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Artisanal processing and preservation practices carried out by silver cyprinid (*Rastrineobola argentea*) processors along the shores of Lake Victoria in Uganda

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Abstract
Silver cyprinid is a common low cost high protein source utilized in the Lake Victoria basin. The nutritional quality of this fish is affected by handling, processing and storage. A cross sectional survey was carried out to establish the processing techniques and related challenges in four silver cyprinid landing sites (Katosi, Kasekulo, Kiyindi and Ssenyondo) on Lake Victoria in Uganda. All processors interviewed (n = 115) their fish directly under. Drying on nets placed on the ground (41.7%) and on raised racks (37.4%) were mainly used for human grade silver cyprinid. 66.7% of the processors who dried their fish on nets on ground and 58.24% of those that dried their fish on raised racks did so to ensure clean fish while 50.0% of those who dried their fish directly on the ground did so to increase the weight of their final product. 46.7% of the processors who dried their fish on raised racks covered their fish with a waterproof material when it rained while the vast majority, 56.3% of the processors who dried their fish on nets spread over the ground and 43.5% of those that dried theirs directly on the sand, did not have a coping mechanism against the rains. For 45.8% of the processors who dried their fish on nets spread over the ground and 51.2% of those that did on raised racks appearance was the main indicator for the end of drying while 52.2% of those that dried their fish directly on the sand use less soil sticking on the surface of the fish as an indicator of the end of the drying process. While 50.0% of the processors who dried their fish directly on the sand cited rain as their main reason for loss, 52.0% and 48.8% of the processors who dried their fish on nets spread over the ground and on raised racks respectively cited by-catch such as haplochromines, prawns and shells as the main reason for losses during processing. Most of the processors (79.3%) processed their fish for human consumption.

Keywords: Silver cyprinid; *rastrineobola argentea*; processing; preservation; salting; drying

1. Introduction
Silver cyprinid (*Rastrineobola argentea*), also known as *mukene* in Uganda is the third commercially important specie accounting for 60% of the total fisheries biomass and 42% of the total fish catches in Uganda [1]. The major factors that affect the nutritional value of this fish are related to how it is handled, preserved and stored [2]. Preservation methods such as salting, drying, smoking, and deep frying have been developed to increase the shelf life and guarantee a sustainable supply all year round. Good hygienic practices including cleaning and disinfection of equipment (such as fishing and drying gear), boat and storage facilities are very important in controlling quality of silver cyprinid [3, 4].
Lake Victoria silver cyprinid is traditionally processed by sun drying on the ground, on mats, or on old fishing nets. The process offers no protection to the product from rain, animals or contamination by insects, sand and dirt. As a result, the silver cyprinid processors suffer greatly from excessive post-harvest losses [5, 6]. During periods of high supply, a lot of fish is spoilt and wasted due to poor processing and preservation at artisanal level, while acute shortage and increased prices of this fish are experienced in periods of low harvest[7].
When there is no supply of ice, as is common among silver cyprinid fishermen, fish should be brought to the shore as quickly as possible. This should be done in a clean boat and in a shade in order to limit spoilage [4, 8]. Sun drying is the most commonly used processing method for small fishes such as silver cyprinid [8]. The ideal weather for drying of fish is dry with low humidity where sun drying typically takes three to ten days though periods of one to three days are common [9].

Regardless of the fact that preservation techniques such as drying are utilized, the quality of silver cyprinid is still lacking. Almost 80% of the silver cyprinid harvested is still not fit for human consumption and is being used for feed and bait for larger fish [10]. This work was therefore carried out to establish the artisanal processing techniques that are prevalent in silver cyprinid landing sites along Lake Victoria in Uganda so as to ascertain why the quality of this fish is still is still low.

2. Materials and methods

A pilot survey was carried out to establish the sites to be selected. In this survey key informants in the Ministry of Agriculture, Animal Industry and Fisheries, and selected landing sites were interviewed and the questionnaire pretested at Kasenyi landing site in Wakiso district for modification to include relevant issues. On establishing the landing sites for the actual study, a survey was carried out to assess the various methods used to process silver cyprinid for human consumption and challenges faced by the processors.

The target population for this survey was the processors of silver cyprinid that was destined for human consumption. Key informant interviews, semi structured questionnaires, photography and onsite observation were used to get details on the methods used by the selected silver cyprinid processors, main landing seasons, source of knowledge on the processing of silver cyprinid, utilization of this knowledge, challenges faced during the processing of silver cyprinid, main consumers of the silver cyprinid, drying times and a rough estimate of the losses experienced.

2.1. Study area

This study was conducted in four landing sites along the shores of Lake Victoria in the Uganda including: Kiyindi, Katosi, Ssenyondo and Kasekuloes. The sites were purposively selected for the study as they were the key silver cyprinid processing sites in Uganda. The geographical location of the study sites is shown in figure 1.

