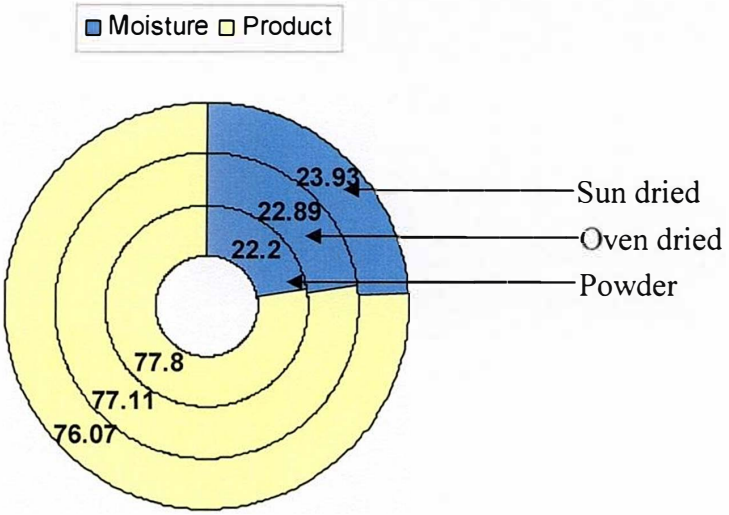


Fig. 3.6. Doughnut diagram showing the moisture content of sun dried fish, oven dried fish and powder production of *E. vacha*.

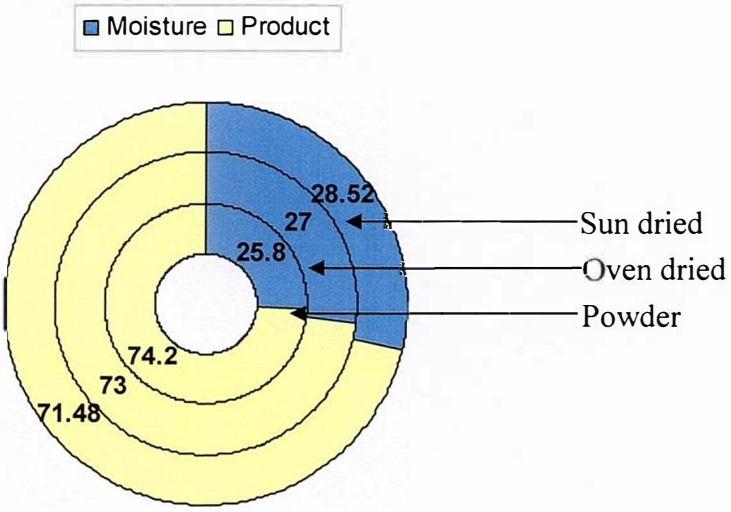


Fig. 3.7. Doughnut diagram showing the moisture content of sun dried fish, oven dried fish and powder production of *C. soborna*.

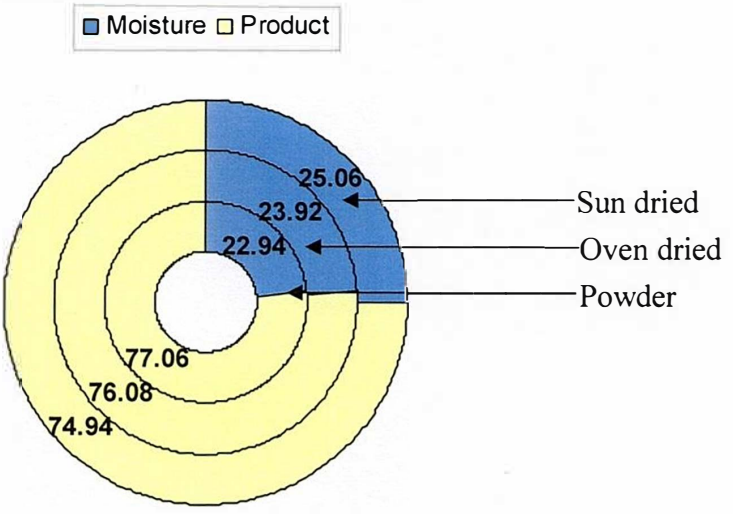


Fig. 3.8. Doughnut diagram showing the moisture content of sun dried fish, oven dried fish and powder production of mixed small fishes.

The powder weight/kg fresh fish was obtained minimum as 117.20 g (11.72%) for *G. giuris* and maximum 258.00 g (25.80%) for *C. soborna* (Appendix table 7 and 11). The ratio between the fresh fish weight and sun dried weight was found minimum as 1:0.123 (*G. giuris*) and maximum as 1:0.259 (*C. soborna*) and mixed fishes. This ratio was more or less similar for all the small fishes used in the experiment (Table 3.3).

Weight of the oven dried fishes and that of powder were of similar ratio with the weight of the fresh fish (Table 3.3). So, there is no weight loss during grinding of the dried fishes.

Table 3.3. Average ratio between per kg weight of sun dried and oven dried fishes and their powder with the fresh fish weight (individual species and mixed species fishes)

Species	Weight of fresh fish (g)	Ratio		
		Fresh fish : Sun dried fish	Fresh fish : Oven dried fish	Fresh fish : Powder
G. giuris	379.00±142.08	1:0.123	1:0.118	1:0.115
C. fasicata	396.50±159.68	1:0.225	1:0.219	1:0.212
P. ticto	298.00±160.73	1:0.191	1:0.181	1:0.174
E. vacha	340.00±180.72	1:0.241	1:0.234	1:0.229
C. soborna	277.00±136.89	1:0.259	1:0.250	1:0.242
Mixed fishes	320.00±144.42	1:0.259	1:0.250	1:0.243

In Table 3.4 weight of dried powder of 1 kg fish are given for five species and a group of mixed species. The maximum weight was 258.00 g/kg (*C. soborna*) and the minimum weight was 117.20 g/kg (*G. giuris*). Weight of the powder thus ranged from 11.72% to 25.80% (Table 3.4, Fig. 3.9).

Table 3.4. Weight and percentage of powder product of five small fishes and a group of mixed fishes per kg weight.

Species	Constant weight (g)	Powder (g)	Percentage
G. giuris	1000	117.20	11.72
C. fasciata	1000	220.10	22.01
P. ticto	1000	172.90	17.29
E. vacha	1000	222.00	22.20
C. soborna	1000	258.00	25.80
Mixed fishes	1000	229.40	22.94

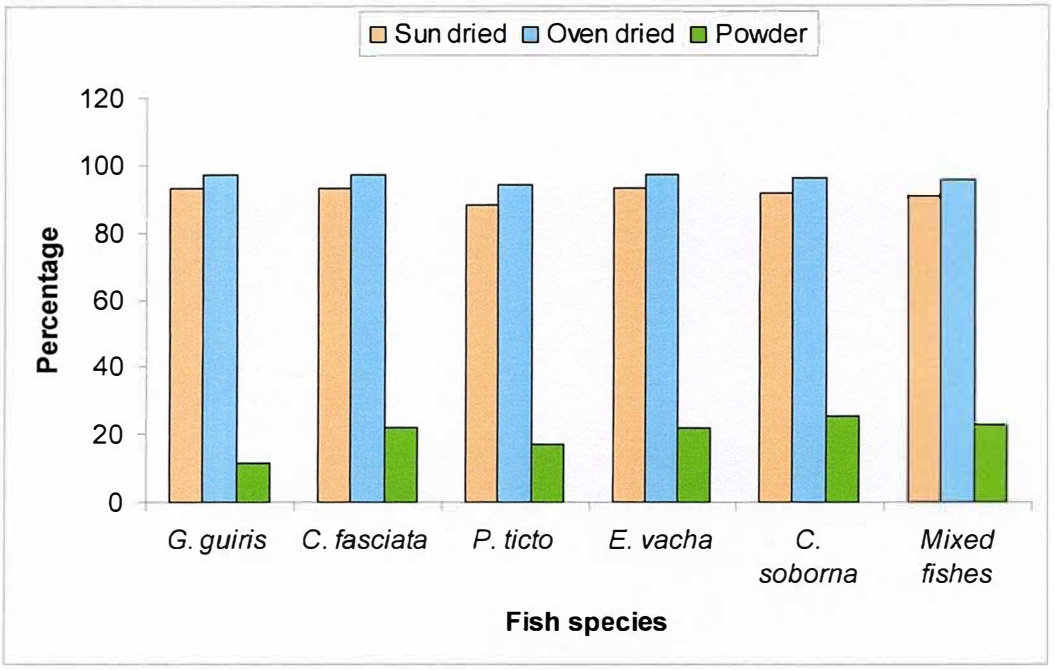


Fig. 3.9: Percentage of weight of sun dried, oven dried fishes and powder of dried fishes to weight of fresh fishes.

Dried fish powder was preserved for off season in good condition for 5-7 months. But in −18°C the powder was in good condition throughout the year (Plate 3.3 and 3.4).

Preparation of different fast food items

For proper utilization of fish powder (FPC) of small fishes some fast food items were prepared which are as follows.

1. Fish Soup

Materials used: (1 small bowl)

1. Fish powder - 2/3 tea spoon
2. Corn flour – 1½ tea spoon
3. Vinegar - 1 tea spoon
4. Soya sauce – ½ tea spoon
5. Tomato sauce – 1½ table spoon
6. Water - 2 cup
7. Green chili – ½ piece
8. Egg – ½ piece
9. Garlic and ginger paste – ¼ tea spoon
10. Salt - to taste
11. Sugar - to taste

Cost: Tk. 17.00 only.

Plate 3.5: Fish soup

Procedure

1. Water was boiled and fish powder was mixed in the boiled water.
2. Masla paste, salt, sugar, vinegar, soya sauce, chili was given in the boiled water.
3. After 5-7 minutes it was boiled.
4. Corn flour was mixed with normal water and then put.
5. The mixture of egg was dropped into the boiled water and mixed. The soup was prepared.
6. The soup to be secured with tomato sauce for taste.

2. Fish Cutlet

Materials used: (2 piece)

1. Fish powder - 2/3 tea spoon
2. Green chili – 1 piece
3. Rice flour – 2 tea spoon
4. Corn flour – 1 tea spoon
5. Green banana (kacha kola)–½ piece
6. Garlic and ginger paste–½ tea spoon
7. Egg – ½ piece
8. Elach, daruchini, gol morich dust – ½ tea spoon
9. Turmeric powder – ¼ tea spoon
10. Zira – ½ tea spoon
11. Salt - to taste
12. Oil – to fry
13. Decorated vegetables

Plate 3.6: Fish cutlet

Cost: Tk. 22.00 only

Procedure

1. The green banana was boiled and washed.
2. All ingredients (except oil, egg, biscuit powder) taken and mixed with fish powder and green banana.
3. Cutlet shape was made and dipped well in the egg and biscuits powder.
4. It was fried in oil till brown colour.

3. Fish toast

Materials used: (2 pieces)

1. Fish powder - 2 teaspoon
2. Sliced bread – 1 piece
3. Potato – 1 piece (boiled)
4. Butter – ½ tea spoon
5. Milk – ¼ cup
6. Egg – 1 piece
7. Salt – to taste
8. Oil - to fry
9. Tomato sauce
10. Biscuit powder
11. Decorated vegetables

Plate 3.7: Fish toast

Cost: Tk. 20.00 only

Procedure

1. First sliced bread were cut in triangular shape.
2. Except oil, all ingredients were mixed with fish powder and mashed potato.
3. After few minutes it makes condense and then layer on bread in one side.
4. Bread dipped well in egg and fried to brown colour.
5. Then to be served with sauce and vegetables.

4. Fish burger

Materials used: (1 piece)

1. Round bread (Banruti) - 1 piece
2. Fish powder – 3 teaspoons
3. Pulse (But dal) – ¼ cup
4. Ginger and garlic paste – ½ tea spoon
5. Zira powder – ¼ tea spoon
6. Coriander powder – ¼ spoon.
7. Turmeric – ½ table spoon
8. Green chili – 1 piece
9. Salt - to taste.
10. Oil - to fry (soyabean)
11. Egg – ½ piece
12. Corn flour – 2 tea spoons
13. Meonase – 2 tea spoons
14. Tomato, lettuce, cucumber– for decoration

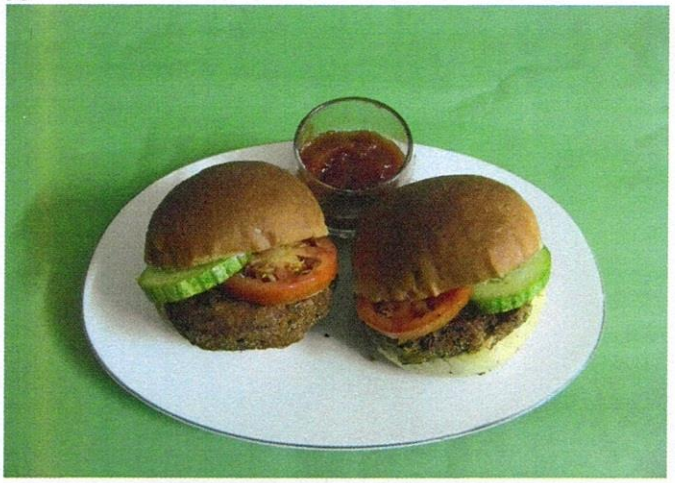


Plate 3.8: Fish burger

Cost: Tk. 25.00 only

Procedure

1. Boiled pulse with water.
2. The pulse mashed and added with fish powder and all ingredients.
3. It was made into round sticks and semi fried in soyabean oil.
4. Bread cut (one side off) into the middle and placed the stick with lettuce, cucumber, tomato and meonase.
5. Then served fish burger with sauce.

5. Fish stick Kabab

Materials used: (2 pieces)

1. Fish powder – 4 teaspoons
2. Potato – 1 piece (boiled)
3. Ginger and garlic paste – ½ tea spoon
4. Zira, coriander – ½ tea spoon
5. Chili powder – ½ tea spoon.
6. Turmeric powder – ¼ tea spoon
7. Salt - to taste.
8. Oil - to fry
9. Corn flour – to bind
10. Egg – 1 piece
11. Biscuit powder – to assess
12. Stick – 2 pieces
13. Tomato sauce – to serve with

Plate 3.9: Fish stick kabab

Cost: Tk. 22:00 only

Procedure

1. All ingredients and fish powder was mixed with mashed potato.
2. Then the paste was properly mixed and it binded to stick.
3. The stick dipped well in the mixture egg and then in the biscuit powder.
4. Fried in the oil to brown colour.
5. It was ready to be served with decorated vegetables.

6. Fish ball with noodles

Materials used: (1 plate)

1. Fish powder – 3/4 teaspoon
2. Flour – ½ cup
3. Noodles – 1 packet
4. Onion bristle brush – 1 table spoon
5. Green chili – 2 piece
6. Salt - to taste
7. Oil - to fry
8. Egg – ½ piece
9. Decorated vegetables

Cost: Tk. 20.00 only

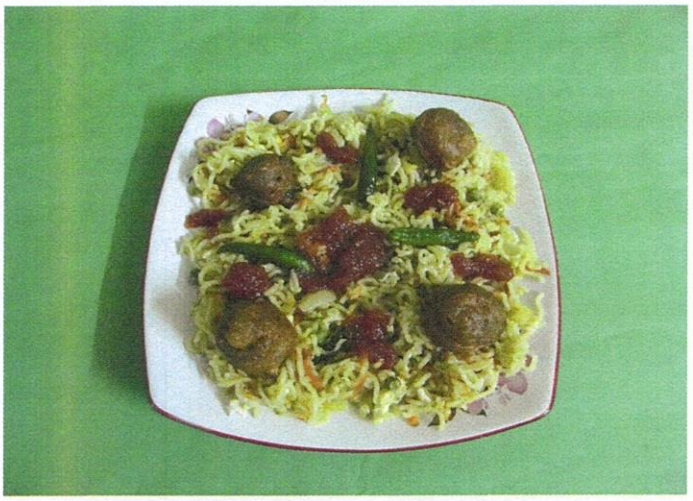


Plate 3.10: Fish balls with noodles

Procedure

1. Noodles boiled in water for 3-5 minutes.
2. Fish powder was mixed with flour and salt.
3. Then the small balls were made and fried in oil to brown colour.
4. Green chili and onion bristle fried in oil.
5. Then boiled noodles to cast in this oil and mixed with fish balls.
6. It was served in plates with vegetables.

7. Fish parota with chatni

Materials used: (2 nos.)

1. Fish powder – 3/4 teaspoon
2. Potato – 2 pieces (medium)
3. Ruli flour – 1 cup
4. Black cumin – ¼ tea spoon
5. Sugar – 1 tea spoon
6. Green chili – 3 pieces
7. Onion bristle
   brush – 2 tea spoons
8. Salt – to taste
9. Soyabean oil – to fry
10. Water – to need
11. Green leaf, pudina leaf, lemon, sugar with chatni

Plate 3.11: Fish parota with chatni

Cost: Tk. 21.00 only

Procedure

1. At first made of chatni by blender or shil pata.
2. Fish powder, potato, green chili, onion, salt, green leaf was mixed to make pure.
3. Then dough was made into flour and pure was put into the middle portion of dough.
4. It was then fried in oil to brown colour and served with chatni.
5. Then boiled noodles to cast in this oil and mixed with fish balls.
6. It was served in a plate with vegetables.

8. Fish Pakora

Materials used:

1. Fish powder – 5/6 teaspoon
2. Mosur pulse/
   Ruli Flour–3 tablespoons
3. Onion bristle
   brush – 3 pieces
4. Garlic and ginger
   paste – 1 tea spoon
5. Green chili – 3 pieces
6. Salt - to taste
7. Oil - to fry
8. Egg – ½ piece
9. Vegetables – ½ cup

Cost: Tk. 14.00

Plate 3.12: Fish pakora

Procedure

1. Except oil, all materials were taken according to taste and mixed well with fish powder and prepared as soft dough.
2. The dough was made into small balls.
3. The pakore were dripped well in the oil to brown colour.
4. Then Pakora was ready to be serve with sauce.

9. Fish Papadom (papore)

Materials used: (1 plate)

1. Fish powder – 4/5 teaspoon
2. Ruli flour – ½ cup
3. Kalo zila – 1 tea spoon
4. Baking powder–½ tea spoon
5. Salt – to taste
6. Oil – to fry
7. Colour - Jafran

Cost: Tk. 10.50 only

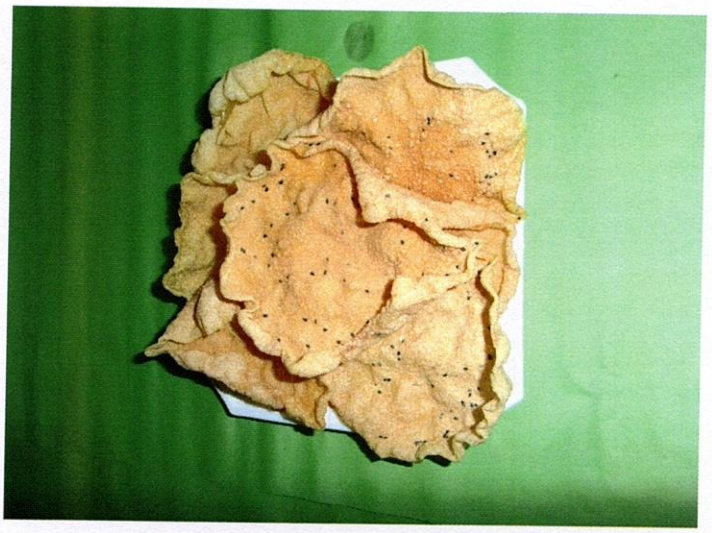


Plate 3.13: Fish papadom

Procedure

1. Salt, kalo zira, baking powder and fish powder were mixed with flour and it sprinkle pan of hot oil by hand.
2. Then it was dried in the sun.
3. After dried it was fried in deep oil and served.

International Union for the Conservation of Nature (IUCN-2001) has given a list of small fishes, which are either critically endangered in Bangladesh. Nowadays more than 100 indigenous species of fishes are going to become endangered because of the use of pesticide, industrial pollution, excessive capture of fishes, use of intertidal fishing gears, occupation and filling up of reservoirs of water etc. (Islam, 2009). As a result, many valuable fish species of rivers, floodplains and estuaries have become threatened and endangered (Hussain, 2010). During peak season a large amount of SIF fishes are caught in the rivers. These fishes sun dried to the adjacent fishing areas. The sun dried fishes are then supplied to the markets throughout the country.

In this research work five economically and a group of mixed important small fish species of 5 families under 5 orders and mixed fishes were used. All these fishes are very much popular and found in large numbers in peak season. During selection of small fishes, taste, their acceptability, economic importance, availability and also market price were considered. Day by day human taste is changing rapidly. At present various types of fish food items are available than the past. Especially some children do not like fish for its bones. But they are more interested to various types of fast foods which can be made by using fish powder. Adults take fish soup for high nutrition. Other portion (waste) of fishes are used in fish meal for fish feed or poultry.

Small fishes are full of bones, so, many people especially urban people dislike and avoid these types of fishes. Besides, cutting, washing and cooking of small fishes are disturbful to them and these consume many times because of our first life living style. Though small fishes, which can be eaten whole with bones are important dietary sources of calcium. For efficient utilization of fish bones as a food, they should be softened (Chie, 1999).

In the present study, it was found that the maximum ratio between the weight of fresh fish and sun dried fish as 1:0.259 in mixed fishes and *C. soborna* and the minimum was as 1:0.123 in *G. giuris*. On the other hand maximum ratio between the weight of fresh fish and powder was found as 1:0.243 in mixed fishes and

minimum was 1:0.115 in *G. giuris*. This finding shows that there is no difference of weight in dry fish and fish powder which was also observed in the present study.

Different parameters of drying method of the experimental fishes were air temperature, humidity and duration of day. Among all the fishes the lowest duration of day was needed 4 days in *C. soborna* and highest duration of days was needed 7 days in *G. giuris* (Table 3.1).

