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Storage practices for silver cyprinid (*Rastrineobola argentea*) at landing sites around Lake Victoria and markets in Kampala, Uganda

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Abstract
Silver cyprinid (*Rastrineobola argentea*) is a very important source of protein especially for low income populations. The storage practices of dry silver cyprinid in Uganda are inadequately documented yet they may potentially contribute to post harvest losses and pose human health risks. This study was aimed at describing the storage practices for dry silver cyprinid from four selected landing sites on L. Victoria and five markets in Kampala. The study also assessed the traders' (n=112) knowledge of safety and quality of silver cyprinid. Data was collected through field surveys which involved use of interviewer administered questionnaires, physical observation and photography. The major storage practices were storage of dry silver cyprinid in closed gunny bags or in the open at ambient temperature (21.3-27.3°C). Most traders (n = 110) stored silver cyprinid for less than 3 months. Storage practices did not follow any standard operating procedures. Quantities stored per trader varied between 6 kg to 50 tonnes in markets and landing sites with a maximum storage capacity of 100 tonnes and 3 tonnes at landing sites and markets, respectively. Major determinants of stored quantities included prevailing demand (67%) at landing sites and available space (36%) in the markets. Traders at landing sites and in markets were generally aware of the need for quality. However, traders at landing sites were more aware about silver cyprinid quality. Some traders (n=10) used Tsunami-100 (active ingredients peroxyacetic acid and hydrogen peroxide) without any guidelines to control insect infestations in their stores. This study highlighted the need for strict stores inspection and training of silver cyprinid dealers on recommended storage practices.

Keywords: Silver cyprinid, *Rastrineobola argentea.* storage practices, Tsunami-100

1. Introduction
There has been increased consumption and utilization of fish as a livelihood support worldwide over the years (Richardson, Steffen, & Liverman, 2011) [28]. In Uganda, silver cyprinid (*Rastrineobola argentea*), a small pelagic fish is of growing importance with over 70% destined for human consumption (Masette, 2013; Legros & Masette, 2010) [23, 21]. The increase in utilization of silver fish in Uganda is due to its low cost, increased awareness of the nutrition value of this fish, the declining catches of table size fishes and increase in population (UBOS, 2015) [33].
Silver cyprinid is processed locally by sun drying (IOC, 2012) to yield a dry product which contains substantial amounts of nutrients such as proteins, minerals like calcium, iron, and vitamin A (Kabahenda, Amega, Okalany, Husken, & Heck, 2011) [17]. However, dry silver cyprinid is prone to several changes during storage such as nutrient degradation, browning, and rotting which can contribute to post harvest losses (Getu, Misganaw, & Bazezew, 2015) [11]. Storage is very important especially during periods of glut when fishers would sell the excess at much lower prices (Akande & Diei-Ouadi, 2010) thus experiencing high losses.
These losses can either be physical, inherent nutrient quality and economic losses with physical and quality losses compounding into economic losses (Getu, Misganaw, & Bazezew, 2015) [11]. Losses experienced at the landing site can have a bigger or smaller impact on the accrued profit or loss from dealing in dry silver cyprinid among the market traders. This is especially true for the local markets where most of the poor-quality human grade silver cyprinid ends up (Kabahenda, Omony, & Hüsken, 2009) [18]. All these translate into market losses due to price fluctuation on the side of silver cyprinid store managers and marketers.

Much as several authors have identified the post-harvest losses associated with the silver cyprinid value chain, little attention has been paid to the handling and storage practices for silver cyprinid at the landing site and in the markets. Evaluating these practices is crucial for understanding the cause of the losses and how they can be minimized. This study was therefore, aimed at assessing the handling and storage practices for silver cyprinid at lading sites and in the market. The study also established the quality assurance criteria used by the dealers in the silver fish value chain.

