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Research Article

Post-Harvest Handling and Microbial Quality of Fish along the Value Chain in Lake Hawassa

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Abstract

The objective of the current study was to investigate post-harvest handling and microbial quality of raw fish meat along fish value chain actors. A survey was conducted on 45 fishermen, 45 fish retailers and 45 fish consumers. Apart from observation, raw fish meat samples were collected from the actors that participated during the survey. About 30 samples were collected from fish actors (10 samples from each actor). The results showed that out of the total responses by the fishermen, about 56% have only gillnet while 31% have owned both gillnet and boat. Only 44% of interviewed fishermen had full gutting equipment. On retailers' side, about 82% of them sell fish directly to consumers in the surrounding of the lake and through door to door service. Plastic containers (58%) and "plastic bag" (26%) were also reported as storage materials. The top two ranked problems mentioned by the fishermen are entry of unlicensed fishermen to the lake (1st) and gillnet stealing (2nd) whereas low supply of fish (1st) mainly by retailors side. The fish consumers buy fish from the lakeside (96%), hotel and restaurant (36%) and door to door sellers (24%). There was non-significant difference ($p>0.05$) in the total count of coli-form and *E. coli* in raw fish samples between fishermen, fish retailers and fish consumers. Total bacterial count of raw fish meat sampled from fishermen, fish retailers and fish consumers was 2.55 cfu/ml, 2.34 cfu/ml and 1.88 cfu/ml, respectively. So, the result indicated that there was no significant difference between fisherman and fish retailers but both have shown statistically significant difference with the fish consumers. Similarly, significance difference was observed for *salmonella* count between fishermen (1.97 cfu/ml) and fish consumers (1.27 cfu/ml). The count of *salmonella* along all actors are below the recommended standard (per 25 ml dilution) though higher count was found in samples collected from consumers than fishermen. Generally, the fishermen and fish retailers used inappropriate fishing, processing and storage materials that have contributed to the increased bacterial load and resulted in deterioration of the quality of fish. Thus awareness creation on hygienic handling of fish, introduction of improved handling and processing equipment are required.

Keywords: Fishermen; Fish retailors; Hygienic handling; Fish consumers; Lake Hawassa

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Introduction

Fish is considered as one of the natural resources which is nutritionally rich food for human consumption It contains high percentage of protein (18.5%) in comparison with cattle meat (16.8%), egg (13.6%) and milk (3.5%) also some species of fish contain 25% fat. Nutritionally the value of fish meat comprises of moisture, dry matter, protein, lipids, vitamins and minerals plus it contains the caloric value of the fish [1,2]

Ethiopia is one of the countries in the sub-Saharan Africa with the highest rates of malnutrition in children [3]. Some of the underlying and basic causes for the problem could be low agricultural production, low and inadequate food consumption and malnutrition, and diseases. Among different livestock food sources, fresh fish meat can be a basic source of protein for children to reduce protein-energy malnutrition. Its dietary contribution of fish as animal proteins which is crucial component in some densely populated countries where total protein intake levels may be low. Additionally FAO mentioned that on average, fish provides about 20–30 kilocalories per person per day. Besides the importance the contribution is low. According to FAO [4], fish consumption is lowest in Africa (9.1 kg per capita per year).

Despite the contribution of fish as food, its muscle tissue undergoes faster spoilage than mammalian muscles due to higher water content, free amino acid content and lower content of connective tissue as compared to other flesh foods [5].Thus keeping the freshness is fundamental to its quality. Fish freshness can be obtained by defining criteria of the changes in the sensory attributes like appearance, odor, color and texture, which can be measured and quantified by sensory organs or instrumental methods. If the freshness of fish is lost, then risks will happen to the consumer. There are few infectious agents in fish which infect humans, some exceptions exist that may result in fatalities. It is also mentioned that the greatest risk to human health is due to the consumption of raw or insufficiently processed fish and fish products [6]. According to FAO [7], the flesh of newly caught fish is free of bacteria though considerable amounts of bacteria may be in viscera, gills and on skin. The growth of pathogenic micro-organisms in fish is reduced by stabilizing the temperature to about 0°C. Thus reducing the spoilage rate and reducing or even possible to eliminate some safety risk. When the fish is stored whole in the ice, the deterioration caused by bacteria is minimal for the first days of storage.