Preservation is necessary during the period of abundance when the fishes are not possible to be consumed. Proper preservation technique the fishes can be made usable during the period of scarcity. Dried fish powder was preserved in a container at normal room temperature in good condition for 5-7 months.

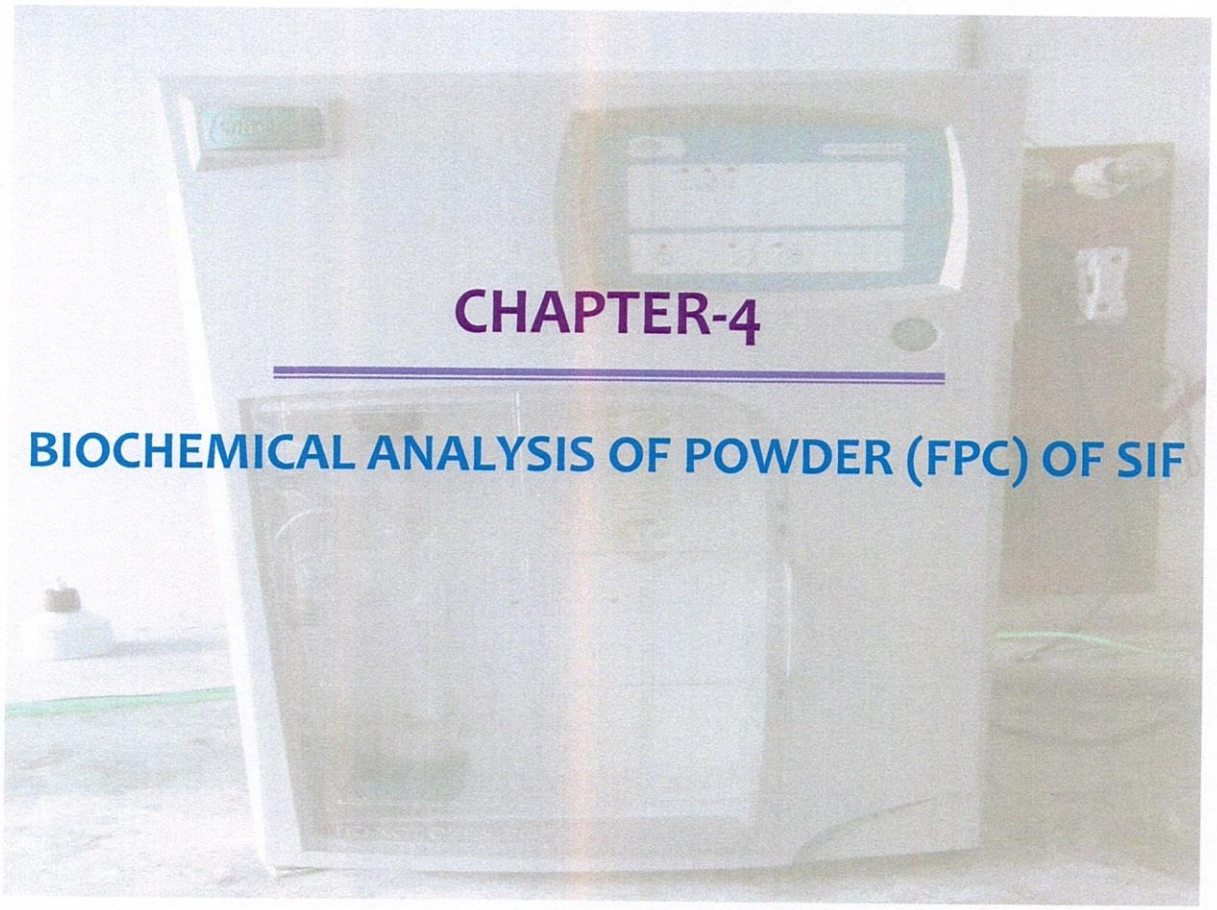
Oven dried fishes were found to have a good smell compared to the sun dried fishes, because of even drying throughout. Hossain and Parween (1987) stated that oven dried shrimps were found to be more hygienic and had a longer shelf-life than traditional and polythene-tent dried ones. Time taken for proper sun drying is 4-7 days depending on the size of the fish. Similar report has been stated by Sultana *et al*. (2011) for some small fishes. From an experiment Haq (2005) also reported that small fishes can be properly dried under the sun in 5-7 days.

Majority of the people of our country live in rural areas. They eat all the small fishes as various common fishes such as 'Bharta' (grounded dish), 'Chorchori' (curry fish) fish with vegetables etc. They have no ability to purchase fast food. So they can involve themselves in drying and grinding fish to make various foods using fish powder. Baby's does not want to small fish for kata. For the purpose, the easy method produced to processed small fish that intake of baby's meal. Hodgepodge is a very common food item in our growing baby. But when it makes to fish, child doesn't like it because its flavour. But if we have to make it powder of fishes they like it. Such as high nutrition, no flavour and so tasty. It could be a great opportunity to engage the rural people in fish processing and utilization. But they have no opportunity to preserve the powder and dried fish in scientific methods.

Many workers were engaged with processing and preservation technique of fishes. But a few of them prepare food items by the powder for human consumption.

Here powder of fishes can be used in many purposes such as delicious snacks, soups, fast food items are more acceptable to all kinds of people, especially child and adults and new generation of Bangladesh. Fish pickles are commercially available in India. Dried chips, papadom like the potato/flour chips, made from the flesh of Chital fish are available as confectionary item and in Chinese restaurants in Bangladesh. Fish sauce are also available used in Chinese restaurants in Bangladesh.

Fish powder after proper drying can be served for quite a long time in air-tight containers kept at a dry place. Powder of sundried fishes are used in vegetables curries, dal at different areas of Bangladesh.



CHAPTER-4

BIOCHEMICAL ANALYSIS OF POWDER (FPC) OF SIF

Chapter Four

BIOCHEMICAL ANALYSIS OF POWDER (FPC) OF SIF

Introduction

In Bangladesh, anemia and vitamin A deficiency have remained unchanged during the last three decades which are the major public health problem (Ahmed, 2000). Small indigenous fishes (like mola, dhela, chela, kachki, puti etc.) have very high contents of vitamin A. Brain development, control of arthritis and diabetes, night blindness, bone formation (reducing risks for osteoporosis), heart disease and hypertension can be prevented by vitamin A, which comes from small fishes. So, small fishes can play an important role as a rich dietary source of vitamin A, iron and other minerals. For example, less than 200g of mola per day supplies the daily recommended vitamin A intake of a child.

Around the world, it is well accepted that fishes are a good source of animal protein and other elements for the maintenance of healthy body (Andrew, 2001). Fish flesh contains up to 15-25% protein, 80% water, 1-2% mineral matter (CSIR, 1962), FAO reported that fishes contain 72% water, 19% protein and 5% calcium. In terms of weight of food consumed, fish ranks third after rice and vegetables (Minkin *et al.*, 1997 and Hels *et al.*, 2002). The protein content of fishes ranges from 14 to 18g/100g raw edible parts (Darnton-Hill *et al.*, 1988). From the last national survey in rural Bangladesh, the mean total protein intake was 48g/person/day, of which fish contributed 3g (Ahmad and Hassan, 1983).

Mannan (1977) demonstrated the speciality of fish protein and Guha (1962) described the fish protein as high-class protein comparable to those derived from other animal sources. Among the fish protein, 85-95% is digestible part which contains all dietary essential amino acids.

Stansby (1954) worked out the macro nutrient contents from the edible flesh of certain freshwater fishes and observed that fishes contained 76.8% moisture, 19% protein, 5% fat and 1.2% ash. Borgstrom (1961) also observed that the fat and

protein contents in fishes depended upon some factors, e.g. size, age, sex, seasonal changes and habitat.

Ahmed *et al.* (1984) investigated on the variation of biochemical composition of seven species of gobi fish in respect of sex and season.

Jafri and Khawaja (1968) determined the chemical composition and nutritional value of some small indigenous fishes. The frequency of changes in the composition of biochemical constituents of any organism vary with the variation of the environmental changes. Small fishes often are easily digestible and contain protein, fat, vitamin, calcium, phosphorous and some other minerals, which are needed for human body (Sultana *et al.*, 1997).

Besides protein source, small indigenous species (SIF) are also a rich source of vitamins and minerals, which is often overlooked in developing countries (Hossain and Afroze, 1991; Roos *et al.*, 2007). Thilsted *et al.* (1997) and Roos *et al.* (2007) described the vitamin A, calcium, iron and zinc contents from the commonly consumed fishes of Bangladesh. Very high content of vitamin A (500-1500 µg RE/100g raw edible parts) was found in Dhela (*Osteobrama cotio cotio*), Darkina (*Esomus danricus*), mola and chanda (*Chanda baculis*) (Roos *et al.*, 2003). Even sun dried fishes contain up to 60-80% protein (Hoq, 2004).

The biochemical composition is an important aspect of fish quality and it influences both the keeping quality and technological characteristics of fish. Large group of consumers have become more health conscious and interested for consumption of food free from health hazard materials.

A good number of works on nutrient composition of fishes of Bangladesh have been done by different researcher viz. Kamaluddin *et al.* (1977); Gheyasuddin *et al.* (1979); Ahmed *et al.* (1981); Rahman *et al.* (1982); Rubbi *et al.* (1987); Al-Habib (1990); Nabi and Hossain (1990); Salam *et al.* (1995); Mollah *et al.* (1998); Nurullah *et al.* (2002); Azam *et al.* (2003), Islam *et al.* (2003); Musa and Bhuiyan (2006); Naser *et al.* (2007); Kamal *et al.* (2007); Mazumder *et al.* (2008); Musa (2009); Sultana *et al.* (2011); Zehra and Khan (2011). Many researches have been

done in the Bangladesh Council of Science Institute of Research (BCSIR), Dhaka; Freshwater Fisheries Research Institute (FRI), Mymensingh; Institute of Nutrition and Food Science (INFS), Dhaka; Bangladesh Agricultural University (BAU), Mymensingh and the University of Dhaka; but very little attention has been paid on the proximate composition of nutrients which are present in dried fishes or fish powder (FPC).

Hunger and nutritive deficiency are major problems of the people of Bangladesh. Among the nutritive deficiency, the protein deficiency is the greatest. The fishes are better and cheaper source of protein. So, the valuable contribution of fish to the total supply of protein cannot be denied.

Bangladesh's over increasing population needs a huge amount of protein, which can easily be fulfilled by producing adequate fishes. Many tropical countries like us have a great nutritional dependence on fishes. There are 61 countries that derive more than 20% of their animal protein supply from fishes (James, 1998).

Actually fishes are valuable source of high grade protein and other organic products. Biochemical analysis is necessary to ensure the nutritional value of raw fish as well as eating quality of the dried products. Recently very few published works on the biochemical assessment of sun dried powder and their products are available in Bangladesh. There is lack of reports on the nutritional values obtained from the dried fish. The present work was aimed to estimate the nutritional value of dried fish dust/powder of some selected small fishes.

Materials and methods

Collection of samples: Samples were collected from the different spots of river bank and fish landing centres of Rajshahi city, during the period from July 2008 to June 2011. Five small fishes and a group of mixed fishes were collected in fresh condition for the present study.

After collection the fishes were brought to the Fisheries Research Laboratory, Department of Zoology, Rajshahi University, washed carefully with tap water, deheaded, degutted and again washed. The fishes were then isolated and depending on size sun-dried up to 4-7 days under fly nets. Using an electric blender the dried fishes were then powdered species wise and kept in separate air tight plastic containers with proper labelling. The dried samples of the selected fishes were then taken to the Bangladesh Council for Scientific and Industrial Research (BCSIR) Laboratories, Rajshahi for the analysis of moisture, protein, fat, phosphorous and Central Science Laboratory, Rajshahi University for the analysis of calcium and iron. The proximate composition of the dried fishes was determined according to the standard AOAC method (1980, 2000) in triplicate.

Determination of moisture content

Quantitative determination of moisture content: Moisture content of the fishes was determined by automatic moisture analyzer model no. MAC 50/NH, RADWAG at 110°C.

One g of fish samples was taken in a porcelain crucible (the weight of the crucible was recorded first) and it was kept for 6 hours at 105°C in an oven. After drying for 6 hours, the sample was kept and cooled in a desiccator for an hour, and the crucible with fish were weighed again. Drying and desiccating process were continued until a constant weight was obtained.

Moisture content was calculated by the following formula:

$$\text{Moisture content (\%)} = \frac{w_1 - w_2}{w_1 - w} \times 100$$

Where, w = weight of the empty crucible

w_1 = weight of the crucible + fishes

w_2 = weight of crucible + dried fishes

Quantitative determination of Protein Content: The protein was extracted by Kjeldahl method by using automatic nitrogen analyzer model no. P SELECTA, Spain. The principle of this procedure was completely converted into ammonium sulphate and the nitrogenous compounds involved the digestion of the sample with concentrated sulphuric acid (H_2SO_4) in the presence of a suitable catalyst.

Reagents

- Sulphuric acid 96% (d =1.84)
- NaOH dilution 40% (p/v)
- Mixed of indicator, special for ammonium titration.
- Kjeldahl catalyst
- Boric acid 4% (p/v)
- HCl 0.189 N
- Distilled water
- Pumice stone granules

It is very important that all the reagents were free of nitrogen.

Apparatus

- Balance of the resolution 0.1mg
- Digestion unit (Bloc – Digest)
- Fume removal
- Distillation unit pro-nitro 1 or 11
- Titration burette

Digestion of the sample

About 0.5 g of the sample was taken and perfectly milled and homogenized into a paper free of nitrogen and introduced in a digestion tube. About 10g of Kjeldahl catalyst, 25ml of pure concentrated sulphuric acid (H_2SO_4) at 96% (d=1.84) and some granules pumice stone were added into the sample tube. Then the digestion tubes were put with the sample into the Bloc-digest with the fume removal working. Between 350° and 420°C and in a period of time variable between 1 and 2 hours.

At the end of the process the obtained liquid was of green colour or transparent blue depending on the used catalyst. The sample was cooled down at ambient temperature. After cooling 50ml of distilled water was added in each tube of sample.

About 50ml of boric acid in an Erlenmeyer flask and some drops of mixed indicator the Erlenmeyer was put below the refrigerant paying attention to let the output tube to be immersed under the boric acid. The distillation was done for enough time in order to be distilled a minimum of 150ml, approximately between 5 and 10 minutes.

After distillation of a sample, blank test was made applying this method, using 5ml of distilled water instead of sample. The ammonia in the boric acid solution was titrated with 0.189N hydrochloric acid (HCl) until the solution changes from green to violet colour. The percentage of nitrogen was calculated by following formula:

$$\% \text{ Nitrogen } = \frac{1.4 \times (V_1 - V_0) \times N}{P}$$

% Protein = % Nitrogen × F

Where,

P = Weight of sample (g)

V_1 = HCl consumption on titration (ml)

V_0 = HCl consumption on blank titration (ml)

N = Normality del HCl

F = Conversion factor to pass from content in nitrogen to content in proteins

The protein content was obtained by multiplying the nitrogen value 6.25.

Quantitative determination of fat: Fat content of the fishes were determined following the methods given by Cocks and Van Rede (1966) and Mehlenbacher (1960). The principle of this method lied in mixing the sample with a solvent n-Hexane which was then removed by distillation and the residue was dried and weighed. The extraction procedure was carried out in Soxhlet apparatus.

The fresh samples (5g) were weighed accurately and it was taken in extraction thimble. The thimble was then placed in n-Hexane for about 8 hours. The quantity of fat was calculated from the formula given below:

$$\text{Fat content (\%)} = \frac{w}{w_1} \times 100$$

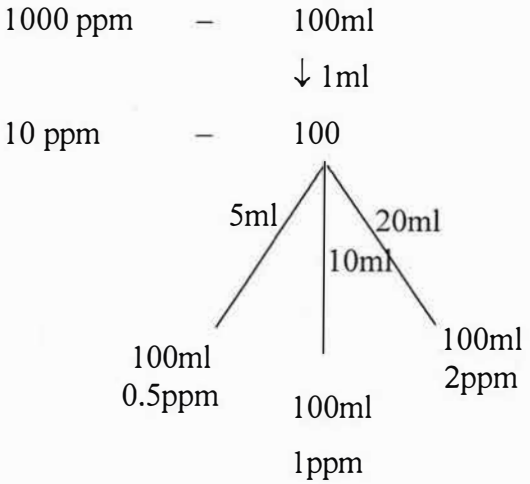
where, w = weight of the oil

w_1 = weight of the sample taken.

Determination of minerals

Preparation of standard solution for minerals: At first standard solution of appropriate concentration was prepared. Then 1 ml from 1000 ppm standard calcium (Ca) solution was taken in 100ml volumetric flask to prepare 10 ppm solution with deionized water 10 ml from 10 ppm was pipetted in 100ml volumetric flask to produce 1000 ppm solution.

Then 5ml, 10ml, 20ml solutions were taken from 1000 ppm solution in 100 ml volumetric flask to prepare 0.5, 1 and 2 ppm solution respectively. Standard preparation diagram is given below-



Procedure

Digestion of the sample: At first the nitric acid (HNO_3) and perchloric acid ($HClO_4$) were decomposed. Then grained and made air tight 0.5g of sample was taken in a conical beaker. Water and 7ml of HNO_3 were added and after mixing

then set aside. The solution was heated (below 100°C) then the sample reaction started.

The mixture was kept aside in a warm place for cooling. After cooling 3ml of $HClO_4$ was added and again heated to concentrate. Midway, if dark then it left for 2-5 minutes and added 1-2 ml portions of HNO_3 and continue heating. When the solution contained material turns yellowish or colourless, decomposition was incomplete. The solution was then filtered into a 100ml volumetric flask using Whatmann No. 41 filter paper. After cooling 1ml of hydrochloric acid HCl) was added to it and used water to prepare fixed volume was made up to 100ml solution. For the estimation of calcium and iron this solution was used.

Calcium: Calcium was determined by AAS (Atomic Absorption Spectrophotometer) Model No. AA-6800 SHIMADZU (Japan)

Calculation

The percentage of calcium was calculated from the well established formula.

$$\% \text{ Calcium} = \frac{\text{Con. of AAS} \times \text{V.F} \times \text{D.F}}{\text{Amount of sample}}$$

Where,

Conc. AAS = Concentration of Atomic Absorption Spectrophotometer

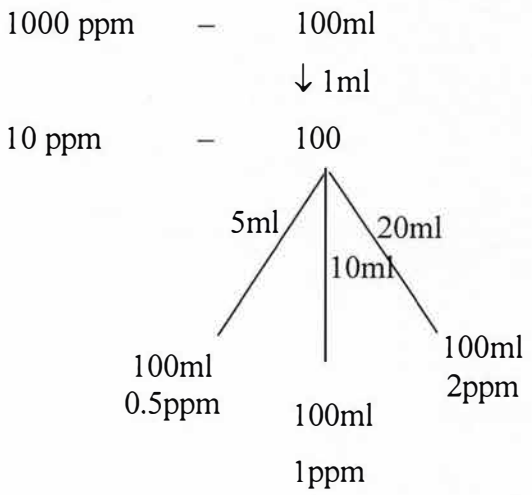
V. F. = Volume factor

D. F. = Dilution factor

A. S. = Amount of sample

Preparation of standard solution for Iron: At first standard solution of appropriate concentration was prepared. Then 1 ml from 1000 ppm standard Iron (Fe) solution was taken in 100ml volumetric flask to prepare 10 ppm solution with deionized water 10 ml from 10 ppm was pipetted in 100ml volumetric flask to produce 1000 ppm solution.

Then 5ml, 10ml, 20ml solutions were taken from 1000 ppm solution in 100 ml volumetric flask to prepare 0.5, 1 and 2 ppm solution respectively. Standard preparation diagram is given below-



Procedure

Digestion of the sample: At first the nitric acid (HNO_3) and perchloric acid ($HClO_4$) were decomposed. Then grained and made air tight 0.5g of sample was taken in a conical beaker. Water and 7ml of HNO_3 were added and after mixing then set aside. The solution was heated (below 100°C) then the sample reaction started.

The mixture was kept aside in a warm place for cooling. After cooling 3ml of $HClO_4$ was added and again heated to concentrate. Midway, if dark then it left for 2-5 minutes and added 1-2 ml portions of HNO_3 and continued heating. When the solution contained material turns yellowish or colourless, decomposition was incomplete. The solution was then filtered into a 100ml volumetric flask using Whatmann No. 41 filter paper. After cooling 1ml of hydrochloric acid (HCl) was added to it and used water to prepare fixed volume was made up to 100ml solution. For the estimation of calcium and iron this solution was used.

Iron: Iron was determined by AAS (Atomic Absorption Spectrophotometer) Model No. AA-6800 SHIMADZU (Japan)

Calculation

The percentage of iron was calculated from the well established formula.

$$\% \text{ Iron} = \frac{\text{Con. of AAS} \times \text{V.F} \times \text{D.F}}{\text{Amount of sample}}$$

Where,

Conc. AAS = Concentration of Atomic Absorption Spectrophotometer
V. F. = Volume factor
D. F. = Dilution factor
A. S. = Amount of sample

Phosphorus: Determination of phosphorus was made by measuring calorimetrically by using a Spectrophotometer Model no. GENESYS TM 20, Thermospectronic, USA. When the ash solution was treated with ammonium molybdate and the phosphomolypdate thus formed was reduced, a blue colour was formed.