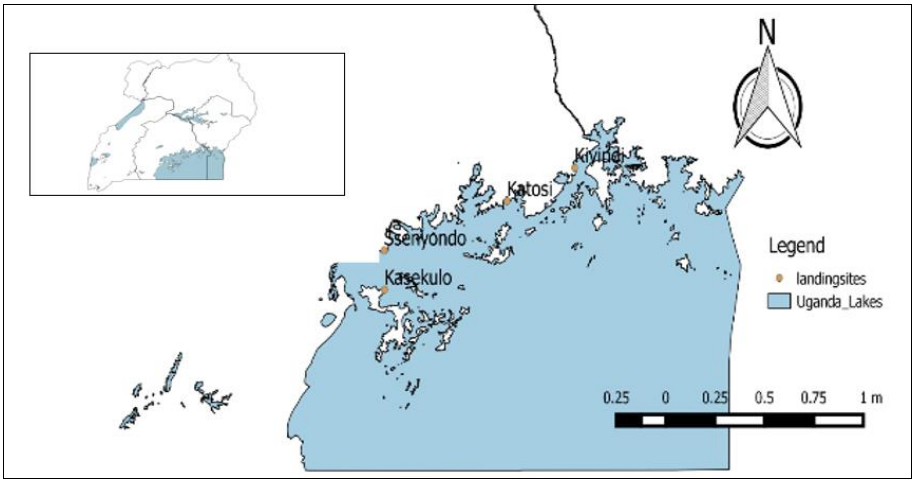

Fig 1: The geographical location of the selected landing sites along the shores of Lake Victoria

2.2. Sample size determination

Information from the key informant interviews with the fisheries officers and the chiefs of the silver cyprinid processors per site was used in the sample size calculation. The sample size was calculated using the equation below [11].

$$M.E = z\sqrt{\frac{p(1-p)}{n}}$$

Where. M.E: margin of error set at 5% for this study, z: tabulated z score which is 1.96 for 95% confidence interval selected for this study, p: expected proportion set at 0.5 and n: needed sample size

This sample size was adjusted to fit the population per site using the equation below [11].

$$n_a = \frac{n_r}{1 + \frac{(n_r - 1)}{N}}$$

Where n_a: adjusted sample size, n_r: originally calculated sample size, N: population size

In contemplation of disparities in data collected and participation acceptance among the silver cyprinid processors, the sample size was increased by 10%. The number of interviewees were proportionately chosen based on the population and processing schedule used per site. Only willing processors were interviewed resulting in variance in actual number of processors sampled. The total number of silver cyprinid processors interviewed were 115 distributed as follows: 28, 31, 40, and 16 processors from Kasekulo, Katosi, Kiyindi and Ssenyondo landing sites, respectively.

3. Results

Seventy-five of the processors interviewed were females. Eighty-five of them were in the range of 30 – 60 years of age, 23 of them were aged below 30 years and seven were above 60 years of age.

3.1. Drying and pretreatment methods used

All the processors interviewed dried their fish under direct sunlight with the highest fraction dried their fish on nets on the ground (41.7%). Others dried on the raised racks (37.4%) while 20.9% dried directly on the sand. Katosi processors dried fish entirely on nets placed on the ground. At Ssenyondo processors dried the fish only on raised racks apart from during periods of high catch when the raised racks were not enough to dry all the fish. In Kiyindi processors dried their fish both on raised racks and on nets placed on the ground whereas in Kasekulo the fish was dried directly on the sand on the beach and on raised racks. Dry salting of silver

cyprinid, which was the only salting method applied as per concentration required by the customer, was only observed in Kiyindi and Ssenyondo.

The reasons as to why the artisanal processors dry the silver cyprinid are presented in Figure 2. Customers' preference (47.0%) was the major reason followed by sun drying being more affordable (30.4%) than other methods such as freezing, deep frying and smoking since the sun's heat is free of charge. Some cited the fact that they found it there as the norm (11.3%). A very small percentage of the processors cited improving quality and shelf life (2.6%), the method being fast and easy (2.6%) and availability of drying space (3.5%) as the reason for sun drying silver cyprinid.

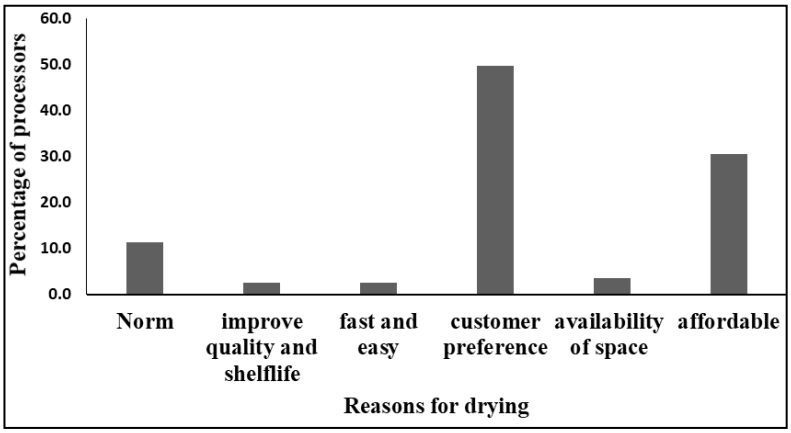

Fig 2: Reasons as to why artisanal processors at four landing sitesalong Lake Victoria in Uganda dry their fish

