




Article

## Unlocking the fish drying process: insights from Char Patharghata in Chattogram district and its distribution channels

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**Abstract:** The process of fish drying in Char Patharghata, Chattogram district, and its distribution channels serve as vital components of the local economy. This study aims to delve into the intricacies of this process, analyzing the activities of each value chain actor from raw fish supplier to dry fish consumer. Through the analysis of various value chain actors, from fishermen to consumers, the study seeks to uncover insights into the dynamics of this industry. From January 2022 to August 2022, semi-structured questionnaires were employed to gather data for this study. Seven main value chain actors were identified, including fishermen, processing center owners, processors, Aratdars, wholesalers, retailers, and consumers. Interviews were conducted with 19 fishermen, 5 owners of dry fish processing industries, 48 processors, 25 Aratdars, 15 wholesalers, 18 retailers, and 22 consumers, selected randomly. The study revealed that a significant proportion of fishermen were illiterate and employed on a contractual basis by fishing vessel owners. Additionally, a substantial majority of dried fish processors were female, with disparities observed in wages between male and female workers. During the observed timeframe, a total of 19 species spanning 14 families were noted to be utilized for drying. Notably, Churi (*Lepturacanthus savala*), Phaisa (*Setipinna phasa*), and Hangor (*Scoliodon sorrakowah*) emerged as the predominant species in this process, with concerns raised regarding the maintenance of dried fish quality. The dried fish industry holds considerable economic importance in the local community, with high consumption rates among residents. However, challenges exist in maintaining the quality of dried fish products. Recommendations are proposed to improve the quality of dry fish and enhance the livelihood standards of fishers, processors, and other stakeholders involved in the processing and distribution of dried fish. These measures aim to foster sustainable growth and development within the industry, benefiting both producers and consumers.

**Keywords:** commission rate; dried fish; net profit margin; processor; quality issue

### 1. Introduction

Bangladesh, located at the northern end of the Bay of Bengal, has sovereign rights over a vast marine area of approximately 118,813 square kilometers. It is blessed with a 710 kilometers long coastline and numerous inland water bodies, hosting a wide variety of aquatic flora and fauna, including fishes, arthropods, mollusks, seaweed, etc. (Alam *et al.*, 2021). Besides achieving self-sufficiency in fish production, Bangladesh ranked 3rd

in fish production from inland open water and 25th in marine production globally (FAO, 2022). In 2017, the country produced a surplus of 0.09 million tons of fish after meeting the national demand of 4.05 million tons (DoF, 2018). Fish is a perishable item and therefore needs to be processed shortly after harvest to prevent spoilage. Among the preservation techniques, sun drying is the easiest and most conventional fish post-harvest preservation process in Bangladesh. Almost all fish and certain shellfish can be effectively preserved for an extended period if they are processed properly. Sun drying, the most cost-effective technique widely employed not only in Bangladesh but in many Asian countries, provides dry fish products that are a valuable source of nutrients, particularly for the low income middle class and lower class people (Reza *et al.*, 2009). Though, dry fishes have better nutritional quality than the raw fishes, their unique taste made this item highly popular in Bangladesh, particularly in the southwest, Haor and hilly regions (Hossain *et al.*, 2017).

The dry fish industry in Bangladesh not only significantly contributes to the country's GDP and foreign earnings but also provides livelihood opportunities for millions of fishermen, dry fish manufacturers, wholesalers, and retailers. During the 2019–2020 fiscal year, Bangladesh exported a total of 4141.49 MT of dry fish, generating a revenue of BDT 54.21 crores which is accounting for 1.39% of the country's overall export earnings (DoF, 2020). However, it has been observed that many conventional sun-dry items fail to meet the necessary standards for human consumption in terms of their physical and organoleptic properties (Alam, 2003). This raises concerns about potential health risks associated with their consumption which may be attributed to conventional drying methods, uses of prohibited pesticides, inadequate maintenance of sanitation and hygiene standards, improper packaging, storage, and distribution practices, as well as water contamination (Rasul *et al.*, 2020).

Despite its significant importance in terms of revenue and employment, the dry fish industry in Bangladesh has not received adequate attention, particularly in terms of research and management. Limited studies have been conducted on this industry, indicating a gap in understanding the distribution channel of dry fish (Ahmed, 1993; Amin *et al.*, 2012; Marine *et al.*, 2014; Mandal, 2021). Though dry fish market differs by regions, the distribution channels were found to be complex throughout the country (Amin *et al.*, 2012; Marine *et al.*, 2014). The processors do not have the authority to sell fish to wholesalers, retailers or general consumers directly, rather they have to supply it to the Arat, a specific place or a trading center or auction house where the intermediaries traded and distributed the products to different parts of the country. Thus, the prices of dry fish products significantly increase from the processors end to the consumers due to the involvement of multiple intermediaries and commission agents in the supply chain (Ahmed, 1993). Through an examination of commission rates, labor costs related to dry fish transportation, price dynamics along the value chain, and quality considerations, it is hypothesized that identifying and addressing these factors will lead to improved efficiency and profitability within the dry fish distribution network.

As a major coastal area, Chattogram district in Bangladesh has become a thriving hub for the dry fish industry. The region boasts easy accessibility to raw fish and boasts natural advantages such as unlimited water sources for washing the fish, ample sunlight, and favorable wind conditions. These favorable conditions have led to the establishment of numerous dry fish industries in this region, solidifying its position as a prominent market for the dry fish industry in Bangladesh. Thus, this study was conducted to investigate what are the processing techniques and understanding of the distribution channel for dry fish in this region. It involved analyzing the activities of each stakeholder involved in fish drying and distribution. The research aimed to uncover important aspects such as commission rates, labor costs associated with the transportation of dry fish to and from Arat, price fluctuations along the value chain, and quality concerns. The findings will be valuable for policymakers in formulating effective strategies to promote the development of the dry fish industry and enhance the livelihoods of individuals working in this sector.

## 2. Materials and Methods

### 2.1. Ethical approval

No ethical approval was required for conducting this research.

### 2.2. Study area and study period

Chattogram is a coastal district, and many dried fish industries are located there. To understand the fish drying process and identify the distribution channels of dried fish, this study selected four different areas (Char Patharghata, Asadganj, Chowmuhani and Colonel Hat) in Chattogram district, Bangladesh from January to August 2022, data were collected from these sampling sites (Figure 1).

