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Quality Assessment of Fresh and Frozen Fish Marketed in the Coastal Area of Togo

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Abstract

Fresh fish undergo several processes after capture, which can impact their quality. To assess the quality of fish sold in the coastal area of Togo, 22 composite samples of fresh and frozen fish, collected from fishermen, wholesalers, importers, and fish shops (distributors of frozen products), were analyzed. Freshness was assessed based on Regulation (EEC) N° 2455/70, Total Volatile Basic Nitrogen (TVBN) based on Regulation (EC) N° 2074/2005, pH by potentiometric method and microbiological analysis according to AFNOR's analytical methods. The results showed that fish from beach fishermen and importers had the highest freshness index (I=3), followed by seining fishermen (I=2.4), fish shops (I=2.2) and wholesalers (I=1.8). The pH ranged from 5.72 (importers) to 6.96 (wholesalers) and the TVBN from 5.402 mg/100g (importers) to 112.62 mg/100g (fish shops), with the lowest values observed among importers and the highest among distributors of frozen products. Overall, 81.82% of samples had TVBN levels below the required threshold of 25 mg/100g. Fishes from fishermen and wholesalers were more contaminated and those from wholesalers were of unsatisfactory hygienic quality. However, *Salmonella* was not detected in any sample. In summary, the quality of fish was satisfactory for importers, acceptable for fishermen and fish shops and unsatisfactory for wholesalers. This study reveals that fish quality varies depending on the actors involved and, therefore, on the practices along the distribution chain. The results reflect the lack of control over the cold chain, hygiene measures and good distribution practices. They highlight the need for awareness raising, for training on good fishing hygiene and good distribution practices, and for improvement or provision of post-harvest handling infrastructure.

Keywords: Fish, post-fishing handling, freshness, hygiene, microbiological quality

Introduction

The quality of fish products includes not only their protein content, especially essential amino acids, and polyunsaturated fatty acids, but also their freshness and sanitary quality (Prache *et al.*, 2021). In Africa, fish consumption is of utmost importance as it represents an excellent alternative to meat protein (Van Hecke & Vanderleenen, 2023). In Togo, fish availability is ensured by local fishing, with a production of approximately 25,000 tons per year, and by imports to cover estimated needs of around 70,000 tons per year (Ali *et al.*, 2016). The supply of fish is quite varied, ranging from pelagic to demersal species (FAO, 2007), and from fresh and frozen fish to dried or smoked fish, allowing for distribution to far areas through various trading channels (FAO, 2007; Van Hecke & Vanderleenen, 2023). However, fresh fish is a highly perishable commodity (Anihouvi *et al.*, 2005) and its preservation after harvesting, particularly in distribution chains, represents a major challenge due to the lack of refrigeration infrastructure (Fall *et al.*, 2019). Indeed, the lack of control of good hygiene practices and the lack of refrigeration in fish distribution chains (Akilimali *et al.*, 2019; Bediang *et al.*, 2020; Brito *et al.*, 2021) have a significant negative impact on fresh and frozen fish quality, resulting in a loss of freshness, an increase in total volatile basic nitrogen and microbial growth (Assogba *et al.*, 2018a). Microbial growth leads to risks of histamine poisoning, which is a real public health problem. Indeed, histamine exposure deserves particular attention because it is most often the primary cause of numerous foodborne illness outbreaks associated with fish consumption (Guillier *et al.*, 2015). Previous studies, notably those by Bediang *et al.* (2020) and Bouka *et al.* (2020) in Togo, revealed significant microbial contamination of fresh fish sold at the fishery harbour of Lomé and high histamine levels in smoked fish. The health consequences of this exposure include food poisoning with moderate to severe effects. Symptoms include hives, edema, skin rashes, nausea, vomiting, abdominal cramps and diarrhea, headaches, and respiratory difficulties (FAO/WHO, 2013). The highest histamine levels are due to post-harvest bacterial contamination and proliferation (Diop *et al.*, 2010), with storage temperatures of 7°C to 15°C being a contributing factor (Dalgaard, 2007 cited by Ka, 2015). Post-harvest processing is therefore a critical step in ensuring the food safety of fresh and frozen fish. It is thus important to assess fish quality based on different post-harvest practices in order to improve those with risks. This research was conducted to evaluate the physicochemical and microbiological quality of fresh and frozen fish throughout the post-harvest chain.