As shown in figure 3 below, the main reason as to why silver cyprinid processors, who dried their fish for human consumption, dried it on raised racks and on nets on ground was because they expected that the method they used would ensure clean fish (66.7% for nets on ground and 58.24% for raised racks). These processors also dried on racks and on nets on ground because their customers demanded the fish dried that way (8.3% for nets on ground and 34.88% for raised racks). Processors who processed silver cyprinid for animals dried their fish directly on the ground in order to increase the weight of the fish with sand since the fish was sold in kilograms (50.0%). Some of those claimed that animal feed doesn't need to be clean (33.33%) while others said that chicken need stones in their feed (16.67%). Other reasons given were, enforcement for those that dried on raised racks in Ssenyondo, norm, faster drying, and affordability of the processing method.

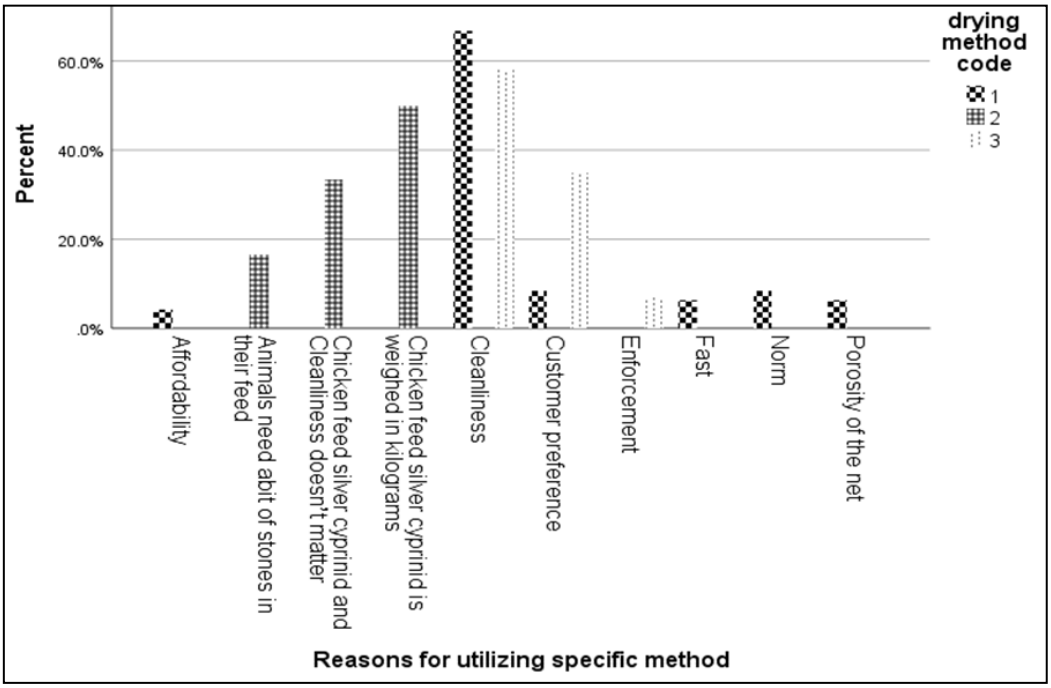

Fig 3: Reasons as to why artisanal processors in four landing sites along the shores of Lake Victoria in Uganda chose a specific technique of drying to dry their fish (1; net on ground, 2; directly on the beach sand and 3; raised racks)

About 78% of the processors did not salt their fish while the rest did. Dry salting was done due to various reasons as shown in Figure 4. The only reason as to why the processors dry salted their fish is because their customers wanted the fish treated that way (100%) those that did not salt also gave reasons of customer preference (51.1%) followed by the fact that that it was the norm (41.11%), instructions from the rack owner and affordability. Salted fish was mainly for export to The Democratic Republic of Congo and Rwanda.

