

Identifying and Mitigating the Factors Causing Post-Harvest Losses in Supply Chain of Inland Fish Industry: A Study of Badin Fish Industrial Cluster

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Abstract:

Very delicious and nutritious but highly perishable after harvesting, is the fish. It is also said that, the fishes are not the potatoes because their journey from farm-to-fork is very crucial and involves value addition at each and every stage of supply chain in order to retain its physical form and nutrient composition. For that, post-harvest losses are of great concern. The improper post-harvest handling and dissemination of fish, destructs the product physically and its quality and taste deteriorate over time. Therefore, this study attempts to identify the risk factors which are liable for post-harvest losses in supply chain of fish. The study employs qualitative research methodology in which experts of the industry were interviewed. The experts were then provided with a risk assessment matrix to rate the risk factors in terms of occurrence and severity. For interviews, thematic analysis was done which resulted in three final themes such as: Practices employed during harvesting of fish, fish handling during auction and transportation and marketing of fish. Then mode was calculated for summarizing the responses acquired from risk matrix filled by the experts. The risks with higher rating of occurrence and severity were exposure of fishes to high temperature, poor hygienic practices at auction halls, poor condition of transport and inadequacy of chilling, over fishing, improper handling during sorting, auctioning and loading in transport, long storage time and poor market infrastructure. These risks pose serious threat to the product's health and the overall sector's sustainability. Finally, some mitigating measures in accordance with global best practices were suggested to mitigate the post-harvest losses and maintain food security which is very challenging for developing countries.

Keywords — Identifying, Inland Fish Industry, Mitigating Measures, Post-harvest Losses, Risk Factors, Supply Chain.

I. INTRODUCTION

Pakistan is an agricultural country where more than half of the population is directly or indirectly associated with agriculture, livestock and/or fisheries. Along with other natural resources, the country is also bestowed with abundant marine and seafood resources that provide prolific prospects for fisheries and aquaculture production. Long

coastline, broad continental shelf and Vast Exclusive Economic Zone with various deltas and estuaries make Pakistan rich in Fishery and Aquaculture possessions [1]. The sector contributes significantly in the national economy providing direct employment to 4 lac people and nearly 6 lac people in associate industry operations but its influence on Gross Domestic Product is very Low. The costal belt of Pakistan i.e., Sindh and

Balochistan play substantial role in fish and aquaculture farming by contributing more than 70% of the total production [2]. The fisheries sector of Pakistan comprises over 290,000 square kilometres of marine waters and 8.6 million hectares of inland water resources being thirty-third in world fisheries production [3]. Sindh is considered as the territory of infinite opportunities. The good surface water quality with vast network of irrigation and drainage and optimal climate makes it suitable for fish and aquaculture farming in the province [4]. The coastal regions of Sindh i.e., Thatta and Badin produced 150,000 metric tons of fish during the year 2019. The fish and fishery produced here are also exported to other countries such as China, Malaysia, Thailand, Japan and Middle East countries earning more than \$400 million. Despite these favourable conditions, the fisheries sector has not realized its communal and commercial potential. Lack of research and planning in policy making, outdated infrastructure, budget allocation by federal and provincial governments, dearth of public-private partnerships in aquaculture farming, overfishing and water pollution causing stock depletion and others pose a serious threat towards the improvement of the sector [5]. Out of them, an important factor that causes hindrance in the progress of the sector is the post-harvest handling of the produce. The malpractices throughout the players of value chain seriously affect production and sale of the high nutritious product. Fish contains 70-80% of water, makes the item more susceptible to spoilage than any other food. There is no precise assortment of inland fisheries information in Pakistan and is a need for the Stock assessment and for government organizations to expand reviews to guarantee consistence. As more information become accessible to govern the activities efficiently [6]. The country has a serious need of "Blue Revolution" proposed by The World Bank Group to revive its fisheries and aquaculture to boost the national economy and to deal with the delinquent food insecurity in the region [7].

