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Compliance of fishery handling facilities to food safety requirements within the fresh Nile perch value chain in Uganda

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ABSTRACT

The study investigated the compliance of fisheries handling facilities to food safety requirements stipulated in the existing laws, regulations, and standards within the fresh Nile perch value chain in Uganda. Data on personnel hygiene facilities, infrastructure, equipment, storage facilities, product and ice handling, waste management, and water quality were collected using a checklist based on current regulations, standards, and codes of practice, through direct observation. Fisher's exact test of independence was used to determine significant differences in compliance based on facility type, market chain, and value chain segments. Fish factories (processing facilities) exhibited the highest compliance, followed by landing sites and local market stalls. There were significant ($p \leq 0.001$) disparities in compliance for all the parameters, across value chain segments. Personnel hygiene facilities, such as changing rooms, toilets, and handwashing amenities, showed suboptimal compliance, with only 48.1% of the fish handling facilities having fully or nearly compliant change rooms. Conversely, 39.2% fish facilities had least or non-compliant toilets, posing a considerable risk of cross-contamination. There was a significant ($p \leq 0.001$) distinction for all the examined parameters between facilities in the export and local market chains. Export-oriented facilities demonstrated higher compliance levels. This study recommends prioritisation of interventions targeting training and infrastructure development for the private sector.

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1. Introduction


Developing countries have continued to engage in international food trade and encourage foreign direct investment as a means of achieving socio-economic development. Friel et al. (2013) emphasizes the profound impact of liberalizing international trade and attracting foreign direct investment on the structure and dynamics of food systems. These changes influence the availability, nutritional quality, accessibility, price, and promotion of foods in diverse locations, thereby posing both risks and opportunities to food security, nutrition, and public health (Friel et al., 2013).

Products from fisheries and aquaculture are among the most traded goods, with 68 million tons traded annually fetching 190 billion USD (Lem et al., 2023). However exports of fisheries and aquaculture products in some developing countries

have declined in terms of both quantity and value over the recent years due to failure to meet the international food quality and safety standard (Shamsuzzaman et al., 2020). The Nile perch value chain is one of the most important value chain providing livelihood to about two million Ugandans and accounts for about 60% of the total fisheries (GIZ, 2021; UNCTAD, 2017). According to Patrick et al. (2020), the fresh Nile perch value chain consists of a broad range of actors including but not limited to fishing crews, collectors/transporters, landing sites' operators, factory agents, local market traders, and industrial processors. Uganda currently has an installed Nile perch processing capacity of 64 tonnes (Patrick et al., 2020).

The significance of adhering to international standards in food production became evident for Uganda following the European Union (EU) import

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ban on fish products in the late 1990s and early 2000s due to high bacterial loads, including *Salmonella* Spp (Ponte, 2007; Rudaheranwa et al., 2003). In response, measures were implemented to meet EU requirements for fishery products, including the adoption of good hygiene practices (GHP) and hazard analysis at critical control points (HACCP) procedures (EC Directive 91/493/EEC of 22 July 1991; Waniala, 2002; Kjær et al., 2012; The Fish (Fishery and Aquaculture Products) (Quality Assurance) Rules 2017)

The 1980s witnessed the introduction of the Structural Adjustment Program (SAP) as a condition for financial support in East African countries (Abila, 2014). In Uganda, policy incentives under the Poverty Eradication Action Plan (PEAP) and the National Fisheries Policy (NFP) facilitated the growth of fish processing factories, supported by tax incentives, import duty waivers, favourable forex retention, and land leases (Namisi, 2000). The fisheries subsector also acquired low-interest loans provided by local or international banks for constructing and equipping fish factories for local and international trade (Abila, 2014). However, despite efforts directed at infrastructural development and financing initiatives for fish processing establishments, these endeavours have primarily targeted medium and large-scale enterprises, leaving micro and small establishments, which handle fish for local trade, largely overlooked.

Concerns arise regarding the compliance of these micro and small establishments, especially considering the challenges faced by exporting companies in developing countries in adhering to stringent food safety standards due to associated investment costs (Bagumire, Todd, Muyanja, & Nasinyama, 2009; FAO, 2022; Whitworth, 2024). Ensuring compliance with pre-set food safety standards at all levels of the food production chain is crucial for improved food safety management in the context of 'farm-to-fork'. However, there is a notable gap in understanding how fishery handling facilities within the fresh Nile perch value chain in Uganda adhere to food safety requirements. With a view of understanding the factors that influence food safety, this study aimed at assessing the compliance of fishery handling facilities to food safety requirements within the fresh Nile perch value chain in Uganda. Understanding the compliance of these facilities is pivotal in the designing of interventions to enhance food safety first within the fresh Nile perch value chain in Uganda and for the wider food-processing sector within the sub-Saharan region.