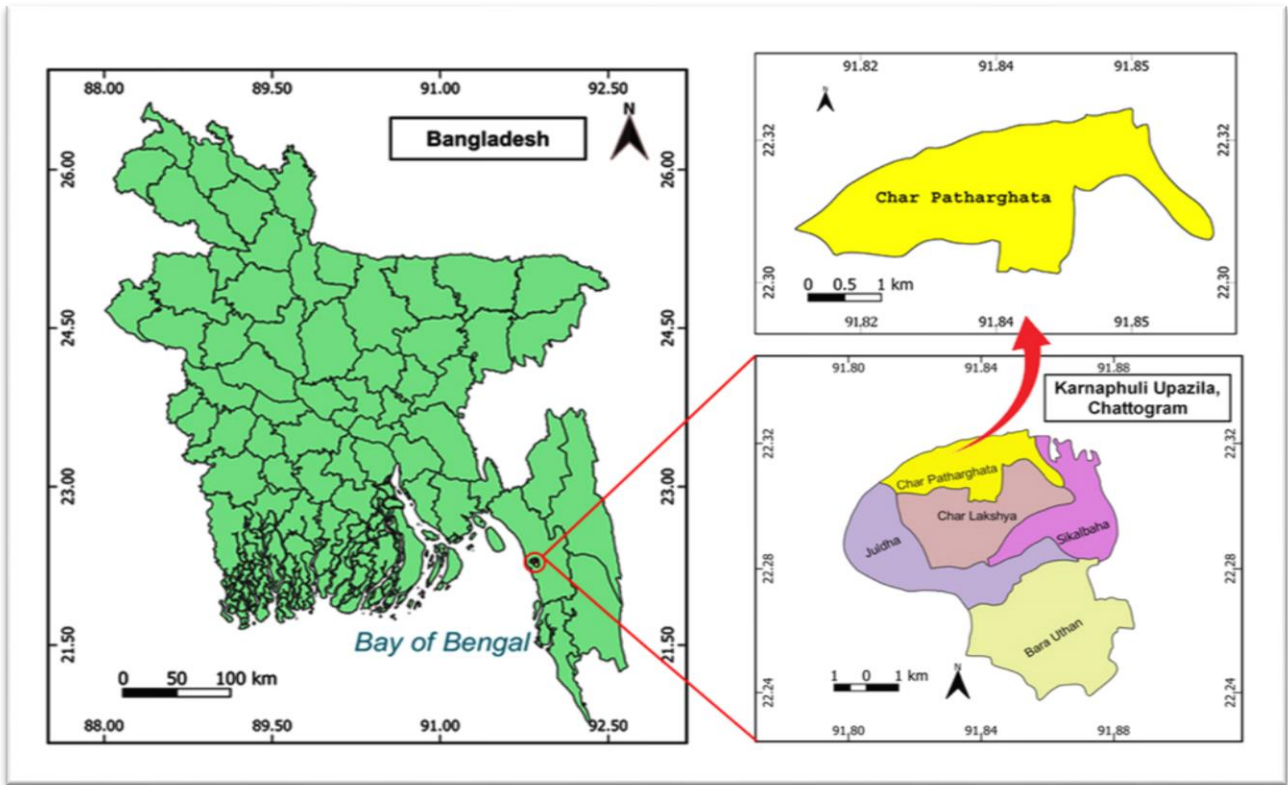


Figure 1. Map indicating the location of Char Patharghata, where dry fish processing method was observed.

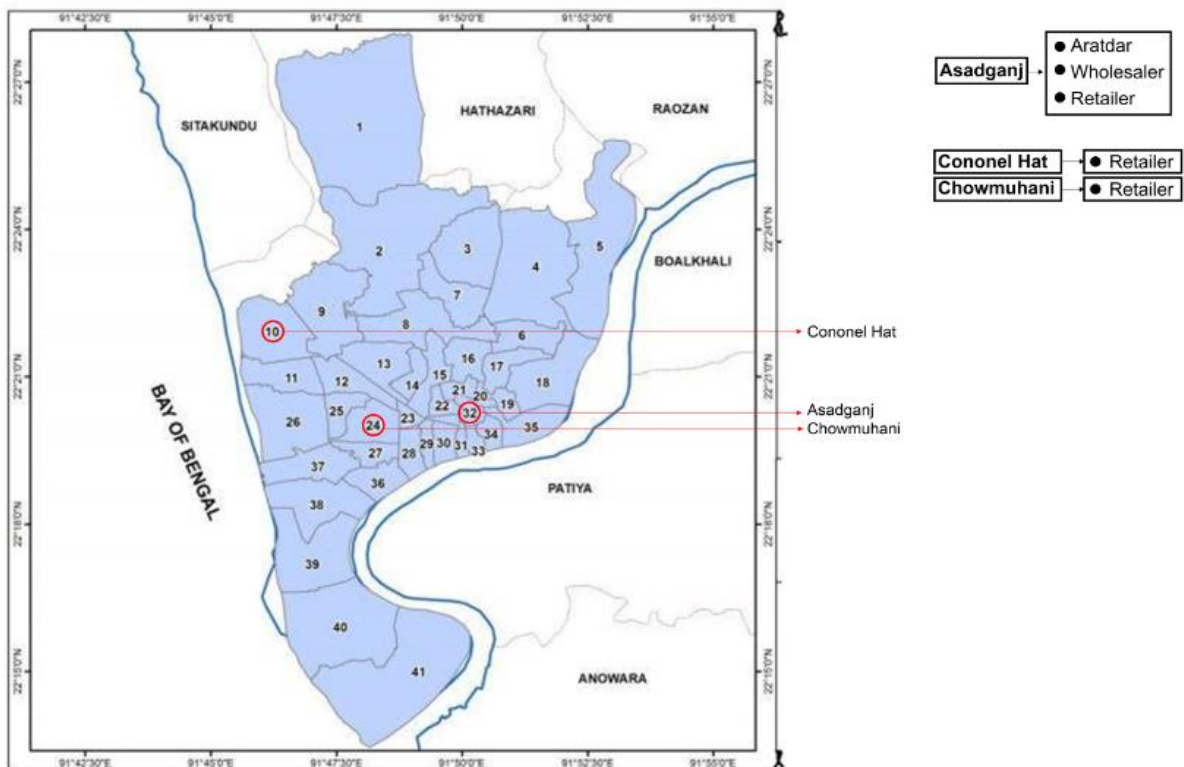


Figure 2. Map showing three areas (Asadganj, Chowmuhani and Colonel Hat) for observing the distribution channel of dried fish (Akter *et al.*, 2018).

Aratdars' and Wholesalers' information were taken from Asadganj, as dry fish are supplied directly to Arats located at Asadganj after processing at Char Patharghata. Asadganj dry fish market is the largest dry fish market in Chattogram. About 44 Arats, more than 200 wholesale shops and 15-20 retail stores are located at Asadganj. Information about retailers and consumers were obtained from three retail markets in Chattogram city namely Asadganj, Chowmuhani and Colonel Hat (Figure 2).

### 2.3. Study design and data collection procedure

Seven value chain actors were identified involving in the dried fish processing and marketing. Seven different semi-structure questionnaires were developed and finalized based on the expert's opinion from the Department of Fisheries, University of Chittagong, Bangladesh. Both qualitative and quantitative approaches were used in this study for collecting data. The total sample respondents were 152 (19 fishermen, 5 dry fish processing industries' owners, 48 processors, 25 Aratdars, 15 wholesalers, 18 retailers, and 22 consumers) and they were selected at random for interview. Additionally, focus group discussions (FGD) were also conducted with fishers, processors and Aratdars. The interviews were also recorded using mobile phone so that no information could be left. Information was also taken from the Chairperson of Asadganj dry fish market to verify the authenticity of the information. In-situ observation of fish drying process and quality management during processing and distributions were made.

### 2.4. Data processing and data analysis

All collected information was summarized and tabulated in the MS Excel sheet and analyzed using Microsoft Office 2013 and the Statistical Software R. All of the graphs in this paper were produced using the Statistical Software R 1.1.463 and map of the study area was created using QGIS 3.16.16. Total cost of dry fish in every step from production to distribution, and profit margin for producer to retailer were calculated using the following formulas of Haque *et al.* (2015). The total cost (USD kg<sup>-1</sup>) of producing dry fish in the processing farm was calculated following formula,

Total cost = price of raw fish + processing cost + Arat commission

The total cost (USD kg<sup>-1</sup>) for Aratdar, wholesaler and consumer in the processing farm was calculated following formula,

Total cost = buying price + other cost

Here, other cost includes transportation cost, labor cost, Arat rent, electricity bill, permanent staffs' salary.

Net profit (USD kg<sup>-1</sup>) had been estimated using following formula,

Net profit = selling price – total cost

## 3. Results

A total of seven main value chain actors were identified during this study in the process of dry fish production and distribution: fishermen, owners of processing centers, processors, Aratdars, wholesalers, retailers, and consumers (Figure 3).

