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Relative abundance of smoked fishes and the diversity of pests associated with their deterioration during storage

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ABSTRACT: Fish is recognized for its high nutritional value and its beneficial effect on the health of consumers. In order to ensure a permanent supply throughout the year, fish is dried or smoked and put in storage. The aim of this study was to determine the biotic constraints related to the deterioration of smoked fishes in three processing basins in the Littoral region of Cameroon. 260 actors were interviewed in the localities of Youpwé, Mouanko and Manoka: 64 fishermen, 89 processors and 107 traders. The inventory of smoked fishes was determined in each locality. During the inspection of the storage tools, *Ethmalosa fimbriata* and *Ilisha africana,* apparently healthy were sampled and put in observation at the National Veterinary Laboratory for 60 days. This study revealed that only women are involved in fish processing. The processors and traders of Youpwé were Cameroonian (84.12%), Ghanaian (4.67%) and Nigerian (11.21%). Their level of education is mainly secondary school education (57.01) and an experience year in activity between 11 and 15 years (49.26%). 33 species of fishes are smoked, the main important of which are *E. fimbriata* and *I. africana*. 9 pest species are associated with stored smoked fishes. *Necrobia rufipes* is the main insect pest during storage of *E. fimbriata* (56.0), *I. africana* (64.0) with a significant difference (F (120: 29): 4.611*, P ≤ 0.05) and *Aspergillus flavus* (F (120; 29): 3.045*, P ≤ 0.05) the most detrimental mold. The pest control methods are more diversified in Youpwé: re-smoking (23%), refrigeration (5%), dry red pepper (41%), garlic (23%), dry salting (8%).

KEYWORDS: Stored Smoked Fish, Insects, Molds, Mites, Control Methods, Littoral-Cameroon.

1 INTRODUCTION

Fish is recognized for its high nutritional value and its beneficial effect on the health of consumers. These nutrients have therapeutic properties, among which: anti-inflammatory, antihyperlipidemic, hypolipidemic, antidiabetic [1]; [2]; [3]; [4]. Fish, in addition to its nutritional value, is a major source of employment and trade through capture, handling, processing and distribution for millions of people who live near water [5]. In the world, faced with an ever-growing population, the demand for this fish product is growing. In 2018, its production was estimated at 179 million tones, 20.5 kg per capita [6]. In Cameroon, this production is estimated at 294.000 tones [7].

However, due to its chemical composition, fish is an easily perishable food and therefore likely to cause very high post-harvest losses. These losses can be caused by poor hygienic conditions during handling, storage, distribution, or by lack of infrastructure during the conservation of the fresh product. In Africa, these losses are between 30 and 35%, affecting the nutritional, organoleptic, technological and hygienic quality of fish [6]. In order to preserve this quality after capture, several preservation techniques are practiced, such as freezing, refrigeration, salting, drying, smoking, frying and fermentation [8]; [9]. On the coasts of Littoral-Cameroon, smoking and drying remain the main modes of transformation [10]; [11]. To ensure the availability of smoked or dried fishes on the market throughout the year, successful storage is essential. However, during storage, many biotic and physical factors affect these fish products [12]; [13]; this,

despite the antioxidant and antiseptic action of the various compounds (formaldehyde and acetic acid) in the smoking on the fish. Indeed, pest infestations are common on smoked and dried fishes in most developing countries, including Cameroon [14]. Harmful pests commonly recorded on stored smoked or dried fish are beetles (*Dermestes* and *Necrobia*), Diptera (bloat flies) and Sarcoptiformes (mites) [15]; [16]. These pests depreciate smoked fish through their biological activity by producing waste (fine meal) or secretions, releases of heat and water vapors, thus creating an environment favorable to the development of molds [17]. Among these different most common molds associated with smoked fish samples in Cameroon are *Aspergillus* spp, *Penicillium* spp, and *Mucor* spp [18]; [19]. During storage under certain conditions, the infestation rate can reach 99.49%, resulting in quantitative losses of the order of 80% to 100% depending on the different species of smoked fish stored in addition to qualitative losses favoring a depreciation of the product [11]. Pest infestation results in losses of 25,044.54 naira for a turnover of 427,500.00 naira in Nigeria [20]. The alteration in the quality of smoked fish can pose a danger to public health because they carry diseases that are pathogenic for humans [19]; [21]. The spoilage of smoked fish due to mold and insect vectors in open markets due to poor storage is of great importance and is a serious problem in Littoral-Cameroon. The objective of this study was to carry out a socio-sanitary survey and to highlight the diversity of pests of smoked fish stored in Manoka, Mouanko, Youpwé (Littoral-Cameroon). This will provide useful information for dealing with the problem of preserving and storing fish and will help to ensure the safety and wholesomeness of smoked fish.

