

# Evaluation of the Hygienic and Microbiological Quality of Dried and Smoked Fish Sold in the Various Markets of the City of Abéché (Chad)

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Received: July 2, 2023

Accepted: August 20, 2023

Online Published: September 6, 2023

doi:10.5539/jfr.v12n4p1

URL: <https://doi.org/10.5539/jfr.v12n4p1>

## Abstract

Fish is a vital source of animal protein and micronutrients for many communities (rural and urban). It could be the cause of serious Toxi-infection with health consequences if handled in unsanitary conditions. The goal of this study aims to assess the hygienic and microbiological quality of dried fish and smoked fish sold in the various markets in the town of Abéché. A total of 30 samples of dried and smoked fish were collected from the vendors surveyed. Germs sought were counted in the laboratory according to the standard method of microbiology. There most of the respondents are female with 96.67%; 93.33% of them are married. The average age of respondents is between 26 and 35 and more than half (56.57%) are uneducated. The average load of dried fish in the three markets is 4.60 X 10<sup>7</sup> CFU/g for FAMT; 7.33 X 10<sup>5</sup> CFU/g for CT; 2.87 X 10<sup>4</sup> CFU/g for CTT; 1 CFU/g for *Staphylococcus aureus*. On the other hand, for smoked fish, the average varies between 6.81 X 10<sup>7</sup> CFU/g for FAMT; 2.28 X 10<sup>6</sup> CFU/g for CT; 1.56 X 10<sup>5</sup> CFU/g for CTT and 1 CFU/g for yeasts and molds. Enumeration of staphylococci in the three (3) samples gave high values in the range of 14 to 90 CFU/g. Additionally, the level of contamination by total mesophilic aerobic flora is 74.67% for dried fish and 36.33% for smoked fish. Therefore, it is necessary to follow up when fish processing to reduce the level of contamination by flora microbial.

**Keywords:** dried and smoked fish, microbiological quality, market, Abéché

## 1. Introduction

Fish is a source of animal origin which African populations often use to cover their needs and ensure their food security (World Fish center, 2005). In the African countries as in many countries in the world, fishing and aquaculture play an important role in the supply of animal protein for food. At Chad, aquaculture is still underdeveloped and concerns only fish farming. However, the Fishing is the third activity in the rural sector (FAO, 2002). Fishing in Chad is practiced in all the surface waters of the country, namely the rivers (the Chari and the Logone) and the Lakes (Lake Chad, Lake Fitri, Lake Léré and the Toupouris Lakes) (LCBC, 2007). In addition to a source of good quality protein for human consumption, fish is also a significant source of income for the population (Femon, 2013). It also constitutes a source of vitamin D, B and A (K. Di ñ ò ba, 2005). Fish meat contains little cholesterol but a lot of mono and polyunsaturated acid whose preventive and protective role against cardiovascular disease has been demonstrated by several studies (Corraze and Kaushik, 1999; Regost *et*

*al.*, 2021; Cahu, 2004; Bourre, 2004 and 2005). By virtue of this dietary quality, the fish has therefore been recommended in food for the prevention of diseases cardiovascular (Dicko *et al.*, 1990). Since the recurring drought that the country has experienced, a significant number of wetland herders (Lake Chad, Lake Fitri and Mayo kebbi) with lost their cattle are converted into sinners. Fishing is practiced by different categories of fishermen, especially professional fishermen and seasonal fishermen who experience this activity by selling fish to resellers who export it to major urban centers notably Abéché for fishing in Lake Fitri and Lake Chad. However, despite the fish is a vital source of animal protein and micronutrients for many rural community, it can also be the cause of serious Toxi-infection with health, political and economic consequences, (WHO 2003). In Abéché the majority of sellers buy fish carried away by lack of river and this can lead to a source microbial contamination; the transformation does not take place at their level. Although this sector is artisanal, it has assets and deserves follow-up for its improvement. It's in this perspective that we initiated this study. Hence, the objective of evaluating the hygienic quality and microbiological characteristics of dried and smoked fish sold in the markets of the city of Abéché

