



Assessment of fish loss in domestic fish markets in Central Kerala

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Abstract

Globally fish loss due to spoilage was estimated to be 10 to 12 million t/year. Unhygienic handling, inadequate icing, and temperature change are some of the major factors contributing to a fish loss in fish markets. Standardized approaches are adopted to quantify the loss of fish in domestic markets through field assessment methods. This study highlighted fish loss in domestic fish markets in central Kerala and identified the factors leading to the quantity loss by classifying the markets into wholesale markets (WM), public markets (PM) and retail markets (RM). The physical loss was one of the major components (32%) of fish loss among the selected markets of central Kerala. Fish loss can be controlled by improving the onboard handling procedures as well as cold chain adoption across the transportation storage and logistics front of the domestic fish supply chain.

Keywords: *Post-harvest fish loss, physical loss, handling loss, quantity loss, quality loss*

Introduction

Global total capture fishery production recorded 96.4 million tonnes in 2018, of which marine and inland waters contributed 81.5 and 11.9 million tonnes, respectively (FAO, 2020). The fisheries sector plays a crucial role in meeting the food, and nutritional security of mankind and its importance is steadily growing as it meets the livelihoods of millions. Apart from providing employment and sustenance to sizeable sections of the society in rural India, the fisheries sector also contributes significantly to the protein supply and food security. The current average annual growth rate of this sector is 4.7%. Fisheries and aquaculture production contribute around 1% to India's Gross Domestic Product (Anon, 2019).

However, improper post-harvest management practices have

resulted in massive fish loss along the supply chain. Fish begins to spoil as soon as it is caught, right from the moment it gets captured within the fishing gear. Once harvested, its post-harvest losses are relatively high and occur mainly due to improper handling at landing centres and poor cold chain management during transportation. Therefore, to reduce fish loss along the value chain, care should be taken throughout the fishing operation, landing, handling, storage, and transportation. Fish that become spoiled or putrid is unusable (Gopakumar, 2000). Food and Agricultural Organization has estimated post-harvest losses in developing countries to be up to 50% of domestic fish production. Since fishes are a highly perishable commodity, they should be maintained under a cold chain and processed at a quicker rate.

The estimated marine fish landings from all the maritime states and two union territories in the mainland of India for the year 2019 was 3.56 million tonnes showing an increase of 2.1% in comparison to landings in 2018 (3.49 million tonnes). With 590 kilometres (370 miles) of coastal belt, 400,000 hectares of inland water resources and approximately 220,000 active fishermen, the fisheries sector contributes to about 3% of the total economy of the state of Kerala (Anon, 2011). The coastal waters of Kerala provide a large variety of pelagic (59%), demersal; (23%), crustacean, molluscan and related species (18%) of commercial importance (Pillai *et al.*, 2007). During the year 2020, Kerala recorded total fish production of about 6.80 lakh tonnes, of which 2.05 lakh tonnes were harvested from the inland sector, and the contribution of the marine sector was 4.75 lakh tonnes (Hand Book of Fisheries Statistics, 2020). The annual per capita fish consumption of Kerala during this period was 19.41 Kg (Anon, 2020). Kerala has a large variety of fish and a highly skilled population of fishermen, which helped the state to become a leading fisheries producer (Aerthayil, 2000). Domestic fish marketing in India is highly unorganized and unregulated, with a dominance of

intermediaries at multi-functional levels (Kumar *et al.*, 2008). The domestic fish market plays a crucial role in the fish trade. Depending on the distance of the market from the landing centre and the type of consumers, the number of intermediaries also varies (Jadhav and Borgave, 2019).

The major actors in fish marketing channels in the domestic sector of Kerala include fishermen, commission agents, vendors/retailers, auctioneers and consumers (Fig. 1) field visits revealed that fish handling practices and preservation methods in ordinary distribution chains are quite unscientific. Unhygienic handling, distribution and transportations lead to a huge loss of fish along the supply chain. Further, on reaching the public markets, fishes are exposed to all sorts of quality abuse till it reaches the consumer. There is a dearth of information on fish loss at domestic fish markets in Kerala. Therefore, an attempt is made here to assess the quantity and quality of fish loss in selected markets and to identify the factors contributing to the fish loss in central Kerala.

