Fish consumption and quality by peri-urban households among fish farmers and public servants in Ethiopia

Metekia Tamiru[a, b†*], Ashraf Alkhtib[c†], Merwan Ahmedsham[a†], Zemene Worku[a], Dawit Adisu Tadese[d], Tilahun A.Teka[e], Fikremariam Geda[a], Emily Burton[c]

[a]*Jimma University, College of Agriculture and Veterinary Medicine, Department of Animal Science, PO Box 378, Jimma, Ethiopia.*

[b]*Ghent University, Faculty of Veterinary Medicine, Department of Veterinary and Biosciences, Heidestraat 19, B-9820, Merelbeke, Belgium.*

[c]*Nottingham Trent University, School of Animal, Rural and Environmental Sciences, Brackenhurst Campus, Southwell, Nottinghamshire, UK, NG25 0QF.*

[d]*Ethiopian Institute of Agricultural Research, National Fishery and Aquatic Life Research Centre, P O. Box 64, Sebeta, Ethiopia.*

[e]*Department of Postharvest Management, College of Agriculture and Veterinary Medicine, Jimma University, Jimma, Ethiopia*

[†]*Shared first authors*

**Corresponding author: metekiatam@gmail.com*

Abstract

The goal of this study was to analyse peri-urban households' fish consumption and fish quality along the value chain of the fish-livestock production system. Data on fish consumption per capita and socio-economic characteristics of the household of 366 households were collected along the fish value chain, covering two rural districts (Omonada and Kersa) and one town (Jimma). Effect of socio-economic characteristics on fish consumption of the interviewed households was analysed using Ordinary Least Square Regression. A total of 36 Nile Tilapia fish were collected from eight locations along the fish value chain. Then, the samples were analysed for microbial, physiochemical, and sensorial attributes. The influence of sample location on physiochemical, qualitative characteristics, and microbiological loads of fish fillets was investigated using one-way ANOVA and orthogonal contrast to separate the means. The mean fish consumption per capta in the study area was 0.541 kg/person/year. Fish consumption of the household was significantly influenced by location and household head sex. Fish consumption was positively influenced by education, family size, and wealth, but negatively influenced by age. The fish value chain in the study area extended from the production site (adjacent to Gilgel Gibe I reservoir) and district retailer shops, Jimma town mobile trader and retailing shops. Except the production site, fish quality across the value chain were lower than the standard. Furthermore, fish samples from marketing sites (Jimma town mobile traders, Jimma town retailer shops, and district retailer shops) had lower ash, fat, crude protein levels, higher TVB-N, higher pH and higher aerobic and coliform loads compared to samples from production sites. Fish samples from district shops and Jimma town traders had significantly lower off-flavour scores compared to the production sites (0.94 points and 1.53 points, respectively). Fish obtained from Jimma retailers had significantly less odour compared to those obtained from Jimma mobile traders by 0.87 points.In conclusion, Ethiopian households' consumption of fish in the integrated livestock-fish farming system is generally low. Yet, it could be improved by reducing fish production cost and shortening the fish value chain. Improving cold chain facilities and implementing household to household extension services about fish consumption would be inevitable to enhance fish consumption in the study area.

Keywords: Fish consumption, Sensorial quality, Aerobic, Coli form

1. Introduction

Fisheries play a pivotal role in ensuring food security and employment opportunities for over 59.5 million people globally (FAO, 2020). Fish provides 19 % of Africans' animal protein consumption(Obiero et al., 2019). It contains a range of dietary minerals, long-chain polyunsaturated fatty acids (Chan et al., 2019), highly digestible protein (Hüsken and Heck, 2012) essential amino acids and vitamins (Tenyang et al., 2014). Fish is rich in essential fatty acids including eicosapentaenoic and docosahexaenoic, which have potent anti-inflammatory properties and can help heart attack victims (Nestel et al., 2015; Vilavert et al., 2017). Furthermore, because it lacks connective tissues, fish is more digestible than other meats (Han et al., 2019).

Fish marketing in Africa, including Ethiopia, is often informal in which actors in informal markets may not give due attention to food safety since the commodity could pose a possible health hazard to consumers (Lokuruka, 2016)). The Ethiopian water body could support a yield of 94,000 tons of fish per year, indicating substantial contribution to food security and income generation (Deng, 2020). Coincident with the potential volume of fishery resources, there is a need to enhance fish consumption habit and improve the quality of available fishery products(Alemu and Adesina, 2016; Yilma et al., 2020). It is evidenced that

the annual per capita consumption of fish was 240 g/person which is less than 10% of fish consumption in East African sub-region (MOA, 2002;Tesfaye and Wolff, 2014). Furthermore, Ethiopia remains at a lower status in fish quality due to a number of determining factors, including the location of the fishery, season, the degree of pollution of the fishing ground, and the infrastructure available for handling and processing of fish (Deng, 2020).