## 2. Methods

### 2.1 Description of the City of Abéché

The study took place in the city of Abéché the provincial capital of Ouaddaï in the department from Ouara located in the east of the country towards the Goz-beida road. It extends between 13°48'584" of north latitude and 20°58'139" east longitude. The study area is under the influence of a climate intertropical with a dry season of 9 months and a rainy season of 3 months. The diet of these two (2) seasons is defined by the fluctuations between the masses of northern dry areas (harmattan) and the masses of maritime wetlands of the South-West (the monsoon). Average rainfall annual is about 300 mm. The temperature of the region is variable according to the periods. There average annual temperature in Abéché is around 28 °C with a variation in the cold season (December to February) between 16 and 35 °C in the dry season (April and May) between 25 and 41 °C. The city has three markets spread over the seven (7) districts. The market of Taradona is located in the second district. In this walk the fish are dominant and sold at the edge of the paved road. This locality has two sites: the market of Taradona and the Ridjil market where there is a lack of dried and smoked fish by the sellers. In these two sites, the fish are displayed in the open air and sold in detail. Of Moreover, these markets are not urbanized and most of the sellers occupy places by chance. Subsequently, the former livestock market is located in the sixth district of the city of Abéché Finally, the central market that is located in the center of the city between first and second boroughs. In this market, fish are sold in a minority.

### 2.2 Period and Type of Study

This is a descriptive cross-sectional study, which was conducted from June 10 to July 27, 2022 in the city of abéché The analyzes were carried out at the microbiology laboratories and INSTA chemistry. This study was focused on the evaluation of the hygienic quality and of dried and smoked fish sold in the markets of the town of Abéché

### 2.3 Microbiological Analysis Methods

#### 2.3.1 Preparation of Culture Media and Diluents

The preparation of the culture media consists first of all in calculating the medium in millilitres. This calculation is made according to the quantity of distilled water in ml. The mass of dehydrated media was weighed on a scale by referring to the indications mentioned on the box. These backgrounds were then mixed with a quantity of distilled water and then brought to the boil with stirring constant with a magnetic stirrer. After sterilization in an autoclave at 121 °C for 15 minutes with the exception of the Hecto media, these media were cooled between 45 to 50 °C. A volume of 15 to 20 ml of medium was poured into previously sterilized Petri dishes. The germs sought were total mesophilic aerobic flora, total coliforms, coliforms thermotolerants, Staphylococcus and Salmonella.

Table 1. Microbiological reference criteria of smoked fish intended for human consumption

Types of products	Microorganismes (UFC/g)						
	FMAT	Salm.	S. P.P.	CTT	ASR	L/M	L. mono.
Smoked Products and of production sources	10 <sup>5</sup>	Abs/25g	10 <sup>2</sup>	10	Absent	10 <sup>2</sup>	100/25g
Sources	Jouve 1996			AFNOR 1996		EU 2005	

**Legend:** TMAF: Total Mesophilic Aaerobic Flora, Salm: Salmonella, CTT: Coliform Thermotolerant, L/M: Yeast and Mold, L. mono: Listeria monocystogenes.

Table 2. Germs sought during the microbiological analysis

N°	Germs searched	References	Middle of culture	Condition of culture
1	Totale Mesophilic Aerobic (-30 °C)	NF. ISO 4833, February 2003.	Plate Count Agar (PCA)	30 °C ;24 à48 hours
2	Total Coliform (30 °C)	NF. ISO 4832, 2006	EMB	30 °C ;24 à72 hours
3	Coliform thermotolerants and E. coli (44 °C)	NF ISO 4833 2006.	EMB	44 °C ;24 à48 hours
4	<i>Staphylococcus aureus</i> (37 °C)	NF. V08-057-1, Novembre 1994.	Chapman	37 °C ;24 à48h 37 °C ;24 à48h
5	Salmonella (37 °C)	ISO 6579-A1 July 2007.	EPT, Broth Rappaport, Hektoen	37 °C ;24h 37 °C ;24h 37 °C ;24h
6	Yeast and molds (30 °C)	ISO 21527-1 July 2008.	Sabouraud	30 °C ;48h

#### 2.4 Counting and Method of Calculation

##### 2.4.1 Search and Enumeration of TMAF (ISO 4833 standard: February 2003)

1 ml is taken from the 10-4 and 10-5 dilutions and introduced aseptically into the boxes of Disposable petri dishes. 15 ml of PCA medium (Plate Count Agar) melted and cooled to water bath at 45 °C. The mixture is homogenized by circular movements of the boxes. After solidification, 5 ml of PCA was added. This second layer prevents the invasion of the box by germs which can make it difficult to read. The boxes have been then incubated at 30 °C. After 24 to 72 hours of incubation, counting is done by comp Stage colonies on plates with 30 - 300 colonies.