Material and methods

Primary data regarding the assessment of fish loss were collected from different wholesale fish markets (WM), public fish markets (PM) and retail fish markets (RM) in Ernakulum district, Kerala, during the year 2018. The wholesale market details were collected from wholesale markets in *Aluva* (WM₁) and *Chambakara* (WM₂), and *Thopumpady* (WM₃). The public market details were collected from *Chambakara* market (PM₁), *Ernakulam* market (PM₂) and *Varapuzha* fish market (PM₃). The supermarket/retail outlet details were collected from *hypermarket* (RM₁), *fish stall/fish hub outlets* (RM₂) and *Matsyafed* (RM₃). From each market sample, 50 respondents were randomly selected by giving due representations to wholesalers, retailers, vendors, transporters etc. The

investigation on fish loss assessment along the domestic supply chain in selected fish markets of central Kerala was carried out by qualitative and quantitative field assessment methods. Information on details of handling and processing activities, the efficacy of the existing practice, transportation access and loss of fish in different stages of marketing was also collected. The load tracking (LT) method and the Questionnaire Loss Assessment Method (QLAM), a formal questionnaire survey approach, was used to quantify and validate critical loss data (FAO, 2011) from selected segments in the fish value chain. The informal fish loss assessment method (IFLAM) was also used to identify the causes and to estimate the amount of fish loss in selected markets. The Hedonic scaling method was used to estimate fish quality attributes from different categories of markets through the sensory evaluation method. While assessing food items, the phrases “like” and “dislike” are used to imply psychological responses. The most commonly used hedonic scales are the 7-point and 9-point hedonic scale, with units extending from “dislike extremely” to “like extremely” (Everitt, 2009). In the present study, a 9-point scale was adopted. Information on the market condition and infrastructure facilities was collected through a field survey. Response from all functionaries, intermediaries and actors in domestic supply chain and distribution channels were systematically recorded and subjected to statistical analysis to assess the fish loss in each segment of domestic fish markets.

Results and discussion

The fish market structure was analyzed based on the major dimensions viz., location, transit from landing centre to market, access to markets, category of markets, quality of raw materials on arrival and distribution infrastructural adequacy, rules and regulations.