2 MATERIAL AND METHODS

2.1 STUDY FRAMEWORK

Cameroon is a country in the Central African sub-region with an area of nearly 475,442 km^2 including 402 km of coastline which is at the heart of intense maritime industrial and artisanal, multi-species and gear fishing activities. Located in the Bay of Biafra, the sea is covered with warm water at a temperature > 25°C, watered by significant runoff entrusted to coastal rivers and estuaries. The study took place in the Littoral-Cameroon region, precisely in 03 sub divisions: Douala II (Youpwé "Tyo1, Tyo2, Tyo3, Tyo4, Tyo5"), Douala VI (Manoka "Dahomey, Plateau, Nyangadou, Kwanci, Creek n1") in the Wouri Division and Mouanko (Laskobo, Lorenz, Kasalafan, Côte d'ivoire, Yoyo 2) in the Sanaga Maritime Division (Fig. 1). These areas were chosen for their volumes of fish landed and also for the high activity of processing smoked fish [11].

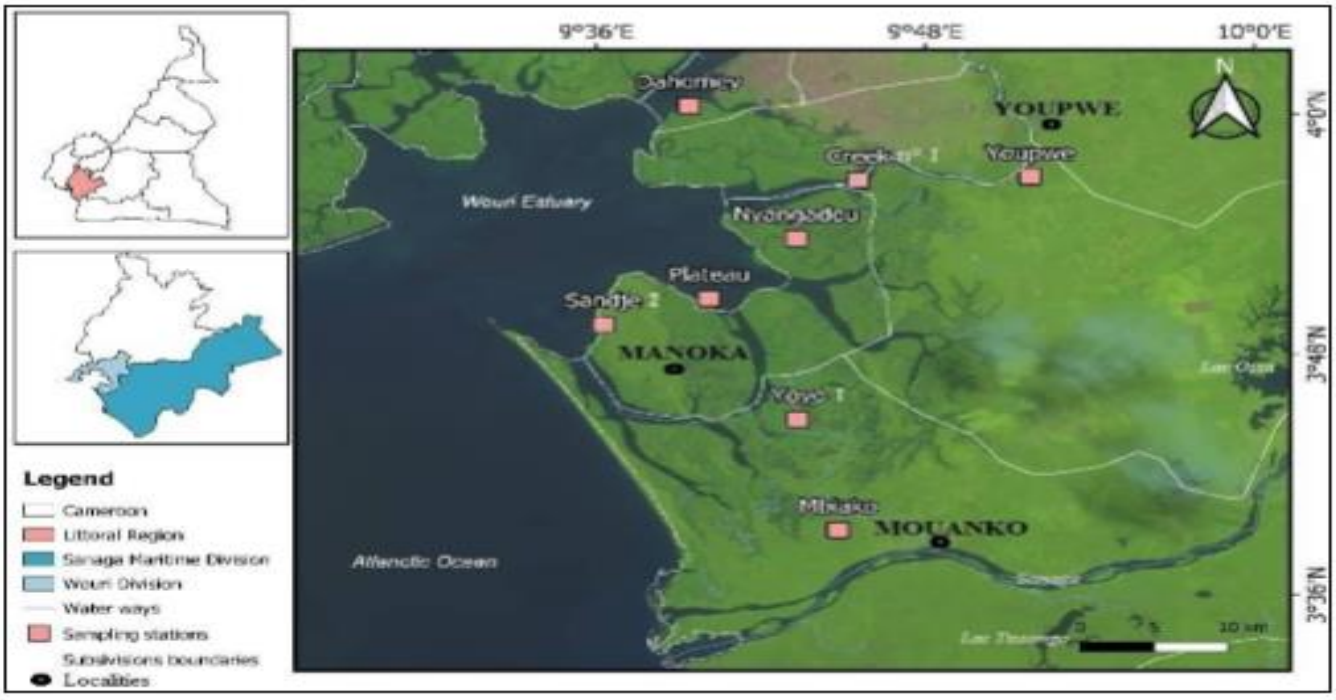

Fig. 1. Location of sampling points in Youpwé, Mouanko and Manoka [11]

2.2 Characterization Of Actors In The Smoked Fish Chain In The Littoral Region

The selection of interviewees was carried out with the aim of obtaining a representative sample of the population of the study area. The actors of the fish sector were chosen according to the profession exercised, which made it possible to retain fishermen, processors and fish traders. To this was added the availability of the actors: only individuals wishing to answer the questions were selected. During the survey in the different subdivisions, 260 actors were interviewed, including: 64 fishermen at the landing stages, 89 processors in the processing sites and 187 traders in various markets. A questionnaire including a socio-demographic section of the players in the sector was developed. To this end, the following information was collected: sex, age, nationality, level of study, year of experience of the actors.