##### 2.4.2 Enumeration of Total and Thermo-tolerant Coliforms (ISO 4832: 2006).

A volume of 1 ml was taken from the 10-2 and 10-3 dilutions and introduced into the Petri dishes at single use, then 15 to 20 ml of sterilized MCK medium is added. The mixture was homogenized se by circular movements with the hand. After solidification, 5 ml of EMB was added. Inoculated plates were incubated at 44 °C for thermotolerant coliforms and 37 °C for total coliforms. The counting was carried out after 24 to 48 hours of incubation.

##### 2.4.3 Search and Enumeration of Presumed Pathogenic Staphylococcus (NF standard V08-057-1, November 1994)

0.1 ml of the stock solution and 0.1 ml of the 10-2 dilution were inoculated on the surface in Petri dishes in which the Chapman medium was previously poured. The boxes were in cubed at 37 °C for 24 hours. After incubation at 37 °C for 24 hours, the colonies do The amples obtained were subcultured into the nutrient broth tubes for the coagulase test. A positive coagulase test result concluded the presence of *Staphylococcus aureus*.

##### 2.4.4 Detection and Enumeration of Salmonella (ISO 6579/A1 standard: July 2007)

The search for and counting of salmonella require several culture media (mi places Rapport, Hectoen) and take place in several stages. ÿ pre-enrichment: it consists in incubating at 37 °C the ground material of 25 g of fish in 225 ml of EPT for 24 hours. ÿ selective enrichment: 1 ml of the pre-enriched solution was inoculated into the test tubes containing 9 ml of Rappaport Vassiliadis Soja (RVS) broth respectively. The pipes are then incubated for 24 hours at 37 °C. ÿ isolation: After enrichment, 0.1ml of the enriched solution was taken and inoculated on the Hectoen selective medium by the streaking method using a sterile glass Pasteur pipette. The plates were incubated for 24 hours at 37 °C.

##### 2.4.5 Research and Enumeration of Yeasts and Molds (ISO 21527-1 standard; July 2008)

Sabouraud medium was used to search for these germs. Indeed, 0.1ml of the 10-2 and 10-3 dilutions 10-1, were inoculated into the selective medium contained in Petri dishes. There Colonies are read after 3 to 5 days of incubation at 25 °C. They are in the form whitish rounded.

#### 2.5 Method of Calculation and Interpretation of Results

After the incubation period mentioned in the standard specific to each germ, we proceed the counting of characteristic colonies for each dish containing less than 300 colonies and 15 colonies minimum or any other number indicated in the standard. The number N of germs present in the sample analyzed is considered as an

average weight of successive dilution and given by the following formula:

$$N = \frac{C1 + C2}{V(n1 + n2 \times 0,5)d1}$$

C1+C2= sum of the characteristic colonies on the two dishes retained

V= volume of inoculums applied to each box

d1= dilution rate corresponding to the first dilution retained

n1 = number of dishes retained at the first dilution

n2 = number of dishes retained at the second dilution.

### 2.6 Statistical Method

The data collected was analyzed using the XLSTAT (6.1.9.) statistical software. Descriptive made it possible to have the socio-economic parameters (mean, standard deviation, percentage and frequency). The analysis of variance (ANOVA) made it possible to make the comparison between the mean of the parameters evaluated. The Newman-Keuls test (for multiple comparison) was used to determine the level of significance between the variable (types of fish sold) at the 5% threshold.

## 3. Results

### 3.1 Investigation

#### 3.1.1 Origin of Dried and Smoked Fish

Dried and smoked fish arrive in Abeche directly from N'Djamena, Lac-Tchad and Hello. The sellers send their money to the wholesalers and they in turn package the fish in hermetically sealed boxes and transported to Ab éh é by lorries of transportation. At the local level, the fish were retailed to end consumers by the sellers.