Many factors impact food preferences and consumption habits, including consumer-related factors (gender, education, nutritional understanding, and culture) and fish-related factors including sensory (freshness, taste, and smell)(Lovelace and Rabiee-Khan, 2015). Fish consumption are influenced by cultural, geographic, and socioeconomic factors(Verbeke and Vackier, 2005). In addition, the frequency and preference of Non-sensory factors (risk perception, behaviour, personal attributes and beliefs) as well as sensory elements (texture, taste, smell, freshness) may influence food preferences, including fish (Honkanen et al., 2005). Moreover, it is reported that fish consumption in Ethiopia is limited due to lack of interest, lack of availability, fear of spoilage, religious matter and lack of habit of consumption (Alemu and Adesina, 2016). Fish consumption, production, and export could all be improved by implementing practical and long-term plans to solve linked obstacle factors in one's own country (Supartini et al., 2018). Younger age groups claimed to be earning higher incomes and having a good educational background would tend to consume more fish in Greek (Kaimakoudi et al., 2013). Fish consumption is higher in older age and in women than in men, and lower in lower income classes in Belgium (Verbeke and Vackier, 2005). There is a variation in fish consumption between different age groups in Spain (Olsen et al., 2008). Moreover, fish price is another factor affecting consumption where the cheaper price of the fish would more likely be preferred for consumption (Sayin et al., 2010). Different countries have diverse cultures which influence fish eating patterns(Kaimakoudi et al., 2013).

The Gelgel Gibe River is located adjacent to Gilgel Gibe I hydroelectric dam in the Jimma Zone of Oromia region, Ethiopia(Abebe et al., 2015). Fish species known in the Dam include *Oreochromis niloticus, Siluri formes,* and *Labeoberbus infermedius*(Gure et al., 2019). Nile tilapia (*Oreochromis niloticus*, L.), is the most caught and consumed species in Ethiopia in general(Abebe et al., 2015).and Jimma Zone in particular. Farmers around the Gilgel Gibe reservoir are engaged in all-inclusive agricultural activities including livestock (cattle, small ruminant and poultry) rearing and wild fisheries catch under extensive production system.

To the best of our knowledge, no in-depth analysis of the determinants of fish consumption and quality by rural households in south-western Ethiopia's mixed fish-livestock systems has been reported. So, this study aimed to look at the socio-economic factors that make Ethiopian farmers less likely to eat fish, and the nutritional value and physiochemical properties of fish as it moves through the value chain.

2. Materials and methods

2.1. Study area

Majority of the population in the rural farming community around Jimma town depends on agriculture for their livelihood. The main agricultural system in the Jimma zone is mixed-crop livestock production and wild fish catch under extensive production systems. Two locations in Jimma zone including Jimma town and nearby districts, namely: Kersa and Omonada, were covered for the purpose of this study (Figure 1). Kersa and Omonada districts are located around the Gilgel Gibe 1 reservoir under integrated livestock-fish extensive production system. Jimma town included four villages, namely: Mentina, Bacho bore, Jiren and B/A/Ketema whereas two districts included two villages, namely: Kersa (Gelo, Bulbul) and Omonada (B/S/Dabo, Waqtola). Jimma city is located 350 km from the capital city of Ethiopia, Addis Ababa, and lies between 7°40´N latitude and 36°50´E longitude at an average elevation of 1750 m.a.s.l in Southwestern Ethiopia. The area has a tropical rainforest climate according to the Koppen climate classification (Beck et al., 2018). In terms of temperature ranges, the area has a 9°C and a 28°C minimum and maximum temperature, respectively, while the mean daily temperature ranges between 20°C and 25°C. The yearly average rainfall in the area is 1624 mm.

2.2. Physiochemical, sensory and microbiological analyses of fish samples

The fish value chain in Jimma Zone starts from the catching site located adjacent to Gilgel Gibe I reservoir, where value addition has not been practiced. Then, district fish retailing shops would receive the fish after which value addition via gutting, filleting, and bagging would be carried out. However, district shops encountered electricity fluctuation problems, which resulted in a partial deterioration of the fish quality. Then, some of the semi-processed and whole fish passing through the value chain would be sold to Jimma town traders and retailing shops where relatively moderate cooling and handling facilities are provided.

A total of 36 Nile tilapia fish were collected from eight locations along the fish value chain (Table1) and stored at -18°C for microbial, chemical, and sensory tests. Each fish was fractioned into three parts: the anterior third (for sensory analysis), the middle third (for chemical and microbial analysis), and the posterior third (for textural analysis) as was described in a previous study (Berizi et al., 2018).

Homogenizer model DI18B, Germany, was used to mince and homogenize the middle part of the sample before it was used for analysis.

In order to figure out the pH, the whole sample (10 g) was mixed with deionized water (10 mL) for 60 seconds, and then the digital pH meter (CG824, Germany) was used to read the reading. The determination of total volatile base nitrogen content was conducted using steam distillation in accordance with a previous report(Cao et al., 2019)

The AOAC methods were used to determine the proximate composition of fish samples (AOAC, 2000): moisture (Method 950.46), total ash (Method 920.153), crude fat (Method 960.39), and crude protein contents (Method 976.05). Crude protein content determination was based on the Kjeldahl method of total nitrogen content analysis. Protein (%) = Nitrogen (%) × 6.25.

2.3. *Survey data and method of sampling*

Purposive sampling technique was employed to select fish consumer respondents including farmers from the two districts and public servants from Jimma town. A total of 366 households (141 farmers from the two districts and 225 public servants from Jimma Town) located along the fish value chain of Jimma zone were interviewed using a structured questionnaire. The questionnaire contained a variety of questions covering fish consumption per capita, household characteristics, and factors affecting fish consumption. Accordingly, districts, namely, Kersa and Omonada were selected purposefully. From each district and Jimma town eight kebeles were selected randomly. Finally, 366 households were randomly selected to represent the study villages (Table 2).

