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Fish handling and postharvest losses around the Fincha'a, Amarti, and Nashe reservoirs in Oromiya, Ethiopia

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This study assessed the factors contributing to postharvest loss of fish around the Fincha'a, Amarti, and Nashe reservoirs in Horro Guduru Wollega, Oromia, Western Ethiopia, using semi-structured questionnaires from January, 2022 GC onward. The aim of the finding was to know the fish handling and post-harvest preservation of fish around the reservoirs. In the study area, 320 respondents were selected using a random sampling system. Findings revealed that 61.1% of respondents consume fish without processing, with only 20.8% using salting and 18.1% practicing drying. The drying process notably affected texture, smell, and color. Most respondents (91.7%) preferred fresh fish due to financial constraints, lack of awareness, and market access. Species preference (40.3%), quality (33.3%), and market demand (23.6%) influenced pricing. Transportation is often done using donkey-back loads that could increase the risk of fish contamination. Although 50% of respondents stored harvested fish for one day without treatment, among these, 88.9% reported no spoilage within a day. Handling materials varied, with metal containers (33.3%) being the most common. Fish is primarily consumed as stew (39.4%) in the study area. Among these, almost all (91.9%) enjoy eating fish. However, it is often viewed as food for children and for the poor by many of them (60.6%). Despite concerns over fish bones and odors of the fish, 80.6% reported no health issues related to consumption. Most respondents (90.3%) discarded spoiled fish due to a lack of training in fish harvesting and preservation. The study indicates that postharvest losses are minimal due to effective harvesting methods, with immediate consumption practices prevalent in the community.

Keywords Fish, Loss, Postharvest, Reservoirs

Fisheries production is influenced by various factors, including species, harvesting and postharvest handling, processing methods, and product types, which encompass both food and non-food applications[1]. Due to the perishable nature of fish products, careful handling is essential to extend shelf life, prevent contamination, and minimize waste[2]. Effective postharvest handling is crucial for various stakeholders, including smallholder fish farmers and participants in aquaculture postharvest value chains, as it creates employment opportunities[1]. Proper preservation and packaging of fish products not only optimize their utilization but also alleviate pressure on fish harvesting by meeting daily consumption demands, thereby sustaining the fisheries subsector[3]. Fish are particularly vulnerable to postharvest losses due to their neutral pH, which promotes microbial growth, and the presence of autolytic enzymes that can exacerbate spoilage in environments lacking cold chain facilities[4]. Losses can occur physically, chemically, or biochemically during capture, transport, storage, and processing, with physical losses being especially prevalent from freshwater harvesting due to the size of the fish[4,5].

Moreover, fish play a vital role in addressing food security challenges. Fish is an excellent source of lean protein, essential fatty acids (notably omega-3), micronutrients: B-vitamins and vitamins A, D and minerals (calcium, zinc, iron, and iodine) often scarce in staple foods like cereals and pulses[6]. In Ethiopia, significant water bodies, including lakes, rivers, and constructed reservoirs such as Fincha'a, Amarti, and Nashe, present substantial fish production potential, estimated at 1,822 tons per year for Fincha'a, followed by Koka and Tendaho at 1,362 and 1,345 tons, respectively[7].

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However, only 333 tons per year are currently harvested[7,8], indicating severe under-utilization of these resources. Key reasons for this under-exploitation include inadequate harvesting techniques, insufficient storage and processing systems, and a lack of awareness regarding the nutritional importance of fish. The methods of preparation and processing significantly impact the nutritional value, consumer preferences, and shelf life of fish products. In the study area, fish has historically not been a dietary staple, which has limited both harvesting and processing practices. Consequently, without effective postharvest practices, significant losses can occur during preprocessing, processing, storage, and transportation[7,9].

Research indicates that the small-scale fishery industry in Ethiopian reservoirs faces substantial annual post-harvest losses[4,10]. Studies conducted in the Amarti and Fincha'a reservoirs[11] have highlighted the types and magnitudes of these losses, suggesting measures to mitigate them. Contributing factors include poor-quality fishing gear, power fluctuations, transportation challenges, and inadequate refrigeration[4]. Despite the critical importance of understanding fish handling and processing in the Fincha'a, Amarti, and Nashe reservoirs, previous research has not adequately documented these practices. The aim of this study was thus to assess fish postharvest handling and fish processing practices in the Fincha'a, Amarti, and Nashe reservoirs in Oromiya, Western Ethiopia.

Materials and methods

Description of the study area

This study was conducted in the districts surrounding the Fincha'a, Amarti, and Nashe reservoirs, located in the Horro Guduru Wallaga zone of the Oromiya regional state in Ethiopia (Fig. 1). The capital town of the zone, Shambu, is situated 314 km west of Addis Ababa. The zone comprises twelve rural districts and ten towns, covering a total land area of 8097.27 km².