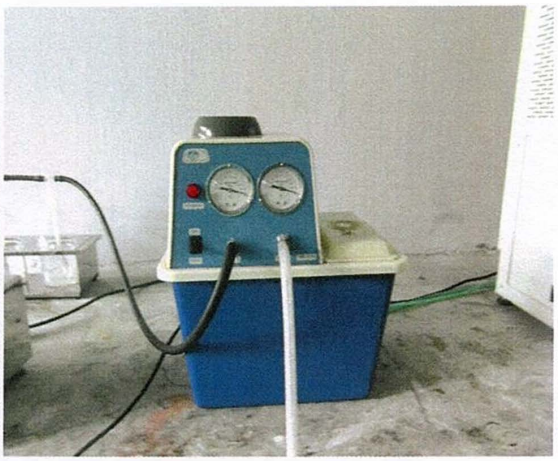
The reagents used were:

1. Ammonium molybdate-sulphuric acid reagent, 25g, ammonium molybdate were dissolved in 300 ml water 75 ml of conc. H_2SO_4 diluted to 200 ml was then added to the ammonium molybdate solution.
2. Hydroquinone solution: 0.5g hydroquinone dissolved in 100 ml water and 1 drop of conc. H_2SO_4 was added to retard oxidation.
3. Sodium sulfuric solution: 200g Na_2SO_3 was dissolved in water, diluted to 1 liter and filtered if necessary.
4. Standard phosphate solution: 0.4394 g pure dry KH_2PO_4 dissolved in water and diluted to 1 liter. Ten ml of this solution was diluted to 100 ml which gave a working standard solution (1ml = 0.01 mg phosphorus).

Procedure: To an aliquot (0.1 ml) of the mineral solution was added 1 ml of ammonium molybdate, 1 ml of hydroquinone and 1 ml Na_2SO_3 solution in this order, and mixing well after each addition. The volume was then made up to 15 ml with water and the solution was thoroughly mixed. After 30 minutes, the optical density of this solution was measured in a photoelectric colorimeter, against a reagent blank (prepared in the same way as the test except that the test solution was omitted) using a red filter (660 m/u).

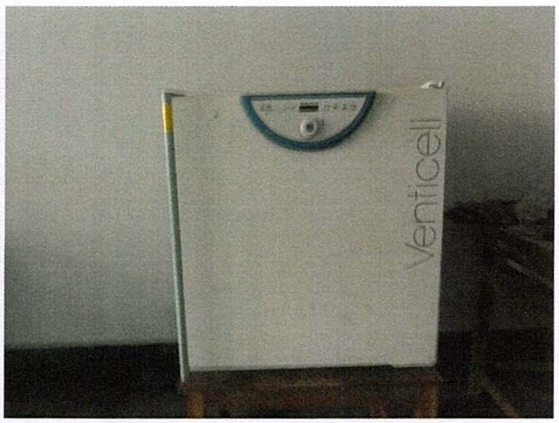
The phosphorus content of the sample was read off from a standard curve (blue coloured) prepared with standard phosphate solution (range 0.01-0.1 mg) following the same procedure as described above.

Pro-Nitro M Distillation plant (Protein)



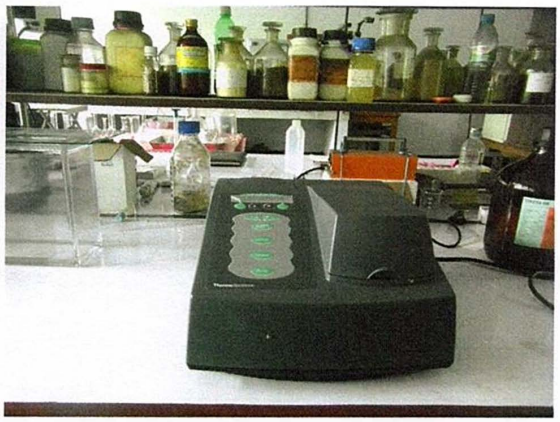
Water circulating vacuum pump (Protein)

Digestion chamber (Protein)



Oven

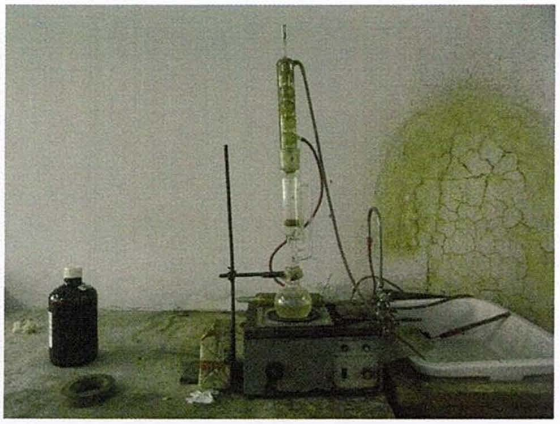
Magnetic stirrer with heating (Phosphorous digestion)



UV-visible Spectrophotometer (Phosphorus)

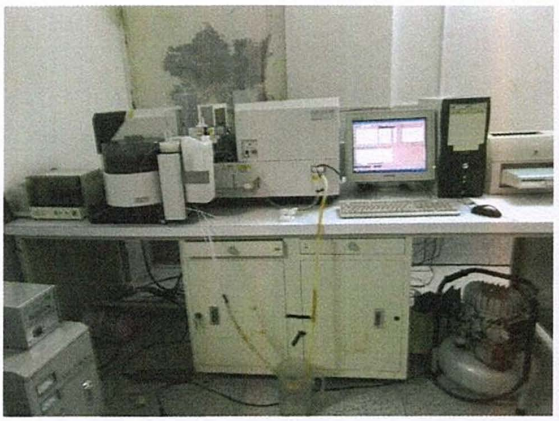
Plate 4.1: Apparatus used in the laboratory for determination of nutritive values (protein, phosphorous) of the studied small fishes (at BCSIR Laboratory, Rajshahi).

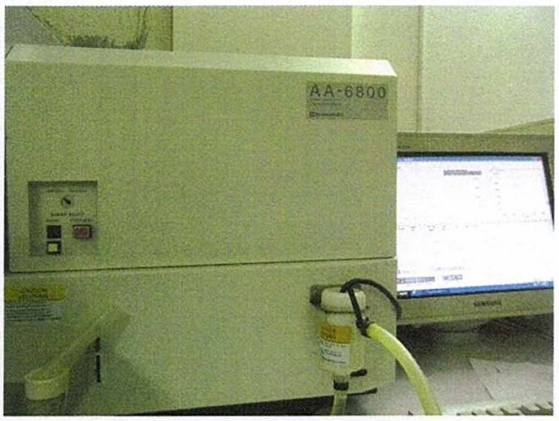
Rotary evaporator with vacuum pump (Fat)



Soxhlet apparatus (Fat)

Automatic moisture analyzer





Atomic absorption spectrophotometer (calcium and iron)

Plate 4.2: Apparatus used in the laboratory for determination of nutritive values (fat and moisture) of studied fishes at BCSIR Laboratory, Rajshahi and determination of calcium and iron at Central Science Laboratory, Rajshahi University, Rajshahi..

Results and Discussion

The present study deals with the compositional variation of protein, fat, moisture and minerals (calcium, phosphorus and iron) of sun-dried fish. The result indicated a wide variation in proximate composition depending on the species. The data obtained on the biochemical composition of experimental fishes are presented in Table 4.1 and 4.2 and Fig. 4a-4f.

Among the mineral contents, calcium was found to range from 1.66% (*G. giuris*) to 2.53% in *P. ticto*. The highest percentage of iron was found in (32.00/100g mixed fishes and the lowest percentage of (20.25/100g) was found in *P. ticto*. Maximum amount of phosphorous was found in *C. fasciata* (2.93%) and the lowest was found in mixed fishes (1.85%).

Moisture content ranged from 12.05% in *C. soborna* to be minimum and the maximum amount of moisture was found in *G. giuris* in (14.28%).

The highest percent of fat was found in (23.63%) in *C. soborna* and the lowest (1.29%) in *E. vacha.*

Finally the highest percent of protein content was found in *G. giuris* (73.32%) and the lowest was found in 57.76% in *C. fasciata.*

Table 4.1. Nutritional contents of the studied small indigenous fishes (SIF).

Name of fishes	Calcium (%)	Phosphorus (%)	Iron (mg/100g)
Glossogobius giuris	1.66	2.79	20.71
Colisa fasciata	2.50	2.93	24.11
Puntius ticto	2.53	2.22	20.25
Eutropiichtheys vacha	2.51	2.62	27.62
Corica soborna	2.50	2.78	31.33
Mixed fishes	2.49	1.85	32.00

Table 4.2. Nutritional contents of the studied small indigenous fishes (SIF).

Name of fishes	Moisture (%)	Protein (%)	Fat (%)
Glossogobius giuris	14.28	73.32	14.50
Colisa fasciata	13.79	57.76	19.60
Puntius ticto	13.04	59.35	9.58
Eutropiichtheys vacha	13.36	66.47	1.29
Corica soborna	12.05	64.66	23.63
Mixed fishes	12.94	58.06	10.58

The result revealed that *E. vacha* contained less fat and other species *C. fasciata*, *P. ticto*, *E. vacha*, *C. soborna* and mixed fishes were rich in calcium. Phosphorous was maximum in mixed fishes whereas, iron was less in *P. ticto* compared to others. The percentage of moisture was also more or less same in all the experimental fishes.

According to the works of Kamal *et al.* (2007), Mazumder *et al.* (2008) and Musa (2009) the nutritional values of the small fishes are rich compared to the larger fish species. Similar report has been stated by Sultana *et al.* (2011) for small indigenous fish species.

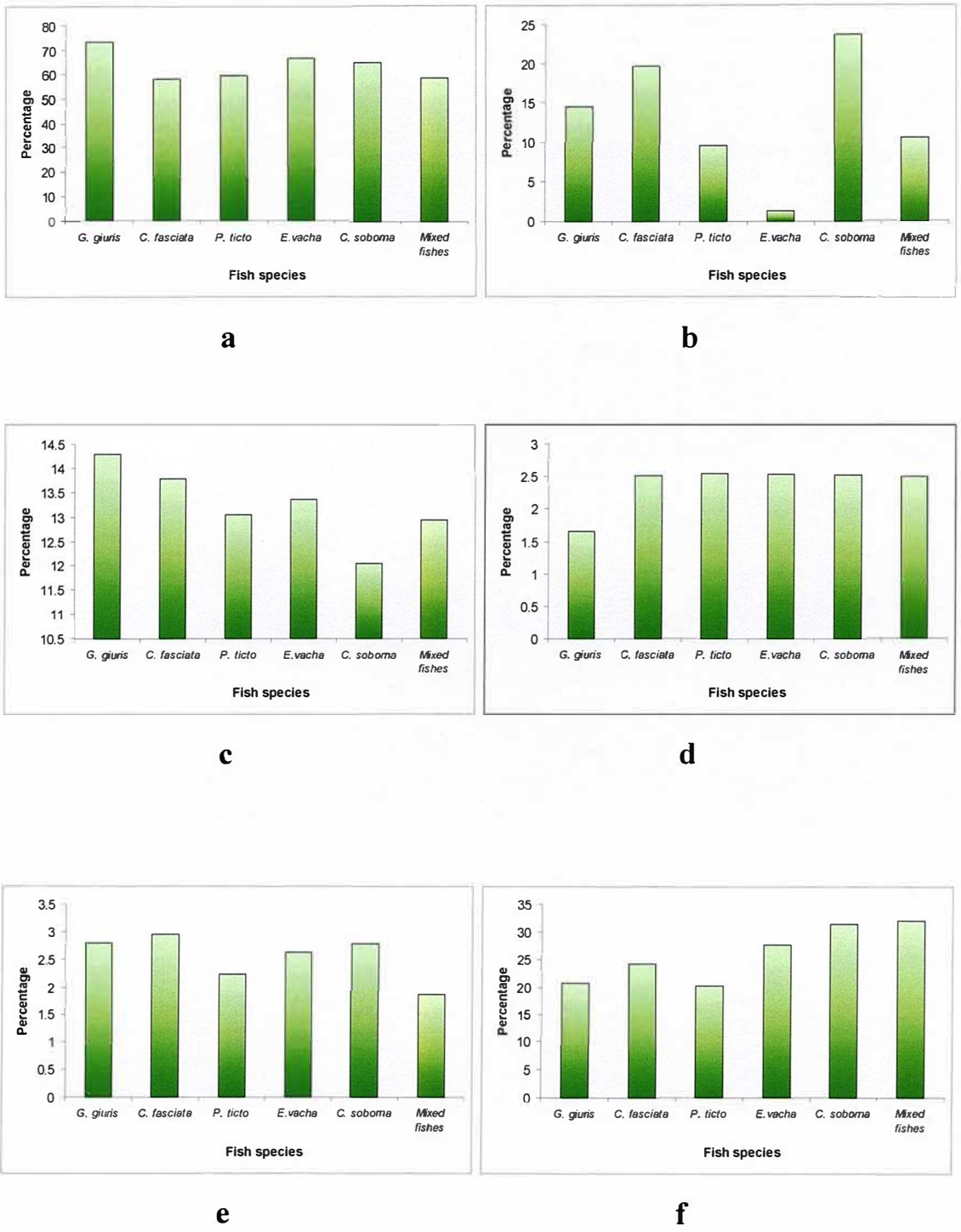


Fig. 4.1: Percentage of a. protein; b. fat; c. moisture; d. calcium; e. phosphorous; f. iron of the studied small indigenous fish species (SIFS).

The biochemical composition (protein, fat, moisture, calcium, phosphorous, iron) of the dried fish powder are recorded. The analysis of nutrient composition shows that the dried small fishes used in the experiments are rich in protein containing 57.76-73.32%. The percentages of fat ranged from 1.29 to 23.63%. These dried fishes were also rich in iron and contain good amount of calcium and phosphorous. Calcium plays essential role in human body for the formation of bones, muscle tone and nervous impulse (Mollah *et al.*, 1998).

It has been reported that *Cirrhina reba* contains 822 mg calcium/100g of fish (Islam *et al.*, 2003), species like *Gudusia chapra*, *Channa punctatus* and *Amblypharyngodon mola* contain 1063, 1093 and 1171 mg Ca/100g, respectively of raw edible parts (Roos *et al.*, 2003). As SIFS are consumed totally along with bones, so there is no wastage of calcium from these fishes. Phosphorous is another essential nutritional element for human, which is also present at a high percentage in the tested fishes.

Moisture: The moisture content of all living systems contributes as much to the essential properties of life. The highest moisture content was found as 14.28% in dry *G. giuris* and the lowest was found as 12.05% in *C. soborna*. More or less similar result was reported by Azam *et al.* (2003); Sultana *et al.* (2011). The authors determined the moisture content of 14 different fishes, which varied widely from 18.23 to 23.61%. Nurullah *et al.* (2003) observed six small indigenous fish species and reported that moisture content ranged from 72.97 to 76.35% with the highest moisture content in *G. chapra* and the lowest in *P. sarana*. Bhattacharyaya *et al.* (1985) reported that sun-dried *G. chapra* contained 9.61-18.64% moisture. According to Hoq (2004), normally the sundried fishes contain an average of 10 to 20% moisture. Sultana *et al.* (2011) also reported that moisture content of 7 dried fish species, which varied widely from 10.30 to 13.50%.

The Indian Central Institute of Fisheries Technology conducted a survey at four fish drying yards of India for quality of dried products, and their examinations showed that the moisture content of the dry fishes varied over a range from 12.3 to 54% of the dried fish that varied according to the season, which was correlated with the relative humidity, and was maximum in rainy season.

Protein: Protein composition ranged from 57.76 to 73.32%. *G. giuris* contained the highest percentage of protein (73.32%). Among the tested fishes *C. fasciata* is less proteinous 57.76%. Protein content varies among the species according to their food habit. Azam *et al.* (2003) found that the values ranged from 6.52 to 40.69% in 14 species of dried fishes. Hoq (2004) concluded that normally the sun-dried fishes contain 60 to 80% protein. Ali *et al.* (1992) found that the protein content of sun dried mola ranged from 59.6-61.2%. Sultana *et al.* (2011) also reported that the protein content of 7 dried fishes ranged from 52.65 to 72.45%.

Nuruallah *et al.* (2003) reported the highest amount of protein in *Xenentodon cancila* (21.70%) and the lowest amount was obtained in *G. chapra* (14.08%). *C. reba* contained 19.74% protein (Islam *et al.*, 2003). Islam and Joadder (2005) also reported that *G. giuris* of protein contain (14.16%) in female and (15.23%) in male. Hoq (2004) concluded that normally the sundried fishes contained 60-80% protein.

All these studies showed that more fleshy fishes contained highest amount of protein compared to the lean fish species. Moreover, dried powder fishes contain more protein than the fresh fish. The drying process may reduce the moisture content and concentrate the proteins in the flesh.

Fat: Fat content also varies among the SIFS. Among the six experimental SIFS fat content ranged from 1.29 to 23.63%. The highest fat content was found in *C. soborna* as 23.63% and the lowest was 1.29% in *E. vacha*. Hussain *et al.*, 1992 reported 3.7 to 17.8% fat content in 23 sundried fishes. Sultana *et al.* (2011) also

found the fat content of *C. soborna* which was 12.66%. The fat content was more or less equal in the studied small fish species.

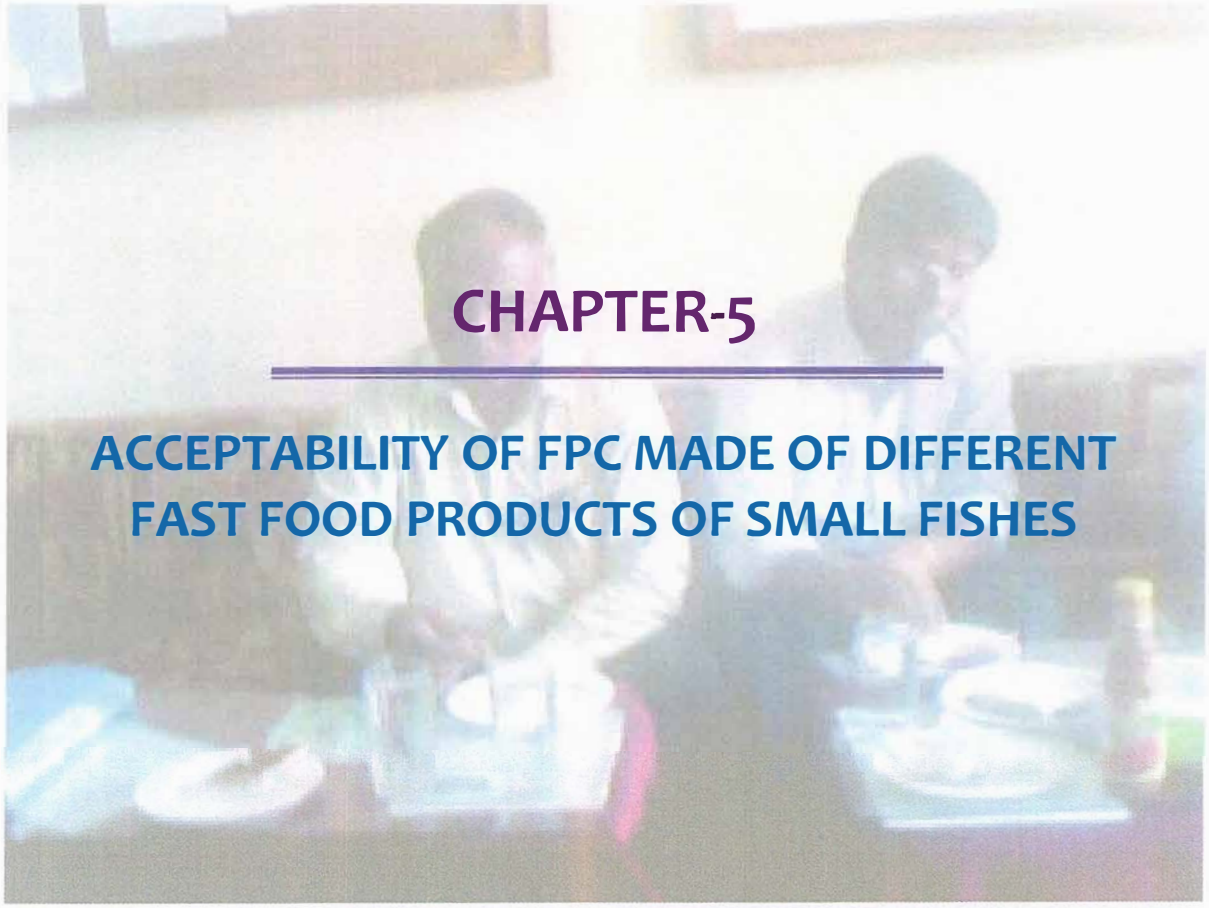
Calcium: Calcium is very much essential in human body for the formation of bones, muscle bone and nervous impulse (Mollah *et al.*, 1998), and fractional calcium absorption in human body is 24% (Larsen *et al.*, 2000). It has been reported that *C. reba* contains 822 mg calcium/100g of fish (Islam *et al.*, 2003). It was reported that *C. reba* contain 890 mg/100g calcium whereas, species like *G. chapra*, *Channa punctatus* and *A. mola* contain 1063, 1093 and 1171 mg Ca/100g of raw edible parts (Roos *et al.*, 2003).

Phosphorous: In the present research phosphorus content of six small fishes ranged between 1.85%-2.93%. Highest percentage of phosphorous content was found as 2.93% in *C. fasciata* and the lowest was found as 1.85% in mixed fishes.

Iron: In present experiment, six experimental dried fishes were found to contain iron ranging from 20.25 mg/100g fish in *P. ticto* to 32.00 mg/100g fish in mixed species. Nurullah *et al.* (2003) reported that iron ranged from 14.50 to 42.20 mg/100 g of raw fish, and Chapila (*G. cahpra*) contained the highest amount of iron among the studied SIFS. Roos *et al.* (2003) reported that *Esomus danricus* was rich in iron (12 mg/100g fish) and among the other iron rich species were *A. mola*, *G. chapra*, *M. vittatus*, etc. However, Roos *et al.* (2003) also commented that the small fishes present in the fish culture ponds are low in iron and calcium, and NCR (Nutrient Contribution Ratio) value of these fishes were all low as <5%.

It is true that all species of fishes are not equally good as sources of all nutrients. Some are relatively high while some are relatively low for a particular nutrient. Among the fish analysed in present study all of them were found as good source of protein, fat and minerals (such as calcium, phosphorus and iron).