Methods

Study Area

The study was conducted in Togo, primarily in the coastal area (figure 1), dominated by artisanal marine fishing and related activities. Fresh and frozen fish samples were collected from fishermen at the main landing sites along the coast (Kodjoviakopé, Ablogamé, Kpémé, and the fishery harbour), from wholesalers and processors (fresh fish market at the fishery harbour of Lomé, in Aného and in Adawlato) and from importers and fish shops (distributors of frozen products) in Lomé. Freshness assessment was carried out during on-site inspections and at the Food Quality Control Laboratory of the Togolese Institute of Agronomic Research (ITRA); pH and TVBN analyses were also performed at the Food Quality Control Laboratory of ITRA, and microbiological analyses were conducted at the Food Microbiology and Control Laboratory (LAMICODA) of the University of Lomé.

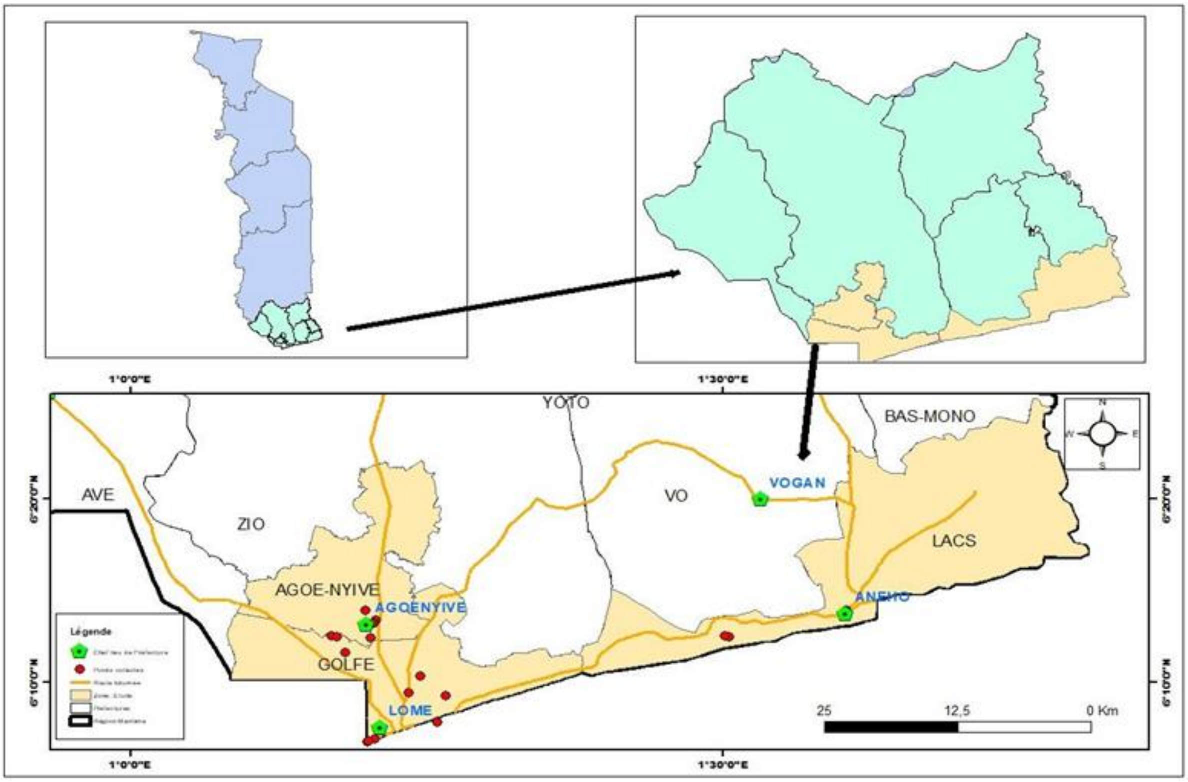

Figure 1: Study area

Sample Collection and Preparation

Sample collection and analysis were conducted from September to November 2025. A random sampling was conducted and fish were collected from 42 local fresh fish stakeholders, fish importers and fish shops.

Samples of local fresh fish (anchovies (*Engraulis encrasicolus*), sardinella (*Sardinella aurita* and *Sardinella maderensis*), and other small pelagic (*Selene setapinnis*)) were collected from Beach fishermen (BF), Seining fishermen (SF) and Wholesalers (WS) (table 1). The samples were mixed according to actor groups, species and sampling sites to form composite samples. Approximately 500g to 1kg of sample was collected per actor. The resulting composite sample (approximately 2.5kg to 3kg) was divided into two parts; one was sent to the microbiology laboratory and the other to the physicochemical laboratory for analysis.