#### 3.2 Profile of Respondents

A total of 30 sellers were surveyed for a month on information relating to different variables and hygienic practices of dried and smoked fish in the three (3) markets in the town of Ab éh é

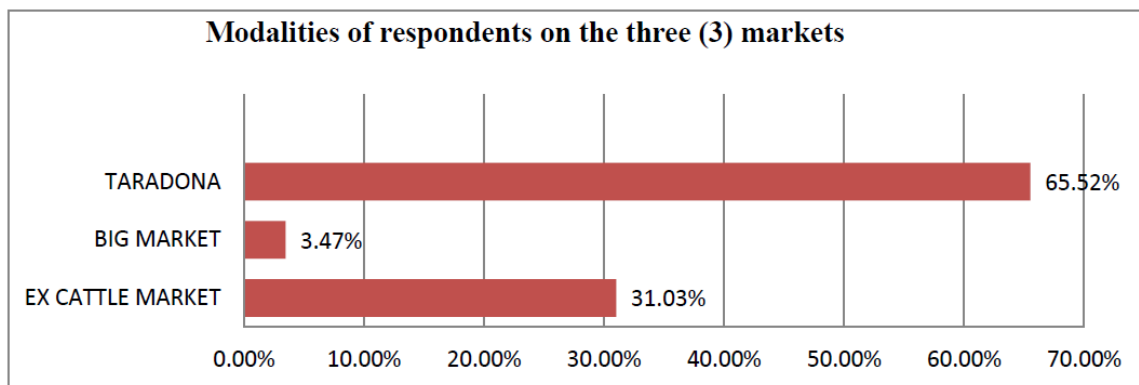


Figure 1. Modalities of respondents on the three (3) markets

Figure 1 represent the rate of sellers according to survey sites. This figure shows that the Taradona market presents more fish sellers with 65.52% followed by the former livestock market with 31.03% and the large market represents a low rate of sellers (3.45%).

Table 3. Distribution according to the characteristics of the respondents

Parametres	Modality	Nombres	Percentages %
Sex	Male	1	3.33
	Feminine	29	96.67
<b>Total (N)</b>		30	100
Age	≥ 25 years	03	10
	26 à 35 years	15	50
	36 to 45 years	12	40
<b>Total (N)</b>		30	100
Marital Status	Married	28	93.33
	Bachelor	0	0
	Widow	2	6.67
<b>Total (N)</b>		30	100
Level of studies	Primary	8	26.67
	Secondary	4	13.33
	Superior	1	3.33
	Not in school	17	56.67
<b>Total (N)</b>		30	100
Type of fish	Dried	13	43.33
	Smoked	17	56.67
<b>Total (N)</b>			99.99
Means of perservation	Boxes	28	93.33
	Bag	2	6.67
<b>Total (N)</b>		30	100

Table 3 represents the socio-professional characteristics of the respondents, including gender female presents 96.67% unlike male 3.33%. The age of respondents is located between 22 and 45 years old, on average 33.55% and most respondents are married with 93.33%. By elsewhere, more than half of the respondents have not been to school, on the other hand those who are educated have a low rate (3.33%). In addition, the majorities of respondents sell smoked fish (56.67%) and keep much more in boxes (93.33%). Le tableau 3 représente les caractéristiques socio-professionnelles des enquêtés, dont le sexe féminin présente 96,67% contrairement au sexe masculin 3,33%. L'âge des enquêtés est situé entre 22 à 45 ans, moyennement 33,55% et la plupart des enquêtés sont mariés avec 93,33%. Par ailleurs, plus de la moitié des enquêtés n'ont pas été scolarisés par contre ceux qui sont instruit présentent un faible taux (3,33%). De plus, la majorité des enquêtés vendent les poissons fumés (56,67%) et conservent beaucoup plus dans des cartons (93,33%).