The population of the zone is approximately 840,709, with 419,252 (49.87%) males and 421,457 (50.13%) females[12]. The Fincha'a, Amarti, and Nashe reservoirs cover an area of 1318 km² and are located between 9° 10' 30" and 9° 46' 45" N latitude, and between 37° 03' 00" and 37° 28' 30" E longitude. The shape file of the area was downloaded from Diva GIS and ArcGis 10.8 software was used to map the study area location. all shapefile used was from CSA shapefile. The Fincha'a watershed experiences a humid climate, with maximum and minimum

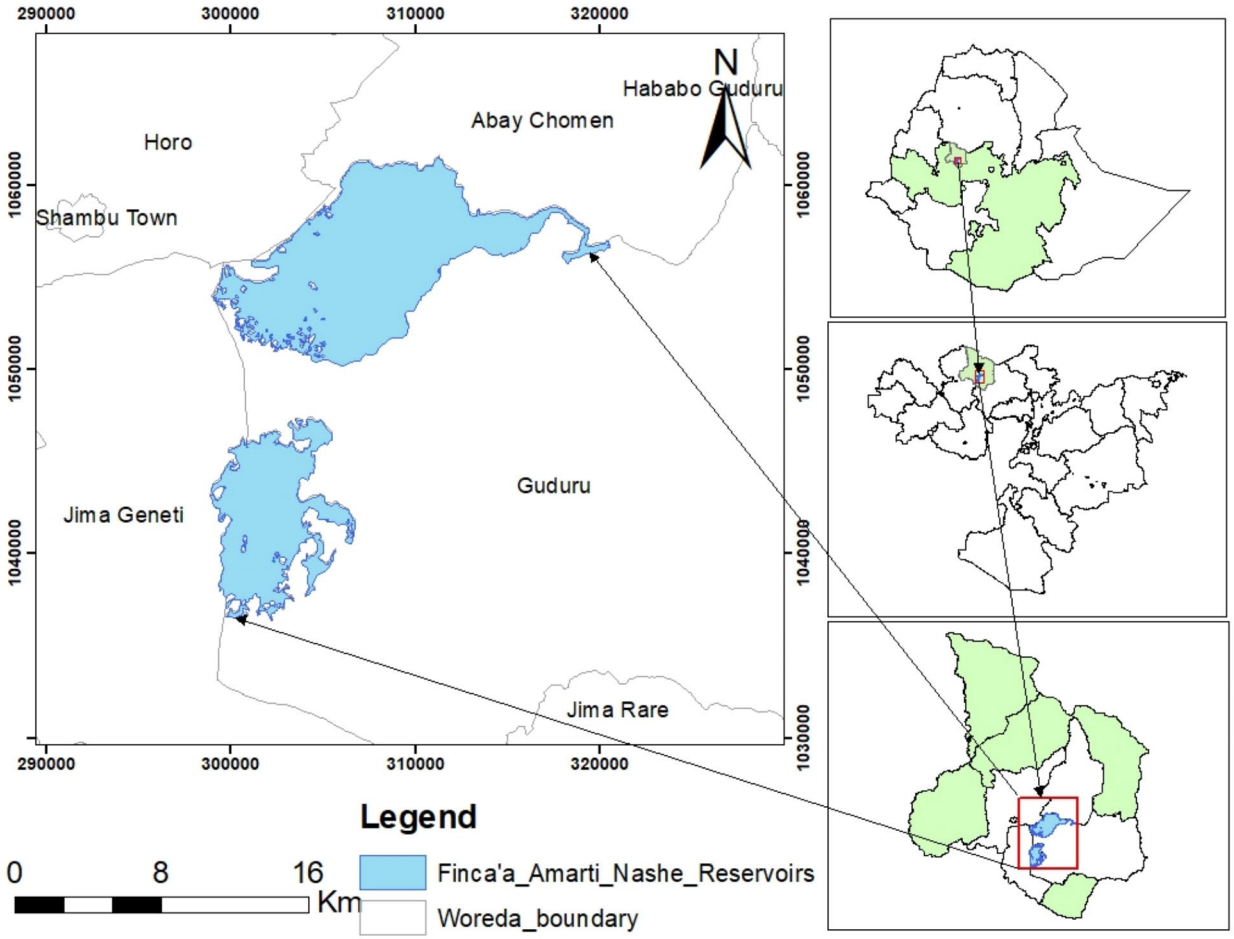

Fig. 1. Location of the Fincha'a Reservoir.

water temperatures ranging from 18.9 to 23.1 °C. The area receives an annual rainfall of 1823 mm, primarily occurring from May to August, with short rains from November to February[13].

Fish handling and postharvest losses around Fincha'a Reservoir

To collect primary data on fish product handling, postharvest losses, fish usage, training levels, and sustainability in the Fincha'a, Amarti, and Nashe reservoirs, semi-structured questionnaires were employed (Fig. 1). Three reservoirs and four fish vendor microenterprises were selected as key informants based on recommendations from local agricultural officers and their willingness to participate in the research.

Data collection involved household surveys and interviews with key informants. The survey questionnaire was pretested on selected household heads in a fishing community near the reservoirs, and the final version was revised based on feedback received during this pretesting phase. The survey was conducted using an appropriate sample size as described below.

Sample size determination

To determine the respondent, a stratified sampling approach was used. The population was divided into subgroups (fishermen, processors, and traders) directly or indirectly involved in and random samples were drawn from each subgroup to ensure representation.

The sample size for the postharvest loss interview process was estimated using the following formula[14,15]: $n = N/(1 + N(e^2))$.

where: n, is the sample size, N is the population size, and *e* is the level precision.