II. LITERATURE REVIEW

Fish are aquatic, cold-blooded and craniate vertebrates having a place with super class Pisces under phylum Chordata. As food, it is the most important source of animal protein having low fat and packed with lots of nutrients that help to promote growth and immunity of human body. It contains vitamins, minerals and Omega-3 fatty acids that stimulate brain functions and protects human body from several diseases such as cardiovascular diseases, autoimmune diseases, depression and mood swings, Alzheimer's disease, stroke, vision impairment and sleep disorders [8]. According to people of Pakistan, white meat is the most delicious and healthier meat which is produced naturally without any external chemical contamination. Fish has earned its position due to immense export and revenue potential along with its contribution in balanced diet. Pakistan has the most extensive networks of irrigation canals and surface water of good quality is available for 10 to 11 months in a year [9]. Fish industry in Pakistan is operated at the federal level under Ministry of Food, Agriculture and Livestock. Fisheries Development Board FDB is advisory body headed by Fisheries Development Commissioner working under the administrative control of Ministry of National Food Security & Research with the aim to promote, facilitate and support the development and dissemination of aquaculture technologies, private sector investment; domestic and export market of fish and fish products and training and capacity building of stakeholders in collaboration with fisheries related institutions and provincial fisheries departments for upgradation of fisheries in the country [10]. In Sindh, Ministry of Livestock and Fisheries is the govern by Sindh Government that deals with both Marine and Inland Fisheries and is assigned with the task of policy making and planning, managing operations of the fish industry, issuing fishing permits and licenses, controls the activities and advises the industry about growth and development. Supply chains of food products are distinguished from the ones for other products due to their fundamental differences, such as the significant and constant variations in food product

quality from the upper-hand side to the lower-hand side of the chain [11]. Supply chain of fish and fisheries is very crucial process because the product is highly perishable in nature and an extreme care should be taken at each step from farm till it reaches the consumer. The capture fisheries production is declining due to overexploiting natural resources [12]. In addition to declining marine fish stocks, inland capture fisheries are also in decline due to ecological degradation and overfishing [13].

There are some issues faced by the country's important sector, they include persistent use of conventional fishing methods, unmonitored overfishing by large industrial trawlers, dilapidated fish storage and processing infrastructure at harbors and failed coordination between federal and provincial fisheries authorities in the past. The decision-makers are deprived of updated fisheries database, and local farmers lack access to credit and capital investments [14]. This an alarming situation especially for those countries where large number of are associated with fish industry [15]. Globally fish losses are estimated to be 1/3 of the total catch each year. These losses can be submerged into two classes, Quantitative losses occur due to mass killing during harvest, disease attack on the fish, damage due to processing, transportation, storage and changes in market forces. Qualitative losses are due to loss of nutrients in the fish, use of non-permitted preservatives and spoilage due to bacterial reaction [16]. This contributes to food insecurity which is one of the biggest challenges, the country is dealing with since birth. According to Food Security Assessment Survey (FSA), 2016, 18% of the population of Pakistan is undernourished [17] The situation got even worse due to Covid-19 pandemic hit across the globe. The government's annual Economic Survey for 2019-2020 also warned that during this pandemic, the economy would be the lowest for the first time in 68 years [18]. Approximately 60 percent of Pakistan's population is facing food insecurity, in which malnutrition is prevalent, according to the United Nations World Food Program [19]. It comes as no

surprise that Punjab and Khyber-Pakhtunkhwa are richer than Sindh [20].

Despite that, Pakistan Agricultural Research Council is currently involved in improving the fish production through intensification of fish culture and timely utilization of inputs such as fertilizer and artificial diets. The use of such inputs and adoption of the intensive fish culture technology can easily enhance the fish production [21]. Research and assessment are conducted to determine the feasibility of developing fisheries or mariculture farms and pilot projects are formulated, where appropriate, to encourage the private sector [22]. Along with these, the country needs a long-term policy framework which guides the supply chain partners by making them aware of these issues and help mitigate them in order to conserve the resources of the country.

III. RESEARCH METHODOLOGY

Post-harvest losses in supply chain of perishable products, an extensively researched topic using a wide variety of research methods. Therefore, in order to comprehend miscellaneous information about the factors that cause post-harvest losses in supply chain, qualitative approach will fully answer the research question of this study. The researchers' main purpose of using qualitative methods should be derived from the direction of the research question. Qualitative methodologies are utilized to investigate more expressive information from the people; their ideas, beliefs and feelings, understandings and views regarding the problem in the study. The experts of industrial cluster of the study area were purposively selected with higher level of experiences, in order to acquire comprehensive knowledge about the factors and their level of impact in the study area. The step-by-step methodology for this study is as follows;

- 1) At first, the general observation was made to the supply chain of the product in the study area. All the stages from harvesting till transportation were critically experienced and pictures and videos were recorded for after review.