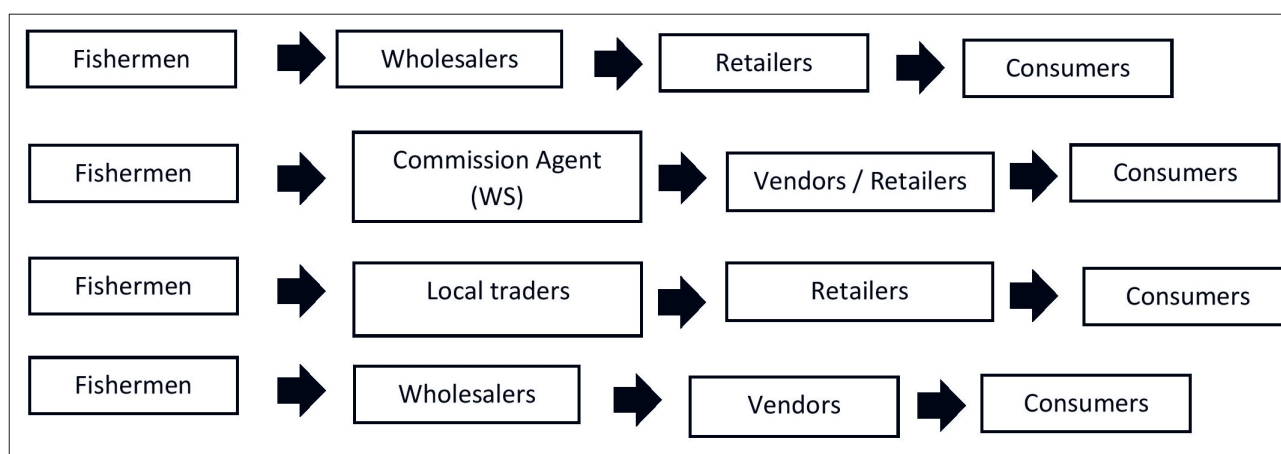


Fig. 1. Different fishmarketing channels

Quality Loss Assessment

Marketing has been defined as all processes involved from the production of a commodity until it gets to the final consumer (Crammer *et al.*, 2001). Generally, quality is the key to successful market access, which creates increased consumer acceptance and revenue for producers. The major ways of post-mortem changes in fish are physical, biochemical, and microbiological (Amos *et al.*, 2007). Post-mortem changes in fish start with the onset of slime formation, rigor mortis and subsequent biochemical changes (Dunajski, 1980). Three samples were drawn from each category of the market for assessment of quality/quantity loss of fish by classifying them as samples I, II & III.

Wholesale Fish Markets (WM)

The market infrastructure was analyzed based on location, type of markets, access to transportation, disposal ways, rules and regulations etc. Observation on quality attributes of fish items from selected markets was compiled on a hedonic scale, and its average scores are recorded to compare the quality loss of fish in wholesale markets as detailed in (Table 1). Among the three wholesale markets under survey, Market I (WM₁) was dominated by a large number of intermediaries like auctioneers, retailers, commission agents etc. About 60% of fish supplied to WM are mainly brought from outside the state of Kerala, about 35% are supplied from neighbouring district harbours and the remaining 15% from within the district harbours (Munambam, Vypin, Chellanam, and Thoppumpady) Table 5. Generally, fish are delivered to wholesale markets in the early morning. One of the major issues at WM₁ is the inadequate parking and berthing facilities for trucks delivering fish.

The market I (WM₁) is a major hub for receiving fish from other states, with approximately 5000 to 8000kg of fish market every day. The score obtained from (Table 1) shows that the overall acceptability of market I (WM₁) was 5.2, (based on the average mean score of attributes) which means market I (WM₁) is neither "like" nor "dislike". This is because about 60% of the fish are mainly brought from other states. Fishes brought from other states to be exposed to temperature fluctuations during transit

Table 1. Attributes scores on quality loss assessments in selected wholesale fish markets (Hedonic scaling method)

Attributes	Market I (WM ₁)	Market II (WM ₂)	Market III (WM ₃)
Colour	5	6	6
Appearance	5	5	6
Odour	6	6	6
Texture	5	6	6
Slime	5	6	6
Overall acceptability	5.2	5.8	6

which influences the quality attributes of fishes. Duarte *et al.* (2020) while reviewing the quality of chilled and frozen fish also observed that the shelf life of fish is influenced by factors such as the type of fish species, stress suffered during capture, storage time and temperature, method of transportation as well as the amount of ice used for preservation.

Daily, an average of 3500- 4000kg of fish were brought to the wholesale market II (WM₂). The supply comes primarily from Market I (WM₁) and state landing centres such as Kayamkumam, Thoppumpady, Chellanam, etc. Hedonic analysis on overall acceptability was recorded as 5.8, which is towards the range "like slightly" score value (based on the average mean score of attributes). They receive a meagre 15% of supply from local harbours such as Chellanam, Thoppumpady and Vypin. The transportation time also directly influences the quality of fish as most of the trucks used in local transportation are non insulated and lacked in-built refrigeration systems and are non-insulated. Delay in loading from landing centres and unloading at markets also adversely affects the quality and lead to quantity loss. These wholesale fish markets in the study area are facing infrastructure constraints on electricity, potable water, waste disposal, drainage system etc.

In the wholesale market III (WM₃), the market handles a variety of commercial species and the estimated quantity of fish handled per day ranges between 3000-3500kg. The overall acceptability of fish quality in WM₃ was recorded as 5.8, which indicates "like slightly" on the hedonic score. As compared with the other two markets, quantity-wise distribution of fish in Market III (WM₃) is less and a major chunk of fish to this market is supplied by Market I (WM₁). A limited amount of fish is also being received from landing centres within the district. The mode of transportation and infrastructure facilities are moderate and comparable to that of Market II (WM₂).