Table 1: Sampling scheme of local fresh fishes

Collection sites	Actors	Species collected	NSA	TNSC	NCS
		n = 3			
Site 1 (E1)	BF	*S. setapinnis**	1	3	1
Site 2 (E2)	BF	*S. setapinnis*	1	3	1
Site 3 (E3)	BF	*S. setapinnis*	1	3	1
Site 4 (E4)	SF	*E. encrasicolus**	1	3	1
		n = 5			
Site 10 (E10)	WS	*Sardinella sp*.*	1	5	1
Site 11 (E11)	WS	*E. encrasicolus*	1	5	1
Site 12 (E12)	WS	*S. setapinnis*	1	5	1
	Total			**27**	**7**

n = number of actors sampled per site, BF = Beach fishermen, SF = Seining fishermen, WS= Wholesalers, E1…E12 = Composite samples, NSA = Number of samples per actor, TNSC = Total number of samples collected, NCS = Number of composite samples.
*The fish species vary and depend on the fishing gear used.

Imported fishes mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*) were collected from Importers (IMP) and Fish shops (FSH) according to the available batches (table 2). The fish collected at three different parts of the batch were mixed according to the actor, species, and sampling site to form the composite sample. Two medium-sized fish were taken per sample, resulting in six fish per composite sample. The composite sample was divided into two parts, one was sent to the microbiology laboratory and the other to the physicochemical laboratory for analysis.

Table 2: Sampling scheme of imported frozen fishes

Collection sites	Actors	Species collected	NSA	TNSC	NCS
		n = 1			
Site 5 (E5)	IMP	*T. trachurus*	3	3	1
Site 6 (E6)	IMP	*S. scombrus*	3	3	1
Site 7 (E7)	IMP	*T. trachurus*	3	3	1
Site 8 (E8)	IMP	*T. trachurus*	3	3	1
Site 9 (E9)	IMP	*S. scombrus*	3	3	1
		n = 1			
Site 13 (E13)	FSH	*T. trachurus*	3	3	1
Site 14 (E14)	FSH	*S. scombrus*	3	3	1
Site 15 (E15)	FSH	*T. trachurus*	3	3	1
Site 16 (E16)	FSH	*T. trachurus*	3	3	1
Site 17 (E17)	FSH	*S. scombrus*	3	3	1
Site 18 (E18)	FSH	*T. trachurus*	3	3	1
Site 19 (E19)	FSH	*S. scombrus*	3	3	1
Site 20 (E20)	FSH	*T. trachurus*	3	3	1
Site 21 (E21)	FSH	*S. scombrus*	3	3	1
Site 22 (E22)	FSH	*T. trachurus*	3	3	1
	Total			**45**	**15**

n = number of actors sampled per site, IMP = Importers, FSH = Fish shops, E5…E22 = Composite samples,
NSA = Number of samples per actor, TNSC = Total number of samples collected, NCS = Number of composite samples.

Sampling was carried out using coolers, dry ice, sterile sampling bags, Bunsen burner, knives, alcohol and sterile gloves. Once collected, samples were transported directly to the laboratories. A total of 22 composite samples were formed based on species, actors and sampling sites.

Laboratory Analyses

Composite samples of fresh and frozen fish were analyzed separately. The freshness of fish was assessed by inspecting and scoring of the skin, eyes, flesh and gills on a scale of 0 to 3, according to Regulation (EEC) N° 2455/70. Fishes were then classified into categories Extra (freshness index of 2.7 or higher), A (freshness index of 2 or higher but less than 2.7), B (freshness index of 1 or higher but less than 2) and C (fishes not respecting the requirements for classification in Extra, A, or B) (European Communities, 1970).

The total volatile basic nitrogen (TVBN) content was determined by steam distillation according to Regulation (EC) N° 2074/2005 (European Communities, 2005). 10g of grounded sample was weighed into a flask, 90 ml of perchloric acid was added and mixed thoroughly for 2 minutes. The solution is filtered and 50 ml of the filtrate is collected in a flask. A few drops of phenolphthalein and 6.5 ml of sodium hydroxide solution are added. The mixture is then distilled and the distillate is collected in an erlenmeyer flask containing 100 ml of boric acid and a few drops of Tashiro reagent. The solution in the erlenmeyer flask is then titrated with 0.05 N hydrochloric acid solution. A blank test is performed with 50 ml of perchloric acid. The TVBN content, expressed in mg/100 g, is calculated using the formula:

$$TVBN\left(\frac{mg}{100g}\right)=\frac{[(V1-V0)x\ 0.14\ x\ 2\ x\ 100]}{M}$$

V1 (ml) = Volume of 0.05N hydrochloric acid for the sample
V0 (ml) = Volume of 0.05N hydrochloric acid for the blank
M (g) = Mass of the sample

The pH was determined by the potentiometric method (ISO 10390:2021). 20g of ground sample was weighed into a flask and 50 ml of distilled water was added and agitated together for 30 minutes. The reading was performed with a pH-meter.