The shelf-life of fish is limited by the activity of microorganism even if there are important non microbiological factors of fish deterioration. A number of microbiological tests of fish and fish products for examining pathogenic bacteria (*Salmonella, V. parahaemolyticus, Staphylococcus aureus, Listeria monocytogenes, E.coli*) or for organisms which are possible indications of fecal contamination (*E. coli*) or other types of general contamination or poor manufacturing practices (coliform bacteria, fecal streptococci, Aerobic Plate Count (APC) can be detected [8]. Thus the current study assessed post-harvest handling of fish and identified microbiological load of raw fish collected from different fishery value chain actors (fisherman up to fish consumers).

Material and Methods

Description of the study area

Lake Hawassa is located in the main Ethiopian Rift valley located in Sidama Region, in which its surface area is 90 km2, with a mean depth of 11 m, a volume of water 1.036 x 109 m3 and a drainage area of 1,250 km [2,9]. Geographically, the lake lies between 6°33'–7°33' N and 38°22'–38°29' E at an altitude of 1680 m.a.s.l. It is a terminal lake with no surface out flow and receives surface inflow through Tikur Wuha River. Among the three commercially exploited species in the lake Hawassa are Tilapia, Catfish and Labeobarbus where Tilapia yield accounts for about 85% by weight of the total annual landings [10] (Figure 1).

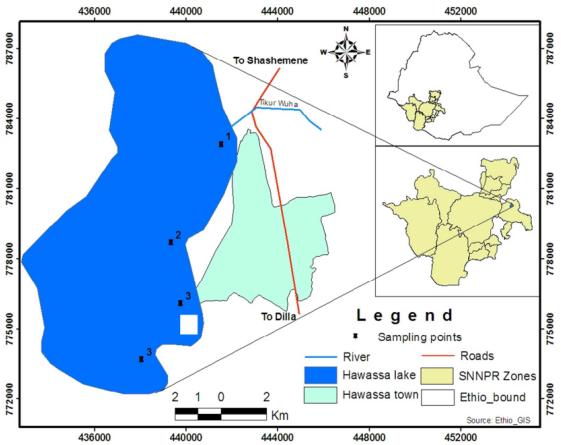

Figure 1. *Map of Lake Hawassa and Hawasa Town [11].*

Assessment methodology

Survey was conducted on fish post-harvest handling practice on different value chain actors such as on 45 fisher men, 45 fish retailers and 45 fish consumers. The fishermen were selected randomly from 256 fish cooperatives members in the surroundings of the lake Hawassa. While the retailers and consumers from the lake side and from surroundings and from door to door.

Procedures for sample collection and laboratory experiment

Sample collection: Filleted fish samples were collected from 10 fishermen, 10 fish retailers and from 10 fish consumers.

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Raw fish meat samples were taken for microbial load analysis immediately after the fishermen harvested and gutted the fish. (Figure 2) The samples from the retailers were taken from their plastic storage material while the samples from the consumers were taken from the prepared raw fish meat dish ready for consumption. From all the actors three fish slices were taken as one sample (25 gram sliced fish sample composition from three fish) (Table 1). The samples were put in ice box and traveled to Adami Tulu Research Center for laboratory analysis before 24 hours.

Sample preparation procedure

The procedure for microbial load analysis of the raw fish meat sample is followed as:

1. Sliced fish sample was each homogenize for 1-2 min at low speed with stomacher machine

2. Measure 1 gram sliced fish

3. Dilution of the measured fish sample with 10 ml of peptone water

4. Mixed uniformly the peptone water with the sliced fish sample

5. About 1 ml diluted fish sample was taken and submerged in 9 ml distilled water test tube

6. Dilution of the fish sample done up to 104

Results and Discussion

Results of survey

Type of occupation and major source of income for fisherman: Indicated the type of major activity and income source of interviewed fishermen. From 100% of fishermen response, 84% of them engaged in fishing while the remaining in both fishing and farming. In contrary to the current result, vast majority of fisher farmer communities in Congo were engaged in both farming and in fishing activities [14]. The fishermen who are involved in fishing and farming activities (15.6%) in the present study were those who are residents in the surrounding of the lake. They usually undertake some farming activities such as vegetable and seasonal maize and other crop production by using irrigation from the lake. Besides crop production activities, they were also engaged in livestock production activities such as small ruminant, poultry and dairy production. The fishermen harvest fish for the purpose of selling (56%) and for both selling and household consumption (44%) (Table 2).