2.4. *Microbiological analysis*

Determination of microbiological counts was performed by adding a 10 g sample to 90 ml of 0.1% peptone–water (Oxoid code CM 9) and then the content was homogenized with a stomacher (IUL-Instruments, Barcelona, Spain). Total viable aerobic bacterial counts were then determined using the pour plate method (plate count agar (PCA, Oxoid code CM 325). The determination of the coliform bacteria count was done using a chromogenic medium (Oxoid code CM 956) with incubation at 37 °C for 24 h. All microbiological analysis were performed at microbiology laboratory of school of veterinary medicine, College of Agriculture and Veterinary Medicine, Jimma University.

2.5. *Sensory evaluation*

The fish samples were evaluated for flavour, odour, texture, and overall acceptability by a panel of 12 judges (food science professionals) prior to being well trained according to standard ISO 8586-1 (1993) using a 7-point hedonic scale presented in Table 3.

2.6. *Statistical analysis*

Farmers' consumption of fish was analysed using Ordinary Least Square Regression. The explanatory variables of the model were location of the household (district or urban), sex (male or female) of the household head, age of the household head (years), education level of the household head (schooling years), household size (person) and household income per capita (ETB/month). The effect of location of sampling on physiochemical, quality attributes, and microbial loads of fish fillet was analysed using one-way ANOVA and orthogonal contrast was used for the mean comparison. All statistical analyses were conducted using R version 3.0.2. (R Core Team, 2021).)

3.Results

3.1. Fish consumption

Summary of fish consumption and household characteristics are presented in Table 4. Results show that the mean per capta fish consumption in the study area was 0.541 kg/person/year. There was significant effect of location, age, education, family size, and income on the consumption of fish ($P<0.05$).

This study indicated that Jimma town households consume significantly more fish than their rural counterparts. Among the factors hypothesized to affect peri-urban households' fish consumption, the coefficients of education, family size, and income were positive, while age remained negative.

3.2. *Fish quality traits*

Tables 5 and 6 show the physiochemical properties of fish samples collected along fish value chain including four catching sites, a Jimma trader, a Jimma retailer, and two shops in the district. The moisture, ash, fat and protein of Jimma trader, Jimma retailer, and shop samples were 76.1%-79%, 1.09%-1.42%, 1.45%-1.72%, and 15.1%-17%, respectively. The moisture content of fish samples was significantly different among sampling sites (P<0.05); however, this difference was small (3%).

Ash, fat and protein content were significantly lower in the fish sampled from Jimma town mobile traders and district shops compared to the catching sites (19%, 16%, 11%, respectively, 23%, 15%, 9%) (Table 5). Fish sampled from Jimma town traders had significantly higher protein, ash, and fat content compared to those sampled from Jimma town retailers. However, the difference was high for ash (8.77%) only while the difference was small (<3%) for moisture, fat, and protein content of fish samples.

Fish sampled from Jimma retailers had significantly higher TVB-N and pH compared to samples collected from Jimma mobile traders (3 TVB-N points and 0.11 points, respectively).

The sensory attributes scores of fish samples revealed that off-flavour ranged from 2.8 (fish sampled from a Jimma retailer) to 4.34 (fish sampled from a catching site) (Table 5). The flavour, texture, and overall acceptability of fish samples were not significantly affected by the source of the samples (P >0.05). Fish samples from district shops and Jimma town traders had significantly lower off-flavour scores compared to the production sites (0.94 points and 1.53 points, respectively). Fish sampled from Jimma retailers had a significantly higher off-flavour score than those sampled from the catching site (by 1.2 points). Fish sampled from district shops had significantly lower odour scores than the fish sampled from catching sites (by 0.53 points). Fish obtained from Jimma retailers had significantly less odour compared to those obtained from Jimma mobile traders by 0.87 points.

Aerobic and coliform microbe loads varied from 6.77 log 10 cfu/g to 7.26 log 10 cfu/g and 4.15 log 10 cfu/g to 5.2 log 10 cfu/g, respectively. Aerobic (coliform) and microbe content in fish samples was considerably greater in district shops (0.43, Jimma Town mobile traders (0.63 (0.83), and Jimma Town merchants (0.33 (0.35), compared to catching sites. However, there was no significant difference in aerobic and coliform microbial loads between Jimma Town mobile traders and Jimma Town retailers.

4. Discussion

4.1. Fish consumption

Ethiopia is endowed with enormous water resources supporting growth of variety of fish species. However, households' fish consumption remains to be limited due to several technical and non-technical factors. The goal of the current study was to determine how to improve fish consumption of the peri-urban households in the integrated livestock-fish farming system in terms of quantity and quality.

The current study indicates that the mean per capita fish consumption in the study area was 0.541 kg, which was a bit higher than 0.34 kg national estimates for 2012(FAO, 2014) and lower than 10 kg estimates for 2007 in sub-Saharan Africa(Gordon, 2001).It has also been reported that religious fasting period by Orthodox Christians would tend to limit protein intake from dairy, red meat and eggs (Haileselassie et al., 2022). However, such protein demand could be met by consuming fish. Significant number of Orthodox Christians do not consume poultry and ruminant products during prolonged fasting period of the year (Mains, 2016). That would lead to severe malnutrition in case of the absence of alternatives. Fish is one of the most important animal sources of food rich in protein and micronutrients in the human diet (Maulu et al., 2021). Thus, fish offer an excellent alternative to poultry and ruminant products for Ethiopians Orthodox Christians during fasting period.