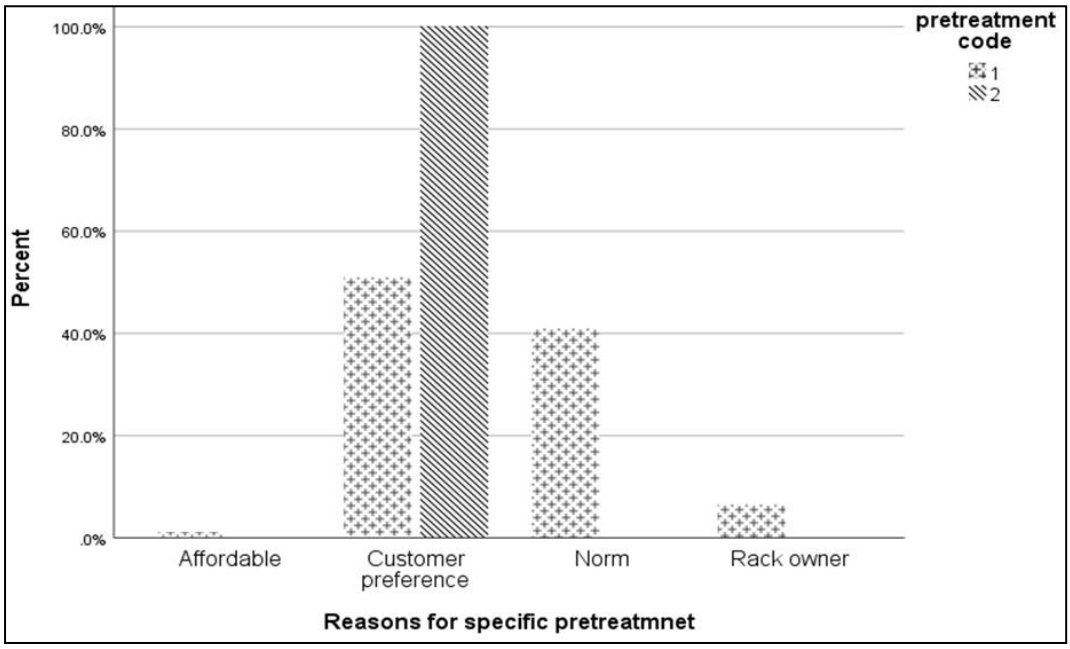

Fig 4: Reasons as to why artisanal processors in four landing sites along the shores of Lake Victoria in Uganda chose a specific pretreatment (1; no salting, and 2; dry salting)

3.2. Challenges faced by processors and the coping mechanisms developed

The highest percentage of the processors cited bad weather conditions (50.0% for nets on ground, 91,67% for directly on the sand and 55.81% for raised racks) as the main challenge faced during drying, followed by birds and other animals (18.75% for nets on ground, 4.17% for directly on sand, and 23.26% for raised racks) which would eat their fish and trample over it. Other challenges included the cost of drying in terms of drying space rent and equipment acquisition high, high boat prices, lack of market, presence of bycatch and dirty drying areas (Figure 5).

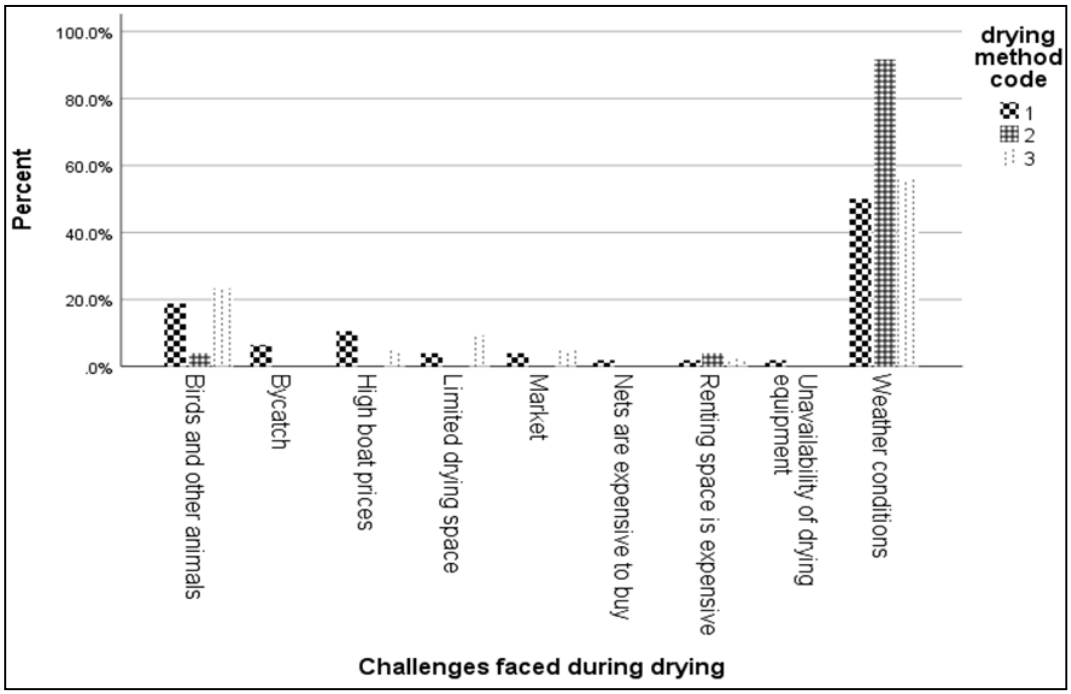

Fig 5: Challenges faced by silver cyprinid artisanal processors in four selected landing sites along the shores of Lake Victoria in Uganda using the different drying methods (1; nets on ground, 2; directly on the sand and 3; raised racks)

The coping mechanisms adopted by silver cyprinid processors are shown in Figure 6. Most of the processors who dried their fish on nets on ground and directly on the sand had no mechanisms to overcome the challenge of bad weather conditions (56.25% for nets on ground and 43. 48% for directly on sand) while others stored their fish during the rain (12.5% for nets on ground and 34. 78% for directly on sand). The processors who dried their fish on raised racks mainly covered their fish when it rained (46.34%) and opened up the covering after the rain stopped while others either did nothing about it (17.07%) or took it to the store to wait for the rain to stop (9.75%). It was difficult to cover fish dried on nets on the ground or directly on the sand. Processors would usually leave it to get spoilt and divert it to animal feed if the rain did

not stop for the whole day.