Public Markets

According to (Table 2), Market I (PM₁) shows an overall acceptability value of 6.4 on hedonic scale, which is the lowest score of acceptability than Market II (PM₂) and III (PM₃), as they scored between "like slightly" and "like moderately" on hedonic. There are many constraints in hygiene, sanitation as well as infrastructure facilities in PM. The fore-noon marketing activities commenced from between 6:30 to 11.00 am, and the afternoon market functions from 2.00 to 6.00 pm. According to seasonal variations and shifts in demand and supply, the duration of the functioning of markets also changes. The supporting facilities are considered to be essential for fish handling and efficient disposal of the fish in markets (Kirema–Mukasa and Reynolds, 1991). The PM under study lacked the basic facilities for hygienic handling and reducing the quality loss of fish. On an average, the total fish arrival in the

Table 2. Attributes scores on quality loss assessments in selected public fish markets (Hedonic scaling)

Attributes	Market I (PM ₁)	Market II (PM ₂)	Market III (PM ₃)
Colour	6	6	6
Appearance	7	7	6
Odour	6	6	6
Texture	7	6	7
Slime	6	7	7
Overall acceptability	6	6.6	6.6

market was observed to be 2100 kg/day. Among the high-value species, major items are black pomfret (*Parastromateus niger*), cobia (*Rachycentron canadum*) and seer fish (*Scomberomorus guttatus*), and the low-value fishes were represented by sardine (*Sardinella longiceps*), mackerel (*Rastrelliger kanagurta*) etc. Efficiency analysis on marine fish marketing in the central zone of the state of Kerala revealed the presence of different marketing channels and functioning of intermediaries along the value chain, it was found that the marketing efficiency was comparatively very high for commercially important species like seer fishes in the local marketing channel (Aswathy *et al.*, 2014).

In PM^s fishes are displayed on polythene sheets without proper icing and exposed to ambient light and temperature conditions which causes intrinsic and extrinsic quality issues. Unhygienic procedures are followed while cleaning and dressing fish in public markets. Utensils such as fish boxes, shawls, knives etc. are not properly cleaned and sanitized before dressing and cleaning fish. The lack of an adequate quantity of potable water supply is another constraint in PM^s. Most of the time, tainted water is reused to rinse dressed fish, which can lead to increased contamination and spoilage. Another major problem in the domestic fish market was the accumulation of waste, which attracts flies and rodents. The thermocol /polystyrene boxes used for transporting fish, after unloading, are left unwashed, which attracts flies and insects and emits a foul smell in the surroundings. The left-over fish are re-iced and kept polystyrene boxes for the next day's sale, further accelerating the rate of fish spoilage. As the fishes were already exposed to temperature fluctuations, there will always more quality loss on such fishes. Besides, quantity loss also happens due to physical damage and deformations with improper handling and negligence from fish handlers, which also contribute towards physical loss to fish at domestic markets. The waste disposal mechanism prevailing in PM^s are quite inefficient. Fish-cutting wastes are usually kept adjacent to the selling area where fresh/dressed fishes are displayed, increasing cross-contamination chances. Around 45% of fishes in PM^s are landed from harbours within the state and 30% from nearby landing centres/ harbours like Thoppumpady harbour and landing centres like Chellanam,

Chambakkara, Munambam, Vypin etc. Loading and unloading workers belonging to various trade unions are involved in fish handling and related jobs. The analysis of selected PM^s revealed that none of PM^s has infrastructure requirements such as sufficient potable water supply, proper display platforms/chilled counters, drainage, sewage treatment and waste disposal facilities.

In Public Market II (PM₂) and III (PM₃) almost similar conditions were observed in terms of general hygiene, infrastructure facilities and overall appearance. The exposure of fishes to ambient temperature lasts many hours, which triggers biochemical changes and lead to quality loss. Post-harvest food losses in perishable crops also revealed that temperature fluctuations accelerate the growth of spoilage, causing micro-organisms, which reflects negatively on the quality and storage life of products (Atanda *et al.*, 2011).