2.3 Determination Of Smoked Fish Species And Numerical Importance

The inventory of smoked fish was carried out according to this developed method [11]; [14]. Thus, the species and each individual of fish in different fishing camps were identified. Specific diversity parameters were taken in each fishing camp. For each inspection, the total number of smoked fish was estimated, as well as the total number per species. The total weight of smoked fish was estimated by baskets for each species group. Then, species identification was made *in situ* for some specimens using the identification keys [22]; [23]. For unidentified specimens *in situ,* in addition to local names recorded, a specimen is taken, preserved in 70% alcohol, and labeled for laboratory identification. Once in the laboratory, more careful observations were made. From processors and traders, the information collected concerned: local names of smoked species, harmful pests and different strategies for limiting post-storage losses of smoked fish.

2.4 Inspection Of Storage Tools And Collection In Vivo Of Smoked Fish

Along with the identification of smoked fish during the survey, the inspection of 20 storage tools per fishing location was carried out, making a total of 60. At the same time, any insects present in the structures inspected were collected, preserved in 70% alcohol, then identified in the laboratory. During this inspection, 75 collections *in vivo* of *Ethmalosa fimbriata* and 75 others of *Ilisha africana* showing no sign of initial infestation were taken there and brought back to the laboratory. In the laboratory, 100 g of each collection were weighed and put in observation.

2.5 Identification And Inventory Of Insect Pests Of Stored Smoked Fish

Once in the laboratory, 100 g of each collection were weighed and introduced into 1200 ml glass jars with ventilated lids and repeated 5 times. These collections were placed under observation for 60 days. Insects that emerged after this period were collected, identified and counted. This identification was made using the identification key for the beetle insect families and the insect identification catalogs of products stored in tropical regions [24]; [25].

2.6 Mycological Analysis: Isolation And Identification Of Fungi

Fish samples were processed aseptically for fungal isolation according to the described procedure [26]. Samples of smoked fish (5g) were carefully crushed and introduced into an Erlenmeyer flask containing 10ml of sterile distilled water. After shaking, one milliliter of the suspension of smoked fish samples was inoculated onto the agar of Sabauroud Chloramphenicol Agar sterilized in a Chamberlain autoclave at 121° C for 15 min. Petri dishes were sealed with parafilm and then incubated at 25°C. Petri dishes were then examined daily for fungal growth for 5 days. Isolates were identified using macroscopic, microscopic morphologies by slide culture technique and lactophenol staining. The isolates obtained were compared with the identification key [27].

2.7 Statistical Analysis

Mean values were subjected to one-way Analysis of Variance followed by Duncan's Multiple Ranges test using SPSS (16.0) software.

3 Results

3.1 Characteristics Of Actors In The Smoked Fish Chain In The Littoral Region

The characteristics of the actors, namely fishermen, processors and traders, in the chain of smoked fish in the Littoral region vary according to the different districts (Tab. 1).

Tableau 1. Sociodemographic characteristics of actors in the smoked fish chain in the localities of Manoka, Mouanko and Youpwé

			Manoka	Mouanko	Youpwé
Actors	Fisherman	Male	42.19	35.94	21.88
		Female	0	0	0
	Transformers	Male	0	0	0
		Female	37.08	46.07	16.85
	Traders	Male	0	0	12.34
		Female	0	0	87.66
Age groups	[19-30]		28.09	28.36	20.56
	[31-40]		35.96	41.76	25.23
	[41-50]		21.35	17.91	44.86
	> 50		14.60	11.97	9.35
Nationality	Cameroonian		13.48	12.65	84.12
	Ghanaian		22.47	25.01	4.67
	Nigerian		64.05	62.34	11.21
Instruction levels	None		17.98	26.87	8.41
	Primary		53.93	49.25	25.23
	Secondary		22.47	17.91	57.01
	Superior		5.61	5.97	9.31
Years of experience	[1-5]		8.47	9.52	5.88
	[6-10]		15.26	19.05	14.71
	[11-15]		42.37	42.86	49.26
	> 15		33.90	28.57	30.15