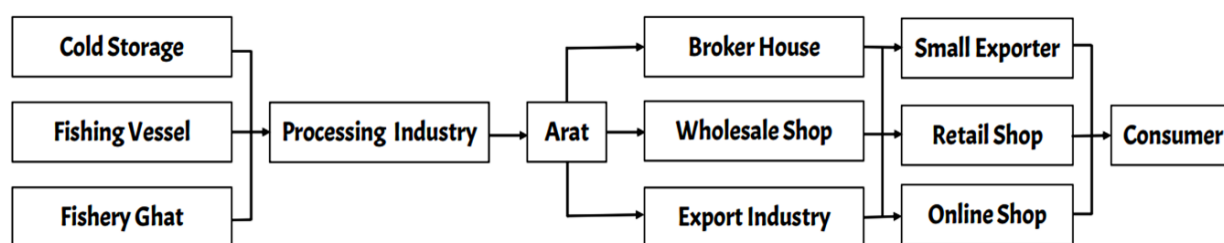


Figure 3. Flow chart of dry fish distribution channel.

### 3.1. Fish drying activities

#### 3.1.1. Sources of raw fish

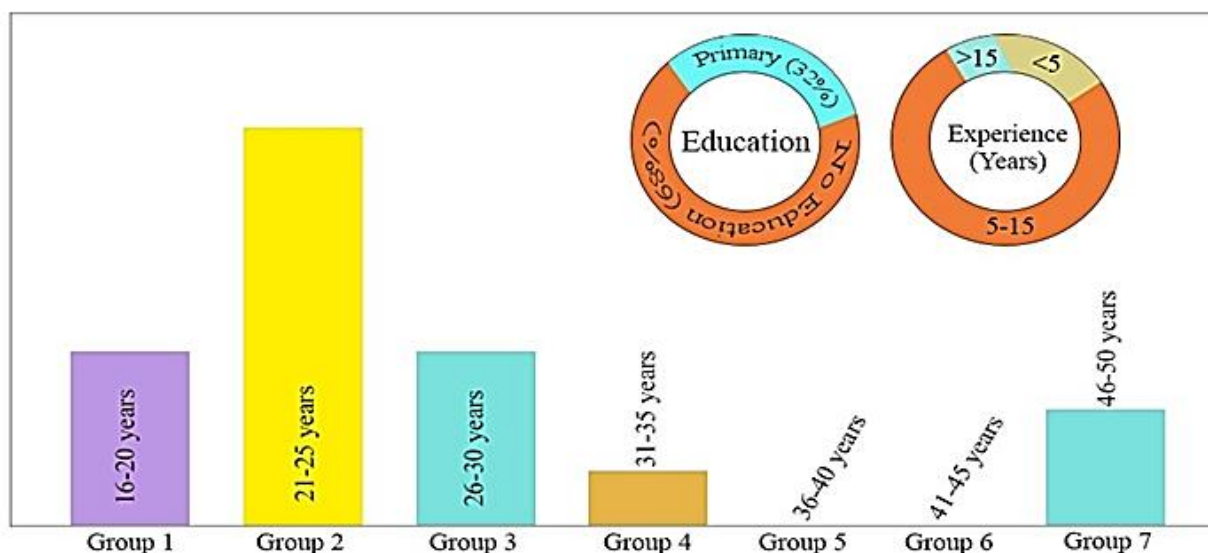
Processing farm owners and fishing vessel owners agreed to supply fish year-round, with raw fish purchased from Bangladesh Fisheries Development Corporation (BFDC) and local landing centers. All fishermen used the Bay of Bengal except during ban periods. Most commercially important fish are used for drying, with 19 species identified during data collection (Table 1).

**Table 1. Observed fish species used for drying within the study period.**

Local Name	English name	Scientific name	Family
Churi	Savalani hairtail	<i>Lepturacanthus savala</i> (Cuvier, 1829)	Trichiuridae
Phasa	Gangetic hairfin anchovy	<i>Setipinna phasa</i> (Hamilton, 1822)	Engraulidae
Hangor	Hammer headed shark	<i>Scoliodon sorrakowah</i> (Bleeker, 1853)	Carcharhinidae
Chapila	Indian River shad	<i>Gudusia chapra</i> (Hamilton, 1822)	Engraulidae
Shapla Pata	Pale-edged stingray	<i>Dasyatis zugei</i> (Müller & Henle, 1841)	Dasyatidae
Fatra	Smooth back herring	<i>Raconda russelliana</i> (Gray, 1831)	Clupeidae
Potka	Green pufferfish	<i>Tetraodon fluviatilis</i> (Hamilton, 1822)	Tetraodontidae
Rupban	Japanese threadfin bream	<i>Nemipterus japonicus</i> (Bloch, 1791)	Nemipteridae
Kamila	Indian pike conger	<i>Congresox talabonoides</i> (Bleeker, 1853)	Muraenesocidae
Bullet	Bullet Tuna	<i>Auxis eudorax</i> (Collette & Aadland, 1996)	Scombridae
Lal Poa	Silver jewfish	<i>Johnius argenteus</i> (Houttuyn, 1782)	Sciaenidae
Kachki	Ganges river sprat	<i>Corica soborna</i> (Hamilton, 1822)	Clupeidae
Maya	Maya pupfish	<i>Cyprinodon maya</i> (Humphries & Miller, 1981)	Cyprinodontidae
Cheowa	Bearded Worm Goby	<i>Taenioides cirratus</i> (Blyth, 1860)	Oxudercidae
Olua	Goldspotted grenadier anchovy	<i>Coilia dussumieri</i> (Valenciennes, 1848)	Engraulidae
Kata	White sardine	<i>Escualosa thoracata</i> (Valenciennes, 1847)	Clupeidae
Chaikka	Big-eyed herring	<i>Ilisha filigera</i> (Valenciennes, 1847)	Pristigasteridae
Chepa	Spotfin swamp barb	<i>Puntius sophore</i> (Hamilton, 1822)	Cyprinidae
Mola	Indian Carplet	<i>Amblypharyngodon mola</i> (Hamilton, 1822)	Cyprinidae

### 3.1.2. The demographic structure of fishermen

The fishermen were classified into different age groups, and it was observed that the majority of them (68%) started earning their livelihood at a young age (16 to 25 years old) and did not pursue further education. Among the respondents, only a small percentage (32%) had the opportunity to complete their primary education. The majority of fishermen (74%) had considerable experience ranging from 5 to 15 years, while 16% had over 15 years of experience. In terms of locality, only 26% of the fishermen were from the local area, while the remaining 74% came from various regions of the country (Figure 4).

**Figure 4. Age variation, educational status and fishing experience of fishers.**

According to the fishermen, they use wooden or steel trawlers for fishing in the Bay of Bengal, continuing their fishing activities until their vessels are filled with fish. During the off-season, they engage in various secondary activities to sustain their livelihoods, such as net and boat making, net repairs, boat maintenance, transportation services, agriculture, manual labor, hawking, and selling produce in local markets. Despite operating under contractual agreements in fishing vessels for approximately nine months per year, the living standards of fishermen do not improve significantly. They typically earn between \$1285 to \$1930 for the entire fishing



season and often have to rely on loans from NGOs or other sources to cover their family expenses. The majority of their income is spent on loan repayments, leading to financial difficulties and further debt, hindering their ability to enhance their living standards. Moreover, most fishermen do not receive financial assistance from government. Some individuals even demand money from the fishermen in exchange for VGF cards.

### 3.1.3. Fish drying season

A 65-day fishing ban in the Bay of Bengal prevents drying activities in the study area during June and July. The peak season for drying occurs from October to January. However, drying activities also occur during the rainy season (June to September) in Char Patharghata. Sunlight is typically used, but plastic or tarpaulin sheds are used during the rainy season to protect the fish from rain (Figure 5).