### 3.3 Microbiological Analysis

The different germs identified and counted are recorded in tables 1.2 and respectively for the three markets in the town of Abéché

Table 4. Microbiological analyzes of dried/smoked fish taken from the market in Taradona

Types of fish and samples		UFC/g					
		Germs					
		TMAF (30 °C)	CT (30 °C)	CTT (44 °C)	<i>S. aureus</i> (30 °C)	Salmonella 25/g	Yeasts and mola (30 °C)
Pisces dried	E <sub>1</sub>	5,6.10 <sup>6</sup>	1,12.10 <sup>5</sup>	2,50.10 <sup>3</sup>	Absence	Absence	Absence
	E <sub>2</sub>	2,17.10 <sup>4</sup>	2,12.10 <sup>3</sup>	4,12.10 <sup>2</sup>	Absence	Absence	Absence
	E <sub>3</sub>	9,26.10 <sup>5</sup>	13,7.10 <sup>4</sup>	8, 3.10 <sup>2</sup>	Absence	Absence	Absence
	E <sub>4</sub>	1,22.10 <sup>5</sup>	6,16.10 <sup>4</sup>	2,6.10 <sup>2</sup>	Absence	Absence	Absence
	E <sub>5</sub>	3,22.10 <sup>7</sup>	2,16.10 <sup>5</sup>	1,6.10 <sup>4</sup>	Absence	Absence	Presence
Pisces smoked	E <sub>1</sub>	7,07.10 <sup>6</sup>	8,6.10 <sup>5</sup>	11,12.10 <sup>4</sup>	Absence	Absence	Absence
	E <sub>2</sub>	3,15.10 <sup>5</sup>	5,17.10 <sup>3</sup>	2,10.10 <sup>2</sup>	Absence	Absence	Absence
	E <sub>3</sub>	10,9.10 <sup>4</sup>	2,10.10 <sup>2</sup>	7,15.10 <sup>3</sup>	Absence	Absence	Absence
	E <sub>4</sub>	8,32.10 <sup>4</sup>	4,02.10 <sup>3</sup>	13,5.10 <sup>2</sup>	Absence	Absence	Absence
	E <sub>5</sub>	4,17.10 <sup>7</sup>	5,8.10 <sup>5</sup>	12,12.10 <sup>3</sup>	Absence	Absence	Presence

**Legend:** TMAF: Total Mesophilic Aerobic Flora; CT: Total Coliforms; CTT: Thermo Tolerant Coliform and S:

## Staphylococcus

The microbial load of the Total Mesophilic Aerobic Flora is around  $2.17 \times 10^4$  and  $3.22 \times 10^7$  CFU/g for dried fish and  $8.32 \times 10^4$  and  $4.17 \times 10^7$  CFU/g for fish smoked. Total Coliforms varied between  $2.12 \times 10^3$  and  $2.16 \times 10^5$  CFU/g for dried fish and between  $2.10 \times 10^2$  and  $8.6 \times 10^5$  CFU/g for smoked fish. As for Thermotolerant Coliforms, the averages are between  $2.6 \times 10^2$  and  $1.6 \times 10^4$  CFU/g for dried fish and  $2.10 \times 10^2$  and  $11.12 \times 10^4$  CFU/g for smoked fish.

Table 5. Microbiological analyzes of dried/smoked fish taken from the central market

Types of fish and sample	UFC/g						
	FAMT (30 °C)	CT (30 °C)	CTT (44 °C)	<i>Staph. aureus</i> (30 °C)	Salmonella 25/g	Yeasts and mold (30 °C)	
Dried fish	E <sub>1</sub>	$2,12.10^4$	$3,30.10^3$	$2,5.10^2$	Absence	Absence	Absence
	E <sub>2</sub>	$2,15.10^5$	$2,6.10^3$	$3,6.10^3$	Absence	Absence	Absence
	E <sub>3</sub>	$4,37.10^3$	$3,18.10^2$	10	Absence	Absence	Absence
	E <sub>4</sub>	$1,10.10^5$	$8,6.10^3$	$1,16.10^2$	Absence	Absence	Absence
	E <sub>5</sub>	$3,18.10^5$	$6,14.10^4$	$4,3.10^2$	Absence	Absence	Absence
Smoked fish	E <sub>1</sub>	$5,12.10^5$	$2,6.10^3$	$2,11.10^2$	Absence	Absence	Absence
	E <sub>2</sub>	$7,56.10^6$	$7,9.10^4$	$6,4.10^3$	Absence	Absence	Absence
	E <sub>5</sub>	$5,24.10^3$	$4,17.10^2$	10	Absence	Absence	Absence