The results of the present study provide the information that the dried or powdered small fishes are equally nutritive as they are in fresh condition. The protein content was more than 50%, with rich supply of iron, calcium and phosphorous (the essential minerals for human growth and life). So, for the nutritional security, small fishes should be grown in every possible waterbodies, and along with the cultured fishes in the fish culture system. During the peak season (monsoon and post-monsoon), at distant areas of northern districts of Bangladesh SIFS are captured at such a quantity that a major part of the catch are wasted (Parween *et al.*, 1997). The unconsumed small fishes can be sun dried and stored, and consumed for longer period for future use, and the rural people will get these SIFS which will provide equal nutrition from these dried small fishes as they can have from the fresh fishes. And SIFS in dry or fresh condition can play vital role in the nutritional security for the rural people of low income groups.



CHAPTER-5

ACCEPTABILITY OF FPC MADE OF DIFFERENT FAST FOOD PRODUCTS OF SMALL FISHES

Chapter Five
ACCEPTABILITY OF FPC MADE OF DIFFERENT FAST FOOD PRODUCTS OF SMALL FISHES

Introduction

At the present time fish protein is said to be more healthier and cholesterol free and the adults are advised to take much fish than meat. Throughout the world one of the popular slogan is "grow more fish". Many countries are dependent on their fisheries resources for their economy. Fish is the second staple food of Bangladesh. In recent years, small fishes in Bangladesh received growing importance because of their high nutritional value.

In Bangladesh it is possible to make a great variety of products from the enormous variety of fishes which are caught. These products will have very different qualities and may be used in a variety of different dishes. In our country people are not habituated with the fast food products made of fishes. The fisheries scientists are researching in this matter for the last couple of years and even today. In the research work firstly fish powder was made from processed experimental fishes. Secondly different fast food items were made from that fish powder. Finally the fast food items were tested experimentally to different people and their remarks were collected.

The work was done with the sense that those fast food items should get their acceptability. Mainly in our country people are much more selective and traditional in their food acceptance. They take some time to accept something new food because of cost and taste of the new food items. That's why the work was done with the experimental species in such a manner that the fast food items made from fishes should get the acceptance to all the people.

In the research work five small fishes and a group of mixed fishes were used which are very popular and nutritious and found in peak season. So if we can preserve these fishes in season and then processed in powder form we can use these fishes to make different types of fast food.

Fast foods include fish soup, fish cutlet, fish burger, fish stick kabab, fish toast, fish parota with chatni, fish pakora, fish ball with noodles and fish papdom. The handling and processing of the products of each species were devised with optimized product quality as well as the appearance, taste and flavour of the products. Preparation techniques varied with one another. Preparation of such fish fast food products will enable to ensure not only an increment of economic profitability of harvest and a supply of cheaper nutrition to the people but also proper conservation of our resources, fish habitat and environment.

The present study provides information on the consumers' preference towards the new products, which would serve as the base line data towards future commercialization of the products and marketing of the products in rural areas that would help to develop a viable value-added product industry in the country. Moreover, the formulation technology would increase the possibility of getting more return of the harvest and provide better nutrition to the people.

Materials and Methods

The consumers acceptability and marketability tests of various fishery products were conducted on 20/30 people of each occupation in Rajshahi City. The tests were conducted in only one way- "Interview Schedule". For this purpose, a very simple questionnaire, easily understandable to all class people was developed.

From the survey of acceptability and remarks, the information were recorded in the following design:

Survey on consumers' acceptability of fish fast foods

1. General information:

Consumer's name:
Profession:

2. Taste of the product:

Comments	Fish soup	Fish cutlet	Fish toast	Fish burger	Fish stick kabab	Fish ball with noodles	Fish parota wih chatni	Fish pakora	Fish papadom
Bad									
Average									
Good									
Very good									

3. Flavour of the product:

Comments	Fish soup	Fish cutlet	Fish toast	Fish burger	Fish stick kabab	Fish ball with noodles	Fish parota wih chatni	Fish pakora	Fish papadom
Bad									
Average									
Good									
Very good									

4. Colour of the product:

Comments	Fish soup	Fish cutlet	Fish toast	Fish burger	Fish stick kabab	Fish ball with noodles	Fish parota wih chatni	Fish pakora	Fish papadom
Bad									
Average									
Good									
Very good									

5 Which one is more tasty?

Comments	Fish soup	Fish cutlet	Fish toast	Fish burger	Fish stick kabab	Fish ball with noodles	Fish parota wih chatni	Fish pakora	Fish papadom
Bad									
Average									
Good									
Very good									

6. In your opinion what should be the acceptable price of the products?

Fish products	Minimum	Average	Maximum
Fish soup			
Fish cutlet			
Fish toast			
Fish burger			
Fish stick kabab			
Fish ball with noodles			
Fish parota wih chatni			
Fish pakora			
Fish papadom			

(Name of the interviewer) (Date)

Results and Discussion

The interview schedule is a very effective tool to generate data from various classes of people who are mostly literate and few illiterates. In the study period 9 experimental fishery products made of five experimental fishes and a group of fishes supplied to the different occupation to eat or swallow and asked them directly to score on score sheet. Before that discussions were made about the products and their preparation, its alternative income generating opportunities and their nutritional, economic and social benefits. Different class people were encouraged to comment on it and allow them to enter in depth of the problem that should be answered. In most cases their answers were spontaneous and self-explanatory.

During consumers' acceptability and market test, 100 test persons were selected in such a way that they could represent different occupation. Major occupations identified were teachers, students, doctors, housewives and others.

From the obtained data remarks are given in Table 5.1 and 5.2. No consumer scored against the product 'very bad'. Score "average", "good" and "very good" combinedly comprise more than people's response.

The price of different fish fast food items was analyzed through questionnaire. People were asked about the reasonable and affordable price. Almost 100% people responded positively. They were asked whether they would produce the products at home if the technology was taught or it bought as usually as readymade form in the market or fast food shop. People were further asked about prices. Very interesting results have come out.

Table-5.1: Total remarks of the consumers (%) towards the taste, colour and flavour of the fast food items made of the powder of the small fishes.

Product	Taste score	Total remark	Percentage (%)
Fish soup	B	0	0
	Av	35	35
	G	45	45
	Vg	20	20
Fish cutlet	B	0	0
	Av	23	23
	G	47	47
	Vg	30	30
Fish toast	B	0	0
	Av	32	32
	G	41	41
	Vg	27	27
Fish burger	B	0	0
	Av	21	21
	G	50	50
	Vg	29	29
Fish stick kabab	B	0	0
	Av	11	11
	G	45	45
	Vg	44	44
Fish ball with noodles	B	0	0
	Av	26	26
	G	41	41
	Vg	33	33
Fish parota with chatni	B	0	0
	Av	21	21
	G	47	47
	Vg	32	32
Fish pakora	B	0	0
	Av	20	20
	G	39	39
	Vg	41	41
Fish papadom	B	0	0
	Av	35	35
	G	39	39
	Vg	26	26

B = Bad, Av = Average, G = Good, Vg = Very good

Plate-5.1: Photographs of consumers' accepted to the different fast food items.

Teachers and doctors were moderate in spending money. Students were very justifiable for the prices and others were very rigid to spend money for the products. The suggestive price of different types of fish fast food products was much higher than the production cost (Table-5.2). Detailed results are shown in Appendix table 21.

Table-5.2: Average price (Tk.) of the fast food items made of the powder of the small fishes and a group of fishes (consumers') remark.

Product	Average Price (Tk.) (Remark basis)	Production cost (Tk.)
Fish soup	21.50±5.75	17.00
Fish cutlet	18.10±3.96	22.00
Fish toast	16.30±3.66	20.00
Fish burger	14.70±3.32	25.00
Fish stick kabab	16.70±4.12	22.00
Fish ball with noodles	17.40±4.27	20.00
Fish parota with chatni	17.00±6.59	21.00
Fish pakora	16.90±4.26	14.00
Fish papadom	16.80±6.30	10.50

Response towards the taste, flavour and colour of the fish soup, fish burger, fish cutlet, fish stick kabab, fish toast, fish ball with noodles, fish parota with chatni, fish pakora, fish papdom varied with different occupation of consumers. About 44% of all occupation scored the taste 'very good' for fish stick kabab. The majority of different occupation highest opined in 'good' taste against to the all fast food products. These are fish soup (45%), fish toast (41%), fish cutlet (47%), fish

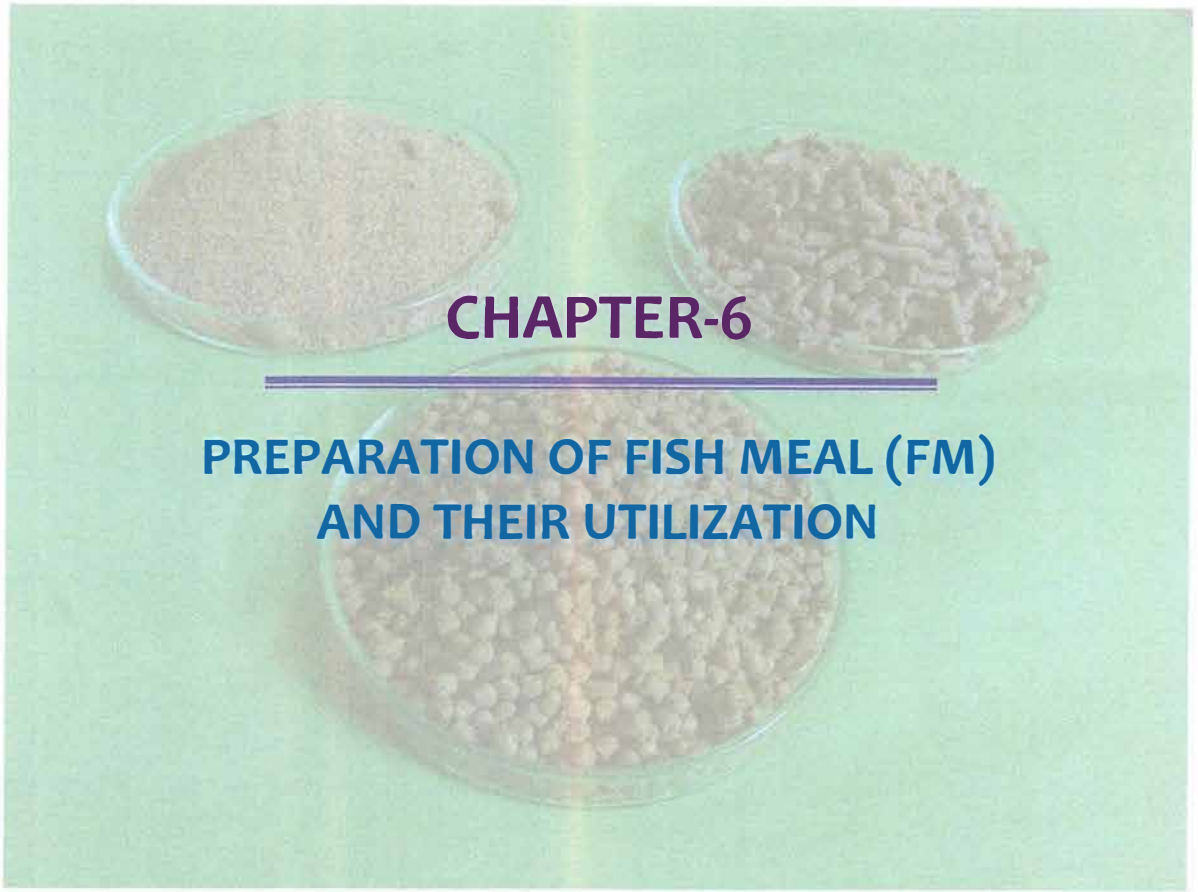
burger (50%), fish stick kabab (45%), fish ball with noodles (41%), fish parota with chatni (47%), fish pakora (39%), and fish papadom (39%) (Table-5.1).

In case of fish soup, fish burger, fish cutlet, fish stick kabab, fish parota with chatni was greatly liked by every section of people, irrespective of different occupation. In taste, overall acceptability, colour and flavour were very much liked by about 50% (good) of the people. Consumers' response towards the taste, flavour and colour of different fish fast foods in relation to occupation are presented in Table-5.1.

Again the different occupation of people scored fish burger (50%) "good" in taste. Again the other fish fast food products like fish stick kabab, fish cutlet different occupation of the people remarked a considerable number in "good" which is 45%. About 35% of all occupation in score the average for fish soup and fish papadom (Table-5.1).

The result indicates that the different occupation of the people were very careful to accept the change. This may be due to the social structure and the nature of job.

The cost of production and profit of the products were assessed. An analysis has been made on the basis of the price of products taken from the market tests, the price of raw materials in the market, tentative cost of productions etc. Among all the fast food products fish burger had the highest production cost (Tk. 25.00). But on the consumers' remarks basis the highest cost was fish soup (Tk. 21.50) and the lowest production cost was in fish burger from consumers remarks (Tk. 14.70) and production cost of fish papadom (10.50%) (Table-5.2).



CHAPTER-6

PREPARATION OF FISH MEAL (FM) AND THEIR UTILIZATION

Chapter Six

PREPARATION OF FISH MEAL (FM) AND THEIR UTILIZATION

Introduction

To ensure the maximum production of fish, it is obligatory to produce suitable, complete and supplemental cost effective diets for use in hatcheries and nursery ponds. Cost effective but quality feed from indigenous ingredients will increase the quality of seed, which is the prerequisite to boost the aquaculture.

The fish meal (FM), which started first in Europe and North America at the beginning of the 19th century, was based mainly on surplus catches of herrings from seasonal coastal fisheries. The residue was originally used as fertilizer, but since the turn of this century it has been dried and ground into fish meal for animal feeding.

In Bangladesh, fish meal is a moderate quality nutritious food which includes moderate protein, minerals, vitamins and other elements which grow in animal and made of fresh fish or fish wastes. The fish meal is a solid product, ground, that has been obtained by removing the water and some or all the oil from fish or fish wastes (Windsor, 1971). Its main use is in the diets of poultry, silkworm (Habib *et al.*, 2001), pigs and fishes which need higher quality protein than does other farm stock, such as cattle and sheep.

Commercially important fish species would constitute an important area of research for the development of aquaculture in Bangladesh. Traditionally, fish meal has been used as the major source of dietary protein for fish and its fry throughout the world; but the scarcity and high price limits its utilization as the source of protein in Bangladesh (Hasan *et al.*, 1997). Also due to the sufficient use of fish meal as in poultry and fish farming; it becomes hard to afford by nursery and hatchery owners. Therefore, it is very much necessary moderate to prepare it cheap and locally available protein source for fish feed.

Fish meal is a quality ingredient in feeds for animals including fishes raised by aquaculture. In this way, it makes a significant indirect contribution to human nutrition. 30% of the world's fish catch is processed into fish meal and raw material currently used for fish meal is diverted to direct human consumption.

The main aim of fish catch is to produce fish for human consumption. Only uneconomic or impracticable catches are used in fish meal. Small fishes are the main stay of fish meal (head, scales, viscera, fin, tail etc.) in fish industry. With proper knowledge fish wastes can be made in the fish meal for animal feeding. There is a good demand for high quality fish meal. Fish meal based diets have been known to yield higher growth in fishes, fish meal being rich in all the dietary essential amino acid (Andrew and Page, 1974). Quality of fish meal fluctuates to the origin and the season as well as processing method used (Ogino and Chen, 1973).

Fishes used for production of fish meal are of three categories

a. fishes caught for the role purpose of fish meal production (for example by Chile, Peru, Norway, Denmark, South Africa and USA).
b. by-catches from another fishery (by most fish producing countries).
c. fish offcuts and offal from the consumption industry (The UK and Germany use these materials to produce white fish meal; South Africa makes rock lobster meal from the carapaces and other parts which are not utilized.).

Fish meal is clean cooked, dried tissue of un-decomposed fishes. Species that form the raw material are sardins, mackerels, ribbon fish, silver belly, sharks and rays. Large sized fishes are cut into pieces while the small ones are treated as a whole. The process of manufacture consists of boiling the fish in sufficient quantity of water in large pots to extract oil. The cooked meal is then pressed to remove water. The resulting cake is then dried in sun, taking care to prevent mixing of sand.

Fish meal is prepared from raw materials of small fishes or shell fishes (Crustaceans). In most cases the whole fishes are used in fish meal. In many cases

trash fishes, dead fishes, scales, fin, viscera etc. are used in preparation of fish meals. A fish meal industry requires a regular supply of raw materials.

Large factories are constructed for continuous operation at places where fishes are landed in considerable quantities. The fishes are run continuously to cookers, from where they are passed to screw presses. The pressed materials are dried in steam cylinders, pressed hydraulically to extract oil and water. The solid meal is packed and marketed.

Fish meal can be stored in air tight sterilized containers for a fairly long period. It forms a very valuable feed for poultry and cattle and increase milk and egg production due to its high protein and vitamin contents. Manufacture of fish meal can be taken up as a cottage industry as it needs cheap equipment.

A few number of mills have been setup for fish meal preparation in Bangladesh. Akand *et al.* (1991) reported that fish diets (FM) wee formulated to contain 30% protein. Latif *et al.* (2008) reported locally made available fish meal can be used in the fish meal as dietary protein source for *Labeo rohita* fingerling.

Miller (1970), Windsor (1971), IAFMM (International Association of Fish Meal Manufactures) 1979-1983 have recommend methods of analysis of nutrients.

Materials and Methods

Preparation of fish meal

The production of fish meal and oil from fresh raw materials gives the highest yield and the best quality final products. Two methods are followed in fish meal preparation.

1. Moisture reduction method
2. Dry rendering method

1. Moisture reduction method: Fatty fishes (e.g., ray fish, mackerel, ribbon fish, silver fish) are used in this method. In the purpose fish shape and oilless most of fishes are used in this method.

2. Dry rendering method: Fatless fishes are used in this method.

Raw fishes → Grinding in machine → Boiling by steam → Pressing

↓ ↓

Water withdrawl→ Drying(140°F)→ Fish pulp made by pressing→Liquid made by pressing

↓

Milling → Sieving → Fishmeal

Fig. 6.1. Schedule of fish meal preparation.

1. Grinding: Most of the big fishes are grinded in machine.

2. Steam boiled: Small sized fresh fishes are cooked by steam. The bones become soft, tissues broken and the oils are extracted.

3. Pressing: Boiled fishes are pressed by hydraulic pressure. Then got fish oil and press cake or pressed by flesh ball. For the purpose extract of oil and water then flesh ball pressed for fish meal.

4. Drying: Flesh ball steam in drying for 140°F then water is extract and flesh ball are dried.

5. Curing: It is an important step and it is done cautiously. After drying the press cake or flesh balls become very hot. Then oxidative polymerization is present. So the press cakes are cooled well.

6. Milling: Flesh cakes are milling in powder.

7. Sieving: Powders are sieved by chaluni then bones extracted and milling fish meal are got.

Types of fish meal

On the basis of the presence of protein fish meals are of 3 types-

Grade A: contains 55-65% to protein

Grade B: 30% up 55% low protein

Grade C: Less than 30% of protein

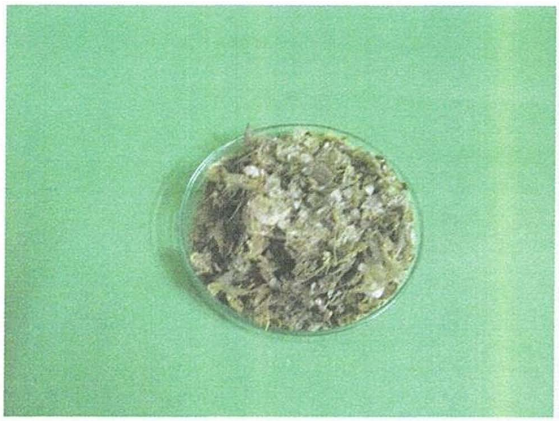


Plate 6.1: Fish waste products.

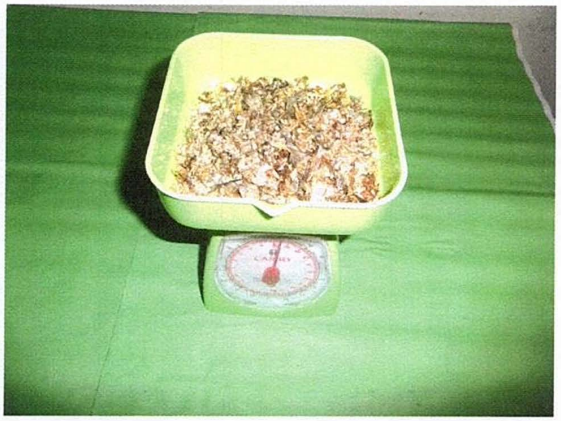
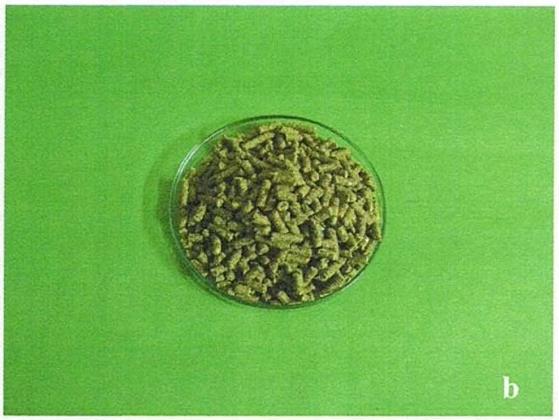


Plate 6.2: Weight of fish waste products.