The income of the majorities of the fishermen (84.4%) was by selling whole fish alone while the remaining percentages of interviewed fisherman sale fish together with crop and livestock products. Reports indicated that 93% of fisherman respondents generated their income through fish trading in Gilegel gibe dam [15] whereas residents elsewhere in

Figure 2. *Procedure for microbial load analysis of the raw fish meat sample.*

Table 1. *Media types used for bacterial identification.*

Identified Bacteria's	Type of media Used for Identification	Time of incubation (hr)	Color	Incubation temp (oc)	source
TC	VRBA	18 - 24	Pink	37	[12]
E.coli	MA	18 - 72	Red	37	[12].
Salmonella	BGA	18 - 24	Pink - Red	35+2	[13]
TBC	SPC	18 - 48	Light yellow (slightly opalescent gel form)	32+2	[13]

Table 2. *Major occupation and income source for livelihood of fisherman.*

Parameters	Frequency (%) (n=45)
Major occupation for their livelihood	
Fishing alone	38 (84.4)
Fishing and Farming	7 (15.6)
Purpose of Fishing	
For selling	25 (55.6)
For selling and for household consumption	20 (44.4)
Income source	
Sale of whole fish alone	38 (84.4)
Sale of whole fish and crops	2 (4.5)
Sale of filleted fish, whole fish, crop and livestock	5 (11.1)

African such as in the lake side of Congo reported that about 65% of their total cash income was through fishing [14]. In contrary to the current study, the finding around Tigray region showed that fishing play little role in the households livelihood despite the presence of lakes, rivers and reservoirs in Tigray region [15].

Fishing equipment

Fishermen groups in the surroundings of Lake Hawassa were categorized in to two. The first group was licensed and organized as fishermen cooperative while the other was illegal and unlicensed group. The licensed fishermen cooperative were organized in different one to five groups and have about 256 members. About 96% of fishermen in the lake side reported that there was no full fishing equipment owned by cooperative members. Only 9% of the fishermen have full fishing equipment (Gillnet, hook line and boat) (Figure 3). The fishermen accomplish their everyday fishing activity by borrowing from the members in the cooperatives. Similarly the fishing equipments such as hooks of different sizes, traps, locally made and the gillnets were rarely used in Ilu Abba Bora zone, south west Ethiopia [16] and gillnet and hook lines reported in Gelegel Gibe Dam as fishing gear [15].

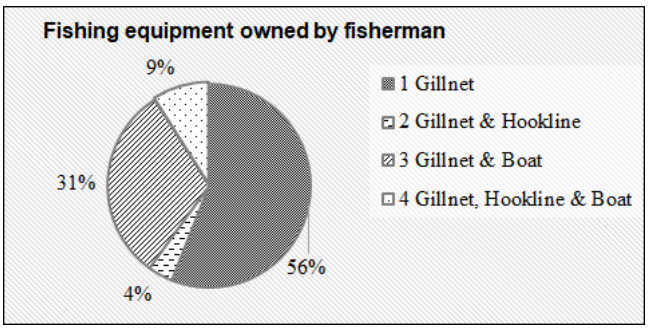

Figure 3. *Fishing equipment owned and utilized by fishermen.*

The improper and inadequate fishing equipment and boat service may results in reduced fish harvest and increased fish post-harvest loss.

Fish storage material, gutting place and transportation system of fisherman

About 87% of the fishermen used whole fish storage material, 57% used wooden box and 13% used plastic box as fishing bucket (Table 3). In addition to that they used different ways to transport and deliver fish to retailers and different customers. The transportation systems as replied by 51% and 44% are on foot and through cart, respectively. Usually when the fisherman deliver the catch fish to the nearby customers and retailers at the lake side they use foot while cart horses or donkeys to transport to different supermarket in the town and to hotel and restaurants.

Table 3. *Fish storage material, gutting areas and transportation system by Fisherman's (Data of 2018 G.C).*

Parameters	Frequency (percent) n=45
Fish storage material immediately after harvest	
Wooden box	39 (86.7)
Plastic box	6 (13.3)
Fish transportation means to retailers	
Cart	20 (44.4)
On foot	23 (51.1)
Bajaje (vehicles)	2 (4.4)
Fisherman's processing areas	
"Shera"(plastic material)	16 (35.6)
Timber made table	14 (31)
Cement made ground	12 (26.7)
Grass (ground)	3 (6.7)

The interviewed fisherman mentioned the frequently undertaken gutting areas of fish. About 36%, 31% and 27% of interviewed fishermen mentioned that gutting was takes place on "shera" timber, and on cemented ground respectively.