Other challenges were overcome by sorting out the bycatch during the drying process, chasing birds and animals away from the fish during the drying process. Notably, the processors who dried their fish directly on the sand tied string around the drying area (13.04%) to prevent animals and birds from walking over the drying fish. Some of the processors who dried their fish on raised racks sold their fish as fast as possible (2.44%) when the market was available to prevent losses incurred by storage of the fish.

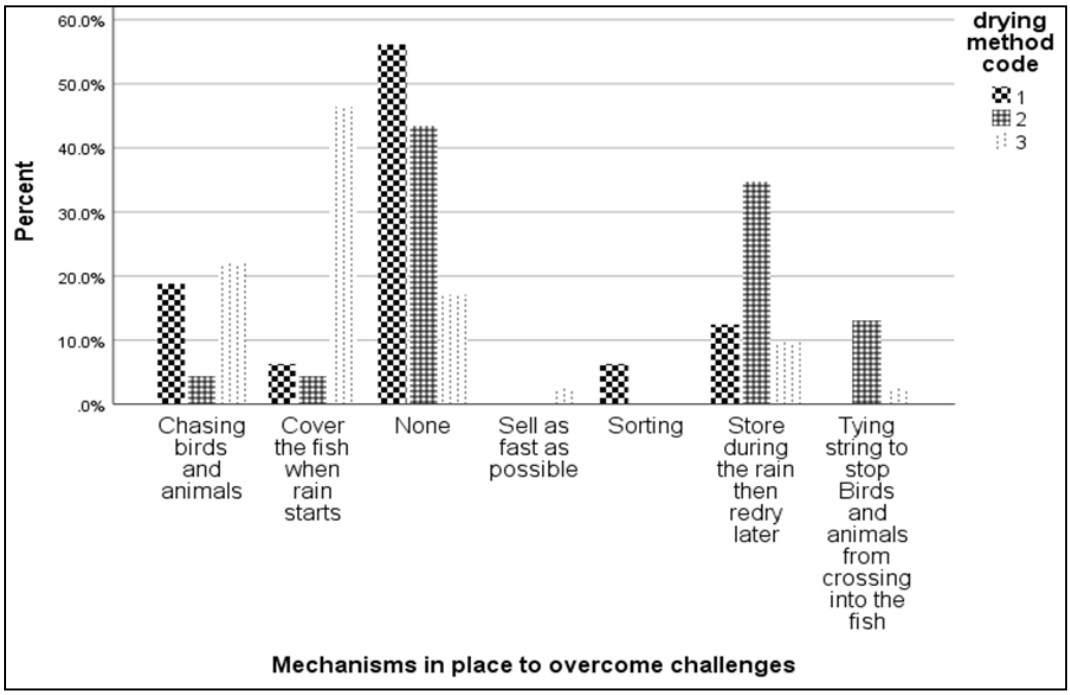

Fig 6: Coping mechanisms to overcome challenges used by artisanal silver cyprinid processors in four landing sites along the shores of Lake Victoria in Uganda using the different methods of drying (1; nets on ground, 2; directly on the sand, and 3; raised racks)

3.3. Indicators for end of drying

Silver cyprinid processors used a range of indicators (Figure 7) to determine that the fish was adequately dry and hence end the drying process. Majority of the processors used the appearance of the fish as an indicator of end of drying (45.83% for nets on ground, 30.48% for directly on the sand and 51.16% for raised rack). The silver shine of the dry fish is more profound than the wet fish. The reduction in amount of soil stuck on the fish was a vital indicator for the processors who dried their fish directly on the sand (52.17%) while brittleness of the fish was another important indicator for the processors that dried their fish on nets on ground (25.0%). Some of the processors that dried their fish on the raised racks pressed the fish for water as an indicator for the end of drying (11.63%) other indicators included texture, size, weight, aroma, and stiffness of the fish.