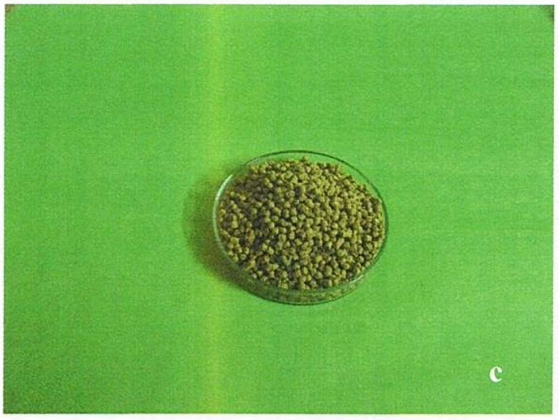


Plate 6.3: Different types of fish meal
(a. fish powder, b. fish pellet, c. fish ball).

Results and Discussion

In general waste products of fish industries are utilized to make fish meal. In our country small fishes are cut into pieces or crashed to fish meal. In Bangladesh, only Cox's Bazar BFDC (Bangladesh Fisheries Development Corporation) has a machine where fish meals are produced. In advanced country like Peru, Norway, South America, USSR, Denmark, USA and Japan which are most developed in this sector manufacture quality fish meal.

Fish meal is composed of:

Moisture – 13%

Crude proteins – 18%

Crude fat – 4%

Crude fibre – 9%

Ash – 35%

S. F. E. – 21%

Table 6.1: Biochemical analysis of fish meal

	Protein	Fat	Ash	Oil	Moisture	Mineral	Vitamin
Fish meal	60-80%	2-15%	10-15%	5-6%	6-12%	10-12%	A, D, K

This chapter reports that no other things are less important source fish. One hand fish flesh is so much nutritive which have 70% flesh and wastes are 30% that is used for fish feed, poultry etc.

The nutritive value of fish meal is shown in the following table.

Table 6.2: The nutritive value and price of fish meal.

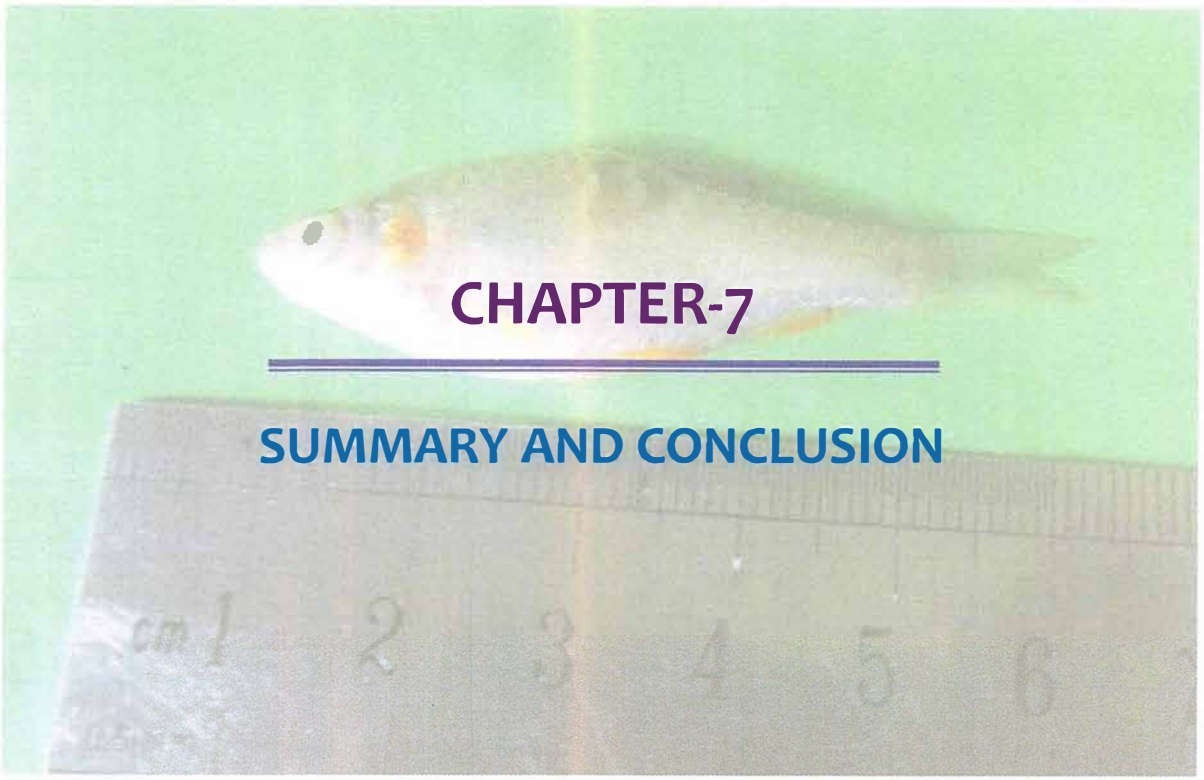
Product name	**Nutritive value (%)**			**Price (Tk./kg)**
	Protein	**Carbohydrate**	**Fat**	
Fish meal (Cheuwa)	50-55	3.7	12.22	55
Fish meal (Vati)	45-60	16.82	7.87	45

(Source: Matsha Saptaha, 2010)

A large number of small edible or non edible fishes are caught from the sea. The edible fishes are consumed in fresh or in processed condition. The unedible small fishes are either left or dried and made into powder (fish meal) to be used as fish feed in aquacultural systems. About 2.38 million mt. tons of marine small fishes are used in fish meal and fish oil preparation. If this fishes are used in the preparation of fish protein concentrate (FPC) this will be a good supplement for nutritional deficiency of the children and also in supplementation of the nutrition deficiency of pregnant or lactating mothers. So, the preparation of FPC or fish meal is of utter importance in supplementing the protein and vitamin deficiency of people of any country of the world.

Utilization of fish meal

Fish meal is a low cost supplementary feed but high quality protein for fish and animals. All essential amino acids including lysine are present in fish meal. Different minerals (iron, lead etc.) are present which made of body form. All vitamins B complex are present in fish meal which are used as fish feed. It is also used for silk worm, poultry, cattle. It is also used as fertilizer. Fish oil is prepared as by products during fish meal preparation. Fish meal also be utilized as bread.



CHAPTER-7

SUMMARY AND CONCLUSION

Chapter Seven

SUMMARY AND CONCLUSION

Summary

Bangladesh is a riverine country, intersected by thousands of tributaries of many rivers and their branches. The Padda is one of the three mighty rivers of Bangladesh. In the past it had huge resources of fish and fisheries items the water of which flowed swiftly throughout the year. But, after the construction of the Farakka barrage everything has become changed. Resources have decreased. At present more than 50 species of small indigenous fishes are recorded from the study area.

Small indigenous fish species (SIFS) have been considered as an excellent source of essential macro and micronutrients which can play an important role in the elimination of malnutrition and micronutrient deficiencies in the population of Bangladesh. Out the 260 freshwater fish species in Bangladesh around 142 are classified as small indigenous fish (SIF). SIF are an integral part of the rural Bangladeshi diet. The SIFS are eaten whole with organs and bones, they contain very large amount of protein, fat, minerals and vitamins. As small fishes are cooked with vegetables and a little oil, they contribute to the food diversity of the rural poor.

Small indigenous fishes of six species under 5 families and 5 orders were selected to determine their edible quantity compared to their wastes. The species were chosen depending on their economic importance. The present work deals with the estimation of percentage of waste weight after dressing weight in a group (eg. 100g) which are used for preparing various types of delicious food items as well as the utilization of the flesh production.

Each species recorded different measurement i.e. total length, total weight, after dressing weight, waste weight and weight after dressing and washing. The mean total lengths of the collected samples ranged from 17.85±5.58 mm (*C. soborna*) to 106.40±18.29 mm (*G. giuris*). The range of their mean total body weight was recorded as 1.03±0.64 g (*C. soborna*) to 12.33±3.99 g (*G. giuris*). The mean edible portion was found to range from 44.93±0.73 g (*E. vacha*) to 84.15±4.14 g (*C. fasciata*). The ratio between the edible portion and waste were minimum as 1:0.025 (*C. soborna*) and maximum as 1:0.382 (mixed fishes). Whereas, *C. soborna* are normally eaten with bones. So, the edible portion is increased more. The highest percentage of weight after dressing and washing was found for *C. soborna* 97.54% and the lowest mixed fishes 72.34%. And the highest percentage of waste product was 27.66% in mixed fishes and lowest 2.5% in *C. soborna*. After sun drying the maximum powder product from 1 kg of fresh fish was 258.00 g in *C. soborna* and the minimum was 117.20 g in *G. giuris*.

In the study, the fresh water small fishes were used because of their seasonal abundance and low cost. *G. giuris* and *E. vacha* are rare species but their availability is scatteredly and they have also high class consumer demand.

Dried fish powder was preserved for off season in a container at normal room temperature. In room temperature fish powder may remain in good condition for 5-7 months. But in -18°C the powder was in good condition throughout the year. Also it can be preserved in refrigerator to normal temperature for one and a half years. Fishes can be used to prepare the delicious fast food which are more acceptable to every kind of our people.

A good number of small fishes standout as fair for more than one mineral. When measures are taken to improve food and nutrition security, there should be a focus on the production and consumption of small indigenous fish species. It will also contribute positively in redressing the problem of micro-nutrient malnutrition of

the country. The flesh contents are more in these small sized species and the fish can be taken whole because of their small size. So the fishes are more economic to provide nutrition.

Fish muscle is a rich source of protein which occupies an important place in human nutrition. They have high digestibility, biological value and growth promotions value. They are well balanced with respect to essential amino acids. Findings of the present result suggests that the experimental fishes can be used as a potential source of different food components.

The biochemical composition (protein, fat, moisture and micro nutrients of preserved and dried fish powder was determined. Among the minerals calcium, phosphorous and iron were determined. Calcium was minimum (1.66%) in *G. giuris* and was maximum (2.53%) in *P. ticto*. The quantity of phosphorous ranged from 1.85% (mixed fishes) to 2.93% in *C. fasciata*. Iron was rich in mixed fishes (32.00 mg/100g) while least in *P. ticto* (20.25% mg/100g).

The moisture contents was 14.28% in *G. giuris* which gradually decreased in *C. fasciata* (13.79%) > *E. vacha* (13.36%) > *P. ticto* (13.04%) > mixed fishes (12.94%) > *C. soborna* (12.05%).

The fish powder contained maximum amount of protein in *G. giuris* (73.32%). Nearly similar amount of protein was found in *E. vacha* (66.47%), *C. soborna* (64.66%), *P. ticto* (59.35%), mixed fishes (58.06%) and *C. fasciata* contained the minimum amount of protein (57.76%).

Fat contents of the fish powder was found in *C. soborna* (23.63%), in *C. fasciata* (19.60%), in *G. giuris* (14.50%), in mixed fishes (10.58%), in *P. ticto* (9.58%) and (1.29%) in *E. vacha*.

Response towards the taste, flavour and colour of fish soup, fish burger, fish cutlet, fish stick kabab, fish toast, fish balls with noodles, fish parota with chatni, fish pakora and fish papadom varied with one and another for different professionals was "very good" for fish stick kabab. The majority of different professionals gave their opinion in "good" taste against the all fast food products. These are fish soup (45%), fish toast (41%), fish balls with noodles (41%), fish parota with chatni (47%), fish pakora (39%), fish papadom (39%).

Among all the fast food products fish burger was of the highest production cost (Tk. 25.00). But in the consumers' remarks the highest cost was fish soup (Tk. 21.50) and the lowest production cost was in fish papadom (Tk. 10.50).

In the common feature of young generation and commercial busy life, many of them prefer different kinds of fast food items because these are readymade and can be taken very quickly. Excess eating of these types of foods causes many nutritional disorders and disease and therefore it should be avoided. The preparation of different fish fast food items made of fish powder are more rich in different food components. So, these items ensure all the healthier, smooth and happy life because fishes have no harmful affect for human body.

On the other hand, the wastes of fishes (i.e. head, fin, scale, viscera etc.) are made to fish meal. Fish meal is medium quality ingredient in feeds for animals including fish raised by aquaculture. Fish meal is a solid product, ground, obtained by removing water and used mainly for poultry. FPC (fish protein concentrate) usually refers to fish meal for human consumption. It is a high quality protein used to improve nutrition in a number of developing countries of the world.

With this point of view, the rural people can be engaged for fish processing and preparation of fish fast foods in small cottage industry basis. So, it would be a great opportunity for better livelihood of the rural poor people.

Conclusion

In Bangladesh, the poor people severely suffer from malnutrition and vitamin deficiency. Whereas, protein and vitamin rich diets are essential for the growing children. Until mid 1900 fish was the main protein supplier of the nation. Being a country of rivers and associated vast floodplains, there was abundance of fish both by diversity and biomass. Due to the pressure of population growth and civilization, the water area declined continuously in the country. Fish species are decreasing from the river Padda because of the construction of the Farakka Barrage resulting on the flow of lesser amount of water.

The poor fishers and rural people, even their children can provide fish in the family's diet, and sometimes they earn a little by selling the excess fish. But the situation is quite different after mid 20^{th} century. The small indigenous fishes became rare and fetch high market price. As a whole the availability of fish is out of reach of the poor. The small fishes play very important role in supplying fats and minerals. So, the production of small fishes should be increased.

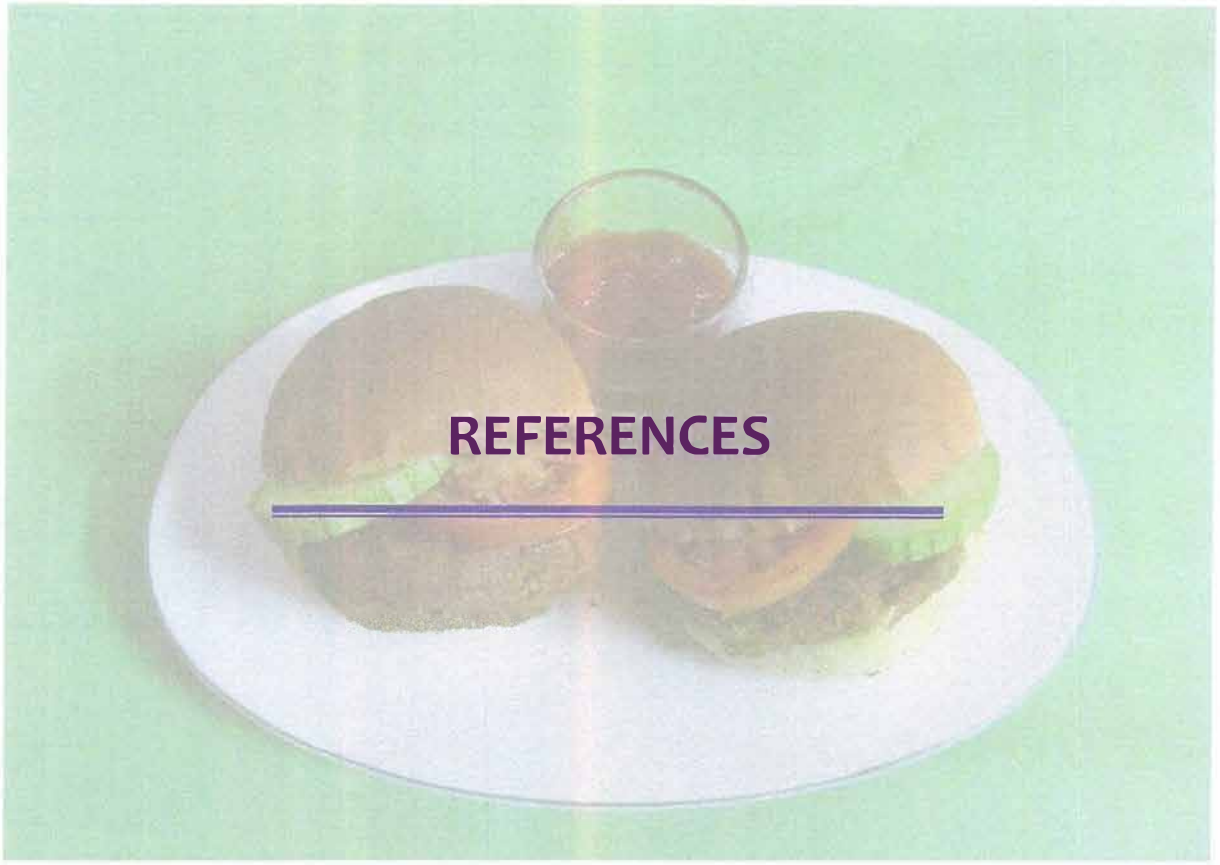
The present study records that the small fishes are attractive source of different fish fast food items such as fish soup, fish burger, fish cutlet, fish stick kabab, fish toast, fish balls with noodles, fish parota with chatni, fish pakora and fish papadom. More research needs to be carried out on various products development.

Studies on the freshness of fishes and storage condition on the preparation of various fish fast food products need to be investigated for effective utilization and acceptance of fish fast food products popularizing among the different section of people in the society.

For nutritional security of the people of Bangladesh, the small fishes can play an important role. A small quantity of SIFS can be distributed among the family members, which is difficult in case of large sized fishes. The ratio of edible and

non-edible wastes are less in case of the small fishes, so the price per unit of edible parts is comparatively less than that of the large fishes. The small fishes can provide the family lower income daily, which will not be possible buy large size fishes. The small fishes are eaten whole, and contain comparatively more nutrients and minerals, so these fishes can protect the people from malnutrition and vitamin deficiency. Specially adults and babies will be completely free from night bindness diseases.

So in conclusion it can be said that small indigenous fishes (SIF) can be well utilized in preparation of FPC or fishmeal which can supplement all the essential amino acids and vitamins for the poor as well as rich people of any country of the world.



REFERENCES

REFERENCES

Adhikari S and Noor A. 1967. Seasonal variation in oil water contents and solid matters in different organs of puntifish (*Barbus puntius*). *Sci. Res.* **4**: 55-63.

Afroze S, Sultana N and Hossain MA. 1997. Small fish as a source of nutrition for our people. pp. 57-63.

Ahmed ATA., Mustafa G and Alam MZ. 1984. Biochemical composition of seven species of gobi fish. *J. Asiatic Soc. Bangladesh (Sci.)*. **4**(1): 67-71.

Ahmed ATA, Mustafa G and Rahman HN. 1979. Solar drying of silver jew fish *Johnius argentatus* in polythene tent dryer. *Bangladesh J. Biol. Sci.*, **8**(1): 23-30.

Ahmed ATA, Rubbi SF, Mustafa G, Muslemuddin M and Ahmed N. 1981. The proximate composition of flesh and food of *Tilapia nilotica* and *T. mossambica*. *Dhaka University Studies, B.* **29**(2): 33-40.

Ahmed F. 1999. Vitamin A deficiency in Bangladesh : a review and recommendation for improvement. *Public Health Nutr.*, **2**:2-14.

*Ahmed F. 2000. Anemia in Bangladesh : a review of prevalence and aetiology. *Public Health Nutr.* **3**:385-393.

Ahmed K. 1981. Nutritional blindness in Bangladesh in touch. VHSS Newsletter, No. 45(Feb), 1-2.

Ahmed K and Hassan N. 1983. Nutritional survey of rural Bangladesh 1981-82. Institute of Nutrition and Food Sciences. Dhaka University, Dhaka, Bangladesh.

Ahmed K, Hossain MA, Huda N and Abdullah M. 1997. Nutritional survey of rural Bangladesh; 1975-76. Institute of Nutrition and Food Science, University of Dhaka, 66 pp.

*Akand AM, Soeb M, Hasan MR and Kibria MG. 1991. Nutritional requirements of Indian major carps, *Labeo rohita* (Hamilton)- I. Effects of dietary protein on growth food conversion and body composition. *Agriculture International*, **1**: 35-43.

Alam AKMA. 1985. *Mini pond.* CARITAS Bangladesh, Dhaka, 49pp.

Al-Habib OAM. 1990. Protein control in some freshwater fishes (Dept. Biol. Coll. Sci., University Mosul, Iraq). Iraqi J. Sci. 31(1): 169-180. [In English with English and Arabic summary].

Ali MA, Hossain MA and Islam MA. 1992. A polythene tent dried for improved sun drying to fish (test varied out in Bangladesh). *Bangladesh J. Training and Dev.* **5**(2): 25-32.

Alikunhi KH, Sukumaran KK and Parmeswaran S. 1972. Studies on composite fish culture: Production by compatible combinations of India and Chinese carps. *J. Ind. Fish. Asso.* **1**: 26-27.

Amin AKMR, Parvez I, Zaman MB and Amin HA. 2009. Study of the present status of endangered small indigenous species (SIS) of fish in the natural waters of the north-west part of Bangladesh, *J. Environ. Sci. & Natural Resources* **2(2)**: 163-168.

*Anderson L, Dibble MV, Turki AR, Mitchell HS and Rynbergen HJ. 1982. *Nutrition in health and disease*. 17th edn. J. B. Lipincott and Company, Philadelphia, USA. pp. 89-98.

Andrew AE. 2001. *Fish processing Technology*. University of Ilorin Press, Nigeria, pp. 7-8.

*Andrews JW and Page JW. 1974. Growth factor in the fish meal component of cat fish diets. *J. Nutr.*, **104**: 1091-1096.

*AOAC. 1980. Official methods of analysis 13th edition. Association of Official Analytical Chemists, Washington D. C., pp. 376-389.

*AOAC. 2000. Official methods of analysis. Association of Official Analytical Chemists. EUA.

*Aref M, Timbely A and Daget J. 1964. Fish and fish processing in the Republic of Mali. *Alex J. Agric. Res.*, **12**(2): 5-108.

Aref M, Timbely A and Daget J. 1965. Fish and fish processing in the Republic of Mali 3. On the destruction of dried fish by the dermestid insects. *Alexandria J. Agric. Res.*, **12**(2): 95-108.

*Azam K, Basher MZ, Asaduzzaman M, Hossain MH and Ali MY. 2003. Biochemical quality assessment of fourteen selected dried fish. *Univ. j. zool. Rajshahi Univ.* **22**: 23-26.

Balachandran KK. 2001. *Post harvest technology of fish and fish products*. Daya Publishing House 1123/72, Delhi. 1-20.