Microbiological analysis was performed using the routine methods of the French Standardization Association (AFNOR) described by Soncy *et al.* (2015). 10g of sample was weighed into a sterile bag containing 90 ml of Tryptone Salt (TS). The mixture was homogenized using a stomacher. The resulting solution was left at room temperature for 45 minutes for reactivation. A series of decimal dilutions was carried out by adding 1 ml or one of the dilutions to 9 ml of TS. The solutions obtained were used to inoculate bacterial growth media, which are then incubated at the appropriate time and temperature for each microorganism. Microorganisms were numbered by counting characteristic colonies and the number is expressed in CFU/g. The microbiological results were interpreted according to a three-class scheme for total Flora, total Coliforms, *Escherichia coli* and *Staphylococcus aureus*, and according to a two-class scheme for *Salmonella sp.* (Couture *et al.*, 2019).

Statistical Data Analysis

The data were organized using Excel and analyzed using R software. The Shapiro-Wilk test was used to check the normality of the data, and Levene test was used to check the homogeneity. Neither condition was met so Kruskal-Wallis test was used to assess significance. Dunn's post-hoc test with Benjamini-Hochberg adjustment was then used to compare the different groups of actors. Mann-Whitney U test and the T-test were used to compare the groups pairwise. Spearman's correlation test was used to analyze the correlation between pH and TVBN, and the Binomial test was used to determine the compliance of the samples with the TVBN threshold value set at 25 mg/100g. For all analyses, the significance level of 5% was used.

Results

Fish freshness according to actors

The determination of the freshness index (figure 2) allowed to classify fishes taken from beach fishermen (I=3) and importers (cold containers on arrival) (I=3) in the Extra category, those taken from seining fishermen (I=2.4) and fish shops (I=2.2) in category A, and those taken from fish wholesalers and processors (I=1.8) in category B.

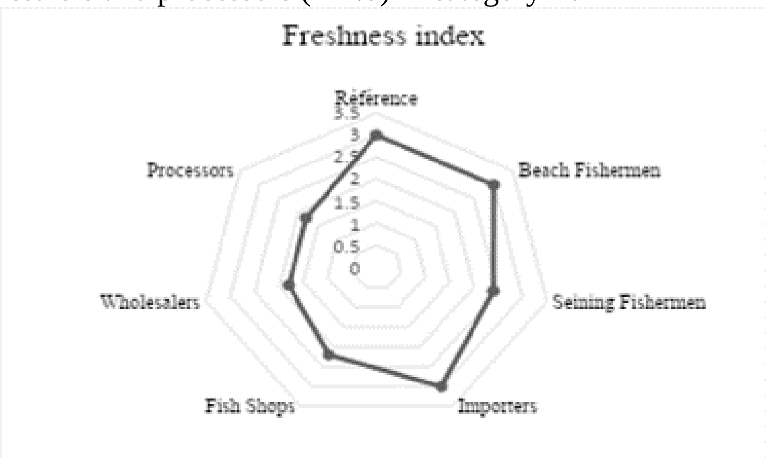

Figure 2: Freshness index according to different actors

pH of fish according to actors

The pH varies from 5.722 (importers) to 6.959 (wholesalers). Figure 3 shows the distribution of fish pH according to actor groups (G1 = Fishermen, G2 = Importers, G3 = Wholesalers, G4 = Fish shops). Fishes collected from importers (cold containers upon arrival) recorded the lowest pH average (pH=6.00). Those collected from fishermen, wholesalers and fish shops showed the highest pH average values (pH=6.85, pH=6.89 and pH=6,57 respectively), which were not significantly different from each other (p = 0.06).

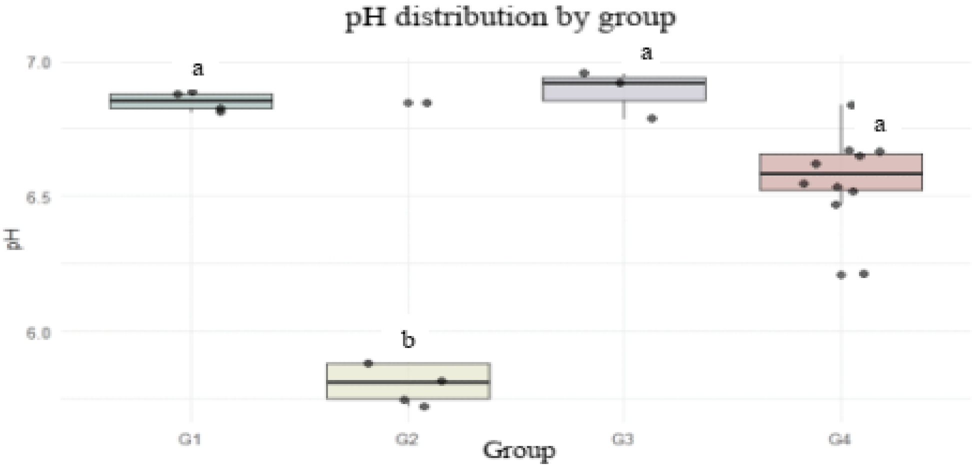

Figure 3: Distribution of fish pH by actors groups G1 (fishermen), G2 (importers), G3 (wholesalers), G4 (fish shops)

Identical letters indicate that the groups are not significantly different from each other. Different letters indicate that the groups are significantly different from each other at 5% significance level. .