It can be seen from Tab. 1 that the fishermen are all male and the processors are female in the study area. Women are helped by children at all levels of the transformation process. Traders are only present in the Douala II subdivision (Youpwé) and largely dominated by women (87.66%). Regarding the age of the respondents, it varies between 19 and 60 years. The most represented age group is the same in Manoka and Mouanko [31-40] with respectively 35.96% and 41.76%. On the other hand, in Youpwé, the [41-50] years is the most represented (44.86%). The age group > 50 years is the least represented in the three localities, namely in Manoka (14.60%), Mouanko (11.97%) and Youpwé (9.35%). Three nationalities are identified as the main players in the fish chain: Cameroonians, Nigerians and Ghanaians. Cameroonians are more represented in Youpwé (84.12 %) and very weakly in Manoka (13.48%) and Mouanko (12.65%). Nigerians are the major players in Manoka (64.05%) and Mouanko (62.34%) and finally followed by Ghanaians. The level of study of populations ranges from no level of study to higher in the three localities. The primary level is the most represented both in Manoka (53.93) and in Mouanko (49.25); on the other hand in Youpwé, it is the secondary (57.01). As for the experience of the actors, it appears from Tab. 1 that the majority of the actors have an experience between [11-15] years, which is 42.37% in Manoka, 42.86% in Mouanko and 49.26 % in Youpwé.

3.2 Diversity Of Smoked Fish And Their Numerical Importance In Manoka, Mouanko, Youpwé Localities

33 species of fish are processed in the three subdivisions surveyed, belonging to 19 families: 7 species divided into 4 families in Manoka and Mouanko, 32 species divided into 20 families in Youpwé (Tab. 2).

Tableau 2. Diversity and frequency smoked fish in the localities of Youpwé, Mouanko and Manoka

Families (%)	Scientifical names	Common names	Manoka	Mouanko	Youpwé
Clupeidae (78.51%)	*Ethmamosa fimbriata* (Bowdich, 1825)	Ethmalose	67.2	66.5	42.0
	Sardinella cameronensis (Regan, 1917)	Sardines	5.3	7.2	1.1
	Pellonula leonensis (Boulenger, 1916)				
	Alosa alosa (Linnaeus, 1758)	Shad	4.8	5.1	2.8
	Ilisha africana (Bloch, 1795)	Razor	15.2	13.2	5.1
Scianidae (3,51%)	*Pseudotolithus elongatus* (Bowdich, 1825)	Hunchback	2.2	1.4	5.4
	*Pseudolotithus senegalensis (*Cuvier et Valenciennes, 1833)	Bar			1.5
Polynemidae (0.38%)	*Polydactylus quadrifilis* (Cuvier et Valenciennes, 1829*)*	Fat Captain			1.1
	Galeoïdes decadactylus (Bloch, 1795*)*	Little captain			
Cynoglossidae (1.07%)	*Cynoglossus senegalensis* (Kaup, 1858)	The sun			3.2
	Cynoglossus browni (Chabanaud, 1949)				
Lutjanidae (1.27%)	*Lutjanus eutactus* (Bloch, 1790)	Carp	1.4	1.3	1.1
Carangidae (0.57%)	*Caranx hippos* (Linnaeus, 1766)	Trevally			0.4
	Caranx senegallus (Cuvier, 1832)				
	Trachinotus teraia (Cuvier and Valenciennes, 1832)				1.3
Ariidae (1.4%)	*Arius heudelot* (Cuvier and Valenciennes)	Machoiron			6.1
Bagridae (0.9%)	*Chrysichthys nigrodigitatus* (Lacepède, 1803)				
Haemulidae (0.50%)	*Plectorhinchus macrolepis* (Boulenger, 1801)	Sea bream			1.5
	Pomadasys jubelini (Cuvier, 1830)	Grey sea bream			
Monodactylidae (0.37%)	*Psettias sebae* (Cuvier, 1829)	Elongated Disc 1			1.1
	Drepane africana (Cuvier, 1829)				
Gadidae (0.33%)	*Gadus morhua* (Linnaeus, 1758)	Cod*			1.0
Mugilidae (1.60%)	*Mugil cephalus* (Linnaeus, 1758)	Mullet			4.8
	Mugil auratus (Risso, 1810)				
Rajidae (1.13%)	*Raja africana* (Capape, 1977)	Line			3.4
Scombridae (0.78%)	*Scomber scombrus* (Linnaeus, 1758)	mackerel*			1.2
	Euthynnus alletteratus (Linnaeus, 1758)	Tuna			1.1
Cichlidae (0.47%)	*Oreochromis niloticus* (Linnaeus, 1758)	Nile Tilapia			1.4
Serranidae (0.44%)	*Epinephelus spp* (Bloch, 1793)	Grouper			1.3
Sphyraenidae (1.78%)	*Sphyraena piscatorum* (Cadenat, 1964)	Pike			5.3
Tetraodontidae (0.03%)	*Ephippion guttifer* (Bennett, 1831)	Tetrodon			0.1
Trichiuridae (4.73%)	*Trichiurus lepturus* (Linnaeus, 1758)	Belt	3.9	5.3	5.0
Charcharinidae (0.50%)	*Carcharhinus leucas* (Müller and Henle, 1839)	Shark			1.5