Marketing channel and method of fish selling by retailors

The interviewed all fish retailers gathered their income by selling fish only. There are two methods of fish selling by retailors. The interviewed retailors either sell directly to individual customers (consumers) (82%) and the remaining percentage for selling their fish to hotel and restaurants. The way the fish was sold to customers and hotel and restaurants were different. It is sold in the form of whole fish only (26%), soup form only (27%) and as filleted form only (21%) (Figure 4). The remaining 27% of the retailers' sale all types of fish dishes (soup, roasted, filleted fish) together.

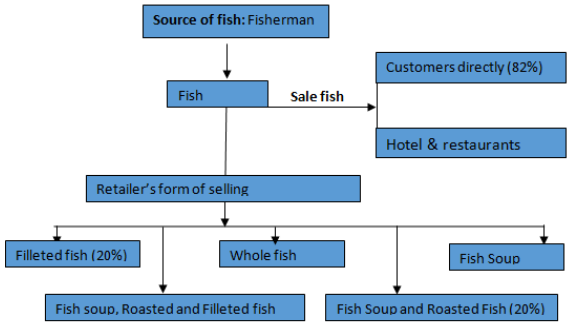

Figure 4. *Fish selling pathway (retailers) and form of selling.*

Storage and transporting materials of fish by retailors

Fish retailers utilize different materials for storage and transporting purposes. As highly perishable commodity, fish requires extremely specialized storage and transporting facilities. The current finding showed that about 58% and 26% of the retailers used plastic containers and plastic bags for storage and transporting purpose, respectively

(Figure 5). The remaining retailers use metallic and wooden box for similar purpose. The study conducted by UA [17] reported that certain fish storage containers that provide good insulation from heat are wooden or Styrofoam container type whereas containers like metal or plastic were reported as poor insulators and may have to be wrapped with wet towels or packed with ice to keep temperatures down. Thus the commonly used plastic bags, plastic containers as well as metallic containers in the present study were not kept with ice and this probably hasten spoilage rate and increased fish post-harvest loss.

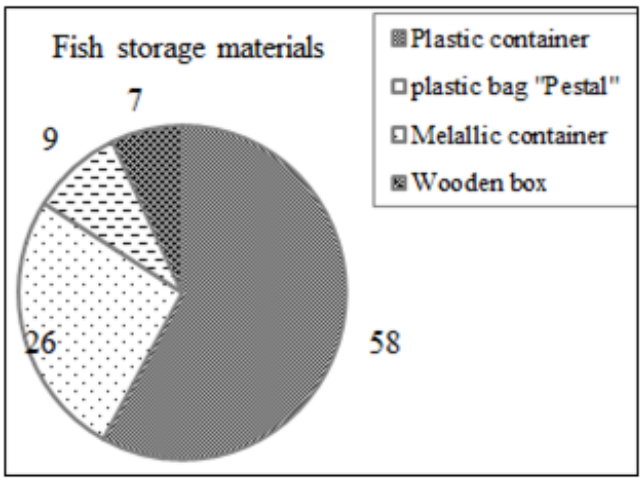

Figure 5. *Fish storage materials.*

Moreover the interviewed retailers receive fish from fisherman by checking the health condition of the fish by using sensory evaluation method. This sensory evaluation was indicated to measure freshness of fish and fish products by using five distinct senses including taste, smell, feel and appearance [18]. Another study report mentioned that, sensory methods are the most satisfactory for assessing the spoilage and freshness of fish and fishery products [19]. Discoloration, slime formation, changes in texture, off-odors, off –flavors, and gas production are signs for fish spoilage [20]. The current study assessed fish spoilage identification method from the response of retailors. From interviewed 100% of retailers, about 51% of them identify spoiled fish by observing color and 35% of them by touching and observing the physical change (Figure 6). According to the retailers' observation, color (dark color) was an indication to identify spoilage of whole fish. This might be due to a prolonged stay of the fish in water (lake) under the nate and due to contamination. The prolonged stay of whole fish might results stress on fish and color change may occur. Long fishing hours as well as extended period between capture and arrival at landing sites was reported as a cause for fish spoilage [21]. Thus delays in hauling nets results spoilage of fish, quality loss and increased fish post-harvest loss.