2. Materials and Methods

2.1 Study area and target population

The study was conducted at four landing sites around L. Victoria (Kiyindi, Katosi, Kasekulo, and Ssenyondo) and five markets (Kalerwe, Kibuye, Nakawa, Owino and Nateete) in Kampala district, Uganda. The location of the study area is shown in figure 1. The target population comprised of silver cyprinid traders operating stores for human grade dry silver cyprinid at landing sites and in Kampala markets. The key informants interviewed were heads of dry silver cyprinid traders or the chairperson for Ssenyondo landing site. The sample size to be considered was determined using the Van Daleen (2009) equation. The sample size was increased by 10% in anticipation of discrepancies in data collected from traders involved in storage. In order to ensure randomization of the study, each store was assigned a number and these were written on papers. The papers were folded, placed in a tin which was shaken and papers corresponding to the calculated sample size were picked. The first store that was met was assigned the first number and the next ones assigned corresponding numbers. Only consenting and willing individuals were involved in the study giving a varied sample size depending on the landing site and market. In total 71 and 41 traders were interviewed at the landing sites and in the markets, respectively.

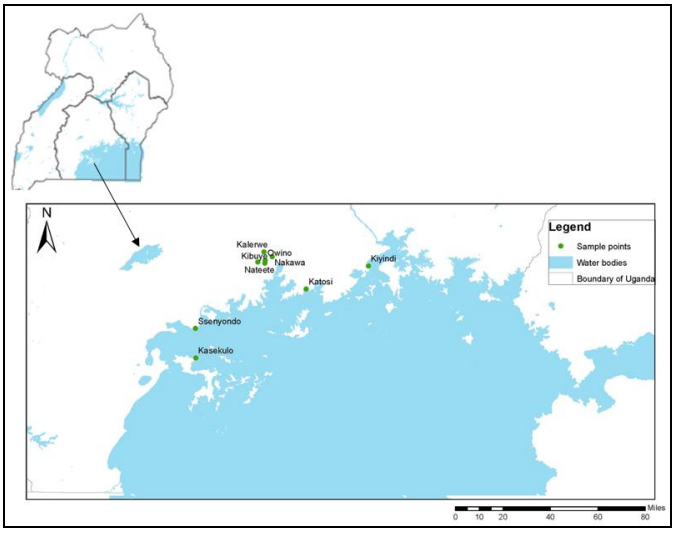

Fig 1: Geographical location of study area

2.2 Data collection techniques

Semi structured questionnaires, key informant interviews (KI), physical observations and photography were the data collection techniques used during the study. The questionnaires were pre-tested at Kasenyi landing site in Wakiso district and Muyubwe landing site in Buikwe district. Following the pre-test, the questionnaires were modified to include all the issues raised. The questionnaires covered aspects on storage practices, duration of storage, utilisation of stored fish and reasons for these varied practices among others.

2.3 Data analysis

Information from the survey on storage practices of dried silver cyprinid at landing sites and markets was summarized in Microsoft excel 2010. A chi square test was performed to test for significant differences among reasons for open and closed gunny bag storage in both landing sites and markets. The results were presented as bar graphs.

3. Results

3.1 Storage methods

The major storage options at landing sites and markets included storing dry silver cyprinid in closed gunny bags (gunny), keeping silver cyprinid open on stalls of the markets and spreading unpacked fish on the floor/tarpaulin in store rooms (Figure 2). Dealers at the landing sites mainly stored dry silver cyprinid in enclosed gunny bags (59%) or directly on the floor (36%). Storage was generally carried out at room temperature (21.3-27.3 °C) in both cases (landing sites and markets) except at Kiyindi landing site where one store owner kept dry fish in gunny bags in a cold room at 4° C. In markets, fish was mostly (81%) stored in stacked and closed gunny bags (without liner) with a tarpaulin over cover whereas gunny bags on racks/platform was least (3%) observed (Figure 2). The rest of the dealers (16%) kept silver cyprinid in the open on their stalls.