Total volatile basic nitrogen TVBN of fish according to actors

Total volatile basic nitrogen rates ranged from 5.402 mg/100g (importers) to 112.62 mg/100g (fish shops). Figure 4 shows the distribution of fish TVBN according to actor groups (G1 = Fishermen, G2 = Importers, G3 = Wholesalers, G4 = Fish shops). The average rate of fish from importers (5.75 mg/100g) was the lowest and was not significantly different (p = 0,1548) from the average rate of fish from fishermen (8,66mg/100g). The average rate of fish from fish shops (41.10 mg/100g) was the highest and was not significantly different (p = 0,9371) from the average rate of fish from wholesalers (27mg/100g).

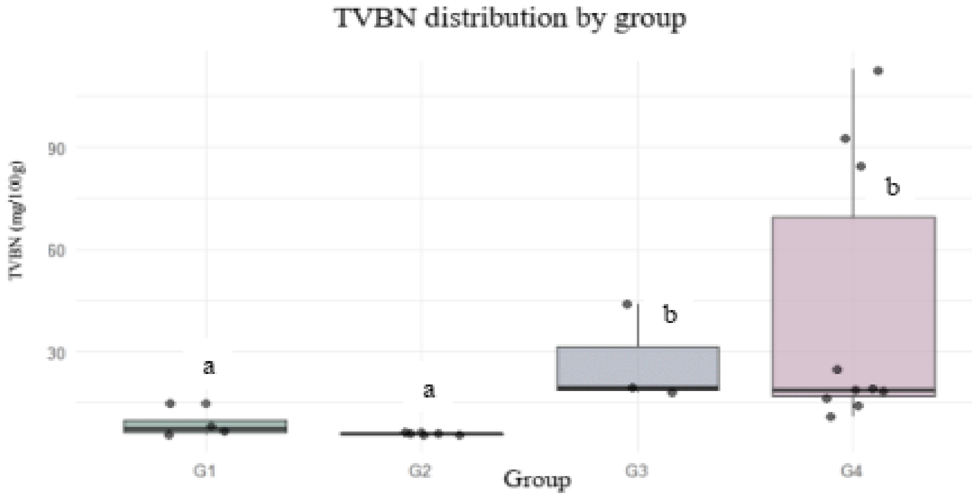

Figure 4: Distribution of fish TVBN by actors groups G1 (fishermen), G2 (importers), G3 (wholesalers), G4 (fish shops)

Identical letters indicate that the groups are not significantly different from each other. Different letters indicate that the groups are significantly different from each other at 5% significance level.

No significant relationship was established between pH and TVBN (rho = 0.158 and p = 0.478).

The majority of samples analyzed (81.82%) had a TVBN content below the required threshold of 25 mg/100 g (Figure 5).

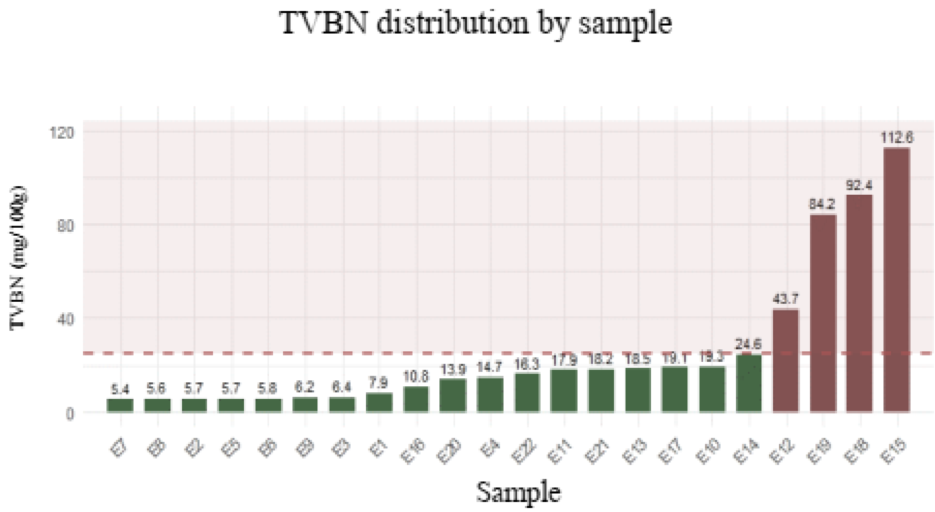

Figure 5: Distribution of TVBN per sample with respect to the threshold of 25 mg/100g