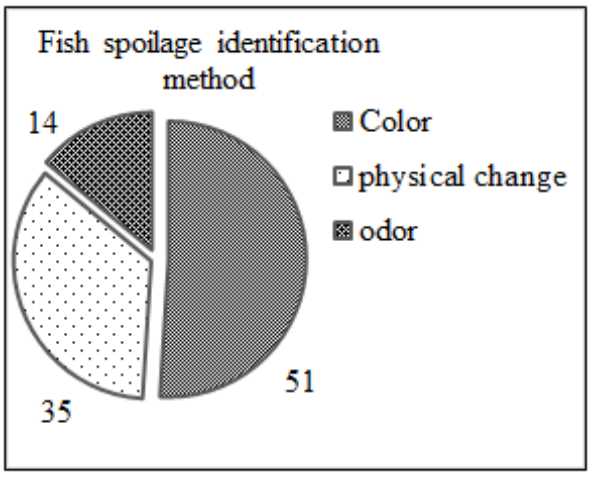

Figure 6. *Spoiled fish identification.*

Fish selling places and system for transporting

Most of the retailers (69%) sell fish directly to consumers. The consumers can be in the lake side or through door to door servicing. About 27% of retailers deliver fish to hotel and restaurants. Similarly Ethiopian fisheries and aquaculture country profile indicated that about 73% of the total fish landed is marketed as fresh in the nearby markets and the rest reaches distant consumers either chilled or frozen (26%), or dried and smoked (1%) [22]. Thus a more traditional habit was existed in selling fish in the surroundings of Lake Hawassa. Different transportation means were used by retailers to transport whole and filleted fish to different hotels, restaurants, small kiosks and to the nearby customers.

About 49% and 47% of the retailers transport fish on foot and through vehicle (Bajaje) respectively. Only 4.4% of them used motorbike to transport fish. According to the UA [17] report, once fish have been placed in transport container, (Table 4) they should be brought to their destination by the quickest possible means that would provide smooth and direct route such as by foot, animal cart, bicycle, vehicle and the like. Additionally, Kohis and Uhl [23] mentioned that adequate and efficient transportation is a cornerstone for modern marketing system. Thus fishermen, fish retailers should be careful in transporting the whole as well the filleted fish as fast as possible to consumers.

Table 1. *Retailors areas to sell fish and their transporting system.*

Parameters	Frequency (%)
Areas to sell fish	
Consumers directly	31 (68.9)
Supermarket	2 (4.4)
Hotel and restaurants	12 (26.7)
Transportation system	
Foot	22 (48.9)
Vehicle (Bajaje)	21 (46.7)
Motorbike	2 (4.4)

Source of fish for consumers

According to consumers', there are different sources of fish for consumption. About 96%, 36% and 24% of the consumers use fish for consumption from lakeside, hotel and restaurants together and from door to door sellers, respectively. The consumers mentioned that they usually come to purchase fish to the lakeside looking for fresh products. Especially most of the consumers (customers) visit the lake side to utilize raw, fresh fish and as well to use fish soup. While the customers in hotel and restaurants utilize fish in cooked form called as "Asa lebeleb", "Asa kotelet" and "Asa gulash" (in Amharic Languages).

Other than the two fish sources for customers, door to door selling's and supermarkets were also used. Usually the types of fish presented by door to door retailers were whole fish and filleted form. Door to door fish selling is not good source for purchasing fish since the storage and transporting material is usually plastic material (Figure 7). Plastic materials are not recommended to store and transport whole as well as filleted fish since the material exposes the fish easily for spoilage and contamination. In the supermarket, filleted fish is presented as ice packed form in refrigerator.

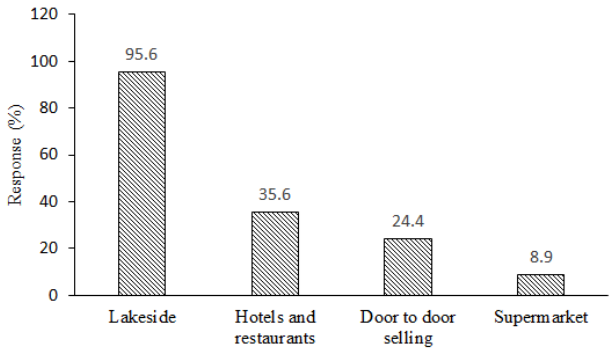

Figure 7. *Fish sources for consumers.*

Fish type usually purchased (preferred) by consumers and criteria for purchasing

According to Figure 8, it showed that usually purchased fish types by consumers. The interviewed fish consumers mentioned that about 58%, 33% and 9% purchase fillet fish, whole fish and frozen fish respectively. Similarly gutted fish (filleted) was more preferred in the study conducted in Ilu Aba Bora zone Oromia region, Ethiopia [16]. The highest percentage for filleted fish purchase might be usually the customers do not know how to process and gut fish. That is why they wanted to purchase readymade raw fish (gutted/ filleted fish) used to eat as raw, roasted form and as well for soup making purpose. The whole fish purchase preference was usually for those who know how to gut and fillet (Table 5).