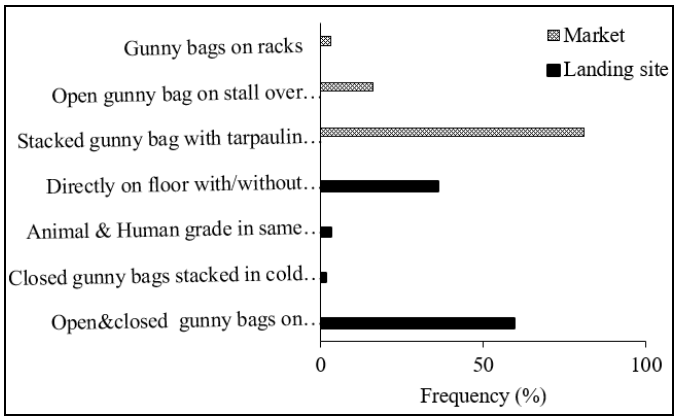

Fig 2: Prevailing storage and packaging practices of silver cyprinid at landing sites around L. Victoria and in Kampala markets.

3.1.2 Reasons for choosing specific storage methods

Silver cyprinid traders at the landing sites and in markets gave varying reasons for the choice of storage methods used (Table 1). Most of the fish dealers at landing sites noted that fish was kept in the open or in gunny bags to maintain quality. On the other hand, traders in markets used gunny bags to maximize space utilization (Table 1). In some locations, contradictory reasons for particular practices were given, for instance packing fish in gunny bags (in markets) and keeping it unpacked in open (at landing sites) were both cited as approaches that prevent browning.

A comparison of the reasons for the common practice of keeping fish un packed and in gunny bags for both landing site and market stores showed the reasons for using gunny bags among the traders in the markets were significantly different (χ^2=48.9 df =6, p< 0.05). Likewise, the reasons for keeping silver cyprinid in the open on the stalls of markets were significantly different (χ^2=12.0, df =3, p< 0.05). The

reasons for storing unpacked fish on the floor/tarpaulin at landing site store rooms were significantly different among the dealers (χ^2= 30.7 df =6, p< 0.05), as well as, those for storing in gunny bags (χ^2=17.8, df =3, p< 0.05).

Table 1: Reasons for some of the observed storage practices at landing sites and markets

	Store practice	Reason	Frequency for reason for practice (%)
Landing sites	Un packed spread on floor/tarpaulin	The floor maintains product quality. The floor protects fish from insect infestation and colour change	29
		Ease of display for customers	19
		Aeration to enhance further drying of the stored silver cyprinid.	19
		Tarpaulin keeps it clean	10
		Prevents browning	10
		Lack of gunny bags	6
		Prevents rotting and excessive drying	7
	Use of gunny bags	Spoilage prevention (safety, clean, quality)	40
		Customer preference	29
		Limited space and big quantities	19
		Easy handling	12
	Regular turning	Prevents browning	100
	Re-drying	Retards colour change and rotting	100
	Spraying stores and sprinkling salt	Prevents pests	100
Markets	Use of gunny bags	Prevent browning	10
		Maximize storage space	36
		Ensure safety and cleanliness	20
		Eases handling	12
		Sales at higher profit	10
		Protection from water	12
	Keeping it open on stalls	Small quantities	40
		Limited space	20
		Prevent spoilage	20
		Cheap	20
	Spraying with pesticides (Tsunami-100)	Pest control	100

n = 71 for landing sites and n = 41 for markets.

3.2 Quantities of dry silver cyprinid stored

Quantities stored per trader varied between 6 kg to 50 tonnes at landing sites and 6 kg to 2 tonnes in markets. Maximum storage capacities could reach over 100 tonnes and 3 tonnes at landing sites and markets, respectively. The quantities of fish stored were determined by various reasons according to traders (Figure 3). At landing sites, prevailing demand was the major determinant (67% of the respondents) while available space (36% of the respondents) was the key determinant in the markets for the amount of fish stored. When the demand for fish was high little was stored since most of it would be bought immediately before it got into the stores. During the rainy season, fish took long to dry and thus the partially dried fish was stored since it could not be sold. The rainy season also discouraged customers from accessing some storage areas thus prompting traders to store more fish while they waited for the customers. On one hand, others harvested less and stored less during the rainy season to avoid losses which were due to the high humidity that promoted spoilage of the dry fish. Those stores at landing sites involved in whole sale marketing waited to accumulate a certain quantity which was determined by the customer. In markets, the quantity stored depended only on the available space.