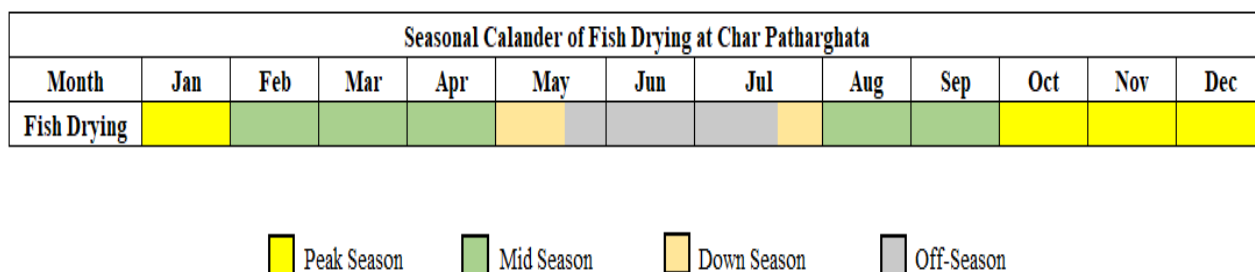


Figure 5. Seasonal calendar of fish drying season.

### 3.1.4. Quantities of fish used for drying and drying platform

The quantity of fish processed ranges from 500 kg to 2 tons per lot, depending on catch availability. Fishermen supply fish to the processing farm under contract. Raw fish are dried on bamboo platforms called "Chung," constructed by planting bamboo poles and tying horizontal bamboos with ropes. Processed fish are hung on these frames for drying. Another type of platform uses bamboo stakes and split bamboos or fences to spread out fish for drying. Platforms are expanded during peak season but reduced or dismantled during the off-season, especially in rainy weather (Figure 6A and 6B).

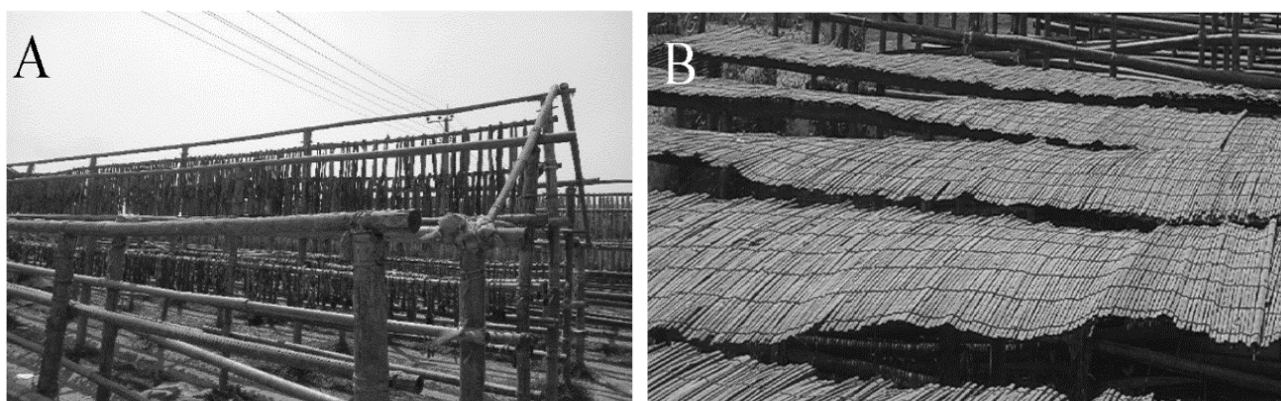
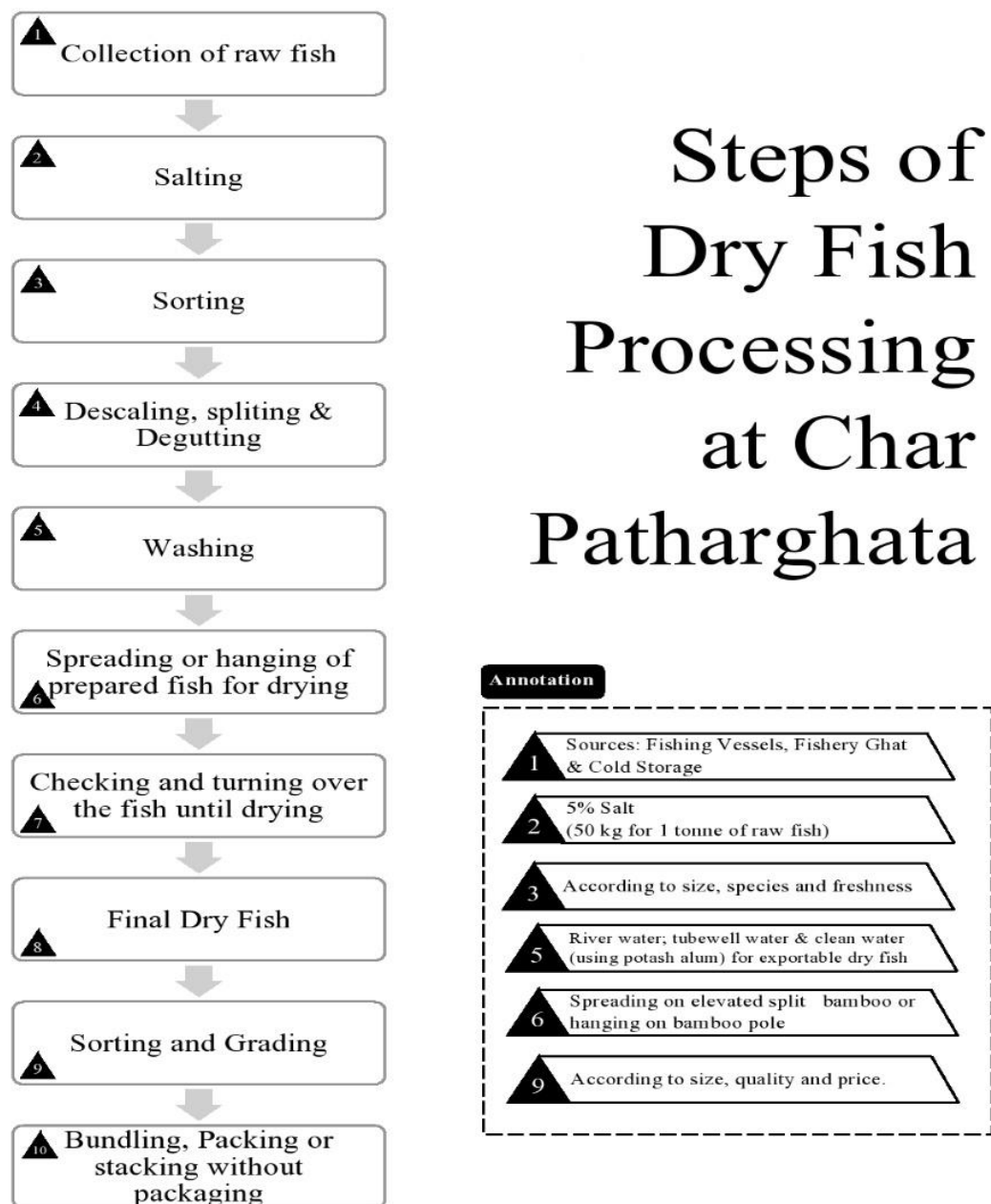


Figure 6. Fish drying platform, (A) Hanging platform where fish are hanged vertically; (B) Elevated split bamboo platform in which fish are placed horizontally. ©The author.