The current study showed that fish consumption by Ethiopian peri-urban households was affected by location, age of household head, which is in agreement with(Gordon, 2001; Onumah et al., 2020).

The positive coefficient of education level indicates a positive correlation between education (as official schooling years) and fish consumption. Educated farmers are more inclined to fish consumption as they most probably know more about its health benefits (Zhang et al., 2021). This result is concurrent with that reported in previous studies (Kaimakoudi et al., 2013; Trondsen et al., 2004) which observed that consumption of fish was positively associated with education level. This has been further confirmed by another study that found higher education levels would lead to a higher purchase of fish (Verbeke and Vackier, 2005). Accordingly, it could be suggested that increasing awareness about the positive outcome of fish consumption on human health would increase fish consumption by peri-urban households. Ethiopia has a strong agricultural extension network which works closely with farmers across the four regions of the country(MoANR, 2017). Accordingly, it could be used as a tunnel to convey correct information about the importance of fish meat in human nutrition by facilitating formal and informal discussions among farmers about the beneficial effects of fish consumption. Thus, agricultural extension approaches should be updated by adding the nutritional information related to fish consumption. These approaches should consider size and geographical location of the household in addition to the household head age.

The positive correlation between household income and fish consumption is in agreement with (Can et al., 2015; Trondsen et al., 2004). In other words, the cheaper the price of fish, the higher the consumption. This could be achieved by applying comprehensive strategy including all stages of fish production value chain including formal establishment of fish farming cooperatives and marketing by prohibiting illegal fishermen, input provision, and cooling and handling facilities. The results of the current study suggest that further study on reducing fish prices (either by increasing output or decreasing production cost) would boost farmers' fish consumption. Many actors are involved in Ethiopia's fish value chain, including producers, whole sellers, middlemen, retailers (shops and mobile), and consumers. Thus, shortening the value chain of fish by boosting fishermen capacity to distribute their fisheries products to end customers may help to reduce the rising fish price.

4.2. Fish quality characteristics

It has been reported that fish consumption is negatively related with low sensory, nutritional and hygiene properties (Temesi et al., 2020). Accordingly, the current study aimed at determining the sensory, nutritional and microbial loads of fish along the fish value chain. The findings showed that chemical composition, physical and sensory characteristics of fish deteriorated in selling sites compared to the catching sites. This result is consistent with the findings of Lo et al. (2019) who found that fish consumption is positively associated to the distance between homestead and lakes. It is noted that the quality of fish can be deteriorated due to the action of microbial multiplication from the fish itself or contamination, oxidation, and endogenous enzymes (Ghaly et al., 2010; W. Jiang et al., 2018). Similarly, mechanistic processes mediated by peroxidase, microsomal enzymes, auto-oxidation, photosensitized oxidation, and lipoxygenase could lead to the lipid oxidation of fish (Mei et al., 2019). Consequently, decaying of fish through decomposition of tissue leads to lipid oxidation and protein degradation, which would in turn result in changes in texture, odour and flavour (Das et al., 2020).

The coliform and aerobic microbial loads of fish in all sites were higher than 7 log cfu/g accepted load in meat samples (H. Jiang et al., 2018) which could pose health risks to consumers along the value chain. This is due to the existence of poor handling and lack of cooling facilities accompanied with prolonged storage and exposure of extreme weather climates along the marketing chains thereby facilitating occurrence of fish spoilage. The high aerobic and coliform bacteria load in the current study is in line with (Can et al., 2015; Hasani and Hasani, 2014) who reported that the lowest level total viable counts in carp fillets increased to 6 log cfu/g after 6 days of storage.

Assessment of fish safety and quality are essential attributes to protect end-users against any health risks acquainted with fish consumption. Spoilage of fish renders it less enjoyable and ultimately inedible due to safety concern resulting from foodborne pathogens in fish (Novoslavskij et al., 2016). The quality of fish depends primarily on safe and good hygienic practices in handling and transportation, and sufficient refrigeration during the course of fish post-catch. In this study, the quality of fish was lower than the standards set by (Practice, 2019) along the value chain. This could possibly be attributable to a lack of proper handling and preservation mechanisms for fish which creates a conducive environment for certain spoilage microorganisms (Sheng and Wang, 2021). Several post-catch operations have been suggested to decrease microbial loads in fish and fishery product. According to Mgwede et al. (2018), it was confirmed that parboiling has significantly reduced the microbial load of fish compared to that found in the fresh fish sample at the selling points. Similarly, it was reported that drying (I.C and S.O, 2013), and smoking and cooking (Ayeloja et al., 2011) were found to decrease the microbial load of fish compared to that found in the fresh fish sample. Microbial load of fish could be reduced by lowering the moisture content using different processes such as drying, smoking and cooking. However, apart from the moisture content of fish sample, fish itself is an ideal media for growth of microorganisms due to its' nutrient rich nature. Despite the effectiveness of the microbial load reduction strategies suggested in literature, societal awareness on measures to be taken to ensure safety and quality of fish along the value chain are very essential. Therefore, increasing the awareness about best practices of post-catch, good handling and cooling of fish would minimize fish quality deterioration along the value chain leading to improve fish quality for end consumers.