** Species caught outside Cameroonian coasts*

The most diversified family in the 3 localities is that of the Clupeidae (78.51%): *E. fimbriata* (58.57%), *I. africana* (11.17%), *Sardinella cameronensis* and *Pellonula leonensis* (4.53%), *Alosa alosa* (4.23%). Tetraodontidae (0.03%) is the least abundant family with *Ephippion guttifer.* The most processed/sold fish at the Youpwé market are *E. fimbriata, Arius heudeloti, Pseudotolithus elongatus* with a respective percentage of 42.0 %; 6.1 %; 5.4 %. While in Manoka, these are *E. fimbriata* at 67.2%, *I. africana* at 15.2%, *S. cameronensis* at 5.3%**.** Similarly in Mouanko, these three species are the most representative, *E. fimbriata* (66.5%), *I. africana* (13.2%) and *S. cameronensis* (7.2%).

3.3 BIOTIC CONSTRAINTS RELATED TO STORAGE

Four biotic factors: Insects, Mold, Mite and Rodents, unequally distributed, are recognized by the populations of the different localities as detrimental to the success of the storage of smoked fish (Fig. 2). Insects are the main pests identified in storage structures, Manoka (70.37%), Mouanko (64.62%), Youpwé (45.12%). In Manoka and Mouanko Youpwé, Molds were recorded at 16 % (Fig. 2A, 2B), while in Youpwé, they were 42% (Fig. 2C). Mites and rodents were poorly represented in the 3 surveyed localities.

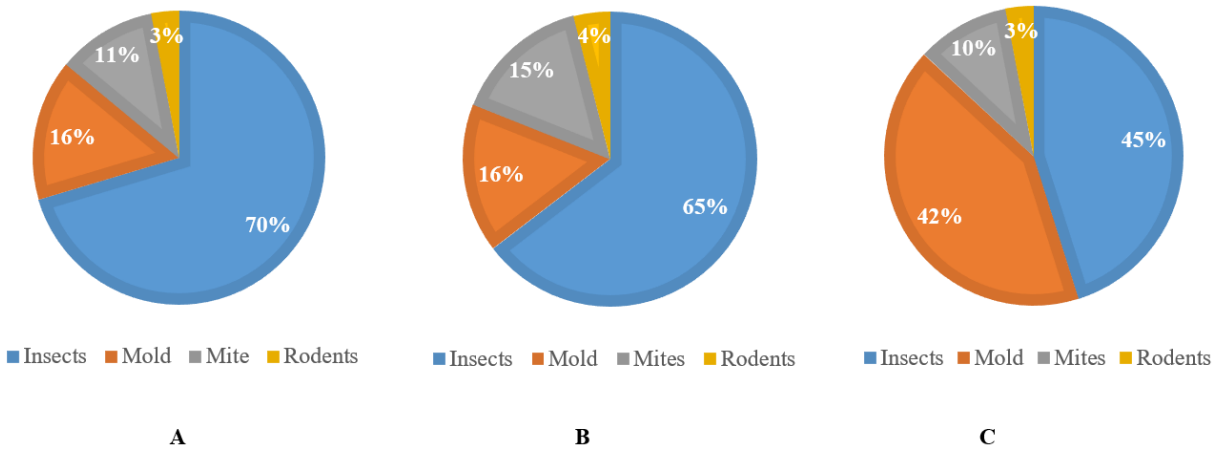

Fig. 2. Frequencies of the different biotic agents mentioned by the populations of A: Manoka, B: Mouanko, C: Youpwé

3.4 NATURAL INFESTATION OF ETHMALOSA FIMBRIATA AND ILISHA AFRICANA COLLECTIONS

The natural infestation of the different collections depends on the localities and the species of smoked fish (Fig. 3). *E. fimbriata* is the least affected collection with 39% in Manoka and 43% in Mouanko (Fig. 3A, 3B). A similar infestation of 50% was recorded for *I. africana* and *E. fimbriata* in Youpwé (Fig. 3C). *I. africana* has the highest infestation rate in Manoka (61%) and Mouanko (57%) (Fig. 3A, 3B).