### 3.1.5. Time and steps needed to prepare dry fish

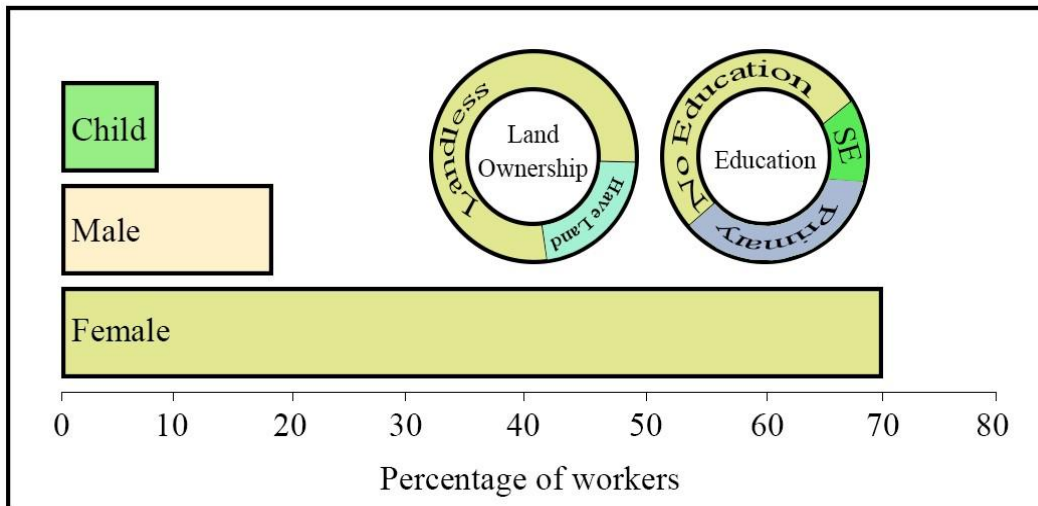
Fish drying typically takes 2 to 5 days, depending on factors like fish size, moisture content, and weather conditions. Smaller fish dry faster, often within 2 days, while larger ones may take 3 to 4 days. Unfavorable weather can extend drying time up to 5 days. Fish are sorted by size and species, salted for preservation, and dried using traditional methods. After drying, they're inspected, sorted by quality, priced, and packed for market, often in jute sacks or baskets. In Asadganj, they're further processed at "Arat" before sale (Figure 7).



**Figure 7. Steps involved in dry fish processing at Char Patharghata.**

### 3.2. Information about processors

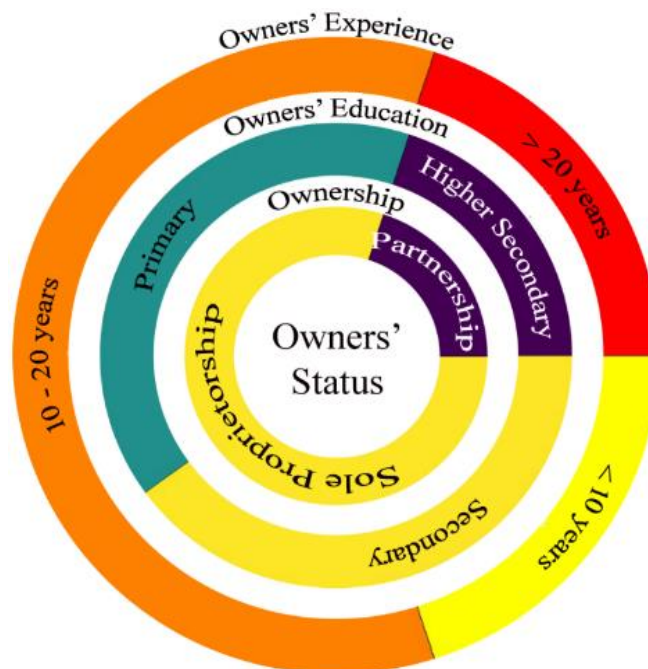
During the peak fish drying season, when abundant sunlight aids in moisture evaporation, around 40-50 workers are employed daily in the processing industry. This number fluctuates based on fishing activities and fish availability. Even in slower periods, a minimum of 15-20 workers are retained for operational continuity. Needy individuals, including men, women, and children, queue up at dawn seeking work opportunities. Monthly salaried employees oversee operations and select daily workers based on efficiency, negotiating fixed wages. Gender-based wage disparities persist, with women often earning less than men. For example, a healthy 28-year-old man may earn \$4.28 to \$5.36 for a 7 am to 5 pm shift, whereas a 50-year-old woman may receive \$4.28 for the same hours due to perceived lower productivity. Some workers are paid hourly, typically receiving \$0.32 to \$0.53 per hour based on performance. Children accompanying adults receive modest wages. About three-fourths of the workforce are female, with the remainder male. Education levels vary: 54.17% have no formal education, 37.50% completed primary education, and 8.30% have secondary education. Only 27% of processors own land (Figure 8).



**Figure 8. The gender distribution, education and land ownership of the workers.**

**3.3. Information about dry fish processing farms’ owners**

In the study area, 80% of the dry fish industry owners conducted their business as sole proprietorships, while the remaining 20% operated as partnerships. Among the owners, 40% had completed primary education, another 40% had attained secondary education, and the remaining 20% had completed their higher secondary level education. In terms of experience, 60% of the dry fish industry owners had 10-20 years of experience, while 20% had less than 10 years of experience, and the remaining 20% had more than 20 years of experience (Figure 9).



**Figure 9. Status of the dry fish industries’ owners.**

The production cost of dry fish depended on factors such as fish size, availability, and market value. The labor cost remained constant for each kilogram of dry fish. According to the respondents, the labor, materials, and other costs to produce 1 kg of dry fish ranged from \$0.21 to \$0.32, varying based on the fish species. Approximately 3-3.5 kg of raw fish was required to produce 1 kg of dry fish (3.5 kg for Churi, Hangor, etc., and 3 kg for Phasa, considering Churi and Hangor as large fish while Phasa as a small fish). The highest net profit



was observed for dry Churi (large) fish, amounting to \$0.32 per kilogram. Dry Hangor (large) fish yielded a calculated net profit of \$0.30 per kilogram. On the other hand, Chapila, Shapla Pata, Fatra, and Olua had a net profit of \$0.14 per kilogram. Potka fish, however, had the lowest net profit, amounting to \$0.12 (Table 2).

**Table 2. Net profit margin calculation for dry fish processor in USD (per kg dry fish).**

Dry fish name	Price of raw fish	Processing cost	Arat commission	Total cost	Selling price	Net profit
Churi fish (S)	2.25	0.27	0.15	2.67	2.89	0.23
Churi fish (M)	4.13	0.27	0.19	4.59	4.82	0.24
Churi fish (L)	5.57	0.32	0.21	6.11	6.43	0.32
Phaisa (S)	1.29	0.21	0.13	1.63	1.88	0.25
Phaisa (L)	1.93	0.32	0.15	2.40	2.68	0.28
Hangor(S)	3.75	0.27	0.19	4.21	4.50	0.29
Hangor (L)	5.79	0.32	0.24	6.34	6.64	0.30
Chapila	1.45	0.21	0.13	1.79	1.93	0.14
Shapla Pata	0.75	0.21	0.13	1.09	1.23	0.14
Fatra	1.29	0.27	0.13	1.68	1.82	0.14
Potka	0.86	0.24	0.13	1.22	1.34	0.12
Maya	1.77	0.27	0.15	2.19	2.36	0.17
Kabila	2.57	0.27	0.15	2.99	3.21	0.23
Poa	2.57	0.32	0.17	3.06	3.32	0.26
Lal Poa	5.57	0.38	0.21	6.16	6.43	0.27
Mola	1.93	0.32	0.15	2.40	2.68	0.28
Cheowa	0.86	0.27	0.13	1.25	1.39	0.14
Rupban	1.34	0.27	0.13	1.74	1.93	0.19
Chaikka	1.71	0.32	0.15	2.19	2.46	0.28
Bullet	0.91	0.27	0.13	1.31	1.50	0.19
Kata	1.66	0.32	0.15	2.13	2.36	0.23
Chepa	2.89	0.32	0.17	3.39	3.64	0.26
Olua	0.80	0.21	0.13	1.15	1.29	0.14

\*Note: S=small; M=medium; L=large

### 3.4. Business in arat

At Asadganj dry fish market, there are a total of 44 Arats where Aratdars trades dry fish and shellfish received from various drying points including Teknaf, Cox's Bazar, Sonadia, Sundarbans, Rangabali, Khulna, Bagerhat, Rampal, Doinkul, Char Pathorghata, Myanmar, India (Kakdwip, Sagordwip, Deegha, Calcutta), among others. Approximately 5-7% of the dry fish supply comes from Char Pathorghata. Each Arat has the capacity to store 10-50 tons of dry fish, depending on its storage space. The commission rate varies depending on the size, type, and price of the fish. For instance, Aratdars may receive a commission of \$ 3.21 for selling 100 pieces of small Hilsa dry fish and \$ 4.82 for selling 100 pieces of large Hilsa dry fish. In some cases, processors may take Dadon (credit with high interest rate) from Aratdars to support the processing of dry fish and the operation of the processing farm. In such circumstances, the commission rate is typically increased (Table 3).