The overall acceptability value in PM was recorded as 6.6, which belongs to "like moderately" in the hedonic scale. As compared with Market I (PM₁) the score range is much higher in market II (PM₂) and market III (PM₃). This is because about 45% of fish landed in this segment are from within the state. In contrast to WM, where the majority of supply is landed from neighbouring states and harbours outside the district, PMs rely mostly on fish supply from local landing centres and harbours, which helps this segment to maintain superior overall acceptance over WM. Even though sellers and vendors in PM^s prefer to fish from nearby and neighbouring districts, less than 20% of the total fish marketed in this segment is delivered from other states as shown in (Table 5).

Retail Markets/ Super Markets

The retail market functions outside the PM^s and WM^s; they maintain the cold chain and store the products under hygienic conditions throughout the distribution process. Quality and nutritional loss of fish marketed from such outlets are very low and deliver the fish to consumers without any compromise on quality. The overall acceptability of retail market I (RM₁) was recorded at 7.2, based on the average mean score of attributes, which implies that it is like moderately. The RM^s control the purchase of raw material/fish based on the consumer demand pattern so that quality and quantity loss is considerably very low in the retail outlets.

From the analysis, it was observed that Market II (RM₂) showed an acceptability of 7.6, which is towards the range of "like very much". In market II (RM₂), the fish are handled hygienically and stored under recommended temperature conditions. Trained/skilled workers are employed for dressing and washing the fish under good hygienic and sanitation conditions. Tables and utensils in fish stalls are cleaned periodically by using

Table 3. Attributes scores on quality loss assessments in selected Retail outlets (Hedonic scaling method)

Attributes	Market I (RM ₁)	Market II (RM ₂)	Market III (RM ₃)
Colour	7	7	8
Appearance	8	8	8
Odour	7	8	8
Texture	7	8	8
Slime	7	8	8
Overall acceptability	7.2	7.6	8

disinfectants. To ensure the proper cleanliness of the fish market, monitoring needs to be followed on regular basis (Nowsad, 2014). In all retail markets, separate areas are marked for cleaning, storing and disposal of waste materials. Based on supply and demand situations, RM^s procure the required quantity of fish. RM^s receive both direct and online customers in their outlets and deliver the items as per the customer's preference. Leftover fishes from RM^s are usually taken by the suppliers and sold in WM; such arrangements enable the retail markets to maintain the delivery of 'same day fish' to their customers and thereby reducing the quality and quantity loss in this market segment and enabling the retail markets to maintain supreme position in the hedonic scale assessment.

It was observed that retail/supermarket III (RM₃) recorded a score value of 8, which corresponds to "like very much" on the hedonic scale. Among this category of markets, fish are sold in different forms like; 'uncut', whole fish, dressed (gilled and gutted), ready to cook etc. These outlets use separate display chillers for keeping processed and unprocessed fish items. All fishery products are labelled and displayed systematically according to size, species, type/form, value, processed, unprocessed, etc., along with price tags. As the unit price of items keeps fluctuating daily, price tags will be changed daily.

The role of processors, traders and intermediaries in fish price determination is significant in most fish markets. The market structure and distance from fishing to onshore landing centres also contribute towards the price determination of fish (Sambuo *et al.*, 2021). When compared to WM^s and PM^s, fish loss in supermarkets/RMs is negligible since they fulfil the required level of preservation, storage, and hygienic conditions with

minimal wastage. The study revealed that the highest overall acceptability value of 8 on the hedonic scale was recorded in RM^s, which is due to the stringent measures followed by these units in terms of engagement of skilled workers for fish dressing and cleaning, adoption of SSOP, systematic procedures for waste processing and disposal, maintenance of proper hygiene and sanitation.

Supermarkets also provide a 'see-through facility' to the cleaning areas, which enables consumers to be satisfied with the fish product they are buying. On average, supermarkets handle 900–1000 kg of fish daily (QLAM). Unsold fish are collected by the same suppliers and marketed in other markets. Compared to other types of markets, the highest level of consumer acceptability (80%) was recorded in RM, mainly due to the freshness of fish.