2. Materials and methods

2.1. Study design and location

The study was conducted as a cross-sectional survey at facilities handling fresh Nile perch products for placing on the market in Uganda. Visits were conducted to all registered landing sites around Lake Victoria, local market stalls around the Lake Victoria basin, and fish processing factories in Uganda. All fish handling facilities handling fresh Nile perch fish and fishery products after it comes out of the lake, and were operational during the study period (September to December 2022), were evaluated to profile their compliance to the stipulated standards' requirements. As shown in [Supplementary Tables 1–3](#), a total of 54 (30 landing sites (15 handling fish for export and the corresponding 15 (located adjacent to the export fish handling areas) handling fish going to the local market), 9 market stalls and 15 Nile perch processing factories) fish handling facilities were operational at the time of the study, and were evaluated.

2.2. Data collection

Primary data were collected by evaluation of the fish handling facilities ([Supplementary Tables 1–3](#)) through direct observation and recording of findings. A checklist ([Supplementary Table 4](#)) of hygiene facilities, personnel protective wear, infrastructure, storage facilities, waste management facilities, water quality, equipment, and fisheries product handling practices, adapted from the standard operating procedures for fish (fishery and aquaculture products) inspection and quality assurance (The Fish (Fishery and Aquaculture Products) (Quality Assurance) Rules 2017), was used to evaluate the fish handling facilities. The facilities were scored as either Total Compliance – 5, Almost Total Compliance – 4, Some Compliance – 3, Least Compliance – 2, or Non-Compliance – 1 using a 1–5 Likert scale based on observations as described in the checklist ([Supplementary Table 4](#)).

2.3. Data analysis

Data on compliance of the fish handling facilities with standards and regulations were derived from the evaluation checklist and assigned numerical codes. The coded data were analysed using descriptive analysis techniques to compute frequency tables. Proportions to establish differences in compliance levels between fish handling facilities, type of market chain, and segments of the value chain were

computed. Fisher's exact test of independence (McDonald, 2014) was used to determine significant differences in compliance of facilities within different market chains, and compliance of facilities within different segments of the value chain at the 5% level of significance. According to McDonald (2014), the Fisher's exact test of independence was deemed appropriate for use because the study was comparing two nominal variables (compliance and market chain, compliance and segment of value chain) to see whether the proportions of one variable are different depending on the value of the other variable. Additionally, the sample size was small with values less than 5 in several cells as shown in Tables 1 and 2.

2.4. Ethical statement

Prior to evaluation of the facilities, permission to conduct the study was obtained from the Fisheries Officers at the public fish handling facilities, and the Managers at the privately owned fish handling facilities. The cross-sectional study collected descriptive data, on the fish handling facilities. The obtained data had no personal, social or political consequences.

3. Results and discussion

3.1. Compliance of fishery handling facilities with food safety requirements

The overall compliance of the fishery handling facilities in the fresh Nile perch value chain is shown in Table 1. The facilities were evaluated for compliance with standards requirements with reference to infrastructure, use of personal protective wear, fishery products

handling practices, water quality, waste management, vermin control, packaging, and transport.

3.1.1. Infrastructure

Out of the evaluated facilities, 53.7% had suitable structures, being either totally compliant (adequate space with clean and dirty areas separated; layout allows for uni-directional flow of products; easily cleanable, durable, non-absorbent water proof walls, floors, and ceilings; floor allows for easy self-drainage) or almost totally compliant (clean and dirty areas separated; layout allows for uni-directional flow of products; easily cleanable, durable, non-absorbent water proof walls, floors, and ceilings), whereas 3.7% were somewhat compliant (spacious; easily cleanable walls, floors, and ceilings) and 42.6% were either least compliant (easily cleanable walls, floors, and ceilings) or non-compliant (limited space; not easy to clean walls, floors and ceilings where they exist; aids cross contamination). The results are in agreement with the findings of a similar study that analysed fish processing and handling units in Uganda (Were B (Makerere University), 2021). According to Were B (Makerere University) (2021), the design of fish handling and processing units was mostly above standards as the infrastructure had proper natural ventilation, appropriate lighting, easily cleanable floors (of either concrete or terrazzo or ceramic tiles), with a general layout allowing for a unidirectional systematic flow of fish from raw material to finished goods. For the fish contact surfaces, as indicated in Table 1, 55% of the facilities were either totally compliant (clean, smooth, durable, non-corrosive, water impermeable, good condition) or almost totally

Table 1. Overall compliance of fishery handling facilities with food safety requirements within the fresh Nile perch value chain.