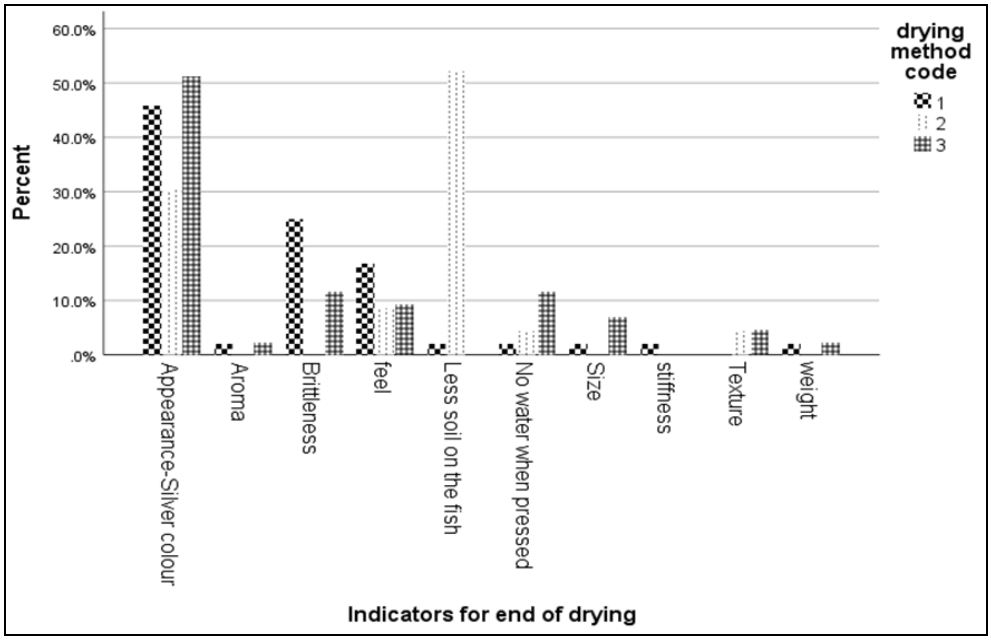

Fig 7: Indicators used by artisanal silver cyprinid processors in four landing sites along the shores of Lake Victoria in Uganda to judge end of drying (1; nets on ground, 2; directly on the sand, and 3; raised racks)

3.4. Drying procedure employed by processors in the four selected silver cyprinid landing sites

The processors processed their fish in four major stages including

Picking of fish from the boat: fish was brought to the shore either spread out on the wooden bottom plank of the boat or packed in special containers that were provided to fishermen by the processors. Fish that was caught in the early hours of the night was usually already in advanced stages of spoilage by the time it reached the shore. The bottom plank of the boat was seldom cleaned and if there was any cleaning, water from the shoreline would be used. The special containers on the other hand were always washed though the washing was done using the water at the shoreline. Processors stepped into the boat over the fish and scooped it into their basins before transporting it to their drying area. Transportation of fish to the drying area was done either on the head or on bicycles for drying areas that were far from the docking point.

Spreading of fish on the drying surface: processors that dried their fish on nets on ground scooped their fish from the basins on their heads using hands and dropped it on the net as they walked across the net. Their hands were covered with seldom washed socks to prevent being hurt by the bones and fins of the haplochromines. Processors that dried their fish on raised racks placed the special container or basin on the side of the rack and spread the fish over the rack using hands or small plates. Processors that salted their fish first heaped it on the drying surface and applied salt to the heap according to the concentration required by the customer. They then mixed the salt into the fish using hands and left the fish to drip dry as the slat entered the flesh of the fish. During this dripping the haplochromines are sorted out before the fish is spread over the drying surface.

Drying of the fish: this process takes about 6 to 8 hours on a sunny day with clear skies and two or more days during rainy days. During the drying process the silver cyprinid is routinely turned using small plates on the raised racks, brooms on the nets on ground and rakes for fish dried directly on the sand. The processors sort out the haplochromines and prawns during this time. Processors chased away birds from the drying area by tying strings around the drying surface, or by manually throwing stones at the birds and shouting.

Removal of fish from the drying area: at the end of drying, the customers that are waiting at the drying area buy the fish in basins. The fish that remains is packed in sacks and taken to the store. In the store, some processors pour the fish directly onto the ground and mix it with that which was already there while others packed their fish in sacks, weighed and stored it ready for the market. However the drying of this fish was not always possible in one day therefore the fish had to be kept either in stores or in the open until the next day when the drying continued.

3.5. Stages during processing where processors expected high spoilage

Most of the processors who dried their fish on raised racks and on nets spread over the ground (73.08% for raised racks and 64.29% for nets on ground) were keener on the cleanliness of their drying area and amenities such as basins and nets, followed by those that found the boat (26.92% for raised racks and 32.14% for nets on ground) as the determinant of the final quality of the fish. Half of the processors that dried their fish directly on the ground did not mind the quality of their fish by the end of drying (50.0%) while 33.33% and 16.67% were keen on the quality of the fish when it reached the shore (at the boat) and the cleanliness of their drying area and amenities such as basins for collecting the fish from the boat. (Figure 8).