Banu CP, Nahar B, Begum M and Ahmed K. 1985. Studies on the protein, riboflavin and iron content of some freshwater fishes and a prawn of Bangladesh. *Bangladesh J. Zool.* **13**(1): 25-28.

Banu CP, Sayeed S and Quazi S. 1991. Mineral content of freshwater fish and meat. *Ibid.* **19**(1): 59-63.

Barman BK, Rahman F and Haque M. 2011. *Community based fish culture approach in Bangladesh*. Paper presented in the IFWF3 Conference held on 14-18 November 2011, South Africa.

BBS (Bangladesh Bureau of Statistics) 1991. Statistical yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh. 729 pp.

BBS, 2009. Report of the household income and expenditure survey (HIES) 2005. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh. Downloaded from http://www.bbs.gov.bd/dataindex/hies_2005.pdf on 1st August 2009.

Bhattacharyya SK, Vandyopadhway JK and Chattopadhyay AK. 1985. Improved dried product on blanching *Gudusia chapra* prior to sun drying. *In*: Harvest and post-harvest technology of fish. Society of Fish Technologists (India). p.531.

Bhuiyan AD, Shahjahan RM, Huda SMA, Nahar G, Rahman R and Shaha AK. 1990. Packaging and storage studies of irradiated dried fish for commercial application. Final Report of the Joint Research Project of BARC. pp. 1-9.

Bhuiyan AS. 1997. Present status and future prospects for the small indigenous fishes of the northwestern region of Bangladesh. Proceedings of the national workshop on small indigenous fish (SIF) culture in Bangladesh. Integrated food assisted development project. Subproject-2 (IFADEP SP2), Dhaka, Bangladesh. pp-65-70.

Bhuiyan AS, Islam N and Hossain T. 1992. A Checklist of the fishes in the Rajshahi Division of Bangladesh. *Rajshahi University Studies Part B*. **20**: 287-306.

Borgstrom G. 1961. New methods in appraising the role of fisheries in world nutrition. *Fishery News, Intern.*, **1**(1): 33-42.

Chie S. 1999. Relationship between chemical composition and crystalline structure in fish bone during cooking. *Journal of Clinical Biochemistry and Nutrition*, **26**(3): 173-182.

*Cocks LV and Van Rede C. 1966. Laboratory handbook for oil and fats analysts Academic Press, London. 88pp.

*Cohen N. 1989. Vitamin A deficiency : Effects and determinants of risk. In vitamin A deficiency in Bangladesh : Prevention and control (Darnton, I. (ed.)). Helen Keller International, Bangladesh. Moni Printers & Package Ltd. pp. 64-75.

CSIR. 1962. Fishes and fisheries raw materials, India, vol. IV, P. 132.

Darnton-Hill I, Hassan N, Karim R and Duthie MR. 1988. Tables of nutrient composition of Bangladeshi foods. English version with particular emphasis on vitamin A content. Helen Keller International, Dhaka, Bangladesh.

Das NG and Hossain MM, 2009. Dried fish. National encyclopedia of Bangladesh. Asiatic Society of Bangladesh. Retrieved from http://www.banglapedia.org/ httpdocs/HT/ D_0282.HTM on 25th April 2009.

*Deb AK and Haque CE. 2011. Every mother is a mini-doctor: ethnomedicinal use of fish, shellfish and some other aquatic animals in Bangladesh. *Journal of Ethnopharmacology*, **134**(2): 259-267.

Doe PE. 1985. Spoilage of dried fish. The need for more data on water activity and temperature effects on spoilage organism. Fishing News Books Ltd. for FAO. 109-215.

DoF. 1996. Matshaw Saptaha Sankalan. Department of Fisheries. The Government of Bangladesh, Dhaka. 117pp.

DoF. 2005. Fishery Statistical Yearbook of Bangladesh 2003-2004. Fisheries resources survey system, Department of Fisheries and Livestock, Matshya Bhaban, Dhaka. 46pp.

DoF. 2010. Fishery statistical yearbook of Bangladesh: 2008-2009. Fisheries resources and livestock, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

DoF. 2011. Fishery Statistical Yearbook of Bangladesh: 2010-2011. Department of Fisheries, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Faculty of Fisheries, BAU, 2008. Book of Abstracts- Regional Workshop on Production and Conservation of small indigenous fish species (SIFS) for improved food and nutrition security and livelihoods of rural populations of South and Southeast Asia. Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh. 36p.

FAO. 1991. *Fish for food and development*. pp. 1-49.

Felts RA, Rajts F and Akhteruzzaman M. 1996. Small Indigenous fish species culture in Bangladesh. *IFADEP Sub-Project-2. Development of Inland Fisheries*. 41p.

FRSS. 2001. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh.

FRSS, 2012. Fisheries Statistical Year Book of Bangladesh 2010-2011. Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh. Volume 28, Number 1. 42pp.

Gheyasuddin S, Rahman A and Mumtazuddin M. 1979. Biochemical composition of shellfishes of Bangladesh. *Bangladesh J. Sci. Res.*, **2**: 15-23.

*Guha BC. 1962. The role of fish human nutrition, fish in nutrition, FAO. Fishing News (Books) Ltd., London. 39-42.

Habib MAB, Ullah MS, Hasan MR and Hossain MS. 2001. Use of silkworm pupae as partial replacement of fish meal in the diets with rotifers as feed additive of Asian catfish, Clarias batrachus (Linn.) fry. *Bangladesh J. Fish.*, **24**: 133-141.

Haq EM. 2005. *Matsho Sampad Sanrankhon O Pusti Jogana Choto Mach* (in Bengali). Souvenir, Fisheries of Current Millennium. Fisheries Graduates Association of Bangladesh (FAB). pp.94.

Haque MF. 2010. *Duti Kotha* (in Bengali). Matshaw Unnayans ProjjukiKormasuchi. Department of Fisheries, Ministry of Fisheries and Livestock, Govt. People's Republic of Bangladesh. iip.

*Hardy R and Keay JN. 1972. Seasonal variation in the chemical composition of Cornish mackerel *Scomber* (L.), with detailed reference to lipid. *J. Food Tech. Z.* pp 125-137.

Hasan MR, Macintosh DJ and Jauncy K. 1997. Evaluation of some plant ingredient as dietary protein sources for common carp (*Cyprinus carpio* L.) fry. *Aquaculture*, **151**: 55-70.

Hasan MR. 2001. Nutrition and feeding for sustainable aquaculture development in the third millennium. In: Aquaculture in the Third Millennium (RP Subasinghe, P Bueno, MJ Phillips, C Hough, SE McGloddery, JR Arthur, eds.). Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. NACA, Bangkok and FAO, Rome. pp. 193-219.

*Heilporn C, Benoît H, Debaste F, van der Pol F, Boey C and Nosnclercq A. 2010. Implementation of a rational drying process for fish conservation. *Food Security* **2**: 71-80.

Hels O, Hassan N, Tetens H and Thilsted SH. 2002. Food consumption energy and nutrient intake and nutritional status in rural Bangladesh: Changes from 1981-82 to 1995-96. *Eur. j. Clon-Nutr.* **57**: 586-594.

Hoq E. 2004. Bangladesher Chhoto Mach (A book on small indigenous fish species of Bangladesh) by Enamul Hoq. Publsihed by Graphic Sign, Mymensingh 2200. pp. 81-84.

Hossain MA. 1992. Fish as food and preservation (in Bengali). *Bangladesh Academy Sc. Magazine*, **18**(1 and 2): 41-52.

Hossain MA. 1996. Various aspect of small indigenous species (SIS) of fish in Bangladesh. *Proceedings of National Workshop on small indigenous fish culture in Bangladesh*. Organized by IFADEP-2 and Department of Zoology, University of Rajshahi. pp.16-23.

Hossain MA. 1997. Various aspects of small indigenous species of fishes in Bangladesh. *Proc. Nat. Workshop on SIF Culture in Bangladesh*. December 12, 1996. Key note speech, IFADEP September 2, pp. 16-30.

Hossain MA and Afroze S. 1991. Small fisheries as resource in rural Bangladesh. *Fishbyte*. **9**(2):15-18.

Hossain MA, Afsana K and Azad Shah AKM. 1999. Nutritional value of some small indigenous fish species of Bangladesh. *Bangladesh J. Fish. Res.*, **3**(1):77-85.

Hossain MA, Ahsan MK and Hussain MA. 2003. Small fish resources in the rivers, flood plains and upland areas of Bangladesh. Proceeding of BAU-ENRECA/DANIDA Workshop on Potentials of Small Indigenous Species of Fish in Aquaculture and rice-field stocking for improved food and nutrition security in Bangladesh, 30-01 October, 2002, BUA, Mymensingh, Bangladesh, pp. 87-96.

Hossain MA and Haque MA. 2005. Species composition in the river Padma near Rajshahi. *Journal of Life Earth Science* **1**(1): 35-42.

Hossain MA and Parween S. 1987. A comparative study on different drying methods of *Macrobrachium dayanum* (Henderson, 1893). *Univ. j. zool. Rajshahi Univ.* **5 & 6**: 53-58.

Hossain MA, Parween S and Mortaza MG. 1999. Estimation of edible contents of some freshwater fish species. *Univ. J. Zool. Rajshahi Univ.*, **18**: 169-171.

Hossain MM. 1994. Exportable dried fishery products of Bangladesh. *Bangladesh J. Fish. Res.*, **1**: 83-90.

*Huang QR, Yu HL and Ru QM. 2010. Bioavailability and delivery of nutraceuticals using nanotechnology. *J. Food Sci.* **75**: R50–R57.

Huq AMS, Khan M, Huq HK, Dey HK, Alam SMN and Mahbubullah M. 1986. Socio-economic study of the typical fishing community in Bangladesh. A report prepared for the Food and Agricultural Organization (FAO), Rome. Department of Economics, University of Chittagong, Bangladesh. 1-10pp.

Hussain MG. 2010. Freshwater fishes of Bangladesh. Fisheries biodiversity and habitat. *Aquatic Ecosystem Health and Management*, **13**(1): 85-93.

Hussain MM, Karim A, Alam Z, Islam MS, Khan A and Hossain A. 1992. Effect of pre-treatment on the drying of ghonia fish *Labeo gonius* in the open sun and in a solar tent. *Bangladesh J. Zool.* **20**: 231-238.

Hussain MG, Kohinoor AHM, Akhteruzzaman M, Rahman MA and Mazid MA. 1997. Biodiversity of small indigenous fish species and fry research activities for production and conservation. Proceedings of the national workshop on small indigenous fish species culture in Bangladesh. Integrated Food Assisted Development Project. Subproject-2 (IFADEP Sp-2), Dhaka, Bangladesh. pp-45-55.

*IAFMM (International Association of Fish Meal Manufacturers) 1979. Recommended method of analysis for determination of crude protein in fish meal. *IAFMM Tech. Bull.* (8).

*IAFMM 1979a. Recommended method of analysis for determination of moisture in fish meal. *IAFMM Tech. Bull.* (9).

*IAFMM 1979b. Recommended method of analysis for determination of ash in fish meal. *IAFMM Tech. Bull.* (10).

*IAFMM 1979c. Recommended method of analysis for determination of sand in fish meal. *IAFMM Tech. Bull.* (11).

*IAFMM 1982. Recommended method of analysis for determination of crude protein in fish meal by the Kyel-Foss procedure. *IAFMM Tech. Bull.* (15).

*IAFMM 1983. Nutrient Analysis tables for U. K. Potters Bar, U. K. IAFMM.

*IAFMM 1983. Recommended method of sampling fish meal for analysis. *IAFMM Tech. Bull.* (16).

INFS. 1977. Food values of national food stuffs (in Bangla). *Inst. Nut. Food. Sci. Univ. Dhaka*. pp. 33.

Islam D, Mustafa MG, Wahed MA and Khaleque MA. 2006. Effects of different storage conditions on the quality and shelf life of tunnel and sun dried *Pampus argenteus*. In: Abstracts of the 2nd Fisheries Conference and Research Fair, held on 18-19 January, Bangladesh Fisheries Research Forum (BFRF), BRAC, Dhaka. p.106.

Islam MA, Hossain BMM, Bhuiyan AS and Absar N. 2003. Biochemical composition and nutritional value of *Cirrhina reba* (Hamilton, 1822) of Bangladesh. *J. bio-sci*. **11**: 127-130.

Islam MN. 2007. Desio Projatir Matshaw Songrokkhone daittoshi babbosthapona kousol (in Bengali). Desio Projatir Matshaw Songrokkhon O Somprosaron avijan 2007. Department of Fisheries, Ministry of Fisheries and Livestock, Govt. People's Republic of Bangladesh. 11-13pp.

Islam MN and Joadder AR. 2005. Seasonal variation of the proximate composition of freshwater gobi, *Glossobgobius giuris* (Hamilton) from the River Padma. *Pakistan Journal of Biological Sciences*. **8**(4): 532-536.

Islam MS and Hossain MA. 1983. An account of the fish of the Padma near Rajshahi. *Raj. Fish. Bull*. **1**(2): 1-31.

Islam S. 2009. More than 100 indigenous fish species are going to become endangered (in Bengali). Prothom Alo: 1-2 Mediaster Ltd. 52. Motijheel Commercial Area, Dhaka-1000.

IUCN (International Union for the Conservation of Nature) 2001. Red book of threatened fishes of Bangladesh. pp. 17-24.

*Iwata K, Ishizaka S, Handa A and Tanaka M. 2000. Preparation and characterization of edible films from fish water-soluble proteins. *Fisheries Science - Tokyo*. **66**(2): 372-378.

*Jacobs MB. 1958. The chemical analysis of foods and food products (3rd edition). p. 393.

Jacquot R. 1961. Organic constituent of fishes and other aquatic animals. In: *Fish as Food*, edited by G. Borgstrom. Academic Press, New York and London. pp. 145-209.

Jafri AK and Khawaja DK. 1968. Seasonal changes in the bio-chemical composition of the freshwater murrel (*Ophiocephalus punctatus*) (Bloch). *Hydrobiologia*, **32**: 206-213.

Jafri AK, Khawaja DK and Qasim SZ. 1964. Studies on the biochemical composition of some freshwater fishes. *Part-1. Muscle. Fish. Technol.* **1**: 148-157.

*James DG. 1998. Production. consumption and demand. In: *Fish drying and smoking, production and quality* (ed. Doe, P.E.) Technomic Publishing Co., Inc. Lancaster. pp. 1-2.

Kamal D, Khan AN, Rahman MA and Ahamed F. 2007. Biochemical composition of some small indigenous fresh water fishes from the river Mouri, Khulna, Bangladesh. *Pak. J. Biol. Sci.* **10**(9): 1559-1561.

Kamal M, Rahman MM, Yesmin L, Islam MN, Nurullah M and Mazid M. 2000. Studies on the post mortem changes in shrimp and prawn during ice storage: ii. Biochemical aspects of quality changes. *Bang. J. Fish. Res.* **4**(1): 91-96.

Kamaluddin A, Malek MA and Sanaullah M. 1977. Deshio Khaddeer Pustiman (in Bangla). Institute of Nutrition and Food Science, Dhaka University. pp. 1-20.

Khuda MQ, De HN and Khan NM. 1962. Influence of age of fish on the distribution of protein in the body. *Pak. J. Sci., Ind. Res.* **5**(1): 20-23.

Khuda MQ, De HN and Khan NM. 1964. Chemical composition and quality of traditionally processed fish. *Pak. J. Sci., Ind. Res.* **5**(2): 70-73.

Kreuzer R. 1974. Fish and its place in culture. *In: Fishery Products* (R. Keruzer, ed.). FAO. 402pp.

Kunda M, Wahab MA, Dewan S, Asaduzzaman M and Thilsted SH. 2009. "Effects of All-male, Mixed-sex and All-female Freshwater Prawn in Polyculture with Major Carps and Molas in the Fallow Rice Fields." *Journal of Aquaculture Research* **41**:103–110.

Larsen T. Thilsted SH, Kongsbak K and Hansen M. 2000. Whole small fish as a rich calcium source. *Br. J. Nutr.* **83**: 191-196.

Latif KA, Alam MT, Sayeed MA, Hussain MA, Sultana S and Hossain MA. 2008. Comparative study on the effects of low cost oil seed cakes and fish meal as dietary protein sources for *Labeo rohita* (Hamilton) fingerling. *Univ. j. zool. Rajshahi Univ.*, **27**: 25-30.

*Lazos ES. 1996. Utilization of freshwater prawn for canned fish ball manufacture. *J. Aquatic Food Product Technology*, **5**: 47-64.

*Love RM. 1970. Water content of cod (*Gadus callarias* L.) muscle. *Nature*. pp.31-185.

Mehlenbacher VC. 1960. *Analysis of fats and oils*. Garrard Press, Champaign, Illinois, 586pp.

Mannan A. 1977. Nutritional aspects of marine fishes and fisheries products. *Nat. Mar. Fish. Seminar*. Edited by A. L. Bhuiyan and A. K. Chowdhury.

Mansur AM. 2005. Necessity of fish storage and processing in Bangladesh.. Souvenir, fisheries of current millennium. Fisheries graduates association of Bangladesh (FAB). pp.25.

Mansur MA, Gheyasuddin S and Bhuiyan AKMA. 1989. Preparation of a new ready to use dried semi-fermented fish product of increased shelf-life from *Puntius* sp. *Bangladesh J. Fish.*, **12**(1): 27-32.

Martin AM. (ed.) 1994. *Fisheries Processing: Biotechnological Application*. Chapman and Hall, UK. 494p.

Mazid MA. 2005. Manual in culture of small and threatened indigenous fish species. Bangladesh Fisheries Research Institute, Department of Fisheries, Bangladesh Agricultural University and Ministry of Fisheries and Livestock. 88p.

Mazumder MSA, Rahman MM, Ahmed ATA, Begum M and Hossain MA. 2008. Proximate composition of some small indigenous fish species in Bangladesh. *Int. J. Sustain. Crop. Prod.* **3**(4): 18-23.

Miller EL. 1970. Available amino acid content of fish meal. *FAO Fish. Rep. (92)*: 6p. issued also in French and Spanish.

Minkin SE, Rahman MM and Halder S. 1997. Fish biodiversity, human nutrition and environmental restoration in Bangladesh In: *Openwater Fisheries of Bangladesh* (C. Tsai and M. Y. Ali eds.) pp. 75-88. The University Press Limited. Dhaka, Bangladesh.

Mollah AH. 1987. Biochemical and nutritional studies on the Bangladeshi freshwater eel, *Anguilla bengalensis* (Bao baim). The distribution pattern of essential amino acids in fish protein concentration. *The Rajshahi University Studies,* **Part-B-XVII**: 9-16.

Mollah AH, Rahman MS and Alam MT. 1998. Study on proximate chemical analysis of Bangladesh freshwater fish, *Rita rita* (Hamilton) and seasonal variation of lipid, protein and related substances. *Univ. j. zool. Rajshahi Univ.* **17**: 1-6.

*Monsure MA, Islam MN, Chakraborty SC and Chaity F. 1990. A comparative study on the quality of traditional and solar tent dried fish. *Bangladesh J. Fish.* **13**(1-2): 33-39.

*Mookherjee HK and Basu SP. 1946. Life history of *Amblypharyngodon mola* (Ham) a delicate food fish of Bengal. *Sci. & Cult.*, Calcutta. **12**(1):54-56.

Moore P. 1990. High value by-products : selected examples from ground fish, salmon and shrimp processing. Seafood 90 Japan - Conference Proceedings. Agra Europe (London) Ltd. England: p.146-147.

Musa ASM. 2009. Nutritional quality components of indigenous freshwater fish species, *Puntius stigma* in Bangladesh. *Bangladesh J. Sci. Ind. Res.* **44**(3): 367-370.

Musa ASM and Bhuiyan AS. 2006. Biochemical composition and nutritional status of *Mystus bleekeri* (Day) of the river Padma in Bangladesh. *Bangladesh J. Zool.* **34**(2): 243-246.

Nabi MR and Hossain MA. 1990. Seasonal variations in the chemical composition of caloric content of *Macrognathus aculeatus* (Bloch) from Chalan beel water. *J. Asiatic Soc. Bangladesh (Sci.)*, **15**(2): 103-110.

Naser MN. 2005. The role of small indigenous species (SIS) of poverty reduction and nutritional Security. In: Saronika of Matshya Saptha, Ministry of Fisheries and Livestock. Government of the People's Republic of Bangladesh. pp. 45-46.

Naser NB, Chowdhury GW, Begum MM and Haque W. 2007. Proximate composition of prawn, *Macrobrachium rosenbergii* and shrimp, *Penaeus monodon*. *Dhaka Univ. J. Biol. Sci.* **16**(1): 61-66.

Nilson 1946. The value of fishes and shellfishes. *Food Research.* **30**: 177.

Nowsad AA. 2003. A new method of fish drying in a solar dryer (in Bengali). Food and Agriculture Organization of the United Nations. BGD/97/017.

Nowsad AA. 2005. Low cost processing of fish in coastal Bangladesh. Empowerment of coastal fishing communities for livelihoods security. GOB/UNDP/FAO Project: BGD/97/017:5/2005. 73p.

Nowsad AA, Ali FM and Azad KAM. 2005. Development of value-added products from by-catch and underutilized fisheries organisms and pilot market testing of product acceptability among rural communities. *Bangladesh J. Fish.* (Special Issue, 2004), **27**: 31-32.

Nowsad AA, Kamal M. and Hossain M. I. 1994. Sea food resources availability, utilization and research in Bangladesh. *Proc. Symp.* Seafood Research in the Pan-Pacific Area, September 30, Mie University, Tsu, 514, Japan. p.137.

Nurullah M, Kamal M, Wahab MA, Islam MN, Ahsan CT and Thilsted SH, 2003. Nutritional quality of some small indigenous fish species of Bangladesh. In: *Small indigenous species of fish in Bangladesh* (MA Wahab, SH Thilsted and ME Hoq eds.). Bangladesh Agricultural University, Mymensingh. pp. 151-158.