For a total population of $N = 3{,}200$, and a desired precision level of 5%, the estimated sample size was calculated to be 356. This size ensures that the results are statistically significant and representative of the population at a 95% confidence level.

Given that the calculated sample size (356) was relatively large compared to the total population (3,200), a finite population correction was applied to refine the sample size to: $n^1 = 1/(1/n + 1/n)$[14,15].

By substituting.

where: $n = 356$, is the sample size, $N = 3{,}200$ is the population size and $n^1 =$ final sample size corrected.

This correction led to a final sample size of $n^1 = 320$. This adjustment helps to accounts for the reduction in variability in smaller populations, ensuring that the sample size is not overly inflated. The sample size of 320 individuals was determined to balance statistical validity and practicality. This size is large enough to provide reliable estimates while being manageable for data collection efforts.

Sampling techniques

Sample collection proceeded following approval from the Wollega University Research Ethical Committee, adhering to ethical standards for human research. The committee confirmed compliance with ethical guidelines regarding this study.

After obtaining approval, the interviewers were trained to ask questions neutrally and to create a comfortable environment for respondents. Anonymous responses were encouraged to promote honesty. both nonrandom and random sampling techniques were employed for data collection. A purposeful (nonrandom) approach was utilized to select fishermen, processors, traders, and agricultural officers.

Follow-up procedures were established to re-engage participants who initially declined to participate, ensuring that the sample remained representative.

Statistical analysis

The collected data were analyzed using quantitative and qualitative methods, employing the Statistical Package for Social Sciences (SPSS 23.0)[16]. Information gathered from verbal discussions with key informants and focus group discussions was carefully recorded and systematically organized by similarity. Descriptive statistics, including percentages, frequencies, means, and standard deviations, were utilized in the analysis.

For qualitative identifying, analyzing, and reporting patterns (themes) with in the data were used for analysis. Through quantify, analyzing the presence of certain words, themes or concepts. These techniques provided a deeper understanding of the qualitative data, complementing the quantitative findings.

Results and discussion

Fish Storage practices

Fish consumption is low among nearby communities due to historical negative perceptions and the short shelf life of fish (Table 1). Many individuals associate fish with unpleasant odors and undesirable taste, leading to a reluctance to include it in their diets which agree with[17]. Furthermore, the perception of fish having a short shelf life exacerbates this issue, limiting its appeal as a regular dietary option. Age plays a role as well; younger fish are more susceptible to heat stress at temperatures exceeding 24 °C[18]. Fluctuations in temperature contributes

S/N	Duration	Frequency	Percent
1	Six h.	27	37.5
2	One day	36	50.0
3	Two days	9	12.5

Table 1. Storage time for fish without spoilage.

to microbial spoilage and biochemical changes during storage and transportation[19], necessitating effective preservation methods.

To extend shelf life, 30.6% of respondents utilized salt, while 69.4% employed no preservation methods. Minimal harvesting is common due to fears of loss, compounded by inadequate metal gear for larger catches, highlighting the need for improved preservation techniques and quality control measures[20]. Processing methods such as gutting, scaling, and salting are practiced to minimize spoilage immediately after harvesting[3].

The study indicates that fish are generally stored for no more than two days, as reported by 12.5% of respondents. This limited storage period is primarily due to inadequate temperature control, as cold chain facilities are nonexistent in the area. Rapid deterioration is a significant concern, especially for younger fish, which are more susceptible to heat stress at water temperatures exceeding 24 °C[21].

Temperature fluctuations during storage and transportation greatly contribute to microbial spoilage and biochemical changes, necessitating effective preservation methods[22]. Inadequate storage conditions can lead to the substantial postharvest losses, which not only affect food security but also economic stability for fishers and their communities[23]. To prolong shelf life, approximately 30.6% of respondents utilize salt as a preservation method, while a significant 69.4% do not apply any treatment (Fig. 2). This lack of preservation is often linked to minimal harvesting practices, driven by fears of loss and spoilage.

The inadequacy of metal gear for larger catches further complicates the situation, underscoring the urgent need for enhanced preservation techniques and quality control measures[24]. Processing methods such as gutting, scaling, and salting are commonly practiced immediately after harvesting and play a crucial role in minimizing spoilage. These methods are vital for maintaining the quality of fish products and ensuring their safety for consumption[25]. Immediate processing not only extends the shelf life but also enhances the marketability of fish, providing economic benefits to local fishers.

The findings of this study highlight the potential for enhancing fish storage and preservation practices to improve community access to fish as a food source. Implementing strategies such as better handling techniques and introducing cold chain facilities could significantly reduce spoilage rates and increase fish consumption. Research indicates that proper storage and preservation methods can mitigate the rapid deterioration of fish products, thereby improving food security and nutritional outcomes in communities[26]. Targeted interventions focusing on education and resource provision are essential for promoting sustainable fishing practices and improving public health outcomes[27]. By addressing the challenges associated with fish storage and preservation, communities can enhance their nutritional intake and economic resilience, ultimately contributing to improved health and well-being.

Fish product preservation practices

A significant majority of respondents (61.1%) indicated that they consume fish products immediately after harvest, without applying any preservation treatments (Table 2). Among those who do utilize preservation methods, 20.8% reported using salting, while 18.1% employed a combination of size reduction, salting, and drying.