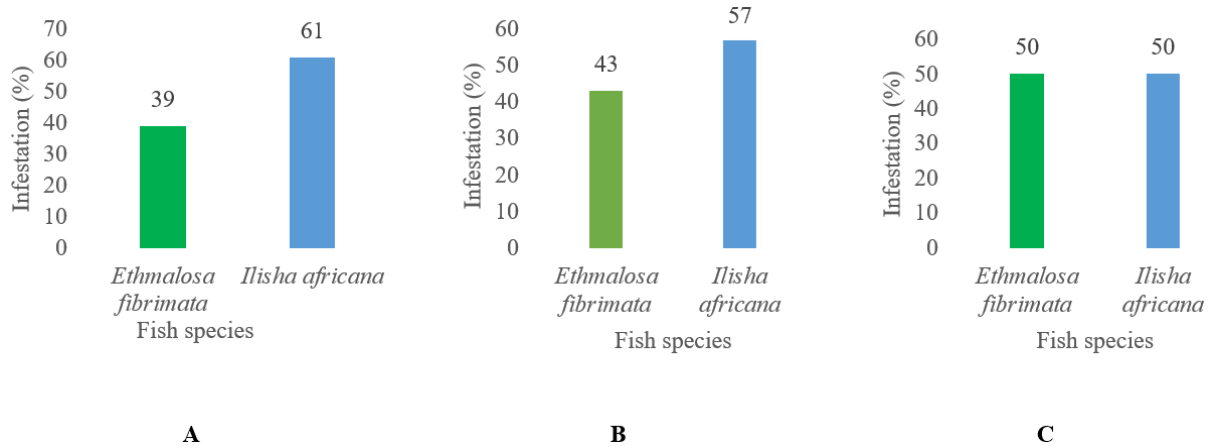

Fig. 3. Natural infestation rate of the two fish species brought from: A Manoka, B: Mouanko and C: Youpwé

3.5 DIVERSITY OF PESTS ASSOCIATED WITH ETHMALOSA FIMBRIATA AND ILISHA AFRICANA COLLECTIONS

From the collections brought back from the field and permanently monitored in the laboratory, it appears that insects, molds and mites emerged both on *E. fimbriata* and on *I. africana* in the localities of Manoka, Mouanko and Youpwé (Tab. 3, 4; Fig. 4).

Tableau 3. Macroscopic and microscopic structures of mold species isolated from Ethmalosa fimbriata and Ilisha africana

	Macroscopic appearance	Microscopic appearance
Aspergillus flavus	Bright, yellow-green, uniform colonies with whitish aerial hyphae and a white border, and a milky pale yellow underside	Hyaline septate hyphae with long, rough conidiophores bearing globose vesicles containing uniseriatephialides covering the entire vesicle
Aspergillus niger	Black colonies on the front and cottony white and on the back the color is pale yellow. Rapid growth and the shape is round	Mycelium not septate, the head bears many conidiophores, phialides formed on the vesicle.
Aspergillus terreus	Fluffy to powdery colonies, yellow to orange brown, a white border, and a milky yellow underside, fast growing	Non-septate mycelium, smooth conidiospore, globose vesicle, biseriateaspergillus head, phialides borne by inserted metules
Aspergillus sp	Lightly powdery brown colony, whitish at the circumference, and a brown underside	Unseptate mycelium, globose conidiophores, uniseriatephialides
Penicillum sp	Powdery, green on the back with concentric whitish alternations on the back more pronounced on the periphery of the Petri dish, flat, concentric, with a creamy consistency uniform, fast and concentric growth	Septate or septate, narrow, penicil branched like a brush by metulae, of medium diameter with hyaline wall; biverticillate and symmetrical phialides present, conidiospores crowned on the phialides; single-celled and small in size with dots in the center; chain arrangement.
Rhizopus stolonifer	Cottony, white on the surface and black-brown when ripe, with black dots on the raised mycelium on the underside, uniform.	Non-septate or coenocytic, large, very large sporocystophore terminating in a bouquet of 3 sporangia presenting at the base the rhizoids; presence of a stolon to which the rhizoids are branched; unicellular and rounded; cluster arrangement.