Nurullah M, Shaha SC, Kamal M, Wahab MA, Thilsted SH and Ochiai Y. 2002. Nutritional values of traditional dried products of freshwater small indigenous fish species of Bangladesh. *Bull. Fac. Edu. Ibabaraki Univ. (Nat. Sci.)*, **51**: 75-86.

*Ogino C and Chen MS. 1973. Protein nutrition in fish- III. Apparent and true digestibility of dietary protein in carp. *Bull. Jap. Soc. Sci. Fish.*, **39**: 649-651.

*Ohshima T. 1996. By products and seafood production in Japan. *J. Aquatic Food Product Technology*, **5**: 27-42.

Parween S, Dutta SK and Hossain MA. 1997. Post harvest management and utilization of SIS fishes including prawns. Proc. Seminar on Small Indigenous Species (SIS) of Fish Culture in Bangladesh, IFADEP SP-2, 12 December, 1996, Rajshahi University. pp. 141-146.

Philips AM, Livingston DL and Poston HA. 1996. Use of calorie sources by brook trout prog. Fish. Cult. 28: 67-72.

Prathiarenum R, Yamprayoon J, Suwansakornkul P, Kiatkungwalkrai P and Suwanrangsi S. 1985. Utilization of fish by catch for fish ball manufacture. FAO Fisheries Report, No. 317(Suppl.), p. 428-449.

Rabbane MG, Mustafa MG, Wahed MA and Khaleque MA. 2006. Investigation of deteriorative changes during freezing preservation of pabda (*Ompok pabda*) and chapila (*Gudusia chapra*) fish. In: Abstracts of the 2nd Fisheries Conference and Research Fair, held on 18-19 January, Bangladesh Fisheries Research Forum (BFRF), BRAC, Dhaka. p.111.

Rahman AKA 1994. Country report on socio-economic issues in coastal fisheries management in Bangladesh. In: Socio-economic issues in coastal fisheries management, Proceedings of IPFC Symposium, Bangkok, Thailand, 23-26 November 1993. FAO Indo-Pacific Fishery Commission, No. 8: 170-175.

Rahman AKA. 2005. *Freshwater Fishes of Bangladesh* (2nd ed.). Zoological Society of Bangladesh, Dhaka, Bangladesh. xviii+394 pp.

Rahman M, Barua S, Sayeed S, Hassan MN, Huque S, Islam SN and Thilsted SH. 2001. Fat and mineral content in small indigenous fish of Bangladesh. *South Asian J. Nutr.*, **3**(1 and 2): 1-6.

Rahman MA, Gheyasuddin S, Rashid MH and Chowdhury MFZ. 1982. Proximate composition and nutritive quality of freshwater zeol fishes of Bangladesh. *Bangladesh J. Fish.* **2-5**(1-2): 37-43.

Rahman SM, Asaduzzaman MD, Saha MS, Siddique MAB and Hossain MM. 2003. Proximate composition and status of some small indigenous fish species in Bangladesh. *Khulna University Studies.* **4**(1): 683-688.

Saha D. 2003. Conserving fish biodiversity in the Sundarbans villages of India. Produced by CIP-UPWARD, in partnership with GTZ GmbH, IDRC of Canada, IPGRI and SEARICE. pp. 439-441.

Saha KF and Guha BC. 1940. Nutritional investigation of Bengal fishes. *Indian J. Med. Res.* **27**: 873-876.

Salam MA, Alam N, Nasiruddin M, Nabi R and Howlader MZH. 1995. Biochemical composition of body muscle and its caloric contents of fishes (*Puntius gonionotus*, Bleeker). *Bangladesh J. Sci. Res.* **13**(2): 205-211.

Samad MA, Asaduzzaman M, Galib SM, Kamal MM and Haque MR. 2010. Availability and consumer preference of small indigenous species of the river Padma at Rajshahi, Bangladesh. *Int. J. Bio. Res.*, **1**(5): 27-31.

Shafi M. 2003. Bangladesh fisheries. Academic press and publishers limited, Dhaka. 204pp.

Sirajuddin ASM. 1986. Vitamin-A and eye sight. Krishikatha. *Agric. Inf. Center, Farmgate, Dhaka*, **45**(1): 450-451.

*Stansby ME. 1954. Composition of certain species of freshwater fishes. *Food. Res.* **16**: 231-234.

*Stansby ME. 1962. "Analytical Methods" Industrial Fishery Technology, Reinhold Publishing Corporation. pp. 339-349.

Sultana N, Shelina A and Hossain MA. 1997. Small fishes a source of nutrition for our people. *Proc. Nat.* Seminar on small indigenous fish culture in Bangladesh.

Sultana S, Parween S and Hossain MA. 2011. Biochemical analysis of some dried SIS fishes of the river Padma in Rajshahi. *J. Life Earth Sci.* **6**: 39-43.

*Tan SM, Chang NM, Fujiwara T, Kuang HK and Hasegawa H. 1988. Handbook of the processing of frozen surimi and fish jelly products in Southeast Asia. Southeast Asian Fisheries Development Centre, Singapore, 30pp.

Tan SM, Miwa K and Konagaya S. 1994. Advances in the fish processing industry in Southeast Asia. In: Proceeding of the International Seafood Research Meeting of Mie University, Mie Academic Press, 134pp.

Tanikawa T. 1985. Marine Products in Japan. Koseikaku Co. Ltd. 506pp.

Thilsted SH, Roos N and Hossain N. 1997. The role of small indigenous fish species in food and nutrition security in Bangladesh. *NAGA*. The *ICLARM* Quarterly, July-December: 13-15.

Wahab MA, Kunda M, Azim ME, Dewan S and Thilsted, SH. 2008. Evaluation of freshwater prawn-small fish culture concurrently with rice in Bangladesh. *Aquaculture Research*, **39**: 1524–1532.

Wahab MA, Thislted SH and Hoq ME (eds.) 2003. Small indigenous species of fish in Bangladesh. Proceedings of BAU-ENRECA/DANIDA Workshop on potentials of small indigenous species of fishes in aquaculture and rice-field stocking for improved food and nutrition security in Bangladesh, 30-31 October 2002, Bangladesh Agricultural University, Mymensingh, Bangladesh and ENRECA/DANIDA. 166p.

*Watson D. 2003. *Performance functional foods*. Woodhead Publishing Limited, Cambridge, England. 216pp.

*Windsor ML. 1971. Fish meal. *Torry Advis. Note*. (49): 12p.

Yusuf HKM, Salamatullah Q, Islam NM, Hoque T, Baquer M and Pandav CC. 1993. Report of the National Iodine Deficiency Disorders Survey in Bangladesh. University of Dhaka, Dhaka, December, 1993.

Zafri A and Ahmed A. 1980. Studies on the vitamin A of freshwater fishes. Content and distribution of vitamin A in mola (*Amblypharyngodon mola*) and dhela (*Rohtee cotio*). *Bangladesh J. Biol. Sci*. **10**: 47-53.

Zafri A and Ahmed K. 1981. Study on the vitamin 'A' content of freshwater fishes; content and distribution of vitamin 'A' in Mola and Dhela. *Bangladesh Journal of Biol. Science*, **10**: 39.

Zehra S and Khan MA. 2011. Dietary protein requirement for fingerling *Channa punctatus* (Bloch), based on growth, feed conversion, protein retention and biochemical composition. *Aquacult. Int.*, **19**(2): 1-13.

* Not consulted in original. Cited from other works.

APPENDICES

Appendix Table-1. Length, weight, waste weight, weight after dressing and washing of *Glossogobius giuris* (Bele).

No. of exp.	Total weight of one group (g)	Number of fish in one group	Total length (mm)		Total weight (g)		Weight after dressing and washing (ADW) (g)	Waste weight (g)
			Min	Max	Min	Max		
1	100	7	100	120	14.0	15.7	81.2	18.8
2	100	9	100	130	10.1	13.0	84.1	15.9
3	100	10	100	135	9.3	12.5	83.2	16.8
4	100	8	110	140	11.2	13.5	83.0	17.0
5	100	7	102	123	13.8	14.5	81.1	18.9
6	100	10	89	112	9.2	12.3	84.5	15.5
7	100	15	60	95	2.9	25.2	81.3	18.7
8	100	8	92	110	11.3	13.3	84.0	16.0
9	100	9	90	110	10.8	12.9	83.3	16.7
10	100	11	90	120	9.0	12.1	84.2	15.8
Range		**7-15**	**89-140**		**2.9-25.2**		**81.1-84.5**	**15.8-18.9**
Mean±SD		**9.4 ±2.24**	**106.4 ±18.29**		**12.33 ±3.99**		**82.99 ±1.25**	**17.01 ±1.25**
Percentage							**82.99%**	**17.01%**

Mean weight after dressing and washing = 82.99 g
Mean weight of wastes = 17.01 g
After dressing and washing per kg = 829.90 g
Wastes weight per kg = 170.10 g

Appendix Table-2. Length, weight, waste weight, weight after dressing and washing of *Colisa fasciata* (Kholisa)

No. of exp.	Total weight of one group (g)	Number of fish in one group	Total length (mm)		Total weight (g)		Weight after dressing and washing (ADW) (g)	Waste weight (g)
			Min	Max	Min	Max		
1	100	14	75	80	7.0	10.8	85.5	14.5
2	100	12	79	82	6.5	9.8	80.8	19.2
3	100	13	68	82	6.1	10.0	87.3	12.7
4	100	14	79	85	6.5	10.8	88.4	11.6
5	100	15	59	75	6.0	9.9	90.8	9.2
6	100	11	44	69	6.4	9.5	82.0	18.0
7	100	13	70	81	6.4	10.0	88.2	11.8
8	100	12	75	80	6.8	9.9	80.2	19.8
9	100	10	79	90	5.8	9.5	79.1	20.9
10	100	10	76	88	5.7	9.8	79.2	20.8
Range		**10-15**	**44-90**		**5.8-10.8**		**79.1-88.4**	**9.2-20.9**
Mean±SD		**12.4 ±1.62**	**75.8 ±10.10**		**8.16 ±1.88**		**84.15 ±4.14**	**15.85 ±4.20**
Percentage							**84.15%**	**15.85%**

Mean weight after dressing and washing = 84.15 g
Mean weight of wastes = 15.85 g
After dressing and washing per kg = 841.50 g
Wastes weight per kg = 158.50 g

Appendix Table-3. Length, weight, waste weight, weight after dressing and washing of *Puntius ticto* (Punti)

No. of exp.	Total weight of one group (g)	Number of fish in one group	Total length (mm)		Total weight (g)		Weight after dressing and washing (ADW) (g)	Waste weight (g)
			Min	Max	Min	Max		
1	100	11	84	100	1.8	10.9	76.4	23.6
2	100	12	89	94	1.7	10.8	76.1	23.7
3	100	17	76	85	2.1	9.9	79.0	21.0
4	100	21	70	83	1.5	7.5	75.1	24.9
5	100	22	56	69	4.1	7.2	67.3	32.7
6	100	23	53	60	4.5	6.0	68.2	32.8
7	100	19	48	60	3.7	6.3	65.0	35.0
8	100	20	54	59	4.8	6.1	64.6	35.4
9	100	15	41	65	1.2	8.5	77.0	23.0
10	100	19	46	66	1.6	7.2	76.2	23.8
Range		**11-23**	**41-102**		**1.2-10.9**		**64.6-79.0**	**21-35**
Mean±SD		**17.9 ±3.88**	**67.9 ±16.40**		**5.37 ±3.10**		**72.49 ±5.24**	**27.49 ±5.26**
Percentage							**72.49%**	**27.59%**

Mean weight after dressing and washing = 72.49 g
Mean weight of wastes = 27.49 g
After dressing and washing per kg = 724.90 g
Wastes weight per kg = 275.90 g

Appendix Table-4. Length, weight, waste weight, weight after dressing and washing of *Eutropiichthyes vacha* (Bacha)

No. of exp.	Total weight of one group (g)	Number of fish in one group	Total length (mm)		Total weight (g)		Weight after dressing and washing (ADW) (g)	Waste weight (g)
			Min	Max	Min	Max		
1	50	25	59	79	1.1	1.2	45.2	4.8
2	50	26	45	75	1.1	1.2	45.1	4.9
3	50	27	48	80	1.0	1.3	45.3	4.7
4	50	29	51	74	0.9	1.1	44.0	6.0
5	50	25	58	75	1.0	1.3	46.0	4.0
6	50	26	45	74	1.2	1.3	45.3	4.7
7	50	27	48	78	1.1	1.2	44.8	5.2
8	50	28	51	74	1.2	1.3	44.8	5.2
9	50	29	50	74	0.8	2.3	43.3	6.7
10	50	26	45	76	1.1	1.3	45.5	4.5
Range		**25-29**	**45-80**		**0.8-2.3**		**43.3-46.0**	**4.5-6.7**
Mean±SD		**26.8 ±1.4**	**62.95 ±13.47**		**1.2 ±0.28**		**44.93 ±0.73**	**5.07 ±0.73**
Percentage							**89.86%**	**10.14%**

Mean weight after dressing and washing = 89.86 g
Mean weight of wastes = 10.14 g
After dressing and washing per kg = 898.60 g
Wastes weight per kg = 101.40 g

Appendix Table-5. Length, weight, waste weight, weight after dressing and washing of *Corica soborna* (Kachki)

No. of exp.	Total weight of one group (g)	Number of fish in one group	Total length (mm)		Total weight (g)		Weight after dressing and washing (ADW) (g)	Waste weight (g)
			Min	Max	Min	Max		
1	50	110	12	25	0.61	1.51	47.98	2.02
2	50	106	12	24	0.81	1.63	48.91	1.09
3	50	98	14	25	0.91	1.60	48.99	1.01
4	50	102	12	23	0.61	1.12	49.76	0.24
5	50	95	13	21	0.81	1.51	49.50	0.50
6	50	92	12	22	0.71	1.09	48.71	1.29
7	50	103	12	27	0.42	1.61	48.82	1.18
8	50	105	12	20	0.41	1.02	47.91	2.09
9	50	108	12	21	0.43	1.03	47.95	2.05
10	50	100	14	24	0.75	1.16	49.13	0.87
Range			**12-27**		**0.41-1.63**		**47.91-49.76**	**0.24-2.09**
Mean±SD			**17.85 ±5.58**		**1.03 ±0.64**		**48.77 ±0.61**	**1.23 ±0.61**
Percentage							**97.54%**	**2.46%**

Mean weight after dressing and washing = 97.54 g
Mean weight of wastes = 2.46 g
After dressing and washing per kg = 975.40 g
Wastes weight per kg = 24.60 g

Appendix Table-6. Length, weight, waste weight, weight after dressing and washing of mixed fish (*C. nama*, *C. ranga*, *A. mola*, *M. pancalus*, *X. cancila*)

No. of exp.	Total weight of one group (g)	Number of fish in one group	Total length (mm)		Total weight (g)		Weight after dressing and washing (ADW) (g)	Waste weight (g)
			Min	Max	Min	Max		
1	100	120	34	82	0.80	6.00	69.10	30.90
2	100	130	20	57	0.20	1.70	73.00	27.00
3	100	107	22	59	0.70	3.90	70.82	29.18
4	100	20	70	142	1.51	14.70	80.22	19.78
5	100	23	170	205	11.0	16.28	83.50	16.50
6	100	130	19	58	0.25	1.10	68.00	32.00
7	100	115	38	46	0.85	1.70	69.00	31.00
8	100	90	40	49	0.95	3.10	72.50	27.50
9	100	123	21	73	0.20	4.10	67.80	32.20
10	100	130	40	47	0.90	1.20	69.50	30.50
Range		**20-130**	**19-205**		**0.2-16.28**		**67.8-83.5**	**16.5-32.2**
Mean±SD		**96.6±39.21**	**64.6 ±49.43**		**3.53 ±4.70**		**72.34 ±5.08**	**27.65 ±5.08**
Percentage							**72.34%**	**27.66%**

Mean weight after dressing and washing = 72.34 g
Mean weight of wastes = 27.66 g
After dressing and washing per kg = 723.40 g
Wastes weight per kg = 276.60 g

Appendix Table-7. Percentage of powder products from fresh fish, sun dried fish and oven dried fish *G. giuris*.

No. of Exp.	Weight of fresh fish (g)	Wt. of sun-dried fish (g) and % of fresh fish	Wt. of oven dried fish (g), % of fresh fish and % of sun-dried fish	Wt. of powder (g), % of fresh fish, % of sun-dried and % of oven dried fish
1	200	27.95 (13.98)	26.85 (13.43) (96.06)	25.70 (12.85) (91.95) (95.72)
2	260	32.75 (12.59)	30.83 (11.86) (94.14)	29.70 (11.42) (90.67) (96.33)
3	300	37.85 (12.62)	36.65 (12.22) (96.82)	35.00 (11.66) (92.47) (95.49)
4	420	50.12 (11.93)	48.76 (11.60) (97.29)	47.30 (11.26) (94.37) (97.00%)
5	500	62.33 (12.46)	59.48 (11.89) (95.42)	58.64 (11.72) (94.07) (98.58)
6	630	73.15 (11.61)	70.30 (11.15) (96.10)	69.12 (10.97) (94.49) (98.32)
7	350	43.45 (12.41)	42.10 (12.02) (96.89)	41.09 (11.74) (94.56) (97.60)
8	550	64.67 (11.75)	61.50 (11.18) (95.09)	59.69 (10.85) (92.29) (97.05)
9	180	26.16 (14.53)	25.09 (13.93) (95.90)	23.89 (13.27) (91.32) (95.21)
10	400	49.93 (12.48)	47.76 (11.94) (95.65)	46.17 (11.54) (92.46) (96.67)
Range	180-630	26.16-73.15	25.09-70.30	23.89-69.12
Mean ±SD	379±142.08	46.83±15.31 (12.64)	44.93±14.65 (12.12) (95.94)	43.63±14.63 (11.72) (92.86) (96.79)

Powder per kg: 117.20g
Percentage of powder: 11.72%

Appendix Table-8. Percentage of powder products from fresh fish, sun dried fish and oven dried fish *C. fasciata*

No. of Exp.	Weight of fresh fish (g)	Wt. of sun-dried fish (g) and % of fresh fish	Wt. of oven dried fish (g), % of fresh fish and % of sun-dried fish	Wt. of powder (g), % of fresh fish, % of sun-dried and % of oven dried fish
1	600	133.52 (22.25)	131.02 (21.83) (98.12)	128.17 (21.36) (95.99) (97.82)
2	550	128.45 (23.35)	126.32 (22.96) (98.34)	124.09 (22.56) (96.60) (98.23)
3	530	113.70 (21.45)	110.00 (20.75) (96.74)	108.32 (20.43) (95.26) (98.47)
4	500	106.58 (21.31)	104.73 (20.95) (98.26)	100.05 (20.01) (93.87) (95.53)
5	450	97.89 (21.75)	94.22 (20.93) (46.25)	91.94 (20.43) (93.92) (97.58)
6	410	85.64 (20.88)	82.37 (20.09) (96.18)	79.66 (19.42) (93.02) (96.70)
7	375	78.90 (21.04)	77.85 (20.76) (98.66)	76.65 (20.44) (97.14) (98.45)
8	300	72.18 (24.06)	70.07 (23.36) (97.07)	67.89 (22.63) (94.65) (96.88)
9	150	43.95 (29.30)	41.49 (27.66) (94.40)	38.33 (25.55) (87.21) (92.38)
10	100	33.61 (33.61)	30.82 (30.82) (91.69)	27.34 (27.34) (81.34) (88.70)
Range	100-600	33.61-133.52	30.82-131.02	27.34-128.17
Mean ±SD	396.5±159.68	89.44±31.66 (23.90)	86.88±31.62 (23.01) (96.57)	84.24±31.77 (22.01) (92.84) (96.07)

Powder per kg: 220.10g
Percentage of powder: 22.01%

Appendix Table-9. Percentage of powder products from fresh fish, sun dried fish and oven dried fish *P. ticto*

No. of Exp.	Weight of fresh fish (g)	Wt. of sun-dried fish (g) and % of fresh fish	Wt. of oven dried fish (g), % of fresh fish and % of sun-dried fish	Wt. of powder (g), % of fresh fish, % of sun-dried and % of oven dried fish
1	550	97.78 (17.78)	95.39 (17.34) (97.55)	92.42 (16.80) (94.52) (96.85)
2	500	92.35 (18.47)	90.61 (18.12) (98.12)	88.73 (17.75) (96.08) (97.92)
3	450	80.97 (17.99)	77.24 (17.16) (95.39)	75.17 (16.70) (92.92) (97.41)
4	400	72.69 (18.17)	70.12 (17.53) (96.46)	68.04 (17.01) (93.60) (97.03)
5	300	60.87 (20.29)	57.10 (19.03) (93.80)	55.33 (18.44) (90.89) (96.90)
6	250	51.98 (20.79)	48.26 (19.30) (94.22)	46.11 (18.44) (88.70) (95.54)
7	200	44.29 (22.14)	41.73 (20.86) (94.22)	39.81 (19.90) (89.88) (95.39)
8	150	30.07 (20.04)	26.47 (17.64) (88.02)	23.59 (15.72) (78.45) (89.12)
9	100	22.42 (22.42)	20.13 (20.13) (89.78)	18.63 (18.63) (83.09) (92.55)
10	80	15.78 (19.72)	13.64 (17.05) (86.44)	10.88 (13.60) (68.94) (79.76)
Range	80-550	15.78-97.78	13.64-95.39	79.76-92.42
Mean ±SD	298±160.73	56.92±27.48 (19.78)	54.06±27.53 (18.42) (93.40)	51.87±27.53 (17.29) (87.70) (93.84)

Powder per kg: 172.90g
Percentage of powder: 17.29%

Appendix Table-10. Percentage of powder products from fresh fish, sun dried fish and oven dried fish *E. vacha*