Checklist item	Non-compliance (n (*row%))	Least compliance (n (*row%))	Some compliance (n (*row%))	Almost total compliance (n (*row%))	Total compliance (n (*row%))
Contact surfaces for fishery products	7 (13)	11 (20.4)	6 (11.1)	11 (20.4)	19 (35.2)
Tool to handle fishery products and ice	2 (3.7)	17 (31.5)	5 (9.3)	6 (11.1)	24 (44.4)
Containers for storage of fish products	7 (13)	12 (22.2)	7 (13)	7 (13)	21 (38.9)
Changing room	21 (38.9)	5 (9.3)	2 (3.7)	14 (25.9)	12 (22.2)
Toilets	5 (9.3)	16 (29.6)	5 (9.3)	12 (22.2)	16 (29.6)
Hand wash facilities	14 (25.9)	9 (16.7)	3 (5.6)	15 (27.8)	13 (24.1)
Appropriate storage	9 (16.7)	17 (31.5)		19 (35.2)	9 (16.7)
Structural suitability	17 (31.5)	6 (11.1)	2 (3.7)	10 (18.5)	19 (35.2)
Acceptable quality water is available for use all the time	5 (9.3)	17 (31.5)	2 (3.7)	12 (22.2)	18 (33.3)
Good fishery product (FP) handling practices to avoid contamination observed by handlers.	5 (9.3)	16 (29.6)	3 (5.6)	10 (18.5)	20 (37)
Appropriate packaging and labelling	17 (31.5)	7 (13)	4 (7.4)	10 (18.5)	16 (29.6)
Waste storage containers, effluent treatment and solid disposal facilities	12 (22.2)	11 (20.4)		19 (35.2)	12 (22.2)
Pests and vermin control	22 (40.7)	1 (1.9)		17 (31.5)	14 (25.9)
All workers wear suitable protective wear	6 (11.1)	15 (27.8)	3 (5.6)	9 (16.7)	21 (38.9)
Transport means are appropriate and reliable	5 (9.3)	16 (29.6)	1 (1.9)	13 (24.1)	19 (35.2)

*row %: row percentages and is given by (n/N)100. Where N is overall number of facilities evaluated and is equal to 54.

Table 2. Compliance of fishery handling facilities by segment of the value chain.

Type of facility	Segment of the value chain						F-exact
	Landing site		Market stalls		Factory		
	*Freq (n=30)	*Col %	*Freq (n=9)	*Col %	*Freq (n=15)	*Col %	
Elements to verify	Infrastructure and equipment						
Contact surfaces for fishery products							<0.001
Non compliance	5	16.7	2	22.2	0	0	
Least compliance	8	26.7	3	33.3	0	0	
Some compliance	2	6.7	4	44.4	0	0	
Almost total compliance	3	10	0	0	8	53.3	
Total compliance	12	40	0	0	7	46.7	
Tool to handle fishery products and ice							<0.001
Non compliance	2	6.7	0	0	0	0	
Least compliance	11	36.7	6	66.7	0	0	
Some compliance	2	6.7	3	33.3	0	0	
Almost total compliance	2	6.7	0	0	4	26.7	
Total compliance	13	43.3	0	0	11	73.3	
Containers for storage of fish products							<0.001
Non compliance	7	23.3	0	0	0	0	
Least compliance	5	16.7	7	77.8	0	0	
Some compliance	3	10	2	22.2	2	13.3	
Almost total compliance	5	16.7	0	0	2	13.3	
Total compliance	10	33.3	0	0	11	73.3	
Changing room							<0.001
Non compliance	13	43.3	8	88.9	0	0	
Least compliance	2	6.7	1	11.1	2	13.3	
Some compliance	2	6.7	0	0	0	0	
Almost total compliance	7	23.3	0	0	7	46.7	
Total compliance	6	20	0	0	6	40	
Toilets							<0.001
Non compliance	5	16.7	0	0	0	0	
Least compliance	10	33.3	6	66.7	0	0	
Some compliance	0	0	2	22.2	3	20	
Almost total compliance	9	30	1	11.1	2	13.3	
Total compliance	6	20	0	0	10	66.7	
Hand wash facilities							<0.001
Non compliance	14	46.7	0	0	0	0	
Least compliance	1	3.3	8	88.9	0	0	
Some compliance	3	10	0	0	0	0	
Almost total compliance	10	33.3	1	11.1	4	26.7	
Total compliance	2	6.7	0	0	11	73.3	
Appropriate storage							<0.001
Non compliance	7	23.3	2	22.2	0	0	
Least compliance	8	26.7	7	77.8	2	13.3	
Almost total compliance	14	46.7	0	0	5	33.3	
Total compliance	1	3.3	0	0	8	53.3	
Structural suitability							<0.001
Non compliance	11	36.7	6	66.7	0	0	
Least compliance	4	13.3	2	22.2	0	0	
Some compliance	0	0	0	0	2	13.3	
Almost total compliance	4	13.3	0	0	6	40	
Total compliance	11	36.7	1	11.1	7	46.7	
	Water quality						
Acceptable quality water is available for use all the time							<0.001
Non compliance	5	16.7	0	0	0	0	
Least compliance	10	33.3	7	77.8	0	0	
Some compliance	1	3.3	1	11.1	0	0	
Almost total compliance	8	26.7	1	11.1	3	20	
Total compliance	6	20	0	0	12	80	
	Fisheries product handling						
Good fisheries product (FP) handling practices to avoid contamination observed by handlers.							<0.001
Non compliance	5	16.7	0	0	0	0	
Least compliance	10	33.3	6	66.7	0	0	
Some compliance	0	0	3	33.3	0	0	
Almost total compliance	9	30	0	0	1	6.7	
Total compliance	6	20	0	0	14	93.3	
	Packaging and labelling						
Appropriate packaging and labelling							<0.001
Non compliance	11	36.7	6	66.7	0	0	
Least compliance	3	10	2	22.2	2	13.3	