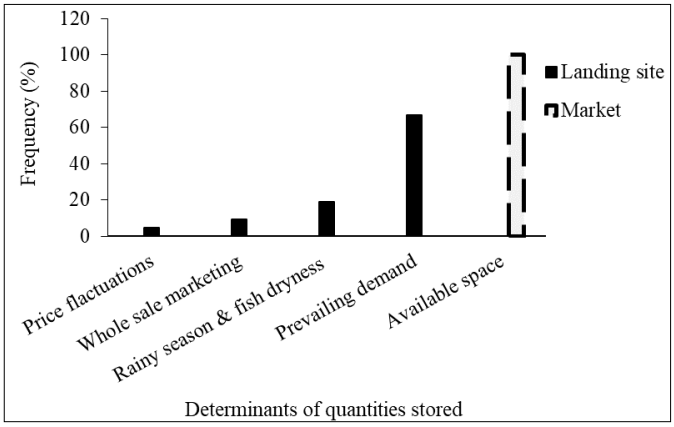

Fig 3: Determinants of silver cyprinid quantities stored at landing sites and markets.

3.3 Storage duration

At the landing site, 57% of dealers kept dry silver cyprinid for 1-3 months while a few individuals (19%) kept it for less than a week (Figure 4). In the markets, silver cyprinid was generally stored for up to 3 months with 77% of the dealers storing for 1-3 weeks, (Figure 4). Storage duration was

determined by both customers and traders. Customers' willingness to purchase the available quality and quantity of silver cyprinid was one of the key determinants of duration of storage. Traders kept accumulating silver cyprinid in the stores until they attained the quantity needed by target customers.

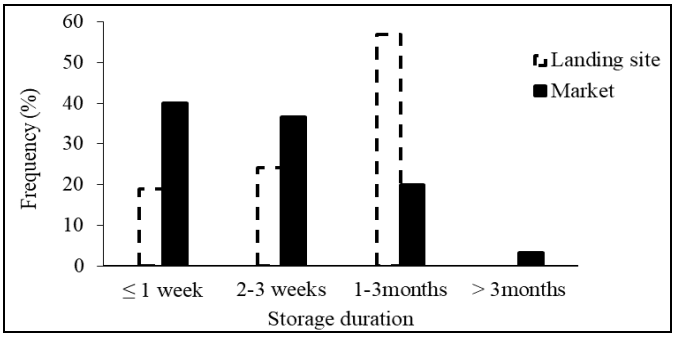

Fig 4: Storage duration of silver cyprinid on landing sites and markets

3.4 Quality assurance measures used in silver cyprinid storage

Silver cyprinid traders reported the use of various quality assurance measures which include: use of closed gunny bags, keeping silver cyprinid open on stalls of the markets, spreading unpacked fish on the floor/tarpaulin in store rooms, spraying with insecticides against mites in the markets, re-drying of inadequately dried fish every after 2 weeks in store, sprinkling salt on gunny bags with the fish, as well as, crevices in store rooms, spraying of store rooms and regular turning of products on the floor at the landing sites (Figure 5). Other practices carried out at landing sites to ensure quality include: spraying and cleaning of stores, ensuring protection from rain (Figure 5). Protection from rain (36%) and keeping in gunny bags (29%) were the most frequent quality assurance practices employed in the markets. This was followed by spraying (12%) with pesticide (Tsunami-100 especially against Hide beetles).

For each of the quality assurance measures, reasons were cited as to why they would influence quality (Table 1).

The quality criteria for silver cyprinid as used by the traders include: absence of foreign material (stones, insects, grass and animal droppings), proportion of fragmented fish, proportion of dried silver cyprinid to haplochromines (by catch) in the batch, foul odour and shiny appearance of the fish. The traders did not follow any official final product quality criteria despite the fact that an official standard provided by the Uganda National Bureau of Standards (UNBS) exists.