- 2) Then, in-depth literature of global and Pakistani authors was reviewed regarding the factors that cause post-harvest losses in fish supply chain. From that, 13 major risk factors, which were discussed by several authors, were identified.
- 3) Semi-structured interviews were conducted with experts of the industrial cluster having experience of more than 20 years in managing and handling the fish supply chain. The sample size selection based on the scope and nature of the research was guided by [23]. Therefore, 10 experts were selected for interviews after consent. Additionally, when it comes to semi-structured interviews, this will allow for ‘openness’, inspiring participants to open up on areas that were not initially planned.
- 4) Finally, mitigating measures in accordance with global best practices are recommended to reduce these risks.

IV. DATA ANALYSIS

4.1. Factors Causing Post-Harvest Losses in Fish Supply Chain

During literature review, 13 common risk factors that cause post-harvest losses in supply chain of fish were identified. The risk factors are shown in the TABLE 1 below;

TABLE 1: RISK FACTORS CAUSING POST-HARVESTS LOSSES IN SUPPLY CHAIN OF FISH

S No.	Risk factors in supply chain of fish
1	Fishing done by using harmful chemicals such as explosives
2	Over fishing or fish discarded as by-catch/Trash
3	Theft of product at various stages of value chain
4	Delay returning to land after catching fish
5	Exposure of fishes to high temperature
6	Poor hygienic practices at auction halls causes contamination

7	Improper handling during sorting, auctioning and loading in transport
8	Inadequate chilling in transport, long and broken roads, loose packaging and dirty boxes
9	Inadequate storage capacity and facilities in market
10	Bacterial infestation during storage causing rancidity of fish
11	Long storage time causes depreciation in quality of fish
12	Less demand of product during hot summer days
13	Delay in delivering fish to market creating supply/demand disturbance.

4.2. Semi-Structured Interviews

After identification of risks, semi-structured interviews were conducted with experts of the industrial cluster of district Badin having high level of experience in terms of managing and handling the fish supply chain. The demography of the e

Table 2: Demography of the Respondents of Semi-Structured Interviews

The interviews were recorded after obtaining consent from experts for later revision for analysis. It generally took 15-20 minutes for interview with each expert. All interviews were transcribed supported with observational notes. Each interviewee was allotted a pseudonym such as E1, E2 etc. to uphold the concealment. The “E” represents expert. The analysis of semi-structured interviews was done using a five stages thematic analysis guided by Braun and Clarke to produce comprehensible themes from set of transcriptions. Upon analysis final three themes were identified.

4.2.2. Theme 1: Practices Employed During Harvesting of Fishes

Experts during interrogation made it clear that the no any use of explosives or chemicals are used for harvesting of fishes in the study area. In fact, most of them did not know about these explosives and their use.

Well, I do not think so that fishing practice is done by using any explosives in this area because the fish farm is owned by farmers themselves, how they can do so? and the product which is nurturing in their farm is their investment so they cannot destruct their product. Also, for public waters the situation is same (E1).

However, they talked about few practices that are banned by the fisheries department such as collecting undersize fish or using prohibited nets with small mesh sizes, are reported in this area.

Few exercises which are prohibited in the ordinance, for example, collecting modest fishes, utilization of unlawful nets is accounted for and the fish gets squandered but the farmer who use to fish in public waters earns his livelihood only from it, so he is forced to do that due to scarce resources (E3).

Upon inquiry about theft of the product at certain stages of supply chain, they clarified that theft is being made due to certain factors at various stages along the value chain and it is reported at large extent.

Theft of the item is done by poor ranchers when they conceal the item at specific spots. During stacking in the vehicle, distributor shrouds the item on course before the arriving at the destination (E4).

Expert 9 clearly explains that theft is mostly done by poor farmers because the price of the product remains generally high due to a highly nutritious product.

Theft is also done during weighing of the product when labor in the market hide the product at certain places in the market. Because the price of one fish which in local language called "Nang" is generally above Rs.1000 based on the specie and the size of the fish. Also, during loading in the transport, transporter or distributor shrouds the product on route before reaching the destination (E9).

Most of the experts were of opinion that delay in returning to land after catching fish is not usually done on board in private fish farms. However, in certain cases of fishing in public waters, the farmer in view of harvesting large amount of product makes delay.