**Table 3. Chart of commission rate, commission rate increased with the increment of price of per kg dried fish.**

Description	Commission	Commission with loan (Dadon)
From BDT 1 to BDT 35 (per kg)	0.06	0.09
From BDT 36 to BDT 100 (per kg)	0.10	0.11
From BDT 101 to BDT 200 (per kg)	0.13	0.14
From BDT 201 to BDT 300 (per kg)	0.15	0.16
From BDT 301 to BDT 400 (per kg)	0.17	0.18
From BDT 401 to BDT 500 (per kg)	0.19	0.20
From BDT 501 to BDT 600 (per kg)	0.21	0.23
From BDT 601 to BDT 700 (per kg)	0.23	0.24
From BDT 701 to BDT 800 (per kg)	0.24	0.25
From BDT 801 to BDT 900 (per kg)	0.26	0.27
From BDT 901 to BDT 1000 (per kg)	0.28	0.29

**Table 3. Contd.**

Description	Commission	Commission with loan (Dadon)
From BDT 1001 to BDT 1100 (per kg)	0.30	0.32
From BDT 1101 to BDT 1200 (per kg)	0.32	0.34
More than 1200 (per kg)	0.35	0.38
<i>Hilsa</i> (100pcs)- Small	3.21	3.75
<i>Hilsa</i> (100pcs)- Large	4.82	5.36
<i>Hilsa</i> per can	3.75	4.29
Cheowa dry fish (per kg)	0.06	0.08
Fish powder (per kg)	0.03	0.04
Kat <i>Hilsa</i> per pcs (Small) 1 to 10 Taka (BDT)	0.01	0.02
Kat <i>Hilsa</i> per pcs (Small) 11 to 20 Taka (BDT)	0.02	0.03
<b>Lal Icha Shutki (dry shrimp) commission rate</b>		
From BDT 800 to BDT 1200 per kg.	0.27	0.29
From BDT 1201 to BDT 2000 per kg.	0.29	0.31

\*The currency values expressed in USD. This commission rate chart was effective from 14 April, 2022. The word “Dadon” refers to loan. Some processing farm owners’ run their business in debt and take loan from Aratdars. Therefore, they have to provide extra commission to Aratdars.

### 3.4.1. Labor cost (for loading and unloading)

Arats employ both permanent and temporary workers. Permanent workers oversee tasks such as managing interactions with processors and laborers, ensuring proper delivery of dry fish to the Arats, distributing wages, and selling dry fish to wholesalers. Dry fish is transported to and from the Arats using dump trucks, mini trucks, or trawlers, with temporary workers responsible for loading and unloading. Labor costs for loading and unloading are provided in Table 4.

**Table 4. Labor cost for delivery of fish from processing area to arat.**

Description	Toll and road cost	Waterways cost
Bagged and open per kg	0.0075	0.0075
Large <i>Hilsa</i> 100 pcs	0.43	0.43
Small <i>Hilsa</i> 100 pcs	0.29	0.29
Per Pitcher	0.32	0.32
Shark ear-per kg.	0.11	0.11
Raising Shark oil per drums	1.07	1.07
<i>Hilsa</i> per can	0.21	0.21
Lakka fish per kg	0.0086	0.0086
Air fish per maund	0.32	0.32
Per Bundle	0.27	0.27
Toloi bundle	0.27	0.27

\*The currency values expressed in USD. “Toloi Bundle” is a local term referring to a sort of bundle made up of coconut fiber or coir used to form a bundle, which is tied to another bundle with rope and contains dried fish.

### 3.4.2. Net profit margin

The highest estimated net profit was recorded for dry Churi (large) at \$0.57 per kg, while the lowest profit was observed for Cheowa dry fish. The buying prices in the table were linked to the prices at which Aratdars purchased dried fish from processors. Other costs included transportation, labor, Arat rent, electricity, and permanent staff salaries. Selling price denoted the price at which Aratdars sold the dried fish to wholesalers (Table 5).

**Table 5. Net profit margin calculation for Aratdars in USD (per kg dry fish).**

Dry fish name	Buying price	Other cost	Total cost	Selling price	Commission	Net profit
Churi fish (S)	2.89	0.08	2.97	3.21	0.15	0.39
Churi fish (M)	4.82	0.08	4.90	5.09	0.19	0.38
Churi fish (L)	6.43	0.08	6.51	6.86	0.21	0.57

**Table 5. Contd.**

Dry fish name	Buying price	Other cost	Total cost	Selling price	Commission	Net profit
Phaisa (S)	1.88	0.08	1.95	2.09	0.13	0.27
Phaisa (L)	2.68	0.08	2.76	3.11	0.15	0.50
Hangor (S)	4.50	0.08	4.58	4.82	0.19	0.44
Hangor (L)	6.64	0.08	6.72	6.86	0.24	0.37
Chapila	1.93	0.08	2.01	2.20	0.13	0.32
Shapla Pata	1.23	0.08	1.31	1.45	0.13	0.27
Fatra	1.82	0.08	1.90	2.06	0.13	0.29
Potka	1.34	0.08	1.42	1.61	0.13	0.32
Maya	2.36	0.08	2.43	2.68	0.15	0.39
Kabila	3.21	0.08	3.29	3.48	0.15	0.34
Poa	3.32	0.08	3.40	3.54	0.17	0.31
Lal Poa	6.43	0.08	6.51	6.75	0.21	0.46
Mola	2.68	0.08	2.76	2.98	0.15	0.37
Cheowa	1.39	0.08	1.47	1.59	0.13	0.24
Rupban	1.93	0.08	2.01	2.14	0.13	0.27
Chaikka	2.46	0.08	2.54	2.68	0.15	0.29
Bullet	1.50	0.08	1.58	1.77	0.13	0.32
Kata	2.36	0.08	2.43	2.66	0.15	0.37
Chepa	3.64	0.08	3.72	3.96	0.17	0.42
Olua	1.29	0.08	1.36	1.58	0.13	0.34

\*Note: S=small; M=medium; L=large

Arats, owned by Aratdars, store dry fish twice a week without chemical agents. Unsold fish are sent to cold storage for preservation. Asadganj is home to more than 200 registered wholesale shops, where wholesalers directly purchase dry fish from nearby Arats. Additionally, many wholesalers in Asadganj also function as retailers. Exporters also participate in the market, buying export-quality dry fish and supplying them to various countries across Asia, Europe, and America to meet the demand of consumers in those regions. Some wholesalers adopt modern business strategies, utilizing online platforms such as social media and websites to promote their products and attract customers.

### 3.5. Net profit margin of the wholesalers

The net profit of wholesalers was found to be significantly higher than that of the producers. The study revealed that the highest net profit, amounting to \$0.66, was observed for 1 kg of dry Chepa fish. On the other hand, the lowest net profit of \$0.34 was observed for a combination of four dry fish varieties: Churi (Small), Hangor (Small), Shapla Pata, and Chaikka (Table 6).