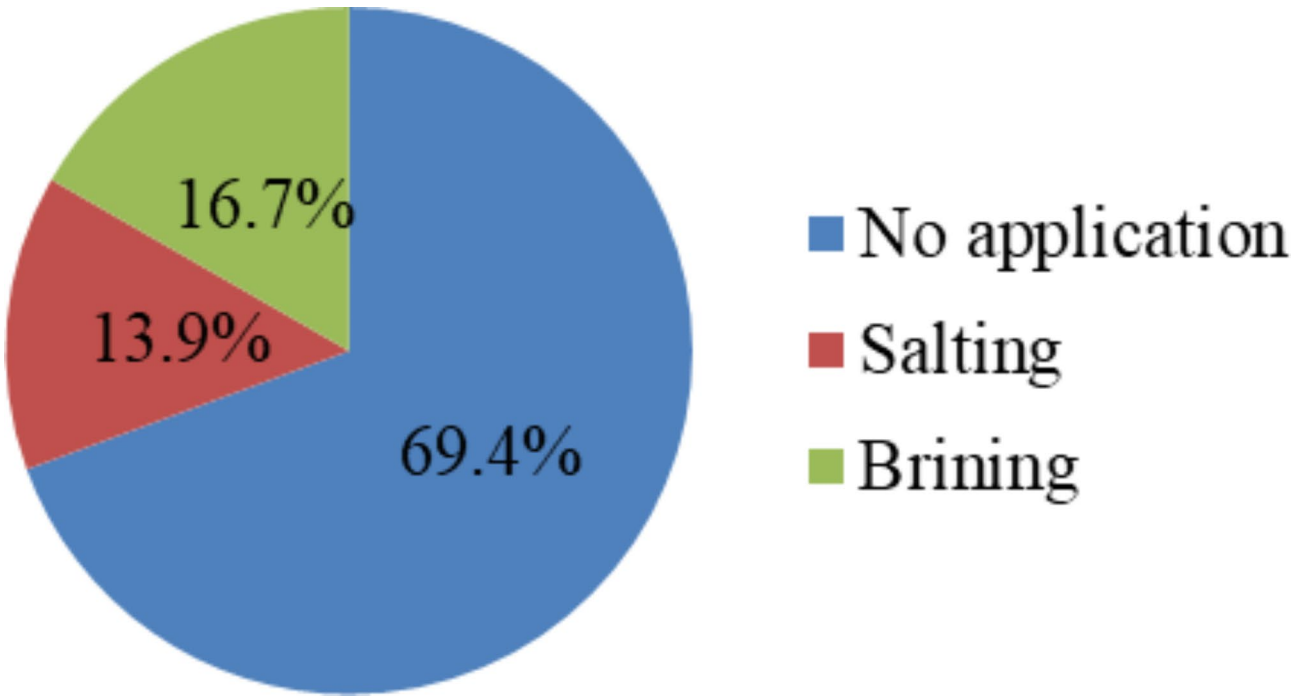

Fig. 2. The proportion of fish preservation practice used.

S/N	Preservation methods	Frequency	Percent
1	No treatment	44	61.1
2	Size reduction, salting, drying	13	18.1
3	Salting	15	20.8

Table 2. Participation of the community in the preservation practice of fish.

S/N	Methods	Frequency	Percent
1	Smell	6	8.3
2	Texture	9	12.5
3	Color	5	6.9

Table 3. Mechanism for checking fish drying.

Given the perishable nature of fish, special care during harvesting is crucial to maintaining product quality[1]. In contrast to many regions where refrigeration and freezing are common practices, these methods are largely unfeasible in this study area due to persistent electricity shortages. Consequently, salting and drying have emerged as the primary preservation methods, which is consistent with findings from similar regions, such as Fincha'a and Amarti[2].

Special care during harvesting is essential to maintain product quality due to the perishable nature of fish[4,28]. While refrigeration and freezing are common in other regions, they are not practiced in this study area due to a lack of electricity. Instead, salting and drying serve as primary preservation methods, consistent with findings around Fincha'a and Amarti[11].

Fish typically lose suitability for human consumption within twelve hours unless processed or kept in a cold environment. Slurry ice has been shown to inhibit microbial growth[29], but due to infrastructure limitations, chilling is not applicable in the area. Inadequate infrastructure for handling, processing, and transportation contributes to postharvest losses[11]. Fish typically become unsuitable for human consumption within twelve hours if not processed or stored in a cold environment. Although the use of slurry ice has been shown to effectively inhibit microbial growth[3], infrastructure limitations prevent its implementation in the area. The lack of adequate facilities for handling, processing, and transporting fish significantly contributes to postharvest losses[2]. Past studies emphasize the need for improved postharvest handling and storage techniques to enhance fish preservation and reduce waste[4,5]. Addressing the infrastructure challenges that support fish preservation such as cold chain facilities and processing are essential for improving the overall quality and availability of fish products in the region.