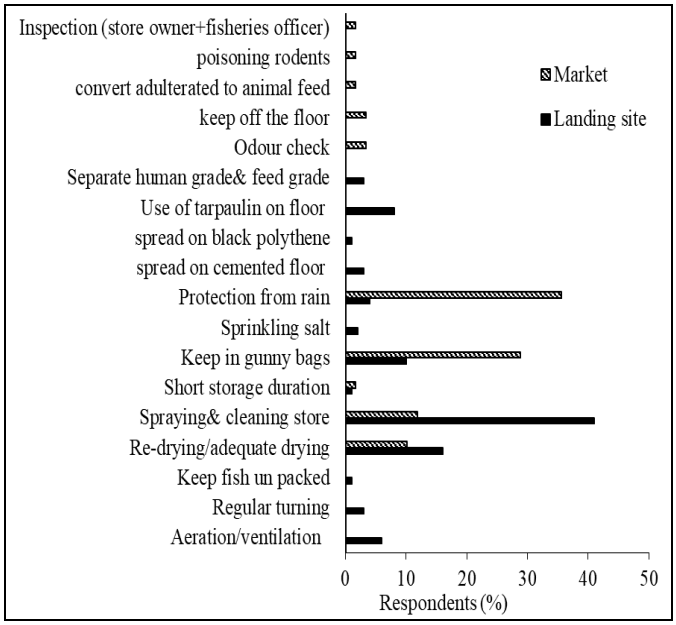

Fig 5: Prevailing quality assurance criteria used during storage of silver cyprinid

3.5 Utilization of silver cyprinid

Silver cyprinid was reported to be used as food for humans and feed for animals. The intended end use was mainly pre-determined at the landing site and the key determinants include: drying method, weather conditions, appearance, quality, size and quantity of by catch. Silver cyprinid dried on ground is generally destined for animal feed while that dried on nets and raised racks is destined for human food. During glut periods, silver cyprinid meant for human food should be big in size, silver in appearance and without by catch, however, during times of scarcity not much attention was paid to size, appearance or by catch (Figure 6a, b, c and d). During the rainy season high humidity and low temperatures favor microbial growth and lipid oxidation of the stored dry silver cyprinid thus making it unfit for human consumption. It was at the landing sites that the final target consumer could be determined but the moment dried silver cyprinid reached the market it was the same cost as that destined for human food.

Fig 6: Some of the determinants of mode of the utilization (a-Silver appearance of human grade silver cyprinid, b-brown silver cyprinid destined for animal feed during glut periods, c-goat droppings in dry silver cyprinid sack, d-a lot of by catch in silver cyprinid)

4. Discussion

4.1 Storage methods

The storage methods observed in this study (open storage and gunny bag storage) were generally similar to those previously reported in various studies (Jumbe, Kibas, Kakongoro, & Tumwebaze, 2007; Kabahenda, Omony, & Hüsken, 2009; Ssebisubi, 2011) [16, 18, 31]. Most silver cyprinid traders reported that keeping the fish in gunny bags (open or closed) prevents browning. Increased aerobic conditions, as with fish spread out on the floor, associated with high moisture and water activity facilitate the process of lipid oxidation which results in browning (Diei-Ouadi & Mgawe, 2011; Huss, 1995) [11, 13]. Therefore, use of gunny bags may contribute by enclosing the mass of dried silver cyprinid whilst reducing oxygen supply and access to moisture. However, there might be incidences where fish packed in gunny bags might deteriorate in quality.