(Continued)

Table 2. Continued.

Type of facility	Segment of the value chain						F-exact
	Landing site		Market stalls		Factory		
	*Freq (n=30)	*Col %	*Freq (n=9)	*Col %	*Freq (n=15)	*Col %	
Some compliance	3	10	1	11.1	0	0	
Almost total compliance	9	30	0	0	1	6.7	
Total compliance	4	13.3	0	0	12	80	
Waste management							
Waste storage containers, effluent treatment and solid disposal facilities							0.001
Non compliance	8	26.7	4	44.4	0	0	
Least compliance	7	23.3	4	44.4	0	0	
Almost total compliance	8	26.7	1	11.1	10	66.7	
Total compliance	7	23.3	0	0	5	33.3	
Vermin control							
Pests and vermin control							<0.001
Non compliance	15	50	7	77.8	0	0	
Least compliance	0	0	1	11.1	0	0	
Almost total compliance	12	40	1	11.1	4	26.7	
Total compliance	3	10	0	0	11	73.3	
Personnel							
All workers wore suitable protective wear							<0.001
Non compliance	6	20	0	0	0	0	
Least compliance	9	30	6	66.7	0	0	
Some compliance	0	0	3	33.3	0	0	
Almost total compliance	9	30	0	0	0	0	
Total compliance	6	20	0	0	15	100	
Transport means							
Transport means are appropriate and reliable							<0.001
Non compliance	5	16.7	0	0	0	0	
Least compliance	10	33.3	6	66.7	0	0	
Some compliance	0	0	1	11.1	0	0	
Almost total compliance	4	13.3	2	22.2	7	46.7	
Total compliance	11	36.7	0	0	8	53.3	

*Freq: frequency; col: column percentages.

compliant (clean, smooth, not durable, non-corrosive, water impermeable, good condition), whereas 34% were below average as either least compliant (clean, rough, not durable, corrosive, water permeable, poor condition) or non-compliant (dirty, rough, not durable, corrosive, water permeable, poor condition). Storage containers, and tools for handling fishery products and ice in all fish handling facilities were more inclined to compliance than non-compliance with 52 and 55.1%, respectively being either totally compliant and almost totally compliant.