Fish drying

The preservation of fish through drying is a traditional method that has gained renewed interest in the context of sustainable food practices and food security. Approximately 27.7% of respondents in a recent study reported using drying as a preservation method, highlighting its relevance in certain communities. In contrast, a significant 72.2% opted for alternative preservation methods, indicating a potential area for education and outreach regarding the benefits of drying (Table 3). Drying extends the shelf life of fish products through various mechanisms. Quality must be maintained throughout the supply chain to preserve nutritional attributes and enhance consumer acceptance, which can be achieved through effective preservation and packaging techniques[30]. The community utilizes solar tents for drying fish, demonstrating the potential for localized preservation methods[31].

The drying process can lead to noticeable alterations in fish quality, which were reported as changes in smell (8.3%), texture (12.5%), and color (6.9%) (Table 3). These changes are critical to consumer acceptance and the overall marketability of dried fish products. For instance, texture changes, such as becoming tougher or chewier, may be perceived negatively by consumers, impacting their willingness to purchase dried products. Similarly, undesirable changes in smell can deter consumers, emphasizing the need for careful monitoring during the drying process. Drying extends the shelf life of fish through various mechanisms, including moisture removal, which inhibits the growth of spoilage microorganisms and by suppressing enzymatic activity[32]. By reducing water activity, drying creates an environment that is less conducive to bacterial growth, thus preserving the product for extended periods.

To ensure the nutritional attributes of dried fish products are preserved, maintaining quality throughout the supply chain is paramount. Effective preservation techniques, alongside appropriate packaging, play a critical role in safeguarding the nutritional value and sensory qualities of fish (Fig. 3). For instance, vacuum sealing and the use of oxygen absorbers can enhance shelf life while minimizing exposure to atmospheric conditions that may degrade quality[33].

The use of solar tents for drying fish is an innovative approach that reflects the potential of localized preservation methods. This technique not only utilizes renewable energy but also allows communities to engage in sustainable practices that reduce reliance on industrial drying methods. Recent studies have shown that solar drying can effectively preserve fish while maintaining quality, making it a viable alternative in areas with abundant sunlight[34].

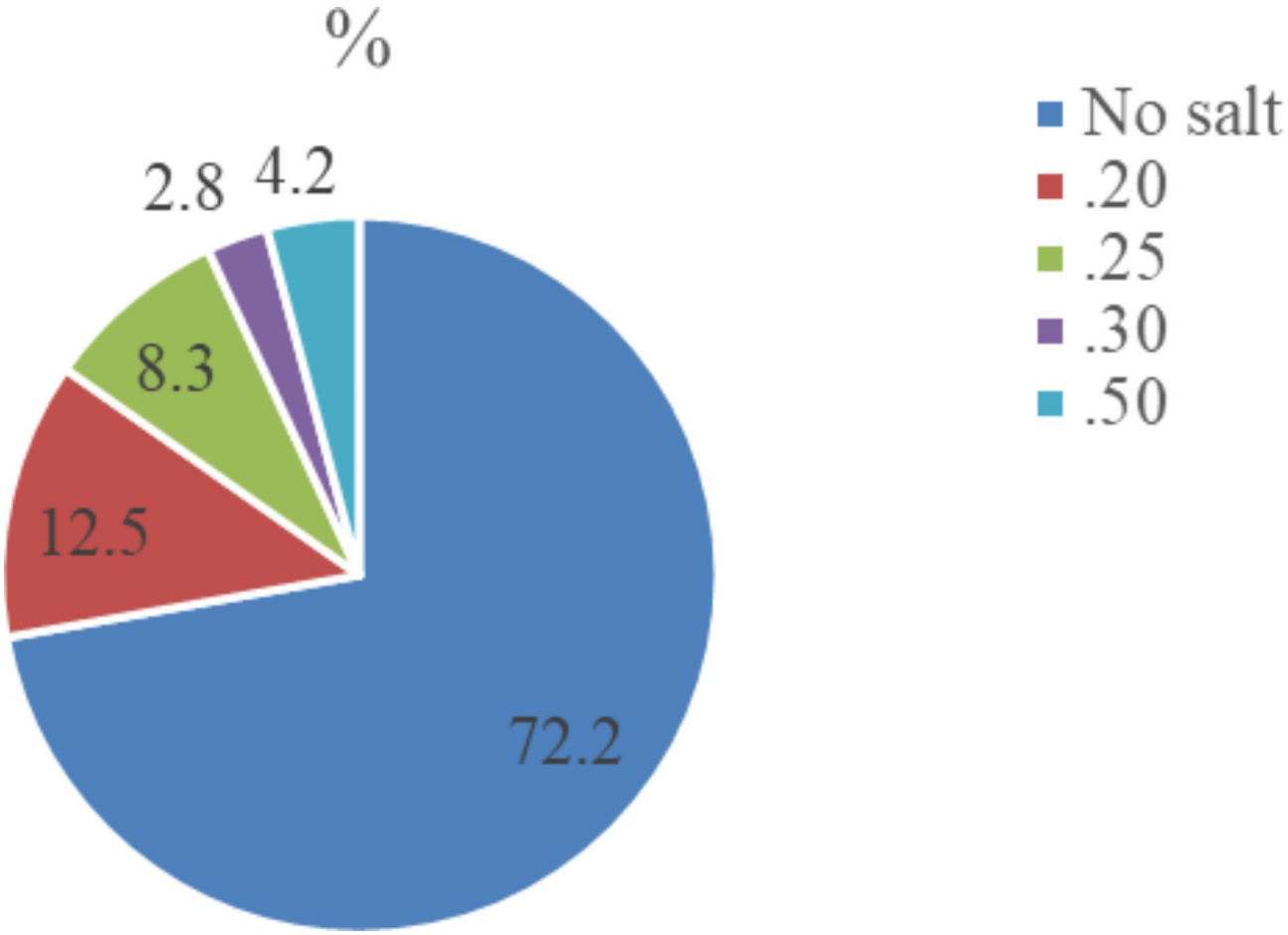

Fig. 3. Amount of salt in kg applied per 1fish for preservation.