5. Conclusion

The current study illustrated that fish consumption in the integrated livestock-fish system in Ethiopia was extremely low. Fish consumption could be improved by decreasing fish price via all-inclusive improvement of the fish value chains. Improving the awareness of farmers about the nutritive value of fish would improve fish consumption. Extension approaches in these areas could be updated including more information about the importance of fish in human nutrition. These approaches should consider household location and size and the household head age.

The quality of fish was lower than the standards set international food standard for fish throughout the value chain. Therefore, increasing the awareness about best practices of post-catch, good handling and cooling of fish would minimize fish quality deterioration along the value chain leading to improve fish quality for end consumers.

Declaration of interest statement

The authors declare that they have no conflicting interest.

References

Abebe, C., Hiwot, T., Genanaw, T., 2015. Opportunities and Challenges of Fish Marketing at Gelgel Gibe Dam in Ethiopia. Jad 5, 1–15.

Alemu, A.E., Adesina, J., 2016. Exploring demand determinants and consumption behaviour in Ethiopia's fish value chain. African Journal of Business and Economic Research 11, 83–101.

Ayeloja, A.A., George, F.O.A., Obasa, S.O., Sanni, L.O., 2011. Effect of post-slaughter time intervals on the quality of the African catfish, clarias gariepinus (Burchell, 1822). American Journal of Food Technology 6. https://doi.org/10.3923/ajft.2011.790.797

Beck, H.E., Zimmermann, N.E., McVicar, T.R., Vergopolan, N., Berg, A., Wood, E.F., 2018. Present and future köppen-geiger climate classification maps at 1-km resolution.

Scientific Data 5. https://doi.org/10.1038/sdata.2018.214

Berizi, E., Hosseinzadeh, S., Shekarforoush, S.S., Barbieri, G., 2018. Microbial, chemical, textural and sensory properties of coated rainbow trout by chitosan combined with pomegranate peel extract during frozen storage. International Journal of Biological Macromolecules 106, 1004–1013. https://doi.org/10.1016/j.ijbiomac.2017.08.099

Can, M.F., Günlü, A., Can, H.Y., 2015. Fish consumption preferences and factors influencing it. Food Science and Technology (Brazil) 35, 339–346. https://doi.org/10.1590/1678-457X.6624

Cao, J., Fu, H., Gao, L., Zheng, Y., 2019. Antibacterial activity and mechanism of lactobionic acid against Staphylococcus aureus. Folia Microbiologica 64. https://doi.org/10.1007/s12223-019-00705-3

Chan, C.Y., Tran, N., Pethiyagoda, S., Crissman, C.C., Sulser, T.B., Phillips, M.J., 2019. Prospects and challenges of fish for food security in Africa. Global Food Security 20, 17–25. https://doi.org/10.1016/j.gfs.2018.12.002

Das, A.K., Nanda, P.K., Madane, P., Biswas, S., Das, A., Zhang, W., Lorenzo, J.M., 2020. A comprehensive review on antioxidant dietary fibre enriched meat-based functional foods. Trends in Food Science and Technology. https://doi.org/10.1016/j.tifs.2020.03.010

Deng, G.T., 2020. Assessment of Factors Affecting Fish Production and Marketing in Gambella Region, Ethiopia. Scientific World Journal. https://doi.org/10.1155/2020/5260693

FAO, 2014. Baseline Report for Ethiopia by Smart Fish Programme of the Indian Ocean Commission, Fisheries Management (FAO component). FAO, Country Review 11–16.

Ghaly, A.E., Dave, D., Budge, S., Brooks, M.S., 2010. Fish spoilage mechanisms and preservation techniques: Review. American Journal of Applied Sciences. https://doi.org/10.3844/ajassp.2010.859.877

Gordon, E., 2001. Fish Production, Consumption, and Trade in Sub-Saharan Africa: A Review Analysis. Oceanologica Acta 24, 113–128.

Gure, A., Kedir, K., Abduro, F., 2019. Heavy metal concentrations in fish tissues from Gilgel Gibe (I) Hydroelectric Dam Reservoir, Ethiopia. Journal of Applied Sciences and Environmental Management 23, 1411. https://doi.org/10.4314/jasem.v23i8.1

Haileselassie, M., Redae, G., Berhe, G., Henry, C.J., Nickerson, M.T., Mulugeta, A., 2022. The influence of fasting on energy and nutrient intake and their corresponding food sources among 6-23 months old children in rural communities with high burden of stunting from Northern Ethiopia. Nutrition Journal 21, 1–15. https://doi.org/10.1186/s12937-022-00759-z

Han, Y., Hao, H., Yang, L., Chen, G., Wen, Y., Huang, R., 2019. Nutritional characteristics of marine fish: Sardinella zunasi Bleeker and immunostimulatory activities of its glycoprotein. RSC Advances 9, 30144–30153. https://doi.org/10.1039/c9ra04913d

Hasani, S., Hasani, M., 2014. Antimicrobial properties of grape extract on Common carp (Cyprinus carpio) fillet during storage in 4 °C. 130 ~ International Journal of Fisheries and Aquatic Studies 1, 130–136.

Honkanen, P., Olsen, S.O., Verplanken, B., 2005. Intention to consume seafood - The importance of habit. Appetite 45, 161–168. https://doi.org/10.1016/j.appet.2005.04.005

Hüsken, S.M.C., Heck, S., 2012. The "Fish Trader+" model: Reducing female fish traders' vulnerability to HIV. African Journal of AIDS Research 11. https://doi.org/10.2989/16085906.2012.671254

I.C, O., S.O, B., 2013. Nutritional and microbial quality of fresh and dried Clarias gariepinus and Oreochromis niloticus. International Journal of Applied Microbiology and Biotechnology Research 1, 1–6.