**Legend:** TMAF: Total Mesophilic Aerobic Flora; CT: Total Coliforms; CTT: Thermotolerant Coliform and Staph: Staphylococcus

The microbial load of the Total Mesophilic Aerobic Flora is around  $4.33 \times 10^3$  and  $.18 \times 10^5$  CFU/g for dried fish and  $5.24 \times 10^3$  and  $7.56 \times 10^6$  CFU/g for smoked fish. Total Coliforms vary between  $2.60 \times 10^3$  and  $6.14 \times 10^4$  CFU/g for dried fish and  $2.40 \times 10^2$  and  $7.9 \times 10^4$  CFU/g for smoked fish. For Thermotolerant Coliforms, it is around 10 and  $3.60 \times 10^3$  CFU/g for dried fish and between 10 and  $6.40 \times 10^3$  CFU/g for smoked fish.

Table 6. Microbiological analyzes of dried/smoked fish taken from the former livestock market

Types of fish and samples	UFC/g						
	TMAF (30 °C)	CT (30 °C)	CTT (30 °C)	<i>S. aureus</i>	Salmonella 25/g	Yeasts and	
Dried fish	E <sub>1</sub>	$5,70.10^5$	$3,33.10^3$	$8,2.10^2$	Absence	Absence	Absence
	E <sub>2</sub>	$14,2.10^3$	$2,5.10^2$	10	Absence	Absence	Absence
	E <sub>3</sub>	$5,60.10^6$	$11,6.10^4$	$10,9.10^2$	Presence	Absence	Presence
	E <sub>4</sub>	$2,66.10^5$	$9,03.10^3$	$8,66.10^2$	Absence	Absence	Absence
	E <sub>5</sub>	$12,2.10^4$	$1,33.10^3$	$15,19.10^2$	Absence	Absence	Absence
Smoked fish	E <sub>1</sub>	$7,9.10^5$	$14,2.10^3$	$9,11.10^3$	Absence	Absence	Absence
	E <sub>2</sub>	$14,39.10^3$	$4,16.10^2$	10	Absence	Absence	Absence
	E <sub>3</sub>	$5,24.10^6$	$2,6.10^4$	$7,40.10^3$	Absence	Absence	Absence
	E <sub>4</sub>	$3,66.10^6$	$7,09.10^5$	$12,20.10^2$	Absence	Absence	Absence
	E <sub>5</sub>	$10,33.10^4$	$5,13.10^2$	10	Absence	Absence	Absence

**Legend:** TMAF: Total Mesophilic Aerobic Flora; CT: Total Coliforms; CTT: Thermotolerant Coliform and S: Staphylococcus

The microbial load for the ex-livestock market is:

- |  |              |
|--|--------------|
| - TMAF : $114,2 \times 10^3$ et $5,60 \times 10^6$ UFC/g | } dried fish |
| - CT : $1,33 \times 10^3$ à $11,60 \times 10^4$ UFC/g    |              |
| - CTT : 10 à $5,19 \times 10^2$ UFC/g                    |              |

- TMAF :  $10,33 \times 10^4$  et  $5,24 \times 10^6$  UFC/g
  - CT :  $4,11 \times 10^2$  et  $7,09 \times 10^5$  UFC/g
  - CTT : 10 et  $9,11 \times 10^3$  UFC/g
- } **Smoked fish**

Table 7. Sprout averages in the three (3) markets

Types of fish	TMAF	CT	CTT	<i>S.aureus</i>	Salmonella	Yeasts and mold
Dried	$4,60 \times 10^7$	$7,33 \times 10^5$	$2,87 \times 10^4$	Presence	Absence	Presence (2X)
Smoked	$6,81 \times 10^7$	$2,28 \times 10^6$	$1,56 \times 10^5$	Absence	Absence	Pr é sence

**Legend:** TMAF: Total Mesophilic Aerobic Flora ; CT: Total Coliforms ; CTT: Thermotolerant Coliform and S: *Staphylococcus*

Microbiological analyzes show that the average load per type of fish for the three markets is:

**Dried fish:**  $4,60 \times 10^7$  UFC/g for FAMT ;  $7,33 \times 10^5$  UFC/g for CT ;  $2,87 \times 10^4$  UFC/g for CTT ; 2 UFC/g for *Staphylococcus*.