This could be due to packaging partially/inadequately dried fish (Kabahenda, Omony, & Hüsken, 2009; Brigitte, Boogaard, & Heijenen, 2004) [18, 5] or that infested by insects whose respiration causes an increase in moisture content of the silver cyprinid (Chandra, Faridullah, Jahan, & Naher, 2016; Getu, Misganaw, & Bazezew, 2015) [6, 11]. Much as gunny bags permit moisture exchange (Obodai, Nyarko, Boamponsem, Coomson, & Aniwe, 2011; Chandra, Faridullah, Jahan, & Naher, 2016) [16, 27], studies of smoked fish have shown that closed packages offer better quality maintenance than open package during storage (Ayodele & Oyeleye, 2013) [3]. Silver cyprinid storage at landing site and in the market can be improved by utilizing hermetic storage technology, ensuring sufficient drying, use of desiccants and storing the gunny bags away from direct sunlight (Kumar & Kalita, 2017) [19]. Silver cyprinid should be stored away from direct sunlight because sunrays could penetrate these bags and hence act as precursors and/ or catalysts to lipid oxidation process (Sam, Jeyasanta, & Patterson, 2015; Fraser & Sumar, 1998) [30, 10] which alongside reducing the lipid content of fish alters the appearance, taste and thus general acceptability of the fish (Gillian & Michael, 1991) [12].

4.2 Choice of storage method

Much as traders of silver cyprinid at the landing sites and in markets cited the need to maintain product quality as the reason for storage in the open or in closed gunny bags, closed gunny bags are a better option for maintaining quality. Closed gunny bags are less permeable to oxygen and moisture as compared to open storage and may thus contribute to reducing the rate of degradation of the dry fish (Alcock, *et al*., 2007) [2]. Further still, when silver cyprinid is placed in gunny bags, it is press packed and the bags can be stacked to leave room for storage of other items (Kabahenda, Omony, & Hüsken, 2009) [18]. However, it is important to ensure adequate drying to avoid conditions that are favourable for nutrient degradation, microbial growth, insect infestation and rotting (Kabahenda, Omony, & Hüsken, 2009) [18].

4.3 Storage duration

Storage duration was determined by both customers and traders which is not in accordance with other researchers (Nurullah, Kamal, Islam, Ahasan, & Thilsted, 2007) [26] who identified quality of the product as one of the determinants of storage duration. Market demand determines the storage duration of dry silver cyprinid in that high effective demand from the market results in fish being stored for a shorter time at the landing site. However, when customers want a certain quantity, the traders keep accumulating silver cyprinid and store it until this quantity has been attained. If the traders obtain more than the quantity needed by one customer then they sell off the rest to other customers. This is especially the case for traders who export silver cyprinid to other countries.

On the other hand, traders can determine the storage duration of silver cyprinid by identifying potential customers and selling their produce to them. The longer storage duration of dried Silver cyprinid at landing site as compared to market can be attributed to the willingness of traders to purchase dried silver cyprinid from landing sites and not markets (EAC & LVFO, 2016). Therefore, the market traders purchase small quantities of dried silver cyprinid which they can keep for a short duration mainly targeting buyers of smaller quantities. Much as the traders and landing site store operators identified varied storage duration of up to 3 months, other studies (Nurullah, Kamal, Islam, Ahasan, & Thilsted, 2007; Sajib, *et al*., 2015) [26] reported two months as being optimal. Three months storage duration means that the fish loses it quality through browning, rancidity, softening, insect infestation and losing consumer appeal among others (Nurullah, Kamal, Islam, Ahasan, & Thilsted, 2007; Azhar & Nasa, 2006) [26, 4].

4.4 Quality assurance measures used in dried silver cyprinid storage

Alongside gunny bags and open storage, other practices such as proper ventilation, protection from rain, sprinkling of salt and spraying stores using agricultural and household pesticides to discourage growth of store room pests and some microorganisms prevent spoilage and maintain quality. Proper ventilation ensures proper aeration. Protection from rain safeguards fish from factors that would facilitate sticking together of the fish, mould growth and rotting. Sprinkling of salt reduces the water activity of the fish and may thus contribute to prolonging shelf life.