Microbiological quality of fish according to actors

Tables 3 and 4 show the microbiological profile of fishes according to actors and the compliance rate of samples according to microbiological standards. Fishes taken from importers (2.96 x 10^4 CFU/g) had the lowest total microbial count and fishes taken from wholesalers had the highest (5.91 x 10^6 CFU/g). Fishes taken from wholesalers, fishermen (1.98 x 10^6 CFU/g) and fish shops (5.33 x 10^5 CFU/g) had total microbial counts that were not significantly different from each other ($p = 0.103$). The total Coliforms count revealed that samples from fishermen (1.18 x 10^3 CFU/g) and wholesalers (9.33 x 10^2 CFU/g) were significantly more contaminated than samples from fish shops ($p = 0.0257$) and importers ($p = 0.0333$). The enumeration of *Escherichia coli* showed that fish from fishermen and wholesalers were significantly more contaminated than samples from fish shops and importers ($p = 0.0021$). The *Staphylococcus aureus* count showed that samples from wholesalers had the highest level of contamination, followed in decreasing order by samples from fishermen, fish shops and importers ($p = 0.01768$). *Salmonella* was not detected in any sample.

Table 3: Microbiological profile of fish according to actors

Actors	Composite Samples	Total Flora (CFU/g)	Total Coliforms (CFU/g)	*Escherichia coli* (CFU/g)	*Staphylococcus aureus* (CFU/g)	*Salmonella sp.* (CFU/g)
Criteria (Couture *et al.*, 2019)		m = 10^6 M = 10^7	m = 10^1 M = 10^2	m = 10^1 M = 10^2	m = 10^3 M = 10^4	m = 0 M = 0
Fishermen	E1	3 x 10^6	1 x 10^3	7 x 10^1	<10^2	ND*
	E2	8.4 x 10^4	2 x 10^1	10^1	<10^2	ND
	E3	4.1 x 10^6	1.5 x 10^3	<10^1	<10^2	ND
	E4	7.4 x 10^5	2.2 x 10^3	5 x 10^1	10^2	ND
Importers	E5	2.3 x 10^4	<10^1	<10^1	<10^2	ND
	E6	4 x 10^4	<10^1	<10^1	<10^2	ND
	E7	3.7 x 10^4	<10^1	<10^1	<10^2	ND
	E8	4.4 x 10^4	<10^1	<10^1	<10^2	ND
Wholesalers	E9	4.2 x 10^3	4 x 10^1	<10^1	<10^2	ND
	E10	4.4 x 10^5	4 x 10^2	2 x 10^1	<10^2	ND
	E11	2.3 x 10^6	1.6 x 10^3	1.5 x 10^3	3.5 x 10^3	ND
	E12	1.5 x 10^7	8 x 10^2	4.3 x 10^2	7 x 10^2	ND
Fish shops	E13	8 x 10^4	<10^1	<10^1	<10^2	ND
	E14	1.5 x 10^6	<10^1	<10^1	<10^2	ND
	E15	3.4 x 10^6	3 x 10^1	<10^1	<10^2	ND
	E16	1.4 x 10^4	9 x 10^1	<10^1	<10^2	ND
	E17	8.8 x 10^2	<10^1	<10^1	<10^2	ND
	E18	5.3 x 10^4	<10^1	<10^1	<10^2	ND
	E19	2.6 x 10^4	<10^1	<10^1	<10^2	ND
	E20	1 x 10^5	3 x 10^1	<10^1	<10^2	ND
	E21	2.7 x 10^4	<10^1	<10^1	<10^2	ND
	E22	1.3 x 10^5	1.4 x 10^2	2 x 10^1	<10^2	ND

ND* = Not Detected

Table 4: Compliance rate of samples from different actors according to microbiological standards and overall assessment of batches analyzed

Actors	Sample conformity percentage (%) Total Flora (CFU/g) m = 10^6	Total Coliforms (CFU/g) m = 10^1	*Escherichia coli* (CFU/g) m = 10^1	*Staphylococcus aureus* (CFU/g) m = 10^3	*Salmonella sp.* (CFU/g) m = 0	Overall Assessment*
Fishermen (G1)	50%	0%	50%	100%	100%	Acceptable Quality
Importers (G2)	100%	80%	100%	100%	100%	Satisfactory Quality
Wholesalers (G3)	33%	0%	0%	67%	100%	Unsatisfactory Quality
Fish shops (G4)	80%	60%	90%	100%	100%	Acceptable Quality

*Determined according to two-class interpretation for *Salmonella sp*. and three-class interpretation for other germs (Couture *et al*., 2019).