**Smoked fish:**  $6,81 \times 10^7$  UFC/g pour FAMT ;  $2,28 \times 10^6$  UFC/g pour CT ;  $1,56 \times 10^5$  UFC/g for CTT et 3 UFC/g for yeasts and molds.

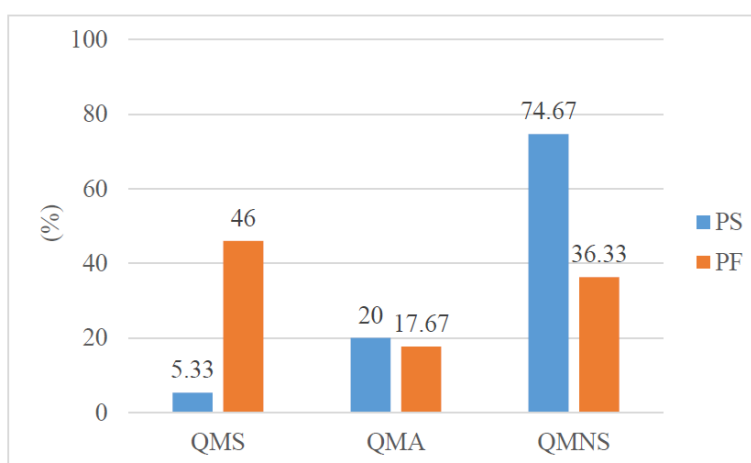


Figure 2. Microbiological quality of fish on the three (3) markets

**Legend:** SMQ: Satisfactory Microbiological Quality, MQA: Microbiological Quality Acceptable, UMQ: Unsatisfactory Microbiological Quality, DF: Dried Fish, SF: Smoked Fish.

The figure shows that the unsatisfactory microbiological quality is 74.67% for the dried fish and 36.33% for smoked fish. On the other hand, 5.33% are satisfactory for dried fish and 46% for smoked fish.

## 4. Discussion

### 4.1 Assessment of Survey Results

The survey found that the majority of dried and smoked fish sold in Ab é ch é come from N'djamena, Lac-Chad and Salamat. Our results corroborate those of (Abdoullahi *and al.*; 2016) who reported that the dried fish of Chad come from the region of Sa lamat. Table 2 shows that the majority of respondents are mama women. children (93.33%) and who have not been to school (56.67%). (Kokou Abotchi 2010; Oula iet al 2007) reported a similar result by carrying out the same studies in Togo and C ô te of ivory. The lack of education does not allow these women to resort to the hygiene of foodstuffs which could have harmful consequences on the health of consumers adds. The conservation of dried and smoked fish is mostly done in coaches. tones (93.33%). These results are in agreement with the observation of (Seid *et al.*, 2021) that the fish are transported to the market, on board tractor-trailers, packaged in boxes and bags. Storage in boxes avoids losses, their spoilage and also retain their nutritional and organoleptic value. The boxes used for the conservation of these fish are boxes whose provenance is doubtful. These are sometimes boxes used for the transport of chemical products which could lead to travel gives. It emerges from this study that the most consumed fish in the town of Ab é ch é are

smoked fish. Our results are similar with the work of (Mananga *et al* 2019) at Brazzaville (Congo) who reported that the same type of smoked fish is consumed the most.