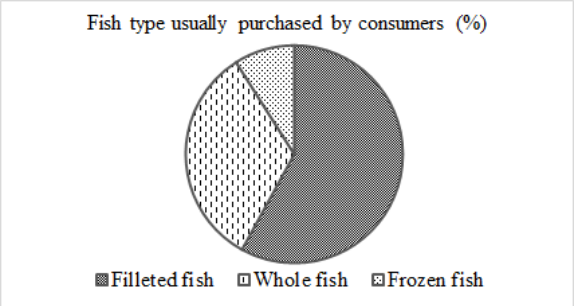

Figure 8. *Fish types usually purchased by consumers.*

Table 5. *Consumers fish purchasing and freshness criteria's.*

Parameters	Percent (%)
Criteria to purchase fish (n=45)	
Freshness	96
Affordability	11
Consumers criteria to identify the freshness (n=45)	
Odor	22
Color	33
Body condition	27
Alive fish	18

Moreover, the interviewed consumers have criteria for purchasing fish. About 96% and 11% of interviewed consumers took freshness as their primary criteria followed by affordability. Additionally fish consumers also have means to identify fresh fish while purchasing such as through observing the color (33%), body condition by touching (27%), odor (i.e unusual smell) (22%) and alive fish (18%). The criteria for identifying freshness were similar with retailer's criteria during collecting fish from fishermen.

Preference of fish dish type by consumers: The interviewed fish consumers mentioned their preference towards different fish dish types. From interviewed 100% consumers, about 96%, 84%, 76% and 71% of them prefer fish soup, roasted fish, raw fish and roasted fish with salad respectively. The more preference for fish soup, roasted fish and raw fish might be related with availability/accessibility of small kiosks presenting fish in different form in the lake side and since most of customers visit the lake side to get fish. In line with the current result, fish was more used as soup and condiments, especially when smoked or dried in Ethiopia [24] (Figure 9).

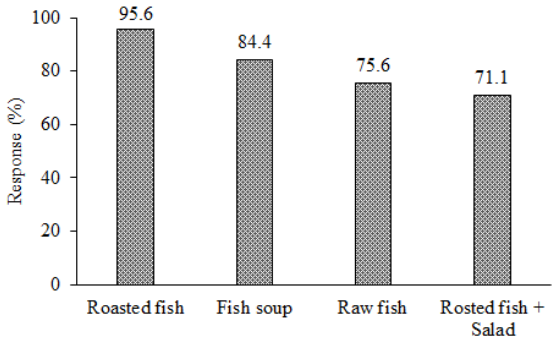

Figure 9. *Preferred fish dish type by consumers.*

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Who consumes fish dish with in the family? (Consumers' response)

Fish are a rich source of high quality protein, a range of micronutrients, and Family members consuming fish essential for human brain development [25]. The table below showed particular members of family consuming different types of fish meal. Except raw fish meat, fish soup, roasted fish and fish with salad are dominantly provided for all the family members as responded by, 47%, 53% and 49% of interviewed consumers respectively (Table 6). Children's were given little emphasis for a separate provision of fish in their daily meal though they were also included in all the family members' response.

Regarding the raw fish meat consumption, even if youths and adults are the major consumers; it was also given for all the family members (27%) including children. About 4.7% of interviewed consumers provide even raw fish meat for children. This might be risky for children since the parasite is very dangerous and fatal. Especially raw or undercooked fish may also harbor the most common food poisoning bacteria, *salmonella* [26]. It is also mentioned that eating raw fish regularly increased the risk of parasitic infections [27]. Moreover the study report by Jackie [28] indicated that consuming raw or undercooked fish is never advised for high risk individuals such as pregnant women, infants, young children and older adults because of it might result illness, sever and life threatening illnesses. It is not only high risk individuals but also for people with weak immune system should avoid eating raw meat and fish [27]. Thus, the consumers at high risk and individuals with weak immune system, should be careful in consuming raw and undercooked fish.