Salting

The preservation of fish through methods like salting is crucial for enhancing shelf life and ensuring food security. Current findings indicate that among respondents, 30.6% practiced salting as a preservation technique, while 16.7% recognized the benefits of using brine solutions. However, the application of topical dry salt, utilized by 13.9% of respondents, has been noted to negatively impact the shape of the fish, potentially affecting its marketability and consumer appeal. Salting enhances shelf life by limiting water activity, with the concentration of the salt solution having a significant effect[35]. Salting is one of the oldest and most effective methods for preserving fish, primarily by limiting water activity, which inhibits microbial growth and enzymatic reactions[32]. The concentration of the salt solution plays a significant role in this process. Higher salt concentrations can more effectively reduce water activity, thus extending the shelf life of the fish. Despite the variation in salt quantity based on personal preference, a notable 91.7% of respondents reported using fresh fish for preservation, which helps mitigate storage issues and enhances the quality of the final product.

Unfortunately, fermented fish products pose health hazards[21]. While salting and brine salting use can enhance preservation, the production of fermented fish products poses health hazards, including the risk of pathogenic contamination if not handled properly[36]. This highlights the importance of adhering to safe processing practices to protect consumer health while retaining the benefits of traditional preservation methods.

Despite the advantages of salting, several barriers hinder effective storage and preservation of fish in low-income communities. In the study area these include a lack of capital (34.7%), awareness of preservation techniques (27.8%), and geographical challenges, such as distance from water reservoirs (20.8%). These barriers significantly impact the ability of communities to access fish, which is a vital source of essential fatty acids and micronutrients[29]. High postharvest losses are particularly detrimental to low-income communities, as they prevent access to important nutritional resources. Fish is an excellent source of omega-3 fatty acids, proteins, and micronutrients, which are essential for maintaining health, especially in regions where alternative sources of these nutrients may be scarce[37]. Addressing postharvest losses through improved fish catching, transport and storage techniques and community education can enhance food security and nutritional outcomes for vulnerable populations.

S/N	Food Item	Way of preparation	Form of consumption
1	Roasted	Fish caught from the reservoir Fine, shell head and internal organ removed Washing out the dirty part Roasting over fire (adding salt, different spices Bone removed during preparation (optional)	Consumed as ready food as a side dish or independently Bone can be removed (optional)
2	Fish cutlet	Fine, shell head and internal organ removed Fish caught from the reservoir Washing out the dirty part Cutting fish products into pieces Place in boiling pot with some amount of water Allowing water to boil and mix with fish pieces	As usual, it is consumed with injera and bread or pancake Bones are removed while eating and during preparation based on each fish species
3	Fish soup	2 fish caught from the reservoir Fine, shell head, bone, and internal organ removed Washing out dirty parts and fish products forced to crash in powder form Crashed fish product, added to warm water Mix thoroughly with warm water and add salt	Drinking used
4	Stew/ittoo/	Fish caught from the reservoir Fine, shell head, bone, and internal organ removed Washing out the dirty part with injera and bread. Add a small amount of boiled fish product water as normal stew Add different spices as required	Consumed as usual stew/ittoo

Table 4. Forms of fish food preparation, processing, and consumption in the study area.

S/N	Way of presentation	Frequency	Percent
1	Quality of product	24	33.3
2	Preferences	29	40.3
3	Demand in marketplace	17	23.6
4	I don't know	2	2.8

Table 5. Factors determining fish market price.

Fish food preparation and consumption

In the study area, tilapia cutlet emerges as the predominant method of fish preparation, favored by 55% of respondents. This preference highlights not only the popularity of tilapia as a versatile and accessible fish but also its significance in local culinary traditions. Following this, other methods such as fish ittoo/waxii/wote (39.4%) and roasting (5.6%) reflect varying cultural practices and preferences for fish consumption (Table 4). Fish is valued for its rich nutrient contents, including protein and omega-3 fatty acids[38].

Fish is widely recognized for its rich nutrients profile, providing essential proteins and omega-3 fatty acids, which are crucial for maintaining overall health and well-being[39]. Omega-3 fatty acids, in particular, are linked to numerous health benefits, including improved cardiovascular health and enhanced cognitive function, making fish an important dietary component, especially for children and pregnant women[40].

Over half of the respondents (54.6%) reported regular fish consumption, while 39.1% consume it occasionally, primarily due to unavailability. This discrepancy indicates that while fish is valued in the community, access challenges may limit its regular consumption. The perception of fish as beneficial for health and child development is notable, with 48.8% of respondents acknowledging its health benefits and 25.6% emphasizing its importance for child growth. This awareness underscores the potential role of fish in improving dietary quality, particularly in regions where malnutrition is prevalent.