#### 4.1.1 Assessment of the Microbiological Quality of Fish

The level of contamination by total mesophilic aerobic flora is 74.67% for dried fish and 36.33% for smoked fish with respective averages of  $4.60 \times 10^7$  and  $6.81 \times 10^7$  CFU/g. Our results are well above the averages reported by (Abdollahi *et al* 2016); (JC Micha *et al* 2018), respectively  $5.5 \times 10^5$  to  $2.2 \times 10^6$  CFU/g in the city of N'djamena (Chad)  $188.07 \times 10^5$  CFU/g for dried fish and  $117.60 \times 10^5$  CFU/g for smoked fish. The high level of contamination of our samples could be explained by non-compliance with hygiene rules at the place of processing and sale. The fish are sold in the open air, around public roads, next to rubbish and next to dirty stagnant water. These could expose them to dust, proliferation of flies and other insects. These can lead to a risk of microbial contamination of dried and smoked fish. Non-compliance with the rules of good hygienic practices by food processors and sellers leads their contamination by coliforms and total flora Hadjer (2014). Faecal coliforms are present in both types of processed fish (dried and smoked) with respective averages of  $1.43 \times 10^5$  CFU/g for dried fish and  $1.22 \times 10^5$  CFU/g for fish smoked with non-satisfaction rates of around 74.67% and 36.33%. (J C. Micha *and al* 2018) reported opposite averages to ours respectively 90.80 CFU/g for dried fish and 23.73 CFU/g for smoked fish. Both results suggest that dried fish are more contaminated than smoked ones. This difference is due to the ensure that the processing of fresh fish into dried fish is done in an unhealthy environment (worn or rolled materials, in the open air, on the ground, within reach of reptiles, flies and other insects) and by the customer who often handles them with his bare hands. According to (Tidjani *et al* 2013); and Attamar (2018), several bacteria responsible for Toxi Collective Food Infections (TCFI) can belong to the flora of the digestive tract and be conveyed by the hands of the wearer (*E. coli* for example). Fecal coliforms are bad markers of the hygienic conditions of the manipulator. Their presence in the food usually shows fecal contamination *E. coli* has not been identified in the samples but the strong presence of fecal coliforms suggests the presence of *E. coli*, because this bacterium represents about 80% of fecal coliforms. That could indicate a risk to consumers. However, the pathogen such as *Salmonella* was not isolated in our samples, contrary to the results obtained by (Abdollahi *et al* 2016), Oku and Amakoromo (2013). They reported the presence of *Salmonella* and *Staphylococcus aureus* in their study. This difference could be explained by the fact that the fishing was carried out in unpolluted waters and also by the smoking treatment for smoked fish. Our results showed a low level contamination of smoked (3.33%) and dried (6.66%) fish by yeasts and mold. According to the AFNOR standard (1996), the fungal flora for dried fish must not exceed 103 CFU/g and 102 CFU/g for smoked fish. These values are therefore at above that recommended by the standard. Our results are reduced to those of (Abotchi 2010); (Abdollahi *et al.*, 2016) who reported a high rate of contamination of dried and smoked fish in their study respectively 92.5% for smoked fish and  $5.9 \times 10^3$  CFU/g for dried fish. This difference would be due to the sample size and also to the environment in which the fish were processed. The spread of fish on mats, tarps, rusty materials, wood and storage on polluted soil, would be the exogenous cause of mold contamination. According to Jeantel *and al.*, (2006), the behavioral attitude would be at the origin of post-contamination of the fish. dried and smoked which would be subject to the proliferation of fungi. On the contrary, according to (Bourgeois *et al.*, 1980), the high contamination of smoked fish can be explained by the great capacity of yeasts and molds to grow on substrates with low activity of the water. From a general point of view, non-compliance with hygiene rules and exposure of products in an unhealthy environment would be the source of microbial contamination in some of our samples.

## 5. Conclusion

The realization of this work allowed us to evaluate the living organisms in fish dried and smoked fish sold in the markets of the town of Ab é h é Dried fish are more contaminated than smoked fish due to non-compliance with Ischikawa rules. Failure to observe good processing hygiene practices leads to contamination of fish after drying and smoking. In Ab é h é the fish come from N'djamena and Salamat and sold in the various markets of the city d'Ab é h é where the *Staphylococcus aureus* was found at the former cattle market unlike to other markets. The level of contamination of the total mesophilic flora is 74.67% for dried fish and 36.33% for smoked fish with a respective average of  $4.60 \times 10^7$  CFU/g. However, despite the fact that the fish suffer contamination from microbial, they are a source of animal protein, micronutrients and a source significant income for the population. Therefore, the study suggests the mastering of condition conservation, processing and proper use in order to avoid or reduce the risk of microbial contamination.

## Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could



have appeared to influence the work reported in this paper.

#### **Informed consent**

Obtained.

#### **Ethics approval**

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

#### **Provenance and peer review**

Not commissioned; externally double-blind peer reviewed.

#### **Data availability statement**

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

#### **Data sharing statement**

No additional data are available.

#### **Open access**

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