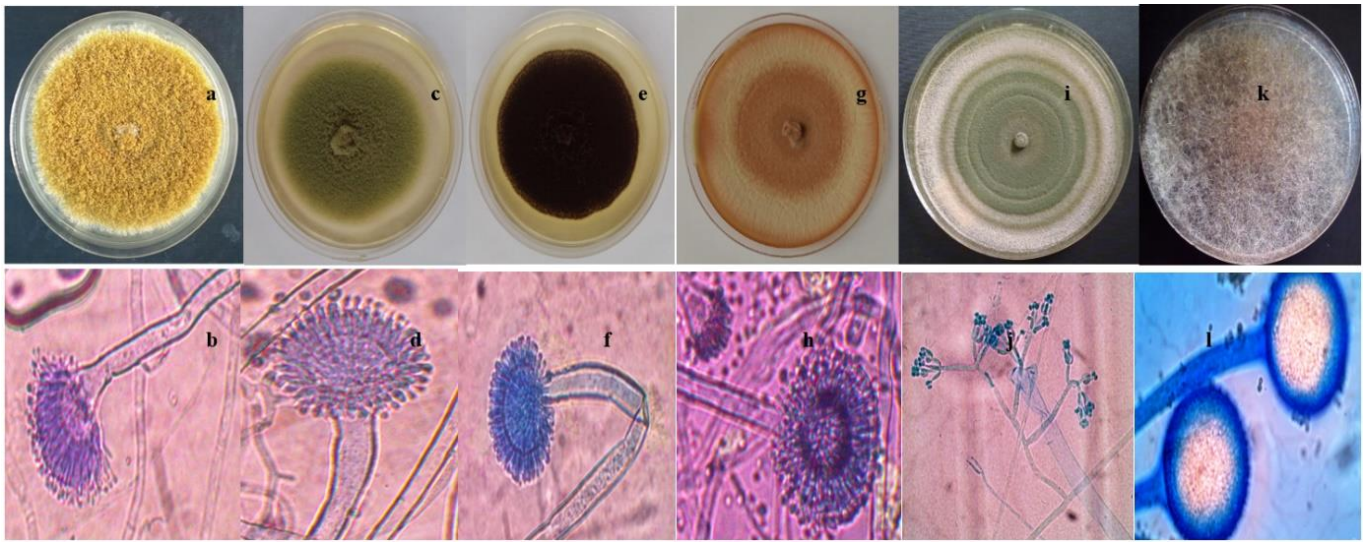

Fig. 4. Pure cultures and relative conidia of champignons a and b: Aspergillus terreus, c and d: Aspergillus flavus, e and f: Aspergillus niger, g and h: Aspergillus sp, i and j: Penicillium sp, k and l: Rhizopus stolonifera

The importance of pests associated with the collections of *E. fimbriata* and *I. africana* was assessed during storage at Manoka, Mouanko and Youpwé (Tab. 4). It was determined by the number of pest species emerged per smoked fish. 280.8 pests are associated with the deterioration of *E. fimbriata* and *I. africana* fish, in the localities of Manoka (77.7), Mouanko (80.3), Youpwé (122.8). The collections of *E. fimbriata* (15) and *I. africana* (15), taken from processors and traders were infested by insect pests, mites and moulds. Insects are more abundant on fish. Indeed, *N. rufipes* is very abundant on *E. fimbriata* (56.0), *I. africana* (64.0). *D. maculates* attacks fish very weakly with *E. fimbriata* (1.0) and *I. africana* (2.2). Apparently healthy fish brought from Youpwé were found to be more infested than those from Manoka and Mouanko. *Lardoglyphus sp* infested *E. fimbriata* and *I. africana* very weakly.

Six fungal isolates with different colony morphology were isolated from the smoked fish (Fig. 4). So three fungal genera, the most dominant was *Aspergillus* in all localities. *A. flavus* is the most isolated mold on smoked fish in all localities with 26.3 on *E. fimbriata* and 24.0 on *I. africana*. *Penicillium sp* is the least abundant on the 2 species, *E. fimbriata* (1.4), *I. africana* (5.4). *A. niger, A. flavus, A. terreus, Aspergillus sp. Penicillium sp, R. stolonifer* were isolated from fish from the 3 localities. From the collections of Youpwé, the 6 molds were isolated, on the other hand in Manoka and Mouanka, *Penicillium sp* and *R. stolonifer* are absent.

The ANOVA showed a significant difference between the number of *N. rufipes* (F (120; 29) =4.611*, P ≤ 0.05) of the 2 fish species, while *D. maculatus* is not significant (F (120; 29) =0.943ns, P≤0.05). Similarly, the ANOVA showed a significant difference between the number of *A. flavus* (F (120; 29) = 3.045*, P ≤ 0.05), the number of *A. niger* (F (120; 29) = 5.703*, P ≤ 0.05), the number of *Aspergillus* sp (F (120; 29) = 3.389*, P ≤ 0.05), the number of *R. stolonifer* (F (120; 29) =20.366**, P ≤ 0.05), the number of *Penicillium sp* (F (120; 29) =17.583**, P ≤ 0.05), the number of *A. terreus* (F (120; 29) = 11.387**, P ≤ 0.05) of *E. fimbriata* and *I. africana.*

3.6 PRESERVATION METHODS DURING STORAGE

To limit the action of biotic agents in the deterioration of smoked fish, populations resort to physical control (re-smoking and refrigeration) and biological control (garlic, salt and dry red pepper) in varying proportions according to localities (Fig. 5). The most practiced physical control in the localities of Manoka (95%) and Mouanko (89%) consists in smoking fish (Fig. 5A, 5B). In Youpwé, the main control method practiced is biological with the use of spices such as dry red peppers (41%) and garlic (23%); physical control consists of re-smoking (23%), dry salting (8%) and refrigeration (5%) (Fig. 5C).