Despite the high enjoyment of fish, reported at 91.9%, there exists a cultural stigma surrounding its consumption. Many respondents view fish as food primarily for children or the economically disadvantaged. This perception may hinder broader acceptance of fish as a staple protein source for all demographics. Addressing these cultural beliefs through education and community outreach could help reframe fish consumption as a valuable and nutritious option for everyone, irrespective of socioeconomic status. While most respondents (80.6%) have not experienced health issues related to fish consumption, concerns remain regarding hazard from fish bones and possibility of unpleasant odor. These issues can deter individuals, especially parents, from including fish in their diets, fearing potential choking hazards or unpleasant smells. Educational initiatives focusing on proper fish preparation techniques could alleviate these concerns, making fish a more appealing option for families.

Factors related to postharvest loss of fish

Market price

Pricing in the fish market is influenced by various factors, notably species preference, product quality, and market demand. According to recent findings, these elements account for 40.3%, 33.3%, and 23.6% of pricing, respectively (Table 5). Understanding these dynamics is crucial for stakeholders in the fishing industry, including fishermen, wholesalers, and consumers.

S/N	Challenges	Frequency	Percent
1	Lack of awareness	20	27.8
2	Lack of capital	25	34.7
3	Distance of the lake	15	20.8
4	Lack of market	12	16.7

Table 6. Challenges for fishing.

S/N	Means	Frequency	Percent
1	On foot	25	34.7
2	Cart animals	6	8.3
3	Donkey back	22	30.5
4	Motorcycle	10	13.9
5	Bajaji	9	12.5

Table 7. Means of transport of fish.

Species preference significantly impacts pricing, with certain fish varieties commanding higher prices due to their popularity and perceived value. For instance, species like tilapia and salmon are favored for their taste and nutritional benefits, leading to increased demand and subsequently higher market prices[39]. This preference is often influenced by tastes, cultural practices, and availability, highlighting the importance of understanding local consumer behavior.

Product quality is another critical factor affecting pricing. Freshness, size, and overall appearance play vital roles in determining how much consumers are willing to pay. High-quality fish that meets health and safety standards can fetch premium prices, while fish that is perceived as subpar may be discounted[32]. Ensuring consistent quality through proper handling and storage practices is essential for fishermen and sellers aiming to maximize their profits.

Market demand, influenced by seasonal trends and consumer habits, also affects pricing. For example, during festive seasons or events, demand for certain fish products may surge, leading to increased prices. Conversely, during off-peak times, prices may drop due to lower demand. Understanding these trends can help fishermen and sellers time their catches and sales to optimize pricing[40].

Additionally, consumer preference based on distance affects market prices. Barriers such as lack of starting capital (34.2%) inhibit fishing participation (Table 6). Consumer preference based on distance is an additional factor influencing market prices. Fish that is readily available and closer to consumers tends to be less expensive due to lower transportation costs. Conversely, fish that must be transported over long distances may incur higher costs, impacting its price in the market. This geographical aspect emphasizes the need for local supply chains to enhance accessibility and affordability[37].

Despite the market dynamics, barriers such as lack of starting capital inhibit fishing participation, with 34.2% of respondents citing this as a significant challenge. Without sufficient capital, aspiring fishermen may struggle to invest in necessary equipment or resources, limiting their ability to enter the market[41]. Addressing this barrier through financial support, training, and access to credit can empower more individuals to participate in fishing activities, thereby increasing supply and potentially stabilizing prices.

Transportation

Transportation challenges significantly impact the fish market, particularly due to the distances between fish reservoirs and markets. This study indicate that respondents primarily rely on foot and carts for transportation (Table 7), which can introduce several logistical hurdles that affect fish quality and market demand.

Longer transportation distances are directly correlated with an increased risk of spoilage. The primary concerns include the deterioration of fish quality, which 32.9% of the respondents identified as a significant issue. Fresh fish is highly perishable, and prolonged exposure to unfavorable conditions during transport can lead to microbial growth and spoilage. This decrease in quality not only affects the product's market value but also poses health risks to consumers[32].

Most respondents (56.2%) reported using donkeys for transport, a common practice in many rural areas due to their availability and low operational costs. However, this method can lead to inadequate handling conditions, contributing to spoilage. Donkeys may not provide the necessary support for maintaining optimal temperatures and conditions during transport, exacerbating the risk of quality loss[37]. Furthermore, transporting fish on foot or using carts may also expose the product to environmental factors, such as heat and contamination, further compromising quality.

The quality degradation resulting from inadequate transportation methods can directly influence market demand, with 23.3% of the respondents indicating that spoilage negatively affects how much fish they can sell. Consumers are less likely to purchase fish that appears damaged or has an off-putting odor, which can lead to reduced sales and financial losses for fishermen. This cycle of spoilage and decreased demand underscores the importance of improving transportation methods to enhance the overall supply chain[39].

To address these transportation challenges, stakeholders can explore several solutions. Implementing better handling practices during transport, such as using insulated containers or improved carts, could help maintain fish quality. Additionally, community training programs focused on best practices in fish handling and transportation could empower fishermen to adopt more effective methods.