Jiang, H., Miraglia, D., Ranucci, D., Donnini, D., Roila, R., Branciari, R., Li, C., 2018. High microbial loads found in minimally-processed sliced mushrooms from Italian market. Italian Journal of Food Safety 7, 45–49. https://doi.org/10.4081/ijfs.2018.7000

Jiang, W., Huang, T., Chen, H., Lian, L., Liang, X., Jia, C., Gao, H., Mao, X., Zhao, Y., Ma, J., 2018. Contamination of short-chain chlorinated paraffins to the biotic and abiotic environments in the Bohai Sea. Environmental Pollution 233, 114–124. https://doi.org/10.1016/j.envpol.2017.10.034

Kaimakoudi, E., Polymeros, K., Schinaraki, M.-G., Batzios, C., 2013. Consumers' Attitudes towards Fisheries Products. Procedia Technology 8, 90–96. https://doi.org/10.1016/j.protcy.2013.11.013

Lo, M., Narulita, S., Ickowitz, A., 2019. The relationship between forests and freshwater fish consumption in rural Nigeria. PLoS ONE 14, e0218038. https://doi.org/10.1371/journal.pone.0218038

Lovelace, S., Rabiee-Khan, F., 2015. Food choices made by low-income households when feeding their pre-school children: A qualitative study. Maternal and Child Nutrition 11, 870–881. https://doi.org/10.1111/mcn.12028

Mains, D., 2016. International African Institute Drinking , Rumour , and Ethnicity in Jimma , Ethiopia Author (s): Daniel Mains Source : Africa : Journal of the International African Institute , Vol . 74 , No . 3 (2004), pp . Published by : Cambridge University Press 74, 341–360.

Maulu, S., Nawanzi, K., Abdel-Tawwab, M., Khalil, H.S., 2021. Fish Nutritional Value as an Approach to Children's Nutrition. Frontiers in Nutrition 8, 1–10. https://doi.org/10.3389/fnut.2021.780844

Mei, J., Ma, X., Xie, J., 2019. Review on natural preservatives for extending fish shelf life. Foods 8. https://doi.org/10.3390/foods8100490

MoANR, (Ministry of Agriculture and Natural Resources), 2017. Agricultural Extension Strategy of Ethiopia Agricultural Extension Strategy of Ethiopia 1–59.

Nestel, P., Clifton, P., Colquhoun, D., Noakes, M., Mori, T.A., Sullivan, D., Thomas, B., 2015. Indications for Omega-3 Long Chain Polyunsaturated Fatty Acid in the Prevention and Treatment of Cardiovascular Disease. Heart Lung and Circulation 24, 769–779. https://doi.org/10.1016/j.hlc.2015.03.020

Nielsen, D., Hyldig, G., 2004. Influence of handling procedures and biological factors on the QIM evaluation of whole herring (Clupea harengus L.). Food Research International 37, 975–983. https://doi.org/10.1016/j.foodres.2004.06.006

Novoslavskij, A., Terentjeva, M., Eizenberga, I., Valciņa, O., Bartkevičs, V., Bērziņš, A., 2016. Major foodborne pathogens in fish and fish products: a review. Annals of Microbiology 66, 1–15. https://doi.org/10.1007/s13213-015-1102-5

Obiero, K., Meulenbroek, P., Drexler, S., Dagne, A., Akoll, P., Odong, R., Kaunda-Arara, B., Waidbacher, H., 2019. The contribution of fish to food and nutrition security in Eastern Africa: Emerging trends and future outlooks. Sustainability (Switzerland) 11, 1–15. https://doi.org/10.3390/su11061636

Onumah, E.E., Quaye, E.A., Ahwireng, A.K., Campion, B.B., 2020. Fish consumption behaviour and perception of food security of low-income households in urban areas of Ghana. Sustainability (Switzerland) 12. https://doi.org/10.3390/SU12197932

Practice, C.O.F., 2019. I N T E R N AT I O N A L F O O D S TA N D A R D S CODE OF PRACTICE FOR FISH AND.

Sayin, C., Emre, Y., Nisa Mencet, M., Karaman, S., Tascioglu, Y., 2010. Analysis of factors affecting fish purchasing decisions of the household: Antalya District case. Journal of Animal and Veterinary Advances 9. https://doi.org/10.3923/javaa.2010.1689.1695

Sheng, L., Wang, L., 2021. The microbial safety of fish and fish products: Recent advances in understanding its significance, contamination sources, and control strategies. Comprehensive Reviews in Food Science and Food Safety 20, 738–786. https://doi.org/10.1111/1541-4337.12671

Team, R.C., Al., E., 2016. R: A language and environment for statistical computing. 2, 1–12.

Temesi, Á., Birch, D., Plasek, B., Eren, B.A., Lakner, Z., 2020. Perceived risk of fish consumption in a low fish consumption country. Foods 9, 1–14. https://doi.org/10.3390/foods9091284

Tenyang, N., Womeni, H.M., Linder, M., Tiencheu, B., Villeneuve, P., Mbiapo, F.T., 2014. The chemical composition, fatty acid, amino acid profiles and mineral content of six fish species commercialized on the Wouri river coast in Cameroon. Rivista Italiana delle Sostanze Grasse 91, 129–138.