From Table 1, the score on sensory evaluation in the whole sale market showed values in-between 5 to 6 for the overall acceptability of various quality attributes like; colour, appearance, odour, texture and slime. For the sensory evaluation analysis in the wholesale market, I recorded a score value of 5 ("neither like nor dislike"), for parameters like colour, appearance and texture of the species. Whereas the hedonic score was 6 *i.e.* "like slightly" among WM₂ and WM₃ which indicate the inferiority of WM₁ over the other two markets. The score value of 6 ("like slightly") for the parameter on odour was unchanged in all three wholesale markets however the value for attributes on slime was lower (5) in WM₁ than in the rest of the two markets, thereby establishing comparatively better handling practices followed in the WM₂ and WM₃.

Quantity Loss Assessment

The term "post-harvest loss"—PHL refers to measurable quantitative and qualitative food loss in the post-harvest system (de Lucia and Assennato, 1994). This system comprises interconnected activities from the time of harvest through processing, marketing and food preparation, to the final decision by the consumer to eat or discard the food. Quantity losses refer to those that result in the loss of the amount of a product. Here for the analysis of the quantity loss of fish, the samples are taken from different markets. The samples were analyzed with help of IFLAM, including LT and QLAM (FAO, 2011). The Table 4

Table 4. Evaluation of percentage fish loss in selected markets through LT tracking and IFLAM method

Type of fish loss	Wholesale (%)	Public markets (%)	Retail outlets (%)
Physical loss (Damaged/ bruised / belly burst)	32	25	20
Market force (Demand and supply)	28	20	18
Quality loss (Sensory evaluation)	28	23	17
Transportation loss (loading/unloading)	22	20	16
Cleaning loss (descaling/cutting)	25	21	15

Table 5. Source of landing of fishes to the different markets through IFLAM and QLAM

Source	Local landing centres (%)	Within the state (%)	Outside the state (%)
Wholesale market	15	35	60
Public market	30	45	25
Retail market	50	40	10

Note: The assessments were collected from the traders and from the log book record that they are maintaining

represents the percentage of fish loss in different markets through LT and IFLAM methods (Load Tracking and Loss Assessment Methods are the assessment tools to assess how fish quality changes, identify why and where losses occur, assess the value of losses, and reduce the losses of fishes). The IFLAM method was conducted within the fishery operators to understand the type of loss, causes of loss, ideas for the reduction of loss etc. And the LT method helps to quantify the physical and quality fish losses along the distribution chain. From the analysis, it is observed that physical loss was more in the wholesale market (32%) in comparison to public markets and retail markets where it was 25 and 20% respectively, which could be due to a lack of proper storage, preservation conditions and better infrastructure facilities.

Factors contributing to the quality and quantity loss

Fish is a perishable commodity, immediately after a catch, a complicated series of chemical and bacterial changes begin to take place within the fish. If these changes are not controlled the fish quickly become spoiled and small-scale fish processing businesses can easily lose revenue due to spoilage. For the reduction of spoilage, fish should be kept at a lower temperature as much as possible, immediately after catching them until the processing starts. According to FAO, 25% of a catch of fish may be lost through one cause or another before its consumption. Various factors influence the rate of spoilage of fresh fish as listed viz., the time gap between the death of fish and final consumption, temperature abuse, poor handling practices, increased microbial contamination, poor processing techniques, animal predation insect infestation, improper packaging and storage, inadequate infrastructure, transportation loss etc. (Getu *et al.*, 2015). Furthermore, high moisture content, high fat content, high protein content, weak muscle tissue, ambient temperature, and unsanitary handling all contribute to fish deterioration. (Daluwatte and Sivakumar, 2018).