Investments in infrastructure, such as better roads or dedicated transport services for fish, could significantly enhance the efficiency of getting fish from reservoirs to markets. These improvements could not only reduce spoilage rates but also increase overall market demand by providing consumers with higher-quality products[40].

Fishing and handling materials

The materials and methods employed in the harvesting and handling of fish play a crucial role in determining the shelf life and overall quality of fish products. Recent findings indicate that traditional gear often leads to longer handling times and increased physical damage, which heightens the risk of spoilage (Table 8). This situation presents significant challenges for fishers and the broader fishing community.

Traditional harvesting gear, such as nets and traps, may not be optimized for minimizing stress and damage to fish during capture. Prolonged handling times can expose fish to environmental stressors that accelerate spoilage, including temperature fluctuations and physical stress from being confined in nets or containers. Research has shown that using more modern or specialized gear can reduce handling times and minimize damage, thereby preserving the quality of the catch[32].

The issue of spoilage is compounded by the fact that only a small percentage (9.7%) of respondents reported repurposing spoiled fish. This indicates a significant underutilization of resources, as spoiled fish could potentially be transformed into products such as fish meal, compost, or even fermented products, which can still be valuable in various markets. The lack of repurposing strategies not only contributes to waste but also highlights a missed opportunity for economic gain within the community[37].

The economic implications of spoilage are considerable. Fishermen face financial losses when a significant portion of their catch is rendered unsellable due to spoilage. This loss can be particularly impactful in low-income communities where fish represents a vital source of income and nutrition. Furthermore, the environmental implications of wasted fish resources are noteworthy, as discarding spoiled fish contributes to waste management challenges and can have negative effects on local ecosystems.

Training needs

Training in fish handling and preservation practices is critical for enhancing product quality and reducing spoilage. Recent data highlights a significant gap in training within the fishing community, with approximately 70.8% of respondents reporting they have not received any formal training, while only 29% have had limited exposure to relevant training programs. This lack of education can lead to suboptimal practices that impact both the quality of fish products and the economic viability of fishing enterprises.

Training plays a vital role in improving fish handling techniques. Fishermen who have received training report enhanced preservation practices, which can significantly reduce spoilage rates and subsequently improve market prices for their products[32]. Proper training equips fishers with the knowledge of best practices, such as quick and gentle handling, optimal storage conditions, and appropriate preservation methods. These skills are essential for maintaining the freshness and quality of fish, which are crucial determinants of consumer acceptance and pricing in the market.

The economic benefits of training extend beyond individual fishers. Improved preservation practices contribute to greater overall efficiency in the supply chain. When fish is handled properly, spoilage is minimized, leading to higher quantities of sellable product. This not only increases the incomes of individual fishers but also enhances the profitability of local markets. Increased demand for high-quality fish products can stimulate economic growth within the community, creating more jobs and improving food security[37].

Those who received training reported improved preservation practices and market prices[42]. Training is also essential for addressing existing infrastructure gaps that can hinder effective fishery resource utilization. Many fishing communities lack adequate facilities for storage and transportation, which exacerbates spoilage issues. By incorporating infrastructure-related training, communities can develop strategies to improve their facilities, such as building better fish storage units or optimizing transport methods to ensure fish quality is maintained from catch to market. This holistic approach to training can empower communities to not only enhance their fishing practices but also advocate for necessary infrastructure improvements[8].

Conclusions

Fish handling and postharvest fish losses around the Fincha'a, Amarti, and Nashe reservoirs in Horro Guduru Wollega, Western Ethiopia were studied. Results showed that most respondents rely on foot transport, which is exacerbated by poor road infrastructure, leading to increased spoilage and diminished quality of fish products

S/N	Containers	Frequency	Percent
1	Plastic container	22	30.6
2	Metal container	24	33.3
3	Woven basket	23	31.9
4	Polyethylene sheet	3	4.2

Table 8. Fish handling materials for transportation.

leading to contamination. Furthermore, it was found that the majority of respondents do not employ effective preservation methods or quality control techniques. While some use traditional methods such as salting and drying, there is a widespread lack of practices like temperature control and proper packaging. Additionally, many fishers utilize metal containers during harvesting, accelerating the fish spoilage further. Significant waste occurs as fish by-products, such as heads and scales, are often discarded rather than repurposed. Given the limited awareness among the local dwellers about the rapid susceptibility of fish to spoilage and contamination, awareness creation regarding fish handling and preservation methods in figuring out the best practices that reduce spoilage and enhance the quality of fish products is recommended in hands-on-practice approach.

Data availability

The compiled or raw data used for this research is available upon request from the corresponding author or first author of the article "firisawoyessa@gmail.com".

Received: 11 May 2024; Accepted: 12 November 2024
Published online: 28 December 2024

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Acknowledgements
I have a great thank to the publishing organization for their kindly support first. The devotion of my advisors also appreciatedLastly Ethiopian ministry of education for funding PhD program.

Author contributions
corresponding Author Firisa Woyessa Ejeta collect data and write up the article. Others Geremu Bultosa (Professor), Diriba Diba (PhD) and Tilahun Abera Teka (PhD) are participate in editing and guidance for the accomplishment of the work.

Declarations

Competing interests
The authors declare no competing interests.

Ethical declaration
Informed consent was obtained from all subjects and/or their legal guardian(s).

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-024-79757-6.

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