From Table 1, it is observed that personnel hygiene facilities in all evaluated fish handling facilities were more inclined to non-compliance than compliance. Only 48.1% of the fish handling facilities had change rooms that were either totally compliant (separate for both genders, enough space, clean, adequate storage space for uniforms, adequate storage space for personal items) or almost totally compliant (separate for both genders, enough space, clean, storage space for uniforms, storage space for personal items). Thirty nine percent (39.2%) of the fish handling facilities had toilets that were either least compliant or non-compliant (few or no clearly designated toilets, dirty, not flushing or no running water, no provision

for hand wash, close and directly opening into fish handling area). This percentage is high given that poor toilet practices can easily lead to cross contamination. The situation is further aggravated by the fact that 42.6% of the facilities had hand wash facilities that were either least compliant (just water and soap, no sanitiser, not appropriately situated, not adequate pressure, and tap system hand operated if available) or not compliant (no provision for hand washing) at all. These results corroborate the findings of a study in Kenya, which highlighted that much as there has been some improvement in adhering to safety standards, the facilities at the landing sites have always been a point of weakness in regard to hygiene (Henson & Mitullah, 2004). These results further corroborate with the findings of a study in Indonesia, which highlighted non-compliance to safety standards, as the fish left the waters to the handlers at different points like markets and processing areas due to factors like personal hygiene and related facilities (Dali & Husain, 2020).

Compliance to food safety standards and HACCP procedures is quite costly but its benefits are worth the investment since it has tremendously translated into protected public health and increased fish exports

to the European market (Guenther, 2022; Whitworth, 2024). Non-compliance has led to bans or rejection of export products causing a hefty loss to the exporting country. For example, when the fishery products from Uganda were banned from the European market in 1997 for failure to adhere to the EU hygiene and processing quality standards, Uganda incurred a loss of approximately thirty six million dollars (USD 36.9 Million) (FAO (2022); Neeliah et al. (2011)). It is therefore prudent that governments, especially in developing countries, support the private sector (fish handling facilities) to undertake structural improvements to assure compliance with standards.

3.1.2. Personnel protective wear

The majority of the personnel (55.56%) were either totally compliant (clean head gear, overall, gumboots, apron and gloves) or almost totally compliant (clean head gear, overall, gumboots, and apron) to the requirements of personnel hygiene, having clean, complete, and appropriate personnel protective wear (Table 1). Previous training, experience in the industry, and education levels of food handlers among other factors, have been reported by other researchers in other countries to be positively associated with compliance to wearing personal protective equipment when handling food to ensure safety (George et al., 2023; Henson & Mitullah, 2004). In a study among fish handlers within the fresh Nile perch value chain in Uganda, Ssubi et al. (2024) reported that the level of education and previous food safety training were positively associated with food safety knowledge, attitudes and practices. Twenty eight (28%) of the evaluated facilities had personnel with either one clean piece of protective gear or more than two pieces of their protective gear evidently dirty. Eleven percent (11%) of the evaluated facilities did not have any protective gear at all.

Amidst the strict adherence to Personnel Protective Equipment (PPE) requirements by the food handlers, researchers have continued to report failure to use the appropriate PPE as well as inappropriate use of it (Finger et al., 2021) as major contributors to the contamination of food products. A study conducted in Vietnam revealed that there was a high prevalence of pathogens both at the work surfaces and on the hands of the fish handlers (Ngoc et al., 2020). Ngoc et al. (2020), indicated that, food handlers are potential sources of microbial hazards (pathogens).

3.1.3. Fishery products and ice handling

Amos et al. (2007), noted poor handling methods after capture as one of the factors that could

influence the food safety of fish and fishery products. It is important to ensure good food handling practices as one of the ways of preventing cross contamination. The fishery handling facilities that were evaluated, exhibited fisheries handling practices that are mostly compliant to requirements. Table 1 shows that over 50% of the establishments were almost totally compliant (organoleptic checks done, promptly handled, handled at appropriate temperature, and well iced) and totally compliant (organoleptic checks done, promptly handled, handled at appropriate temperature, well iced, and proper records kept) whereas only 5.6% were completely non-compliant (Organoleptic checks not done, not promptly handled, handled under harsh temperature, and not iced). These results are in agreement with another study by Ssubi et al. (2024), where for instance, over 90% of the fish handlers reported that they performed quality checks on all batches of the fish that they handled at their facilities. However, the results obtained in this current study are contradictory to those reported in Indonesia where most of the fish handling practices, both at landing sites and markets, were non-compliant (Dali & Husain, 2020). That study reported that too little ice was being used compared to the amount of fish in the boxes, and this could cause a decline in fish quality (Dali & Husain, 2020).