According to the percentage fish loss assessment, it was observed that the major factors contributing to the fish loss in markets are improper handling, lack of developed infrastructure, inadequate transportation facilities and damage caused during harvest

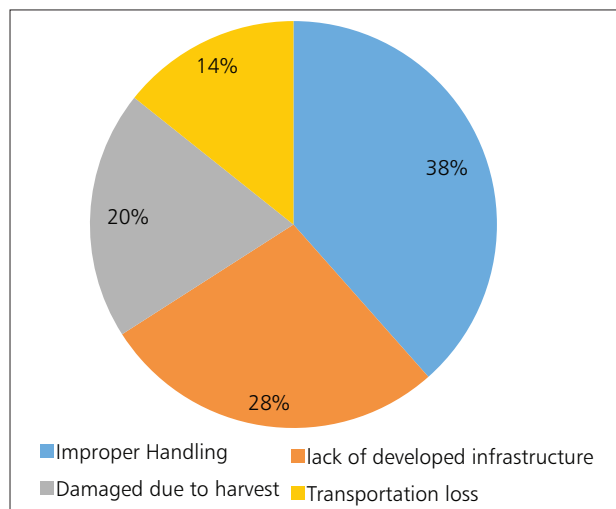


Fig. 2. Factors contributing to the fish loss assessment of fish along with value chain (QLAM) (Percentage fish loss assessment)

(Fig. 2). Among the major factors, the improper handling, has made highest percentage (38%) contribution towards fish loss followed by the lack of developed infrastructure damages due to harvest handling and transportation loss (Fig. 2). Training on proper operations, fish handling, and maintenance for those involved in local fish markets would be particularly beneficial, in which case on-site technical support from central/local government extension staff and resource persons would be beneficial for improving and promoting quality control and hygiene measures in local fish markets (Sato *et al.*, 2010).

The study further revealed that changing weather conditions along with poor chain management during transportation also influences the product quality and loss of fish as delays in delivery of fish to the market accelerate the spoilage and result in low-value realization. Lack of ice boxes, unavailability of good quality ice, the high price of ice, money lending at a high rate, and fluctuation of fish prices are some of the other constraints existing in domestic markets. Careless handling of fish during distribution can result in the fragmentation of the fish, which might make the fish become unsalable and adds to fish loss. The use of improper packaging, poor quality water utilized during this phase, inadequate processing capacity, and infestation/predation by insects, birds, and rats are some of the sources that contribute to fish loss and wastage during post-harvest handling operations (gutting, drying, fermenting, canning, filleting and packing). Market force losses occur when the demand-supply situation fluctuates, during peak landing seasons the market functionaries tend to slash the price, to take advantage of surplus quantity, which however most of the wholesale and public markets cannot handle, results in fish loss. The vendor may suffer a market force loss if the price of fish lowers due to overstock.

Market force loss is difficult to quantify precisely because it often precedes quality and physical losses.

Source of fish supply

Fish supply to domestic markets in Kerala is mainly sourced from marine and inland sectors of the state as well as from neighbouring states like Andhra Pradesh, Tamil Nadu, Karnataka, Goa etc. Generally, fish are packed in insulated and non-insulated trucks and transported to different markets in Kerala. Transportation of fish with insufficient icing can cause temperature abuse and contributes towards fish loss in the transportation chain. There is no regular and effective mechanism to monitor and control the transportation of fish from neighbouring states. Kerala receives over 1000 tonnes of fish every day from neighbouring states (Anon, 2020). In the WM, about 60% of the fish supply is coming from outside the state whereas in PM and RM the percentage share was 25% and 10% respectively (Table 5). Fish supply to the retail market in Kerala is mainly from local landing centres which account for about 50%. Fish supply to PM is mainly sourced from within the state (45%) followed by the RM which accounts for 40% of the supply chain. Based on the study it was observed that the source of fish supply is one of the important factors significantly contributing towards the fish loss in the domestic supply chain of fish markets in central Kerala.

Conclusion

The main reasons for quality and quantity losses in domestic fish markets were a lack of basic facilities, improper preservation methods, dirty handling, and temperature abuse during shipping. In wholesale markets, fresh fish that seems tasty and of good quality is not such, as revealed through QLAM study using sensory rating procedures. However, retail markets frequently outperformed wholesale markets in terms of hedonic scaling due to the availability of skilled labour and higher infrastructure support. Inadequate icing and temperature abuse were major factors contributing to a fish loss in public markets and they also lack potable water supply, proper display platforms/chilled counters, drainage, sewage treatment and waste disposal facilities. The seafood supply chain in domestic fish markets' are inefficient due to the presence of multifaceted intermediaries, who also contribute to fish loss in terms of both quality and quantity.

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