Tesfaye, G., Wolff, M., 2014. The state of inland fisheries in Ethiopia: a synopsis with updated estimates of potential yield. Ecohydrology & Hydrobiology 14, 200–219. https://doi.org/10.1016/J.ECOHYD.2014.05.001

Trondsen, T., Braaten, T., Lund, E., Eggen, A.E., 2004. Health and seafood consumption patterns among women aged 45-69 years. A Norwegian seafood consumption study. Food Quality and Preference 15, 117–128. https://doi.org/10.1016/S0950-3293(03)00038-7

Verbeke, W., Vackier, I., 2005. Individual determinants of fish consumption: Application of the theory of planned behaviour. Appetite 44, 67–82. https://doi.org/10.1016/j.appet.2004.08.006

Vilavert, L., Borrell, F., Nadal, M., Jacobs, S., Minnens, F., Verbeke, W., Marques, A., Domingo, J.L., 2017. Health risk/benefit information for consumers of fish and shellfish: FishChoice, a new online tool. Food and Chemical Toxicology 104, 79–84. https://doi.org/10.1016/j.fct.2017.02.004

Yilma, S., Busse, H., Desta, D.T., Alemayehu, F.R., 2020. Fish Consumption , Dietary

Diversity and Nutritional Status of Reproductive Age Women of Fishing and Non-Fishing Households in Hawassa , Ethiopia : Comparative Cross Sectional Study. Frontiers in Science 10, 7–13. https://doi.org/10.5923/j.fs.20201001.02

Zhang, H., Sun, C., Wang, Z., Che, B., 2021. Seafood consumption patterns and affecting factors in urban China: A field survey from six cities. Aquaculture Reports 19, 100608. https://doi.org/10.1016/j.aqrep.2021.100608

Figure 1. Map of the study area

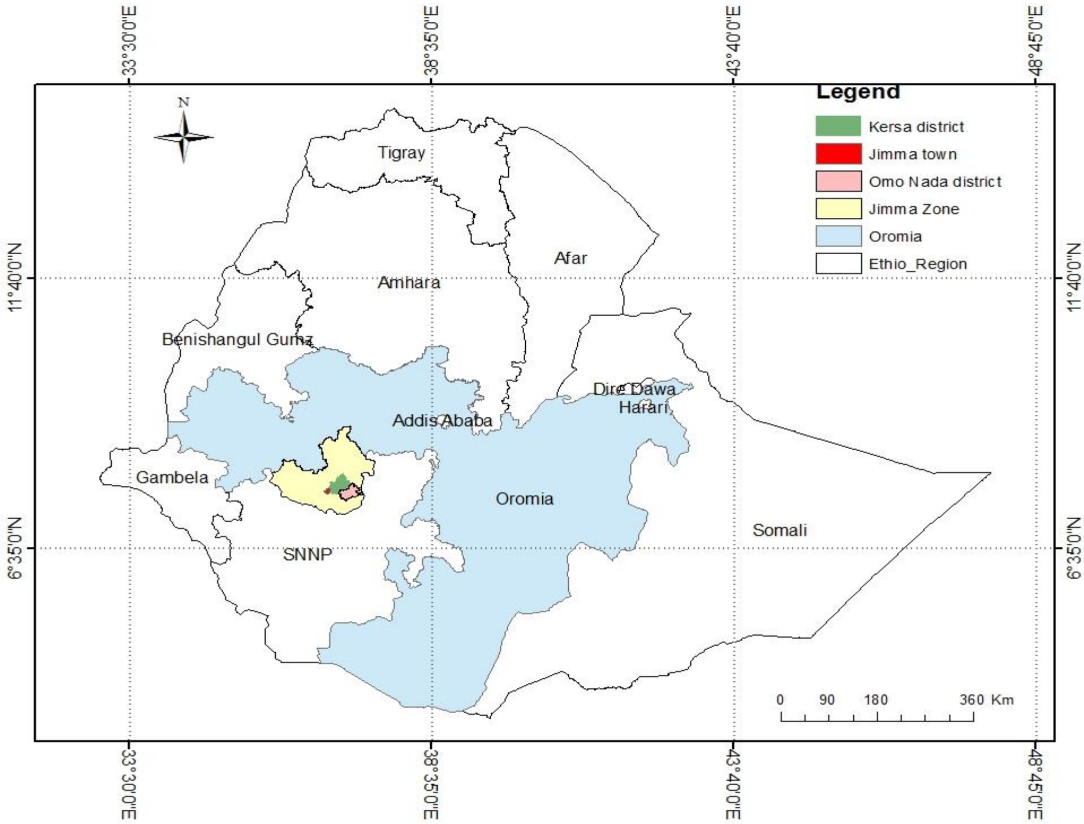

Table 1. Fish sampling sites and post-harvest operations along the value chain

Location	Distance from catching site by car drive(km)	Cooling	Handling
Production sites			
Waktole	0	No	No
Burka sandabo	0	No	No
Gelo	0	No	No
Bulbul	0	No	No
Districts			
Kersa local market	5-10	Fluctuation is common	Gutting, filleting and bagging
O/N local market		Fluctuation is common	Gutting, filleting and bagging
Jimma town			
Jimma town trader	30-50	Good cooling	Gutting filleting and bagging
Jimma town retailer		Moderate cooling	Gutting filleting and bagging

Table 2. General description of the study area.