3.1.4. Transport

Whereas the transport system is frequently a challenge in developing countries when it comes to food safety management, the results in Table 1 showed that only 9.26% of the facilities were using non-compliant transport means. The above percentage (9.26%) accounted for fish transport vessels that were rough inside, corrosive, not easily cleanable, open, uninsulated, and evidently dirty. Thirty five percent (35.19%) of the facilities were using smooth, durable, non-corrosive, easily cleanable, covered, insulated, clean, and properly self-draining transport vessels. The FAO Codex Alimentarius guidelines recommend that fish transporting vessels should be easy to clean and disinfect, and should be cleaned and disinfected regularly and as appropriate since fishery products are exposed to lengthy handling and distribution before reaching the final consumer (Codex Alimentarius Commission, FAO, 2012; Al-Busaidi et al., 2016).

3.1.5. Water quality

According to Codex Alimentarius, food-handling facilities should have sufficient clean water for use at all

food handling points for the handlers to wash their hands and utensils regularly (Codex Alimentarius Commission, 2009). Water quality is one of the major factors that influence food safety in fish and fishery products (Amos et al., 2007). Usually, poor water quality due to contamination of lakes through sewage disposal, often leads to fish and fishery products contamination with pathogens such as *Escherichia coli* and *Salmonella serovars* (Bagumire, Todd, Nasinyama, Muyanja, Rumbelha, et al., 2009; Fuhmann et al., 2015).

The results showed that water quality was less compliant than in Vietnam where 94.5% compliance was reported for water quality and availability for use all the time (Van et al., 2022). In the current study, 55% of the facilities were almost totally compliant and totally compliant, implying that they had potable or clean water from a protected water source, flowing at appropriate pressure most of the time. These findings collaborate the findings of another study where 63.1% of the fish handlers in the fresh Nile perch value chain in Uganda reported using municipal water as their source for potable water (Ssubi et al., 2024). Among the facilities, 33.3% had a clear water quality and safety-monitoring plan being implemented. Despite such a high level of compliance to water quality requirements within the fresh Nile perch value chain, 9.3% of the fisheries handling facilities were using poor quality water from unprotected sources.

3.1.6. Waste management

Among the fishing handling facilities, 57% had effluent treatment systems and solid waste dumpsites located within a safe distance from the processing area. The remaining over 40% had waste management systems that were either least compliant (coverable, and well maintained waste storage containers available) or non-compliant (Table 1). This existing situation could easily lead to cross contamination. Similar findings were reported in some of the fish farms where waste management was a big problem that could lead to cross contamination (Bagumire et al., 2020). These findings suggest a need for the standards and regulatory agencies such as Uganda National Bureau of Standards and Ministry of Agriculture, Animal Industry and Fisheries to sensitize the fish handlers on food safety management in relation to waste management.

3.1.7. Vermin control

Results in Table 1 shows that 40.7% of the fish handling facilities had very poor vermin control systems. In these facilities, vermin had open access to the fish

handling areas; there was no access prevention for animals and birds, and no evidence at all for vermin control. Table 1 shows that most facilities in the fresh Nile perch value chain were failing to comply with the food safety requirements for vermin control. Microorganisms of concern in fishery products such as *Salmonella serovars* are naturally prevalent on most vermin, birds, and animals (Abulreesh, 2012; Bagumire, Todd, Nasinyama, Muyanja, Rumbelha, et al., 2009). There is a need to improve food safety in the fresh Nile perch value chain by encouraging the private sector to put in place appropriate vermin control mechanisms through training and infrastructure development.

3.1.8. Packaging

Packaging allows transportation of fish for longer distances while maintaining the integrity of fish, and extending its shelf life by minimizing direct contact with handlers who may otherwise contaminate the fish (Nguyen et al., 2023; Thi et al., 2020; Vergheze et al., 2015). In this current study, it was observed that 31.5% of the fisheries handling facilities were using non-food grade packaging materials such as wooden crates, baskets, sisal sacks, dirty and torn nylon sacks and not labelled at all. Fish handling facilities (48%) were using food grade, labelled, and impervious packaging material majorly plastic crates and basins (Table 1). The results suggest a need to encourage the application of appropriate labelling within the fresh Nile perch value chain. Fish handling facilities should be encouraged to use appropriately technologically designed primary packaging materials, which come in direct contact with the fish products.

3.2. Compliance of fishery handling facilities at varying segments of the fresh Nile perch value chain

The study revealed that fish factories were the most compliant followed by landing sites and market stalls. As shown in Table 2, bigger proportions of the factories were either totally compliant or almost totally compliant with the various food safety requirements, whereas for market stalls, the bigger proportions were either non-compliant or least compliant. These findings support Humphrey (2017), who reported that the majority of market stall owners are financially constrained, unlike factories. This implies that they cannot afford to invest in some safety equipment and consumables that are essential in ensuring compliance with the food safety requirements. Compliance with food safety requirements has been indicated by some

Table 3. Compliance of fishery handling facilities by market chain of interest.