Most of the experts were of opinion that delay is not done in harvesting the product in case of private fish farms but it is experienced by farmers who fish in public waters. They usually tend to keep the fishes on board without icing and when sufficient quantity is collected, only then they go to market for sale (E3).

All the experts believe that fishes are exposed to high temperature throughout their value chain incorporating much losses due to the unawareness and carelessness of supply chain partners.

Fishes are exposed to high temperatures at various stages of supply chain such as during harvesting, at landing sites, during auction and sale especially in hot summer days. However, if the weather is extremely hot, the fishes die inevitably and come to the surface of water prior to their harvesting.

But an extremely cold temperature is also not favourable to live fishes due their cold-blooded nature (E5).

4.2.3. Theme 2: Fish Handling During Auction and Transportation

For this theme, which contribute much of the post-harvest losses, the experts gave insights of how fishes are treated when they arrive at auction halls/market for sale and purchase and also during their transportation from market to their respective destinations within and outside the district. The E2 briefs author about the situation;

Actually, fishes that come in market are generally unsorted but counted. The fishes upon sorting and counting are place in mounds according to the species and the farms from where they have arrived. The places in market are generally dirty thereby create contamination in the product. Also, during

weighing and finally at auction the product is placed on filthy floors (E2).

An expert gives a complete profile of how fishes is dealt in market and during loading in transportation. He is of view that fishes are physically and chemically destructed very much at this stage of the value chain.

Yes, the product is found to be handled improperly during sorting and is thrown here and there. Stepping on fishes is also done in the market of study area. During auctioning the person stand on fishes damaging them physically. Loading in transports is done by throwing the fishes in local transports filled sometimes with crushed ice. This badly affects the fish physically leaving visible marks on its body (E10).

Most of the experts from the sample were of view that market infrastructure plays a vital role in fish quality and form when it is stored for long. They said that;

Lack of effective storage containers, inefficient electricity supply in the market area cause bacterial infestation during storage, completely destructs the fish and makes it unfit for human consumption and is considered as a loss. This loss occurs mostly during hot summer days (E6).

They made it clear that this happens only when the fish remains unsold in the market but if it is continuing to be practiced, it can result in huge losses in terms of physical product and financial because the whole system of sale and purchase in the market runs on credit.

Yes, but not all the times, long storage time with inadequate storage facilities causes depreciation in fish quality. However, this risk only applies when the product is not sold at the time of auction and also there are certain species of fishes which are produced here but not consumed by local people are stored in market. When sufficient quantity is gathered such as 1400-1600 KGs, they are

transported to distant markets of Karachi and other areas of the country (E4).

An expert interpreted that condition of transport vehicles is not up to the mark as they are of old models with dirty and rusted racks which can easily spoil the product.

Generally, the transports use for movement of fishes in this area are local vehicles namely "Suzuki Ravi", "Hyundai Shehzore" and other minitrucks of Japanese companies. They have rusted storage racks at the back which increase the chances for fish to immediately spoil. Even they don't maintain the weight of the product keeping in view the curb and gross weight of the vehicle during transport. Mostly during transportation, the vehicles go out of order, the ice melts and the product starts to spoil (E1).

4.2.4. Theme 3: Marketing of Fishes

It was highlighted by the all experts of industrial cluster that during this stage of marketing of fresh fishes, the role of climate is very important as it is proportional to the demand of the product.

Because the efficacy of fishes upon utilization is generally hot and when it is devoured in mid-year days, it seriously influences the well-being of people. So, the people tend to purchase the fish and consume it when the temperature is normal. That's why the demand is reduced subject to seasonal changes (E8).

When it was inquired about the deliberate delay in supply of product to market the experts responded that it is the farm owners

Sometimes, fish farm owners make deliberate delay in supply of the product to nearby market in fear of receiving less price. They transport their product to distant markets which creates risk of product damage on route (E7).

When questioned about oversupply and less price of product they said that;

It is also seen that the market is oversupplied by the product when the demand for the product is low.

This initiates the chances of quality loss in the product because market is not capable of handling such amount of product (E3).

The experts interpreted that market malpractices are being done to overcome the losses to some extent the pointed out that:

To maintain the profits, marketeer sale the inferior quality fish to small road-side shop owners, who cut the fish before sale. Then, it becomes very easy for them to sale and unaware people cannot easily spot any flaws (Fish Farm owner).