The results of pH, TVBN and microbiological analysis are summarized in Table 5 with means and standard deviations.

Table 5: Summary of pH, TVBN and microbiological analysis results

Groups	pH	TVBN (mg/100g)	Total Flora (CFU/g)	Total Coliforms (CFU/g)	*E. coli* (CFU/g)	*S. aureus* (CFU/g)
Fishermen (G1)	$6{,}85^{a} \pm 0{,}036$	$8{,}66^{a} \pm 4{,}13$	$1{,}98.10^{6a} \pm 1{,}89.10^{6}$	$1{,}18.10^{3a} \pm 9{,}16.10^{2}$	$3{,}5.10^{1a} \pm 3.10^{1}$	$1.10^{2a} \pm 0$
Importers (G2)	$6{,}00^{b} \pm 0{,}476$	$5{,}75^{a} \pm 0{,}3$	$2{,}96.10^{4b} \pm 1{,}63.10^{4}$	$1{,}6.10^{1b} \pm 1{,}34.10^{1}$	$1.10^{1b} \pm 0{,}00$	$1.10^{2a} \pm 0{,}00$
Wholesalers (G3)	$6{,}89^{a} \pm 0{,}091$	$27{,}0^{b} \pm 14{,}5$	$5{,}91.10^{6a} \pm 7{,}92.10^{6}$	$9{,}33.10^{2a} \pm 6{,}11.10^{2}$	$6{,}5.10^{2c} \pm 7{,}64.10^{2}$	$1{,}43.10^{3b} \pm 1{,}81.10^{3}$
Fish shops (G4)	$6{,}57^{a} \pm 0{,}164$	$41{,}1^{b} \pm 39{,}0$	$5{,}33.10^{5a} \pm 1{,}11.10^{6}$	$3{,}5.10^{1c} \pm 4{,}45.10^{1}$	$1{,}1.10^{1b} \pm 0{,}32.10^{1}$	$1.10^{2a} \pm 0{,}00$

In each column, means with identical letters are not significantly different from each other. Those with different letters are significantly different from each other at 5% significance level.

Discussion

Fish freshness according to actors

The maximum freshness (I=3) of fish taken from beach fishermen (figure 2) is due to fishing techniques, minimal time spent in the fishing area and the landing method. Fishes arrive mostly alive at the landing site, unlike seining fishing, with longer periods (on average 3 to 6 hours according to our field surveys) between capture and landing, while refrigeration is not practiced on board the pirogues. The investigations of Bellec *et al.* (1989) on artisanal fishing in West Africa confirm our findings that the freshness of local fish on landing is closely linked to fishing techniques and gear. The freshness of fish collected in containers from importers (I=3) demonstrates the control of refrigeration from fishing to importation, and therefore the satisfactory quality of frozen fish imported in Togo. Freshness decreases as fish progresses through the distribution chain, from importers and fishermen to distributors (I=2.2 and I=1.8). This is due to the variations of temperature in the cold chain and the long duration of fish preservation in freezing. Our results are confirmed by Bellec *et al.* (1989) and Bokossa *et al.* (2022). However, the classification of the inspected samples as Extra, A, and B confirms the acceptable freshness of fresh and frozen fish sold in the study area. Our results are in line with those of Assogba *et al.* (2025).

Total volatile basic nitrogen and pH of fish according to actors

The pH distribution (Figure 3) shows levels below neutral, demonstrating the acceptable freshness of fresh and frozen fish sold in the study area. Any value above the neutral threshold (pH = 7) indicates the degradation of nitrogen compounds and therefore a loss of freshness according to Farzana *et al.* (2014). The low pH of fish collected from importers slows down the microbial growth within these samples, thus enhancing their quality. Brito *et al.* (2021), in their study on the quality of fish marketed in Benin, found pH values ranging from 6.1 to 6.8, consistent with our results. The distribution of total volatile basic nitrogen (Figure 4) shows low levels found in fish from importers and high levels in fish from fish shops. The low levels at importers are mainly due to autolysis of fish tissues. They indicate control of the cold chain in the import process, thus reflecting the freshness and quality of frozen fish imported in Togo. Brito *et al.* (2021) in Benin found that imported fish had a significantly lower TVBN content than local fish. However, TVBN rate increases as fish progresses through the distribution chain and moves from one actor to the next. This is due to breaks in the cold chain or temperature fluctuations and poor hygiene and handling conditions, leading to microbial growth. The study of Bokossa *et al.* (2022) demonstrated the effects of temperature variations in distribution chains of frozen fish and the one of Akilimali *et al.* (2019) showed the negative impact of inappropriate distribution conditions on fresh fish quality. The highest levels of TVBN (figure 5) were found in samples from wholesalers (E12 = 43.71mg/100g) and fish shops (E15 = 112.62mg/100g; E18 = 92.4mg/100g; E19 = 84.2mg/100g). These levels, significantly exceeding the regular threshold of 25mg/100g, are likely due to breaks in cold chain, long storage in freezing and microbial growth. They indicate a loss of freshness and quality of these fishes. Consuming these noncompliant samples can be dangerous, as microbial growth may lead to a risk of histamine poisoning. Diop *et al.* (2010) showed that the highest histamine levels in fish were linked to post-capture bacterial contamination and growth. However, the majority (81.82%) of samples remain acceptable (Figure 5). This is due to efforts made by each actor, aware of the perishability of fresh fish, to ensure that it is used or processed quickly in a context where cold storage options are almost non-existent or expensive. Kouamé *et al.* (2019) demonstrated the importance of processing, especially smoking, as a preservation alternative to the perishability of fresh fish.