**Table 6. Net profit margin calculation for wholesaler in USD (per kg dry fish).**

Dry fish name	Buying price	Other cost	Total cost	Selling price	Net profit
Churi fish (S)	3.21	0.09	3.30	3.64	0.34
Churi fish (M)	5.09	0.09	5.18	5.57	0.39
Churi fish (L)	6.86	0.09	6.95	7.39	0.45
Phaisa (S)	2.09	0.09	2.18	2.57	0.39
Phaisa (L)	3.11	0.09	3.20	3.75	0.55
Hangor (S)	4.82	0.09	4.91	5.25	0.34
Hangor (L)	6.86	0.09	6.95	7.50	0.55
Chapila	2.20	0.09	2.28	2.68	0.39
Shapla Pata	1.45	0.09	1.53	1.88	0.34
Fatra	2.06	0.09	2.15	2.68	0.53
Potka	1.61	0.09	1.70	2.20	0.50
Maya	2.68	0.09	2.77	3.32	0.55
Kabila	3.48	0.09	3.57	3.96	0.39
Poa	3.54	0.09	3.62	4.07	0.45
Lal Poa	6.96	0.09	7.05	7.50	0.45
Mola	2.98	0.09	3.07	3.54	0.47

**Table 6. Contd.**

Dry fish name	Buying price	Other cost	Total cost	Selling price	Net profit
Cheowa	1.59	0.09	1.67	2.14	0.47
Rupban	2.14	0.09	2.23	2.68	0.45
Chaikka	2.68	0.09	2.77	3.11	0.34
Bullet	1.77	0.09	1.86	2.36	0.50
Kata	2.66	0.09	2.75	3.21	0.47
Chepa	3.96	0.09	4.05	4.71	0.66
Olua	1.58	0.09	1.66	2.20	0.53

\*Note: S=small; M=medium; L=large

### 3.6. Dry fish business in retail market

Retailers from three distinct markets, Asadganj, Chowmuhani, and Colonel Hat, favor procuring dry fish from the largest wholesale market situated at Asadganj. Their preference is primarily driven by convenient access and reduced transportation expenses. Furthermore, Asadganj's wholesale market boasts a diverse array of dry fish options, enabling retailers to meet the varied demands of their clientele. There were 25, 26, and 25 different dried fish species found at the three local dry fish markets in Asadganj, Chowmuhani, and Colonel Hat, respectively (Table 7).

**Table 7. Available dried fishes in three retail markets (Asadganj, Chowmuhani, and Colonel Hat) in Chattogram gathered in June 2022.**

Asadganj	Chowmuhani	Colonel Hat
Churi	Churi	Churi
Phasa	Phasa	Phasa
Hangor	Chapila	Fatra
Chaikka	Shapla Pata	Kabila
Kabila	Fatra	Chepa
Fatra	Potka	Chaikka
Bullet	Saltfish	Laitta
Chepa	Kabila	Rupchanda
Cheowa	Poa	Mola
Chapila	Lal Poa	Cheowa
Kata	Mola	Olua
Shapla Pata	Maya	Chapila
Olua	Cheowa	Kata
Haush	Rupban	Riksha
Rupchanda	Chaikka	Surma
Poa	Bullet	Lal Poa
Koral	Kata	Maya
Lakkha	Chapa	Rupban
Mola	Olua	Koral
Surma	Rupchanda	Chapila
Laitta	Laitta	Salted Ilish
Salted Ilish	Koral	Lal Icha
Lal Icha	Salted Ilish	Bhula Icha
Bhula Icha	Lal Icha	Chaga Icha
Chaga Icha	Bhula Icha	Keinga Icha
	Chaga Icha	

Buying prices were the prices at which retailers purchased dried fish from dried fish wholesalers. Other costs included transportation costs, labor costs, retail shop rent, electricity bill, permanent staff salaries, and so on. Highest net profit (\$2.57) observed for dried Chepa, whereas, Shapla Pata yielded the lowest net profit of \$1.12 (Table 8).

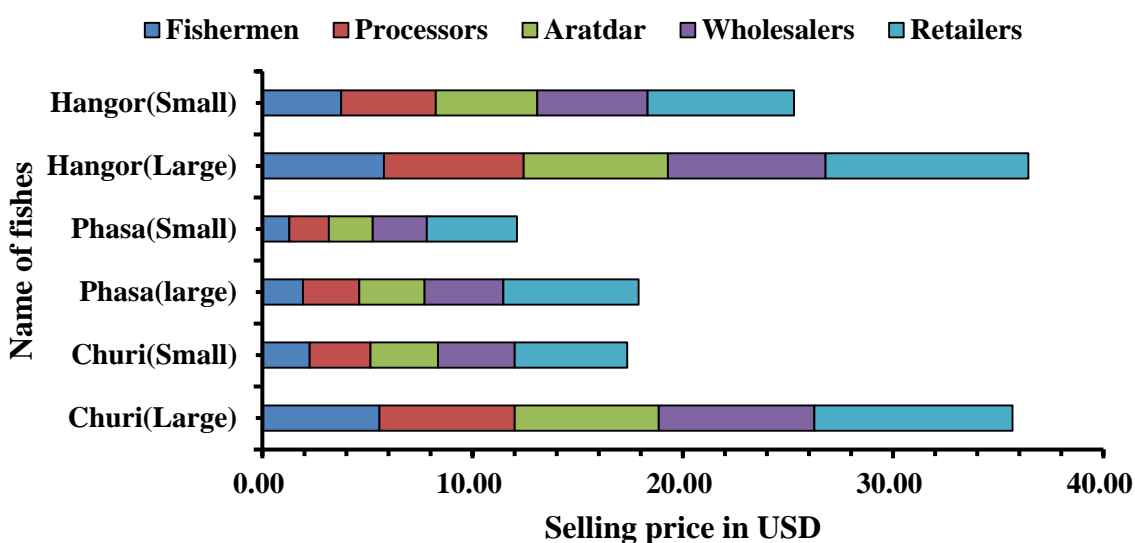
**Table 8. Profit margin calculation for retailer in USD (Per kg dry fish).**

Dry fish name	Buying price	Other cost	Total cost	Selling price	Net profit
Churi fish (S)	3.64	0.43	4.08	5.36	1.28
Churi fish (M)	5.57	0.43	6.01	7.50	1.50
Churi fish (L)	7.39	0.43	7.83	9.43	1.60
Phaisa (S)	2.57	0.43	3.00	4.29	1.28
Phaisa (L)	3.75	0.43	4.18	6.43	2.25
Hangor (S)	5.25	0.43	5.68	6.96	1.28
Hangor (L)	7.50	0.43	7.93	9.64	1.71
Chapila	2.68	0.43	3.11	5.36	2.25
Shapla Pata	1.88	0.43	2.31	3.43	1.12
Fatra	2.68	0.43	3.11	5.57	2.46
Potka	2.20	0.43	2.63	4.29	1.66
Maya	3.32	0.43	3.76	5.36	1.60
Kabila	3.96	0.43	4.40	6.43	2.03
Poa	4.07	0.43	4.51	6.43	1.92
Lal Poa	7.50	0.43	7.93	9.86	1.92
Mola	3.54	0.43	3.97	5.89	1.92
Cheowa	2.14	0.43	2.58	4.07	1.50
Rupban	2.68	0.43	3.11	4.82	1.71
Chaikka	3.11	0.43	3.54	5.36	1.82
Bullet	2.36	0.43	2.79	4.61	1.82
Kata	3.21	0.43	3.65	5.57	1.92
Chepa	4.71	0.43	5.15	7.71	2.57
Olua	2.20	0.43	2.63	4.50	1.87

\*Note: S=small; M=medium; L=large; Here, net profit margin estimated for the dry fish retailer at Asadganj.

**3.7. Selling price comparison of fish in every distribution channel**

From the selling price of the fish and dry fish, it is clear that the primary stakeholders of this sector, fishermen and processors are the most ill paid. However, Aratdars, Wholesalers and Retailers are the most benefited stakeholders in the marketing process of dry fish. In most of the cases, prices of dry fish became doubled to reach from producer level to consumer (Figure 10).