Type of facility	Market chain of interest				F-exact p-value
	Export		Local		
	*Freq (n=30)	*Col %	*Freq (n=24)	*Col %	
Elements to verify	Infrastructure and equipment				
Contact surfaces for fishery products					<0.001
Non compliance	0	0	7	29.2	
Least compliance	0	0	11	45.8	
Some compliance	0	0	6	25	
Almost total compliance	11	36.7	0	0	
Total compliance	19	63.3	0	0	
Tool to handle fishery products and ice					<0.001
Non compliance	0	0	2	8.3	
Least compliance	0	0	17	70.8	
Some compliance	0	0	5	20.8	
Almost total compliance	6	20	0	0	
Total compliance	24	80	0	0	
Containers for storage of fish products					<0.001
Non compliance	0	0	7	29.2	
Least compliance	0	0	12	50	
Some compliance	2	6.7	5	20.8	
Almost total compliance	7	23.3	0	0	
Total compliance	21	70	0	0	
Changing room					<0.001
Non compliance	0	0	21	87.5	
Least compliance	2	6.7	3	12.5	
Some compliance	2	6.7	0	0	
Almost total compliance	14	46.7	0	0	
Total compliance	12	40	0	0	
Toilets					<0.001
Non compliance	0	0	5	20.8	
Least compliance	0	0	16	66.7	
Some compliance	3	10	2	8.3	
Almost total compliance	11	36.7	1	4.2	
Total compliance	16	53.3	0	0	
Handwash facilities					<0.001
Non compliance	0	0	14	58.3	
Least compliance	0	0	9	37.5	
Some compliance	3	10	0	0	
Almost total compliance	14	46.7	1	4.2	
Total compliance	13	43.3	0	0	
Appropriate storage					<0.001
Non compliance	0	0	9	37.5	
Least compliance	2	6.7	15	62.5	
Almost total compliance	19	63.3	0	0	
Total compliance	9	30	0	0	
Structural suitability					<0.001
Non compliance	0	0	17	70.8	
Least compliance	0	0	6	25	
Some compliance	2	6.7	0	0	
Almost total compliance	10	33.3	0	0	
Total compliance	18	60	1	4.2	
	Water quality				
Acceptable quality water is available for use all the time					<0.001
Non compliance	0	0	5	20.8	
Least compliance	0	0	17	70.8	
Some compliance	1	3.3	1	4.2	
Almost total compliance	11	36.7	1	4.2	
Total compliance	18	60	0	0	
	Fishery products & ice handling				
Good fisheries product (FP) handling practices to avoid contamination observed by handlers.					<0.001
Non compliance	0	0	5	20.8	
Least compliance	0	0	16	66.7	
Some compliance	0	0	3	12.5	
Almost total compliance	10	33.3	0	0	
Total compliance	20	66.7	0	0	
	Packaging and Labelling				
Appropriate packaging and labelling					<0.001
Non compliance	0	0	17	70.8	
Least compliance	2	6.7	5	20.8	

(Continued)

Table 3. Continued.

Type of facility	Market chain of interest				F-exact p-value
	Export		Local		
	*Freq (n=30)	*Col %	*Freq (n=24)	*Col %	
Some compliance	2	6.7	2	8.3	
Almost total compliance	10	33.3	0	0	
Total compliance	16	53.3	0	0	
Waste management					
Waste storage containers, effluent treatment and solid disposal facilities					<0.001
Non compliance	0	0	12	50	
Least compliance	0	0	11	45.8	
Almost total compliance	18	60	1	4.2	
Total compliance	12	40	0	0	
Vermin control					
Pests and vermin control					<0.001
Non compliance	0	0	22	91.7	
Least compliance	0	0	1	4.2	
Almost total compliance	16	53.3	1	4.2	
Total compliance	14	46.7	0	0	
Personnel					
All workers wore suitable protective wear					<0.001
Non compliance	0	0	6	25	
Least compliance	0	0	15	62.5	
Some compliance	0	0	3	12.5	
Almost total compliance	9	30	0	0	
Total compliance	21	70	0	0	
Transport means					
Transport means are appropriate and reliable					<0.001
Non compliance	0	0	5	20.8	
Least compliance	0	0	16	66.7	
Some compliance	0	0	1	4.2	
Almost total compliance	11	36.7	2	8.3	
Total compliance	19	63.3	0	0	