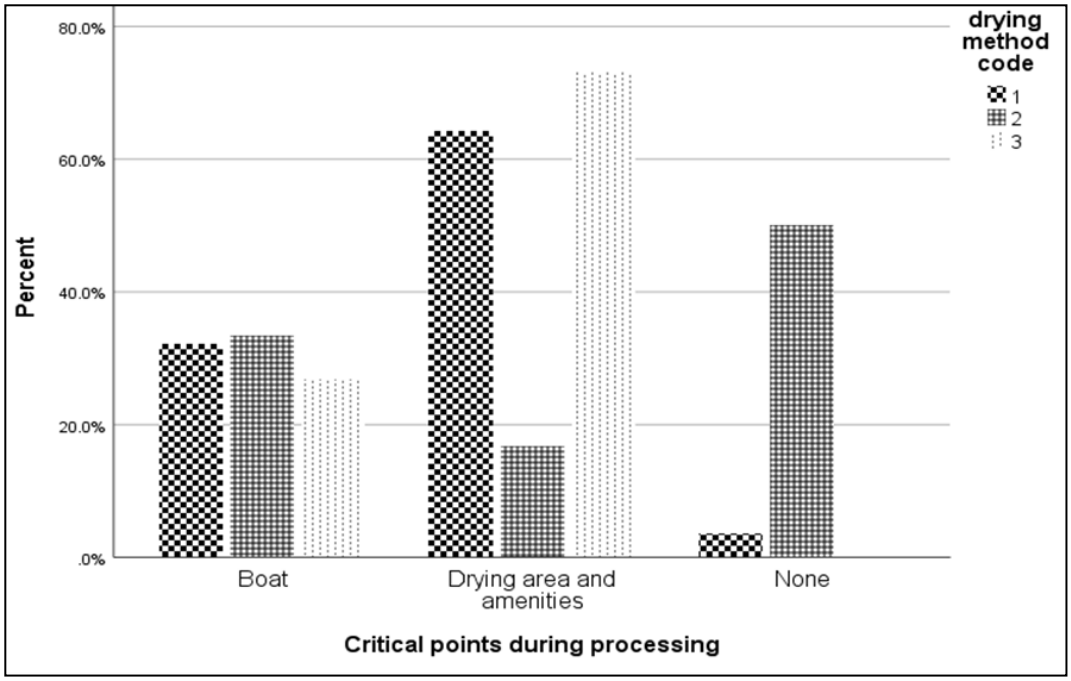

Fig 8: Points at which the artisanal silver cyprinid processors in four landing sites along the shores of Lake Victoria in Uganda expected contamination (1; nets on ground, 2; directly on sand and 3: raised racks)

3.6. Reasons for loss experienced during processing

Majority of the processors were satisfied with their fish and did not acknowledge losses since their fish was sold as volumes which increased after drying due to the less compact nature of dry fish or did not change if some physical losses were faced. Nevertheless, a number of reasons were cited for the losses in silver cyprinid catch at the different selected landing sites (Figure 9). By-catch including haplochromines, prawns and snail shells was the major reason cited for the losses experienced by the processors who dried their fish on nets spread over the ground and on raised racks (52.03 for the nets on ground and 48.84 for the raised racks) followed by bad weather conditions such as cold and rainy days (20.83% for nets on ground and 41.86% for raised racks). Those who dried their fish directly on the sand cited bad weather conditions (50.0%) as the major reason for losses followed by by-catch (33.33%). Other losses experienced were attributed to high boat prices of fish compared to the market price at the end of drying, birds and animals and the rancid aroma of silver fish.

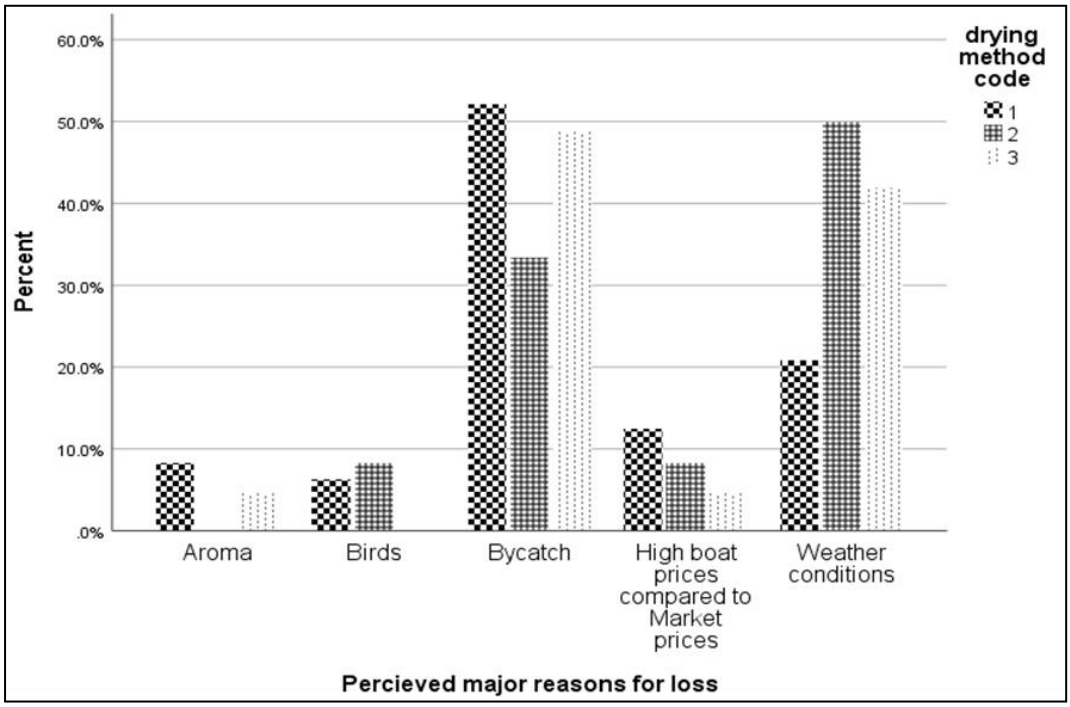

Fig 9: Reasons given by the artisanal silver cyprinid processors in four landing sites along the shores of Lake Victoria in Uganda for the losses experienced during procesing (1; nets on ground, 2; directly on the sand and 3; raised racks)