**Figure 10. Comparison of selling price of raw fish to dry fish in USD (fishermen to retailer)**

**3.8. By-products of dry fish processing industries of char patharghata**

In the dry fish processing industries of the study area, trash fish (below 2 inches in size) and by-catch of fishing, including small crabs, crab exoskeletons, and mollusks, are dried along with discarded portions of raw fish such as guts, fins, swim bladders, and gills. These dried ingredients are used for various purposes; including the



production of fish feed meal and poultry feed meal. Rotten fish, which are unsuitable for human consumption, are also utilized in the preparation of fish and poultry feed. The dry materials are supplied to feed processing factories, where they undergo further processing to create powdered forms, which are then used as supplementary feed for fish and poultry. The price of each kilogram of dry materials varies between \$0.21 and \$0.37, depending on the quality of the product. In addition to the processing of dry fish and feed materials, the dry fish processing industries at Char Patharghata also engage in the processing of fish scales. The process involves washing the fish scales in river water and soaking them in detergent for several hours. After rinsing, the scales are spread on plastic mats for drying, which typically take 1-2 days under sunlight and natural airflow. Once dried, the scales are sent to processing plants for further refinement and grading. Fish scales have various uses, including as jewelry items or raw materials for certain medicines. However, due to limited domestic demand, the majority of fish scales are exported to different countries.

#### 4. Discussion

Bangladesh is a maritime as well as a riverine country and thus fish and fisheries products have a significance impact on its economy. In the processing farm of the present study area, 40 to 50 people are employed every day during the peak period of the fish drying process. About 75% of the employees at the dry fish processing farm are women, while remaining 25% are men. Among the various segments of the fisheries industry, the dry fish industry has a crucial role in the country's economy in terms of employment generation, food security, and foreign exchange earnings (Kubra *et al.*, 2020). A significant portion of the population is involved in this industry, making it an essential component of the country's socioeconomic fabric. Despite its significance, the inner workings and challenges faced by the dry fish industry remain relatively unexplored.

Initially, raw fish is collected from various sources and processed into dry fish at the processing centers. Once the dry fish is processed, it is supplied to the Arats located at Asadganj, Chattogram. Aratdars or owners of Arat (Arat is a warehouse in which dry fishes are stored for selling), also known as commission agents; act as intermediaries between the processors and wholesalers. They bring the dry fish from the processors and sell it to wholesalers, earning a commission. In the Asadganj dry fish market; there is an association that regulates the business activities according to specific rules. It was observed that the dry fish trade mostly operates on credit, with trusted wholesalers purchasing in bulk from Aratdars and paying in installments. Retailers, exporters, and occasional consumers buy dry fish from the wholesalers, who distribute the products to different parts of the country. Wholesalers may also serve as exporters, exporting dry fish items to various countries in Asia, Europe, and America. The Asadganj dry fish market association ensures the ideal distribution and financial security of every registered trader, maintaining a standardized value chain to prevent unregistered dealers and third parties from benefiting.

Identification of different fish species used for drying in different regions is crucial for understanding product diversity, consumer preferences, and regional availability (Hossain *et al.*, 2015). This information is helpful for decision-making in fishery management, conservation, and market strategies within the dry fish industry. In terms of diversity of fish species used for drying, the present study align with previous studies (Mehedi *et al.*, 2020; Nahiduzzaman *et al.*, 2020) and identified a wide range of fish species (19 fish species) that are used throughout the year for drying, with Churi, Phasa and Hangor being the most common species in different regions (Mehedi *et al.*, 2020; Nahiduzzaman *et al.*, 2020). The drying season was also found to be consistent throughout the year, with peak periods from October to January, which is consistent with the findings of Rhaman *et al.* (2017) who reported the peak periods from October to December.

Bangladesh is actively working to eliminate child labor from every sectors of the society. However, child labor was found to be common in the dry fish industry, emphasizing the need for action. Promoting gender equity and equality also a prime goal of the government, and it has implemented strict laws and regulations to ensure these principles are upheld. Unfortunately, like many other sectors, gender discrimination in wages was also prevalent in dry fish industry, with female workers who constitutes about 80% of the workforce in this industry (DoF, 2015) being significantly underpaid compared to males. To address these issues, robust monitoring systems and enforcement of labor laws are essential. Providing high-income alternative livelihood options for both male and female workers can reduce vulnerability and reliance on child labor.

This price variation occurs due to the involvement of Aratdars. Aratdars play a crucial role in the distribution process, but their high commission rates contribute to the high prices faced by consumers. This, in turn, affects the profitability of processors, leading to lower wages for workers and the potential exploitation of child labor. To address these issues and improve the overall welfare of workers, it is essential to examine and regulate the commission rates charged by Aratdars. By implementing measures to control excessive profit-taking by Aratdars, it is possible to increase the income of processors, which can then be used to provide fair wages to

workers. This approach can help alleviate the economic vulnerability of workers and create a more equitable distribution of profits within the industry. Similar to the study conducted by Amin *et al.* (2012), this study also reported a significant increase in the prices of dry fish from the processing stage to the retail level.

In present study, it was also observed that these standards were not followed, making the products highly susceptible to insect and microbial pollution. Maintaining proper quality standards in the production of dry fish is crucial to ensure the safety and hygiene of the final product. There is a growing concern about the quality standards of the dry fish products produce throughout the country (Reza *et al.*, 2005). Insect infestation and microbial contamination not only lead to significant losses in terms of quantity but also pose health risks to consumers. Therefore, it is imperative to establish and enforce stringent quality control measures throughout the drying process.

First and foremost, the dry fish industry provides substantial employment opportunities, particularly in rural areas where alternative sources of income may be limited. The results of the study revealed that a considerable number of workers, including women and children, are engaged in the processing of dry fish. This employment not only supports the livelihoods of individuals and their families but also contributes to poverty alleviation and economic empowerment at the grassroots level. However, the matter of concern is that majority of the workers lack formal or institutional education and this scenario also reported by other study that explored the education levels of dry fish processors in different regions of the country (Kubra *et al.*, 2020). The presence of employment opportunities even for individuals with limited educational backgrounds in the drying industries is crucial, particularly when or where access to formal education and other job prospects may be limited. However, to enhance their productivity, and open up avenues for career growth there is no alternative of formal education. Moreover, it is essential to take capacity-building measures, such as vocational training and entrepreneurship programs, also necessary to empower the workforce and enable them to find alternatives livelihoods during the off-seasons.

## 5. Conclusions

The analysis of the distribution chain and fish drying process in Char Patharghata, Chattogram district, underscores the potential of the fish drying sector as a significant contributor to both foreign currency earnings and meeting the protein demands of the local populace. However, critical challenges such as the absence of trained processors, inadequate quality measures, and financial instability among producers, Aratdars, and wholesalers hinder the industry's sustainable growth. Addressing issues like child labor, gender discrimination, pricing dynamics, and quality control, while emphasizing skill development, is essential for fostering a conducive working environment. Implementation of simplified processing procedures, advanced training, sanitation awareness programs, and financial support from government and non-government organizations can enhance export capacity and ensure dry fish quality. Despite persistent challenges, the industry remains a crucial source of employment and food security. Future studies should focus on bridging identified research gaps and exploring additional measures for enhancing the industry's socio-economic impact.

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## Data availability

Data may be obtained on reasonable request from the corresponding author.

## Conflict of interest

None to declare.

## Authors' contribution

Conceptualization: Mou Dey, Mohammed Shahidul Alam, Shuvo Bhowmik; Methodology: Mou Dey; Software: Mou Dey, Mohammed Shahidul Alam; Validation: Mohammed Shahidul Alam; Formal analysis: Mou Dey, Shuvo Bhowmik; Investigation: Mou Dey, Shuvo Bhowmik; Data curation: Mou Dey; Writing original draft: Mou Dey; Writing review and editing: Mohammed Shahidul Alam; Visualization: Mou Dey, Mohammed Shahidul Alam, Shuvo Bhowmik; Supervision: Mohammed Shahidul Alam. All authors have read and approved the final manuscript.

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