Microbiological quality of fish according to actors

The microbiological profile of the samples analyzed (Table 3) shows that fish from importers remain within standards and are satisfactory concerning total Flora ($4.2x10^3$ to $4.4x10^4$ CFU/g), total Coliforms ($<10^1$ to $4x10^1$ CFU/g), *Escherichia coli* ($<10^1$ CFU/g), *Staphylococcus aureus* ($<10^2$ CFU/g) and *Salmonella* (absence in 25g). Fishes from fish shops are unsatisfactory concerning total Coliforms ($<10^1$ to $1.4x10^2$ CFU/g), acceptable concerning total Flora ($8.8x10^2$ to $3.4x10^6$ CFU/g) and *Escherichia coli* ($<10^1$ to $2x10^1$ CFU/g) and satisfactory concerning *Staphylococcus aureus* ($<10^2$ CFU/g) and *Salmonella*. Quality of fishermen's products is compromised as fish are satisfactory concerning *Salmonella* and *Staphylococcus aureus* ($<10^2$ to 10^2 CFU/g), acceptable concerning total Flora ($8.4x10^4$ to $4.1x10^6$ CFU/g) and *Escherichia coli* ($<10^1$ to $7x10^1$ CFU/g) but unsatisfactory concerning total Coliforms ($2x10^1$ to $2.2x10^3$ CFU/g). Quality is poor at the wholesalers, as fish are unsatisfactory concerning total Flora ($4.4x10^5$ to $1.5x10^7$ CFU/g), total Coliforms ($4x10^2$ to $1.6x10^3$ CFU/g) and *Escherichia coli* ($2x10^1$ to $1.5x10^3$ CFU/g). In summary, the microbiological quality of the analyzed fishes is satisfactory for importers, acceptable for fishermen and fish shops and unsatisfactory for wholesalers (table 4). The high contamination of local fresh fish, especially with germs resulting from hygiene failures, reflects deficiencies in practices from fishing to commercialization. Indeed, fishing techniques, landing methods (particularly the landing on the ground in unsanitary environments), poor gear and utensils maintenance, unsanitary sales outlets, poor hygiene practices and inadequate cold chain management are all factors that negatively impact the microbiological quality of local fresh fish. On the other side, imported fish are carefully packaged and kept refrigerated. The hygiene failures stem from lacks of infrastructure adapted for post-fishing handling, training in best practices, and sanitary controls by relevant authorities. Our results are consistent with those of N'Guessam *et al.* (2018), Akilimali *et al.* (2019), Brito *et al.* (2021) and Bokossa *et al.* (2022) who found that local and imported fresh fish were contaminated by various germs but still remained of acceptable microbiological quality. Our results also line with those of Assogba *et al.* (2018b), who demonstrated the negative impact of a break in the cold chain on the microbiological quality of frozen fish. The authors thus highlighted the negative impact of inadequate hygiene and cold chain management on the quality of seafood products.

Conclusions

The study revealed that the quality of fresh and frozen fish distributed in the coastal area of Togo varies depending on the actors involved. Locally freshly caught fish and frozen fish at the point of entry into the country are of better quality than fish sold by wholesalers and fish shops. Furthermore, frozen fish is more acceptable from a microbiological standpoint than fresh fish. All of this brings up the questions about handling and distribution conditions of fish, especially local fresh fish, and the measures to be implemented to ensure safe products for consumption. Therefore, improving the quality of fish sold in the study area requires awareness raising and training actors in good hygiene and distribution practices. It also requires improving artisanal fishing techniques, promoting onboard refrigeration of catches, and upgrading post-fishing handling infrastructure.

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