*Freq: frequency; *col: column percentages.

researchers to be positively linked to the level of education attained by the food handlers, the amount of investment capital applied as well as the food safety training of the food handler or business owner and employees (Dagne et al., 2021; Grema et al., 2018; Ssubi et al., 2024; Van et al., 2022). However, another study conducted in Lisbon, Portugal, reported no significant association between food contact surface hygiene procedures' compliance and education level, years of employment nor food safety training (Oliveira et al., 2021). The findings of this study accentuate the recommendation by Ssubi et al. (2024) that regulatory authorities need to monitor fisheries handling facilities that handle fish for local consumption to enhance domestic food safety rather than concentrating predominantly on fish exporting factories. This change of focus will: – protect the health of local fish consumers, lead to increased productivity, and subsequently lead to the sustainable competitiveness of Uganda's fishery products on the global market.

Results in Table 2 show that there was poor sanitation regarding toilet facilities, especially at the landing sites and market stalls. For the evaluated facilities, the toilets at 50% landing sites and 66.7% market stalls were either least compliant or non-compliant (few or

no clearly designated toilets, dirty, not flushing or no running water, no provision for handwash, close and directly opening into fish handling area). Toilets located at 70% of the factories were either almost totally compliant (separate for both genders, slightly few in number (staff:toilet number), clean, functional flush system, handwash provision, not directly opening into processing area) or totally compliant (separate for both genders, appropriate number (staff:toilet number), clean, functional flush system, handwash provision, not directly opening into processing area). These findings confirm the results obtained by Joseph Kungu et al. who cited very poor sanitation at the landing sites in Uganda (Kungu et al., 2021).

The results (Table 2) further showed that there was a significant difference ($p \leq 0.001$) in the compliance levels of the fish handling facilities at the various segments of the fresh Nile perch value chain.

3.3. Compliance to food safety requirements of fishery handling facilities within the local and export market chains

Table 3 shows that for all parameters examined, facilities handling fish for export were more compliant

than the facilities handling fish for the local market. For example, whereas approximately 95% of the local fish handling facilities had hand washing facilities that were either least compliant or non-compliant, 90% of the export fish handling facilities had hand washing facilities that were either almost totally compliant or totally compliant. This is attributed to the export facilities striving to adhere to the same standards as required in the target export markets. Ian Goulding (2016), noted that the fish safety guidelines provided in the European Union Commission Manual of Food Safety emphasized hand washing as a key aspect of staff hygiene. As recommended by Ssubi et al. (2024), the regulatory authorities in Uganda should work towards the harmonization of food safety regulations and their implementation across both (export and local) market chains.

For all examined parameters, there was a significant difference ($p \leq 0.001$) in the compliance levels of the fish handling facilities between the export and local market chains. This difference in the compliance levels of the fish handling facilities between the export and local market chains may lead to differences in the microbiological quality of the fishery products within the two value chains.

3.4. Limitations to the study

This being a cross-sectional survey, causal relationships could not be easily established, and as thus it was not possible to authoritatively draw conclusions on the implication of the compliance levels of the fishery handling facilities to food safety requirements. Further research on the compliance of the fishery handling facilities over longer periods is needed to derive more accurate conclusions on the implication of compliance of facilities to food safety requirements on the safety of food products. A further study to analyse the microbiological quality of fishery products within the fresh Nile perch value chain is recommended to provide science based guidance on the most appropriate interventions for improved food safety outcomes.

4. Conclusion

There was better compliance with food safety requirements at the factories and landing sites as compared to the market stalls. Fishery handling facilities for export market were more complaint with food safety requirements than those for local markets. This implies that more emphasis is required in terms of infrastructure development, sensitization, and training on the local market chain. There is a need to emphasize the

improvement and provision of personnel hygiene facilities such as changing rooms, toilets, and hand wash facilities. Further attention should be given to vermin control, waste management, and packaging, as these were observed to be the most non-compliant.

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Author contributions

Johnson A. Ssubi conceptualized the study design and methodology, data collection, data analysis and interpretation, writing of the original draft, review & editing of the manuscript for intellectual content, and is the corresponding author. **Ivan M. Mukisa** contributed to the conceptualization of the study, supervised the work, and provided input through critical review & editing of the manuscript for intellectual content. **Charles K. Muyanja** contributed to the conceptualization of the study, supervised the study, and further provided input through critical review & editing of the manuscript for intellectual content. All authors read and approved the final version of the manuscript to be published, and agree to be accountable for all aspects of the work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The datasets generated during and/or analysed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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