Table 6. *Family members consuming fish.*

Types of fish dishes	Family members consuming fish (Frequency, percent) (n=45 consumers)				
	Children	Youngsters	Adults	Elderly	All family members
Fish Soup	4 (8.9)	10 (22.2)	6 (13.3)	4 (8.9)	21 (46.7)
Roasted fish	3(6.7)	8 (17.8)	10 (22.2)	-	24 (53.30
Raw fish	2 (4.7)	11 (24.4)	14 (31.1)	6 (13.3)	12 (26.7)
Fish with Salad	1 (2.2)	8(17.8)	14 (31.1)	-	22 (48.9)

Fish consumption trend

The consumption trend of fish and frequency of consumption were indicated in the table below. The interviewed consumers mentioned that about 0.95 fish consumed in a month which means almost 1 fish per month per person. This means that about 11.4 tilapia fish was consumed per person per year (Table 7). The average size of Nile tilapia in Lake Hawassa is about 317.5 gram [29]. Thus, if a person consumed about 11.4 tilapia fish which measured a maximum size, it means that 3.42 kg fish was consumed per person in a year (11.4*317.5 gram=3619.5 gram/3.62 kg). However the recommended fish consumption rate according to FAO [4] is about 25 kg/year per person. In line with the present finding, Ethiopia's estimates for 2012 indicated that 0.34 kg per capita consumption [30] though the current result is only for Hawassa. In contrary to the current result, local per capita fish consumption was reported as 8.5 kg/year in production areas (Arba Minch and Sodo areas, as well as at Awassa [31]. Additionally the study conducted by John and Rios [32] mentioned that in areas surrounding lakes and rivers, yearly consumption can reach up to 21 kg per capita.

Table 7. *Monthly fish consumption (number of fish) and frequency of consumption (month).*

Characteristics	Mean+SE (n=45 consumers)
Monthly fish consumption (number of fish per person)	0.95+0.10
Frequency of fish consumption (per month per person)	1.53+0.18

The lower consumption rate could be related with longer fasting period by Ethiopian Orthodox religion. Additionally, the increased demand and the lower production (supply) that resulted increased price all together limited the consumption of fish as food. Moreover, the respondents consumed about 1.53 times per month which is close to two times per month. Thus fish production enhancement as well greater awareness should be created to improve consumption of fish in the future.

Problems of fishermen and fish retailors

The fishermen and fish retailers face different problems during production, harvesting and marketing. The respondents of both actors ranked their problems according to their area of activity. The fishermen top ranked problems are entry of unlicensed fishermen to the lake (1st) gillnet stealing (2nd) and waving of our boat when wind comes (3rd). Unfortunately waving may not be taken as problem by itself since it is natural. But the problem might be related with the strength of their fishing boat. So, it is very difficult to harvest with smaller boat with less capacity, lesser strength traveling very long distance for conducting the fishing. Regarding the entry of unlicensed fishermen, they usually harvest fish fingerlings at unreached (early) stage which is very bad for production of fish. It might cause depletion of fish production. They were not only involved in harvesting of fish fingerlings but also they steal gillnet of licensed fisherman's' at their middle of harvesting. According to Amare [33], illegal nets, net thefts, poor product handling, unorganized delivery, short of specific landing sites, entrance of any individuals in the lake at any time and lack of ownership of the lake are among the mentioned constraints in case of Lake Tana. Some of the mentioned constrains are common with the current study such as net theft and entrance of any individual in the lake

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for harvesting. In earlier findings, different constraints of fish farming were mentioned such as lack of sufficient capital (access to credit) to purchase fishing gear, unavailability of motor for boats and marketing constraints in Lake Tana [34]. Similarly, the study conducted in Tigray region revealed that the major constraints of fishing activities are financial constraints that limited the capacity to buy technology, transportation device, storage equipment and buying boats and nets followed by shortage of technology to preserve fish and lack of demand for the fish products [35].

But with the retailer side, the mentioned constraints are different from the fishermen. These are shortage of fish supply, fish supply and increased price together and increased price alone are the top three constraints mentioned by the retailors (Table 8). Thus, the government should supply better improved boats for fishery cooperatives, set policy regarding the entry of unlicensed fishermen and individuals to the lake.

Table 8. *Problems faced by fishermen and fish retailors.*

Problems	Rank
Fishermen	
Entry of unlicensed fishermen and catch fish fingerlings	1
Gillnet stealing (by unlicensed fishermen)	2
Waving of our boat when wind comes (poor strength boat)	3
Sinking of their gillnet	4
Attack by dangerous animals (hippopotamus)	5
Fish retailors	
Low supply of fish	1
Both low supply and increased fish price	2
Increase in of fish price	3

Laboratory results

Microbial analysis for raw fish meat: Four bacterial parameters were analyzed for raw fish meat. The types and number of bacteria were considered in the current study related with hygienic fish handling. Bacteria's such as Total Coliform and E.coli did not show significance variation among the three fish actors (fishermen, fish retailers and fish consumers) though the count for all the three actors didn't satisfy the safe standard The gutting area and storage material (Table 9) environment could be a means for higher bacterial load of fish meat collected from the fishermen. A study finding indicated that careless handling of landed fish, its stowing and cutting are the means for increased bacteria to infect the fish from outside environment [36]. The existence of higher E.coli and coliforms might be related with contamination of fecal origin from poor hygienic practices or due to inadequate processing, and even from production environment [37] Therefore, the consideration of fecal origin in this study could majorly related with gut waste during filleting that might contaminate the raw fish meat.