4. Discussion

4.1. Drying techniques and pretreatment used

Preservation by drying under direct sunlight, as was done by all the processors interviewed, ensures a decrease in moisture content thus slowing down the proliferation of microbes that depend on moisture to survive [12]. The main drying technique used by these processors was nets on ground. This ensured cleanliness to some extent since there was no direct contact with the ground. However, a small fraction of the processors still dried their fish directly on the beach sand. These traditional methods coupled with the poor handling practices expose the fish to contamination from domesticated animals (chicken, dogs and livestock) and wildlife (birds, lizards, and flies) which are important carriers of pathogens [3, 13, 14].

Drying on racks, which was adopted by some processors, has been suggested by other researchers as an appropriate method that can help reduce losses since the fish can easily be covered with water proof material during the rain [15, 16]. A higher quality product can also be obtained since pests and domestic animals or dirt cannot easily contaminate the fish. Raised racks also facilitate better air flow over the fish thus leading to shorter drying times [4]. Salting of fish prior to drying, as was done by a small fraction of the processors due to customer demand, is recommended since it ensures that the microorganisms are prohibited, enzyme activity is reduced and insects and vermin are kept away [9, 17, 21].

4.2. Drying time and indicators of end of drying

Drying of fish at the landing sites took between 7 to 9 h after which the processors deemed the fish dry enough to be sold. It was also noted by other researchers that the majority of the artisanal processors of silver cyprinid in Mfangano and Rusinga Islands, Kenya dried their fish for 6 – 8 h on a good dry weather day and over 2 days otherwise [3]. The drying time used is typically one day on a sunny day with clear blue skies and low humidity [8, 9]. The degree of dryness was checked by appearance and touching to feel its texture, brittleness and dryness. Depending on the fish species, naturally dried fish should take about 3 – 10 days to dry to a moisture content of 15% and below given that the conditions are good and that it does not rain[4]. 7 – 9 hours is therefore not sufficient to bring the moisture content to 15% and below in order to arrest the growth of molds and preserve its keeping quality

4.3. Challenges faced by silver cyprinid processors

Silver cyprinid processors faced a major challenge of bad weather conditions. Rains generally led to delays in drying thus leading to spoilage of the fish. Fish easily spoils due to its high moisture content that encourages the proliferation of microbes and activity of enzymes. Spoilage of fish due to delays in drying was also the main reason for losses experienced by the processors because spoilt fish is not highly priced or diverted to animal feed. The low-income earners who buy the poor-quality fish are exposed to potential health hazards or unwholesome products increasing their vulnerability to disease [22].

Birds and animals in the drying area led to contamination of the fish by droppings and also loss of actual fish through being eaten. Processors had to pay children to chase the birds away from the fish all day leading to some of the children missing school. Paying the children to chase away animals combined with high boat prices compared to the selling price negatively affected the economic balance of these processors.

Hauling fish directly onto the wooden plank of the boat without any preservation strategy led to cross contamination of the fish between the fish and other fish or between the fish and the wooden plank that was either rarely cleaned or cleaned using the contaminated lake water at the shore hence spoilage of fresh fish by the time the fish reached the shore. Limiting the rate of deterioration of fish requires that the fish is transported to the shore as quickly as possible, held in a clean boat and on ice if possible [4, 14, 22, 23].

Turning of the fish using plates, brooms and rakes as was done at these sites could lead to injury of the fish tissue exposing it to the atmospheric air and light thence enhancing lipid oxidation and also belly bursting causing leakage of enzymes from the viscera to breakdown fats and proteins leading to both nutritional loss and autolytic oxidation [24]. The socks used for spreading the silver fish over the nets on the ground were seldom washed and would be a contamination point [25]. Throwing of fish from the height of the top of the head to the ground would also lead to damage of the fish [26].

Processors used basins to collect fish from the boat and could cause damage to the skin of the fish as they scooped it out of the boats. Stepping on the fish during the turning process on the nets on ground, could lead to even more degradation from microbial contamination and spillage of enzymes [24].

5. Conclusion

There is not standard and controlled method for processing of silver cyprinid at the landing sites in Uganda. The silver cyprinid is mainly dried. Two main drying techniques are generally used for human grade silver cyprinid: use of nets on ground and on raised racks. Most processors dry their fish on nets on ground. Silver cyprinid meant for animal feed is dried directly on the ground. Salting is carried out by a few processors as per customer demand and this salted fish was mostly for export. Implementation of a standardized processing protocol for silver cyprinid maybe essential for ensuring consistent product quality.

6. Acknowledgements

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