The experts said that covid-19 badly affected the fish industry and its operations.

Recent covid-19 badly affected both marine and inland fisheries not only here but in other parts of the country as well and the global complete lockdown resulted in huge losses both in terms of financial and material. Appr15% of poor labour and daily wage workers lost their jobs (E2).

In July, the operations again started following the SOPs from Sindh government but they continued at sluggish pace till October and from then the circumstances are normal till date (E2).

V. DISCUSSION

Food security is of major concern especially for low-income food-deficit countries. This is generally because of unawareness of supply chain integrity and lack of technology advancements at various stages during the movement of product. This becomes more critical when the product is extremely perishable in nature such as fish. the quality and physical features in the end product reveal, how the product was being handled prior to its sale. The experts of supply chain interpreted that in inland fisheries sector of the country, the product integrity is highly neglected by the labor at different stages of value chain. Product is exposed to high temperature during hot summer days, condition of auction halls is also not up to the mark and the product gets infected by pests and bacteria, overfishing is also done very much in the area, traditional methods are employed for chilling the product during transportation, theft of the product at various stages and finally market malpractices are

adopted to retain profits while selling low quality fishes. However, these problems have resulted in many financial losses to fish farm owners, marketeers and poor labor who directly and solely depend upon this business. So, it became an urgent need to draw the focus of problem towards the policy makers and institutional heads so that they can take stern actions against these circumstances in order to maintain food security and improve the livelihood of marginalized communities and finally mitigating measure in accordance with global best practices were recommended to reduce the losses.

VI. CONCLUSION

In attempt to identify the factors in the specific study area which is Badin district, the research was conducted with the help of experts of the industry who gave a complete profile of the post-harvest risks factors, their cause of occurrence, along with level of impact in the supply chain of fish. The risk factors that are severely responsible for the decreased product safety are as under;

- Exposure of fishes to high temperature.
- Poor hygienic practices at auction halls causing contamination
- Inadequate chilling in transports, long routes, loose packaging and dirty storage boxes.
- Over fishing or fish discarded as by-catch.
- Long storage time causing rancidity of fish.
- Improper handling during sorting, auctioning and loading in transport.

These risks must be evaluated by creating awareness among the people involved in the industry, government help, technology advancement and improving the infrastructure of fish handling system in order to conserve the most important resource of the country.

VII. RECOMMENDATIONS

- The very first recommendation which should be quickly adopted to bound the supply chain companions to follow the code of conduct and Standard Operating Procedures, issued by the concerned ministry to ensure the product's sustainability and healthiness and to revive and amend its fisheries policy and ordinance at state level.
- It is recommended to the Fisheries Department and to the local administration of the district to ensure the presence of the Quality Control Inspector from the concerned department at the time of auction and transportation.
- Transportation of fish towards market and further from market to their respective destinations, should be made immediately in vehicles keeping in view the curb weight of the vehicle. Cold supply chain can play a great part here.
- It is recommended that fish shouldn't be kept beyond six hours at ambient temperature before it is iced, if its shelf life is to be maintained to meet the market's quality demands.
- It is also recommended that the fishes throughout their movement from farm to fork should be kept in the temperature range from 0°C to 4°C.
- During harvesting, it is suggested that the fish should be immediately removed from the fish net or grills because it leaves blemishes on the skin which influences its bodily features after the death of the fish.
- Neat and cleaned display tables should be kept for product display during auction rather than keeping them on filthy floors to avoid contamination and bacterial infestation.
- Sorting and weighing of the product should not be done very harshly and roughly prior to their auction to avoid physical damage.
- The use of Controlled Atmospheric Packaging, CAP or Modified Atmospheric Packaging, MAP can protect the product inside it, from external environmental perils more efficiently and effectively than normal boxes.
- It is recommended to thoroughly disinfect the complete area of the market before and after every auction.
- Before storage the fish must be subjected to pre-storage treatments to increase the shelf life of product to some extent which includes, washing and cleaning before storage, use of chemicals and bio-preservatives such as Chlorine Dioxide, Hydrogen Peroxide, addition of Lactic Acid Bacteria for protection against *L. Monocytogenes* and *Salmonella Listeria*, use of Gamma Radiations.
- Theft of the product can be stopped by using traceability tools and techniques.

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