The raw fish meat total bacteria and *salmonella* count showed significance difference at ($P<0.05$) level where higher count persisted for the fisherman and fish retailers than the consumers. The more TBC and *salmonella* count for the fisherman might be related with unhygienic processing takes place at the landing site (environment) and also contamination of more by the waste of the gut during filleting. In fact cleaned fish meat may arrive to consumers hand and that might be the reason for reduced Total bacterial count and *salmonella* count. According to FSANZ [37], TBC is quite high if the bacterial flora present is 106 to 107. A normal range of for total bacteria is also indicated from 102-107 cfu (colony forming units)/cm2 on the skin and between 103 and 109 cfu/g in the gills and intestines [20]. The current finding reveled the count is within the standard for all the actors. Even the count for overall TBC of the three actors is also with in the satisfactory ranges though there is variation in count among the three actors. However, the count for Ecoli (1.92 × 105) and Total coliform (1.80 × 105) are not satisfactory since their identification is more than 102 and

Table 9. *Microbial count of raw fish meat (M+SD/log10 cfu/ml)*

Fish Actors	n	No. of Total Bacterial count	No. of Coliform count	No. of Ecoli count	No. of *Salmonella*
Fisherman	10	2.55a+0.35	1.67a+ 1.02	1.91a +0.84	1.97a+0.34
Fish retailers	10	2.34a+0.44	1.95a + 0.81	1.96a + 0.34	1.57a+0.52
Fish consumers	10	1.88b+0.67	1.79a + 0.89	1.89a + 0.36	1.27b+0 .64
Total	30	2.26+0.57	1.80 + 0.89	1.92 + 0.55	1.60+0 .58

104 respectively [37]. Still the *salmonella* count is not with in the standard since *salmonella* shouldn't be detected per 25 g dilution [8]. The increased *salmonella* species count might be associated with gastrointestinal tract disease that can be found in water, especially of contaminated coastal regions or ponds [38] and from fish boxes (containers) and on the hands of fishermen [39]. *Salmonella* can also contaminate fish during storage and processing [40].Therefore this all mentioned reasons increased the *salmonella* count and make it beyond the standard limit. Although the total bacterial count is with in satisfactory standard the other three counts are not satisfactory. Thus, training should be provided for the fishermen and fish retailors on hygienic fish handling and processing after training need assessment.

Conclusion

Full fishing equipment is very important for achieving the fish harvesting activity. In spite of the importance, most of the fishermen lack full fishing materials. Besides considerable number of fish retailers use inappropriate fish storage and transporting materials during selling. The inappropriate equipment used by the fish retailors increases its bacterial contamination and exposes the fish to be spoiled. The majorities of consumers interviewed were purchasing fish from door to door sellers (fish retailors) where their storage and transporting material of the fish is mainly "Plastic bag". Plastic bags are inappropriate for fish selling and not recommended at all due to the fish can easily be contaminated with it. Although fishing has several advantages for the fishermen, they reported entry of unlicensed fisherman in the lake as their main problem that usually leads to early harvesting of fish fingerling and steeling of gillnet. Similarly, shortage of fish supply and an increase of the price of fish were reported as major problem reported by fish retailors. Even though significance variation for total bacterial count and *salmonella* count between fish samples from the fishermen and fish consumers, the total bacterial count satisfied the international bacterial count standard of the raw fish meat. For the other investigated bacteria counts such as Ecoli, total coliform and *salmonella*, the count was unsatisfactory.

Recommendation

Since all types of bacteria's count arise initially due to unhygienic handling, processing, processing equipment, personal hygiene and the environment, training should be organized to create awareness on the hygienic handling and processing of fish. Regarding the entry of unlicensed fishermen, the government should take control measured through discussing with the licensed fishermen cooperatives. As one of the means, may be creating other job opportunity for the unlicensed ones, could reduce the stealing of gillnets and harvesting of fish fingerling. This measure could even reduce the productivity of fish and the potential of the lake as well. Moreover introducing improved handling, processing equipment and facilities could be crucial for keeping the quality and safety of fish in the future.

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