Village	Altitude (m.a.s.l)	Temperature (℃)	Rainfall (mm)	No of household interviewed
Kersa district				
Gelo	1740- to 2660	7.4-30	1577 mm	36
Bulbul				34
Omonada district				
B/ S/dabo				39
Waqtola	1000- to 3340	12-27	1131mm	32
Jimma town district				
Mentina				47
Bacho bore				76
Jiren	696- to 3,337	12-29	91.72	59
B/A/Ketema				43

Note: district kebeles are represented by a common altitudinal, temperature and rainfall figure due to unavailability of geographical data for each kebeles

Table 3. Quality index method scheme for sensory attribute measurements

Score	Flavour	Off flavour	Texture	Odour	Overall acceptability
7	Rich full	Very strong	Extremely fine	Very pleasant	Very desirable
6	Full flavour	Strong	Very fine	Pleasant	Desirable
5	Slightly full	Slightly strong	Fine	mildly pleasant	Slightly desirable
4	Neither full or weak	Highly perceptible	Moderately fine nor coarse	Neutral /no odour	Neither desirable nor undesirable
3	Slightly weak	Moderately perceptible	Moderately coarse	Slightly unpleasant	Slightly undesirable
2	Moderately weak	Slightly perceptible	Slightly coarse	Moderately unpleasant	Moderately undesirable
1	Weak	None	Coarse	Unpleasant	Very undesirable

Source: (Nielsen and Hyldig, 2004)

Table 4. Description of variables and mean (standard deviation) of each variable affecting respondents fish consumption in the study area

	Description	Mean (standard deviation)
Fish consumption	Kg/person/year	0.541(0.475)
Location (%)	Dummy: 1=rural, 0=otherwise	% Peri-urban households
Sex of household head (%)	Dummy: 1=female, 0=otherwise	35.6
Age of household head (%)	Continues: years	37.7 (5)
Education	Continues: schooling years	5.2(4.21)
Household size	Continues: person	4.3(3.98)
Income of household	Continues (Bir/month)	444(24.2)

Table 5

Effect of location, sex, age, job, education, family size and income on fish consumption by farmers and public servants

Factor	Coefficient	Standard error	P value
Location (rural)	0.314	0.138	0.022
Sex of household head (female)	-0.056	0.073	0.451
Age	-0.117	0.041	0.004
Education of household head	0.185	0.081	0.023
Household size	0.072	0.025	0.004
Household income	0.197	0.047	<0.001
Log likelihood	-317		
R^2	0.26		

Table 6. Physiochemical, sensory attributes and microbial loads of fish fillet as affected by location of sampling

Parameters	Catching site	Jimma mobile traders	Jimma retailers	District shops	SEM
Physiochemical					
Moisture (%)	79	76.11	76.1	76.1	0.317
Ash (%)	1.42	1.14	1.04	1.09	0.005
Fat (%)	1.72	1.44	1.48	1.46	0.007
Crude protein (%)	17	15.42	15.6	15.6	0.066
Total volatile basic nitrogen (%)	12	23.15	17.4	20.4	0.067
pH	6.23	6.71	6.56	6.64	0.026
Sensor attributes (1 to 7 score)					
Flavour	3.54	3.67	3.67	3.71	0.268
Off flavour	4.34	4	2.8	3.4	0.44
Texture	3.42	3.67	3.56	3.17	0.307
Odour	3.5	3.67	2.8	2.97	0.327
General acceptability	3.98	4	3.13	3.5	0.512
Microbial loads					
Aerobic (Log10 cfu/g)	6.77	7.4	7.12	7.2	0.109
Coliform (Log10 cfu/g)	4.15	4.98	5.22	5.2	0.439

Table 7. Physiochemical, sensory attributes and microbial loads of fish fillet as affected by location of sampling (Coefficient (SE))

	Catching site vs:		
	Districts shops	Jimma town mobile traders	Jimma town retailers
Physiochemical traits			
Moisture (%)	-11.5 (1.1*)	-4.99 (1.42)*	-11.5 (1.42)*
Ash (%)	-1.31 (0.019)*	-0.395 (0.024)*	-1.79 (0.024)*
Fat (%)	-1.05 (0.023)*	-0.88 (0.029)*	-1.33 (0.029)*
Crude protein (%)	-5.94 (0.229)*	-5.94 (0.3)*	-9.9 (0.3)*
Total volatile basic nitrogen (%)	33.5 (0.231)*	15.8 (0.31)*	54.14 (0.31)*
pH	1.63 (0.091)*	1.49 (0.12)*	2.33 (0.12)*
Sensory attributes			
Flavour	0.7 (0.928)	0.553 (1.99)	0.533 (1.99)
Off flavour	-3.8 (1.2)*	-1.33 (1.97)	-6.13 (1.97)*
Texture	-1 (1.06)	1 (1.37)	0.556 (1.37)
Odour	-2.13 (1.13)*	0.667 (1.46)	-2.8 (1.46)
General acceptability	-1.93 (1.77)	0.066 (2.29)	-3.4 (2.29)
Microbial loads			
Aerobic (Log10cfu/g)	1.72 (0.376)*	1.42 (0.486)*	2.51 (0.486)*
Coliform (Log10cfu/g)	4.21 (1.52)*	3.33 (1.96)*	4.26 (1.96)*

*: $P \leq 0.05$