However, some of the practices such as sprinkling salt, spraying with a pesticide, re-using packages (gunny bags) and compacting fish reduce the rate of deterioration of one quality parameter and promote another or pose a health threat to the consumers. For instance, the unregulated use of pesticides to destroy storage pests may pose a health risk (Getu, Misganaw, & Bazezew, 2015) [11]. Although, Tsunami-100 (active ingredients peroxyacetic acid and hydrogen peroxide) is a food grade pesticide known to reduce *Escherichia coli*, *Listeria monocytogenes* and *Salmonella enterica* (United States Patent No. 5,409,713, 2009), there was no assurance for its regulated application. Tsunami-100 is harmful or fatal if swallowed and effluents containing this product are toxic to birds, fish, and aquatic invertebrates (United States Patent No. 5,409,713, 2009). The sprinkling of salt on dried fish in gunny bags intended to discourage some microbes and insects from infesting the fish, as well as, potentially reducing water activity, on the other hand could potentially facilitate lipid oxidation in case of high iron and copper content in the salt (Huss, 1995) [13]. Thus, the chemical purity of salt used would need to be verified if this practice is to be encouraged. Re-using the gunny bags without any treatment to reduce contamination and compacting of the dry fish using bare feet are potential sources of contamination (Akande & Diei-Ouadi, 2010) [1]. Re-drying which discourages insect infestation, microbial growth and rotting of stored dry fish can also promote lipid oxidation and associated browning from exposure to sunlight (Akande & Diei-Ouadi, 2010) [1].

Practices such as re-drying, sprinkling salt, keeping fish in the open and packaging partially dried fish in closed gunny bags may lead to degradation of nutrients like proteins, lipids, vitamins and minerals thus compromising the nutritive value of dried silver cyprinid (Kabahenda, Omony, & Hüsken, 2009; Masette & Khakasa, 2012) [18].

4.5 Utilization of silver cyprinid

The factors observed that determine intended end use were similar to those previously reported (EAC & LVFO, 2016; LVFO, 2012; Legros & Luomba, 2011) [8, 225]. The factors include silver cyprinid quality, quantity caught, presence of by catch and presence of foreign matter such as stones, glass. This is probably because consumers are becoming more aware of the adulteration and are ready to pay for the better quality demanded. Although there is detailed documented standard for human grade dry fish in Uganda, traders at landing sites do not know about it and mainly depend on the accrued benefit when turning the low-grade silver cyprinid to animal feed.

Each individual involved in silver cyprinid storage followed their own guidelines in deciding whether the fish should be destined for food or feed and these were determined by the input and accrued profit from sales in any form. If the silver cyprinid was highly costed, then the traders would do their best to make sure that this was sold at the price of human food. One coping strategy was be by purchasing good quality silver cyprinid and mixing it with their poor-quality silver cyprinid. Likewise, if the silver cyprinid was cheap especially in the glut season then traders would not take extra precaution to ensure that this was fit for human food. On the other hand, for some traders the main priority was to ensure that all the silver cyprinid was sold at the price of human food silver cyprinid.

Thus, the end product quality is not in accordance with the Uganda standard specifications for dried silver cyprinid which stipulates that human grade dried silver cyprinid should be free from adulteration that affect their appearance, edibility and keeping quality like sand, stones, metallic chips, plant parts, dirt and insects (EAS, 2014).

5. Conclusions

The major storage methods for dry silver cyprinid practiced at landing sites around L. Victoria and Kampala markets include open storage and storage in gunny bags. Other practices include proper ventilation, protection from rain, sprinkling of salt and insect pest control by spraying stores. Quantities stored per trader varied between 6 kg to 50 tonnes at landing sites and 6 kg to 2 tonnes in markets. Storage duration varied from 1-3 months and was mainly influenced by prevailing demand and the quantity of fish available. The variation in quality assurance measures practiced at the landing sites and in the markets and the fact that traders are unaware of the national standard for silver cyprinid could be major factors contributing to quality of the final product. There is therefore need for policy to regulate some of the practices and to enforce compliance with product specifications There is need for research on utilization of more efficient packages and storage practices that do not result in losses of key nutrients, promote palatability of the stored dry fish and do not pose a health risk to the silver cyprinid consumers.

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