No. of Exp.	Weight of fresh fish (g)	Wt. of sun-dried fish (g) and % of fresh fish	Wt. of oven dried fish (g), % of fresh fish and % of sun-dried fish	Wt. of powder (g), % of fresh fish, % of sun-dried and % of oven dried fish
1	60	13.67 (22.78)	11.60 (19.33) (84.86)	10.10 (16.83) (73.88) (87.06)
2	100	26.21 (26.21)	24.42 (24.42) (93.17)	23.44 (23.44) (89.43) (95.98)
3	180	35.12 (19.51)	34.08 (18.93) (97.03)	33.01 (18.33) (93.99) (96.86)
4	250	51.85 (20.74)	49.19 (19.67) (94.86)	47.92 (19.17) (92.42) (97.42)
5	300	87.54 (29.18)	85.23 (28.41) (97.36)	83.39 (27.79) (95.25) (97.84)
6	400	98.37 (24.59)	96.11 (24.02) (97.70)	94.87 (23.71) (96.44) (98.70)
7	460	113.37 (24.76)	111.72 (24.28) (98.07)	109.48 (23.80) (96.11) (97.99)
8	500	117.37 (23.47)	114.31 (22.86) (97.39)	112.42 (22.48) (95.78) (98.35)
9	550	140.22 (25.49)	138.49 (25.09) (98.76)	136.73 (24.86) (97.51) (98.73)
10	600	135.86 (22.64)	131.34 (21.94) (96.89)	130.09 (21.68) (95.75) (98.82)
Range	60-600	13.67-140.22	11.60-138.49	10.10-136.73
Mean ±SD	340±180.72	82.01±44.46 (23.93)	79.67±44.02 (22.89) (95.60)	78.14±43.78 (22.20) (92.65) (96.77)

Powder per kg: 222.00g
Percentage of powder: 22.20%

Appendix Table-11. Percentage of powder products from fresh fish, sun dried fish and oven dried fish *C. soborna*

No. of Exp.	Weight of fresh fish (g)	Wt. of sun-dried fish (g) and % of fresh fish	Wt. of oven dried fish (g), % of fresh fish and % of sun-dried fish	Wt. of powder (g), % of fresh fish, % of sun-dried and % of oven dried fish
1	500	104.47 (20.89)	102.92 (20.58) (98.52)	100.52 (20.10) (96.22) (97.66)
2	450	99.89 (22.19)	97.67 (21.70) (97.77)	95.86 (21.30) (95.96) (98.15)
3	400	95.86 (23.96)	94.21 (23.55) (98.27)	92.91 (23.23) (96.92) (98.62)
4	320	89.21 (27.87)	87.39 (27.30) (97.95)	85.75 (26.79) (96.12) (98.12)
5	300	85.31 (28.44)	83.21 (27.74) (97.54)	81.15 (27.05) (95.12) (97.52)
6	250	69.29 (27.72)	67.20 (26.88) (96.98)	63.18 (25.27) (91.18) (94.01)
7	200	55.94 (27.97)	53.96 (26.98) (96.46)	51.09 (25.54) (91.33) (94.68)
8	180	51.57 (28.65)	47.69 (26.49) (92.47)	45.70 (25.38) (88.62) (95.82)
9	100	41.68 (41.68)	38.29 (38.29) (91.86)	36.16 (36.16) (86.75) (94.43)
10	70	25.12 (35.85)	21.37 (30.53) (85.07)	19.09 (27.27) (75.99) (89.33)
Range	70-500	25.12-104.47	21.37-102.92	89.33-100.52
Mean ±SD	277±136.89	71.83±25.83 (28.52)	69.29±26.42 (27.00) (95.28)	67.14±26.73 (25.80) (91.42) (95.83)

Powder per kg: 258.00g
Percentage of powder: 25.80%

Appendix Table-12. Percentage of powder products from fresh fish, sun dried fish and oven dried mixed fishes (*C. nama*, *C. ranga*, *A. mola*, *M. pancalus*, *X. cancila*)

No. of Exp.	Weight of fresh fish (g)	Wt. of sun-dried fish (g) and % of fresh fish	Wt. of oven dried fish (g), % of fresh fish and % of sun-dried fish	Wt. of powder (g), % of fresh fish, % of sun-dried and % of oven dried fish
1	80	16.46 (20.57)	14.52 (18.15) (88.21)	12.73 (15.91) (77.33) (87.67)
2	140	30.78 (21.98)	28.06 (20.04) (91.16)	26.10 (18.64) (84.79) (93.01)
3	200	45.24 (22.62)	42.65 (21.32) (94.27)	40.03 (20.01) (88.48) (93.85)
4	250	61.72 (24.69)	58.68 (23.47) (95.07)	56.38 (22.55) (91.35) (96.08)
5	300	78.36 (26.12)	75.24 (25.08) (96.02)	72.83 (24.27) (92.94) (96.79)
6	360	97.98 (27.22)	94.27 (26.19) (96.21)	91.12 (25.31) (92.99) (96.65)
7	400	110.06 (27.52)	108.02 (27.00) (98.15)	105.40 (26.25) (95.76) (97.57)
8	440	124.51 (28.29)	121.62 (27.64) (97.67)	118.74 (26.98) (95.36) (97.63)
9	500	138.29 (26.05)	127.08 (25.42) (97.54)	125.01 (25.00) (95.94) (98.37)
10	530	135.49 (25.56)	132.31 (24.96) (97.65)	130.04 (24.54) (95.97) (98.28)
Range	80-530	16.46-135.49	14.52-132.31	12.73-130.04
Mean ±SD	320±144.42	83.08±40.90 (25.06)	80.24±40.65 (23.92) (95.19)	77.83±40.48 (22.94) (91.09) (95.59)

Powder per kg: 229.40g
Percentage of powder: 22.94%

Appendix table: 13. Ratio of sun dried and oven dried fish and their powder from the fresh fish *G. giuris*

No. of Exp.	Weight of fresh fish (g)	Weight of sun-dried fish and ratio from total (g)	Weight of oven dried fish and ratio from total (g)	Weight of powder and ratio from total (g)
1	200	27.95 (0.139)	26.85 (0.134)	25.70 (0.128)
2	260	32.75 (0.125)	30.83 (0.118)	29.70 (0.114)
3	300	37.85 (0.126)	36.65 (0.122)	35.00 (0.116)
4	420	50.12 (0.119)	48.76 (0.116)	47.30 (0.112)
5	500	62.33 (0.124)	59.48 (0.118)	58.64 (0.117)
6	630	73.15 (0.116)	70.30 (0.111)	69.12 (0.109)
7	350	43.45 (0.124)	42.10 (0.120)	41.09 (0.117)
8	550	64.67 (0.117)	61.50 (0.111)	59.69 (0.108)
9	180	26.16 (0.145)	25.09 (0.139)	23.89 (0.132)
10	400	49.93 (0.124)	47.76 (0.119)	46.17 (0.115)
Mean ±SD	379 ±142.08	46.83 ±15.31	44.93 ±14.65	43.63 ±14.62
Ratio from total (g)		1:0.123	1:0.118	1:0.115
Per kg (g)		123	118	115

Appendix table: 14. Ratio of sun dried and oven dried fish and their powder from the fresh fish *C. fasciata*

No. of Exp.	Weight of fresh fish (g)	Weight of sun-dried fish and ratio from total (g)	Weight of oven dried fish and ratio from total (g)	Weight of powder and ratio from total (g)
1	600	133.52 (0.222)	131.02 (0.218)	128.17 (0.210)
2	550	128.45 (0.233)	126.32 (0.229)	124.09 (0.225)
3	530	113.70 (0.214)	110.00 (0.207)	108.32 (0.204)
4	500	106.58 (0.213)	104.73 (0.209)	100.05 (0.200)
5	450	97.89 (0.217)	94.22 (0.209)	91.94 (0.204)
6	410	85.64 (0.208)	82.37 (0.200)	79.66 (0.194)
7	375	78.90 (0.210)	77.85 (0.207)	76.65 (0.204)
8	300	72.18 (0.240)	70.07 (0.233)	67.89 (0.226)
9	150	43.95 (0.293)	41.49 (0.276)	38.33 (0.255)
10	100	33.61 (0.336)	30.82 (0.308)	27.34 (0.273)
Mean ±SD	396.5 ±159.68	89.44 ±31.66	86.88 ±31.62	84.24 ±31.77
Ratio from total (g)		1:0.225	1:0.219	1:0.212
Per kg (g)		225	219	212

Appendix table: 15. Ratio of sun dried and oven dried fish and their powder from the fresh fish *P. ticto*

No. of Exp.	Weight of fresh fish (g)	Weight of sun-dried fish and ratio from total (g)	Weight of oven dried fish and ratio from total (g)	Weight of powder and ratio from total (g)
1	550	97.78 (0.177)	95.39 (0.173)	92.42 (0.168)
2	500	92.35 (0.184)	90.61 (0.181)	88.73 (0.177)
3	450	80.97 (0.179)	77.24 (0.171)	75.17 (0.167)
4	400	72.69 (0.181)	70.12 (0.175)	68.04 (0.170)
5	300	60.87 (0.202)	57.10 (0.190)	55.33 (0.184)
6	250	51.98 (0.207)	48.26 (0.193)	46.11 (0.184)
7	200	44.29 (0.221)	41.73 (0.208)	39.81 (0.199)
8	150	30.07 (0.200)	26.47 (0.176)	23.59 (0.157)
9	100	22.42 (0.224)	20.13 (0.201)	18.63 (0.186)
10	80	15.78 (0.197)	13.64 (0.170)	10.88 (0.136)
Mean ±SD	298 ±160.73	56.92 ±27.48	54.06 ±27.53	51.87 ±27.53
Ratio from total (g)		1:0.191	1:0.181	1:0.174
Per kg (g)		191	181	174

Appendix table: 16. Ratio of sun dried and oven dried fish and their powder from the fresh fish *E. vacha*

No. of Exp.	Weight of fresh fish (g)	Weight of sun-dried fish and ratio from total (g)	Weight of oven dried fish and ratio from total (g)	Weight of powder and ratio from total (g)
1	60	13.67 (0.227)	11.60 (0.193)	10.10 (0.168)
2	100	26.21 (0.262)	24.42 (0.244)	23.44 (0.234)
3	180	35.12 (0.195)	34.08 (0.189)	33.01 (0.183)
4	250	51.85 (0.207)	49.19 (0.196)	47.92 (0.191)
5	300	87.54 (0.291)	85.23 (0.284)	83.39 (0.277)
6	400	98.37 (0.245)	96.11 (0.240)	94.87 (0.237)
7	460	113.91 (0.247)	111.72 (0.242)	109.48 (0.238)
8	500	117.37 (0.234)	114.31 (0.228)	112.42 (0.224)
9	550	140.22 (0.254)	138.49 (0.251)	136.73 (0.248)
10	600	135.86 (0.226)	131.64 (0.219)	130.09 (0.216)
Mean ±SD	340 ±180.72	82.01 ±44.43	79.67 ±44.02	78.14 ±43.78
Ratio from total (g)		1:0.241	1:0.234	1:0.229
Per kg (g)		241	234	229

Appendix table: 17. Ratio of sun dried and oven dried fish and their powder from the fresh fish *C. soborna*

No. of Exp.	Weight of fresh fish (g)	Weight of sun-dried fish and ratio from total (g)	Weight of oven dried fish and ratio from total (g)	Weight of powder and ratio from total (g)
1	500	104.47 (0.208)	102.92 (0.205)	100.52 (0.201)
2	450	99.89 (0.221)	97.67 (0.217)	95.86 (0.213)
3	400	95.86 (0.239)	94.21 (0.235)	92.91 (0.232)
4	320	89.21 (0.278)	87.39 (0.273)	85.75 (0.267)
5	300	85.31 (0.284)	83.21 (0.277)	81.15 (0.270)
6	250	69.29 (0.277)	67.20 (0.268)	63.18 (0.252)
7	200	55.94 (0.279)	53.96 (0.269)	51.09 (0.255)
8	180	51.57 (0.286)	47.69 (0.264)	45.70 (0.253)
9	100	41.68 (0.416)	38.29 (0.382)	36.16 (0.361)
10	70	25.12 (0.358)	21.37 (0.305)	19.09 (0.272)
Mean ±SD	277 ±136.89	71.83 ±25.83	69.39 ±26.53	67.14 ±26.73
Ratio from total (g)		1:0.259	1:0.250	1:0.242
Per kg (g)		259	250	242

Appendix table: 18. Ratio of sun dried and oven dried fish and their powder from the fresh mixed fishes

No. of Exp.	Weight of fresh fish (g)	Weight of sun-dried fish and ratio from total (g)	Weight of oven dried fish and ratio from total (g)	Weight of powder and ratio from total (g)
1	80	16.46 (0.205)	14.52 (0.181)	12.73 (0.159)
2	140	30.78 (0.219)	28.06 (0.200)	26.10 (0.186)
3	200	45.24 (0.226)	42.65 (0.213)	40.03 (0.200)
4	250	61.72 (0.246)	58.68 (0.234)	56.38 (0.225)
5	300	78.36 (0.261)	75.24 (0.250)	72.83 (0.242)
6	360	97.98 (0.272)	94.27 (0.261)	91.12 (0.253)
7	400	110.06 (0.275)	108.02 (0.270)	105.40 (0.263)
8	440	124.51 (0.282)	121.62 (0.276)	118.74 (0.269)
9	500	130.29 (0.260)	127.08 (0.254)	125.01 (0.250)
10	530	135.49 (0.255)	132.31 (0.249)	130.04 (0.245)
Mean ±SD	320 ±144.42	83.08 ±40.89	80.14 ±40.55	77.83 ±40.48
Ratio from total (g)		1:0.259	1:0.250	1:0.243
Per kg (g)		259	250	243

Appendix Table-19: Consumers' response towards the taste, colour and flavour of the fast food items made of the powder of the experimental fishes in relation to different professionals.

Product	Taste score	Occupation (N = 20)				
		Teacher	Doctors	Students	Housewives	Others
Fish soup	B	0	0	0	0	0
	Av	4	6	8	8	9
	G	10	8	10	9	8
	Vg	6	6	2	3	3
Fish cutlet	B	0	0	0	0	0
	Av	5	6	6	4	2
	G	8	10	9	10	10
	Vg	7	4	5	6	8
Fish toast	B	0	0	0	0	0
	Av	6	8	8	6	4
	G	9	7	8	8	9
	Vg	5	5	4	6	7
Fish burger	B	0	0	0	0	0
	Av	6	5	3	4	3
	G	12	10	10	8	10
	Vg	2	5	7	8	7
Fish stick kabab	B	0	0	0	0	0
	Av	2	4	3	1	1
	G	10	10	8	8	9
	Vg	8	6	9	11	10
Fish ball with noodles	B	0	0	0	0	0
	Av	7	6	7	4	2
	G	8	7	8	8	10
	Vg	5	7	5	8	8
Fish parota with chatni	B	0	0	0	0	0
	Av	5	4	5	3	4
	G	10	12	10	10	5
	Vg	5	4	5	7	11
Fish pakora	B	0	0	0	0	0
	Av	6	3	5	4	2
	G	8	6	6	9	10
	Vg	6	11	9	7	8
Fish Papadom	B	0	0	0	0	0
	Av	8	4	9	5	9
	G	7	10	6	11	5
	Vg	5	6	5	4	6

B = Bad, Av = Average, G = Good, Vg = Very good

Appendix Table-20: Consumers' response towards the expected price of the fast food items made of the powder of the experimental fishes and in relation to different professionals.

Fast food items	Price (Tk.)	Occupation (N = 20)				
		Teachers	Doctors	Students	Housewife	Others
Fish soup (single bowl)	Minimum	15	15	20	20	10
	Maximum	25	30	30	35	15
	Mean±SD	20±7.07	22.5±10.61	25±7.07	27.5±10.61	12.5±3.54
Fish burger (1 piece)	Minimum	15	10	12	15	8
	Maximum	20	15	20	20	12
	Mean±SD	17.5±3.54	12.5±3.54	16±5.66	17.5±3.54	10±2.83
Fish cutlet (3 pieces)	Minimum	15	20	10	14	8
	Maximum	30	30	20	22	12
	Mean±SD	22.5±10.61	25±7.07	15±7.07	18±5.66	10±2.83
Fish stick kabab (2 pieces)	Minimum	15	15	12	15	8
	Maximum	20	25	20	25	12
	Mean±SD	17.5±3.54	20±7.07	16±5.66	20±7.07	10±2.83
Fish toast	Minimum	12	14	10	15	7
	Maximum	20	25	20	25	15
	Mean±SD	16±5.66	19.5±7.77	15±7.07	20±7.07	11±5.65
Fish ball with noodles	Minimum	10	12	10	20	12
	Maximum	20	20	20	30	20
	Mean±SD	15±7.07	16±5.66	15±7.07	25±7.07	16±5.66
Fish parata with chatni	Minimum	15	12	20	15	6
	Maximum	25	20	30	20	8
	Mean±SD	20±7.07	16±5.66	25±7.07	17.5±3.54	7±1.41
Fish pakora	Minimum	15	10	12	15	12
	Maximum	25	15	15	30	20
	Mean±SD	20±7.07	12.5±3.54	13.5±2.12	22.5±10.61	16±5.66
Fish papadom	Minimum	10	12	20	15	6
	Maximum	20	20	30	25	10
	Mean±SD	15±7.07	16±5.66	25±7.07	20±7.07	8±2.83

Appendix Table-21: Production cost of different fish fast food items.

Products	Materials used	Production cost (Tk.)
1. Fish soup (1 small bowl)	Fish powder - 2/3 tea spoon	6.00
	Corn flour – 1½ tea spoon	4.00
	Vinegar - 1 tea spoon	
	Soya sauce – ½ tea spoon	
	Ginger garlic paste – ¼ tea spoon	
	Green chili – ½ piece	
	Egg – 1/2 piece	
	Water – 2 cup	3.00
	Salt - to taste	4.00
	Tasting salt – to taste	
	Sugar – to taste	
	Tomato sauce – 1 ½ teaspoon	
	Total	**17.00**
2. Fish cutlet (2 pieces)	Fish powder – 2/3 tea spoon	5.00
	Green banana – 1 piece	2.00
	Rice flour – 2 tea spoon	4.00
	Corn flour – 1 tea spoon	
	Garlic ginger paste – ½ tea spoon	
	Zira powder – ½ tea spoon	
	Elach, daruchini, gol morich dust – ½ tea spoon	
	Green chili – 1 piece	
	Salt – to taste	3.00
	Oil – to fry	
	Egg – ½ piece	8.00
	Decorated vegetables	
	Total	**22.00**

Contd.....

Products	Materials used	Production cost (Tk.)
3. Fish toast (2 piece)	Fish powder – 2/3 teaspoon	5.00
	Potato (medium) – 1 piece	2.00
	Butter – ½ tea spoon	3.00
	Milk – ¼ cup	
	Salt – to taste	
	Oil – to fry	
	Egg – 1 piece	8.00
	Sandwich bread – 1 piece	2.00
	Biscuit powder – to asses	
	Tomato sauce	
	Decorated vegetable – requirements	
	Total	**20.00**
4. Fish burger (1 piece)	Round bread (banruti) – 1 piece	4.00
	Fish powder - 3 tea spoon	5.00
	Pulse (boot dal) – ¼ cup	4.00
	Ginger garlic paste – ½ tea spoon	3.00
	Zira powder – ¼ teaspoon	
	Coriander powder – ¼ tea spoon	
	Green chili – 1 pieces	
	Onion (crush) – 1 piece	
	Egg – ½ piece	4.00
	Salt – to taste	2.50
	Oil – to fry	
	Decorated vegetable with meonase	2.50
	Total	**25.00**

Contd.....

Products	Materials used	Production cost (Tk.)
5. Fish stick kabab (2 pieces)	Fish powder – 2/4 tea spoon	6.00
	Potato (medium) – 1 piece	2.00
	Garlic ginger paste – ½ tea spoon	4.00
	Zira powder – ½ tea spoon	
	Chili powder – ½ tea spoon	
	Corn flour – 1 tea spoon	
	Salt - to taste	
	Oil – to fry	
	Egg – 1 piece	8.00
	Stick – 2 pieces	
	Biscuit powder – to asses	2.00
	Decorated vegetable, sauce	
	Total	**22.00**
6. Fish ball with noodles (8 pieces ball) 1 plate noodles	Noodles – 1 packet	10.00
	Fish powder – ¾ teaspoon	5.00
	Ruli flour – ½ cup	5.00
	Onion brush – 1 table spoon	
	Green chili – 2 pieces	
	Egg – ½ piece	
	Salt - to taste	
	Water – to requirement	
	Oil – to fry	
	Decorated vegetables- coriander leaf	
	Total	**20.00**

Contd.....

Products	Materials used	Production cost (Tk.)
7. Fish parota with chatni (8 pieces)	Ruli flour – 1 cup	4.00
	Fish powder – 2/4 tea spoon	5.00
	Potato (medium) – 2 pieces	2.00
	Green chili - 3 pieces	5.00
	Onion brush – 2 tea spoon	
	Black cumin – ¼ tea spoon	
	Sugar – 1 tea spoon	
	Oil – to fry and dough	
	Salt – to taste	
	Water – to requirement	
	Pudina leaf, coriander leaf, lemon	5.00
	Total	**21.00**
8. Fish pakora (1 plate, 8 pieces)	Fish powder – 5/6 teaspoon	5.00
	Ruli flour – 3 table spoon	2.00
	Onion bristle brush – 3 pieces	3.00
	Ginger garlic paste – 1 tea spoon	
	Green chili – 3 pieces	
	Salt – to taste	
	Oil - to fry	
	Some vegetables (potato, green pea, carrot etc.)	
	Egg – ½ piece	4.00
	Total	**14.00**
9. Fish papadom (1 plate, 8 piece)	Ruli flour – ½ cup	4.00
	Baking powder – ½ tea spoon	
	Fish powder – 2/4 tea spoon	5.00
	Black zira – ½ tea spoon	1.50
	Salt – to taste	
	Oil – to fry	
	Jafran colour – to assess	
	Water – to requirement	
	Total	**10.50**