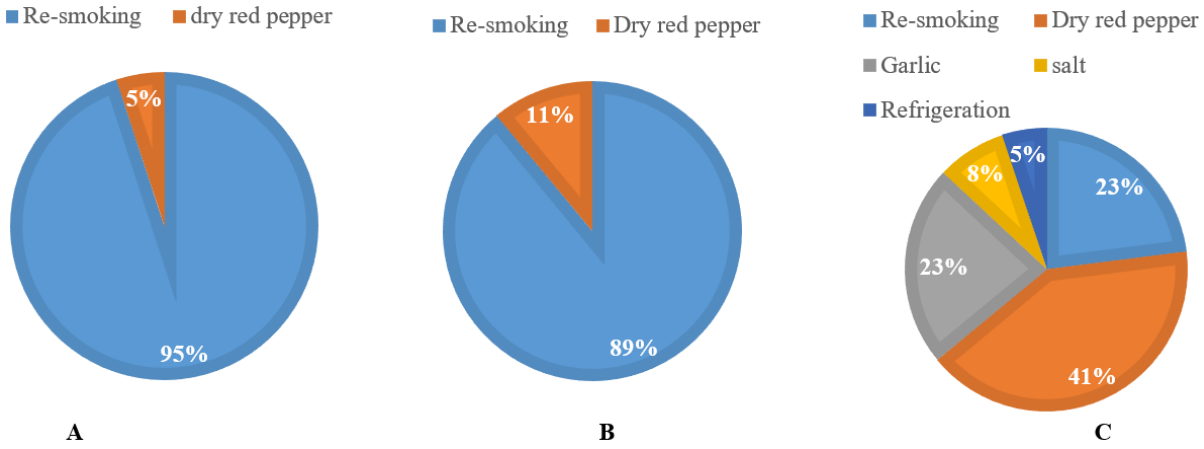

Fig. 5. Distribution of smoked fish pest control means in the different localities: A: Manoka, B: Mouanko, C: Youpwé

Tableau 4. Diversity of pests associated with collections of Ethmalosa fimbriata and Ilisha africana during storage at Manoka, Mouanko and Youpwé

		N.rufipes		*D. maculatus*		*Lardoglyphus sp*		*A. flavus*		*A. niger*		*A. terreus*		*Aspergillus sp*		*Penicillium sp*		*R. stolonifer*		Total
		E. fimbriata	*I. africana*	*E. fimbriata*	*I. africana*	*E. fimbriata*	*I. Africana*	*E. fimbriata*	*I. africana*	*E. fimbriata*	*I. africana*	*E. fimbriata*	*I. africana*	*E. fimbriata*	*I. africana*	*E. fimbriata*	*I. africana*	*E. fimbriata*	*I. africana*	
Manoka	Dahomey	2.0±1.6^{a}	1.2±0.8^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	0.8±0.4^{c}	1.4±0.5^{a}	2.20±1.7^{c}	0.6±0.5^{a}	0.0±0.0^{a}	1.0±0.0^{c}	0.0±0.0^{a}	1.0±0.0^{b}	0.6±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	04/07
	Plateau	3.2±1.9^{a}	3.2±0.8^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	0.0±0.0^{a}	1.0±0.9^{a}	3.4±1.1^{g}	0.0±0.0^{a}	1.0±0.7^{b}	2.2±0.8^{e}	1.0±0.7^{c}	0.0±0.0^{a}	1.6±0.8^{e}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	05/04
	Nyangadou	2.2±1.9^{a}	5.0±1.5^{e}	0.0±0.0^{a}	0.2±0.1^{a}	1.0±0.0^{d}	0.6±0.5^{b}	2.9±1.3^{e}	0.8±0.5^{a}	1.6±1.1^{e}	1.4±0.5^{d}	0.2±0.0^{a}	1.4±0.5^{d}	0.4±0.2^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	06/06
	Kwanci	1.8±0.8^{a}	2.8±1.9^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	1.0±0.0^{d}	1.2±0.9^{a}	1.8±0.8^{a}	1.0±1.1^{b}	1.6±0.9^{e}	0.6±0.5^{a}	0.0±0.0^{a}	0.2±0.0^{a}	1.4±1.1^{d}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.4±0.5^{c}	06/06
	Creek n 1	1.8±0.9^{a}	4.2±1.9^{b}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	0.4±0.5^{b}	2.2±1.3^{c}	0.4±0.2^{a}	0.8±0.4^{a}	0.2±0.1^{a}	0.6±0.4^{a}	0.0±0.0^{a}	1.0±0.7^{b}	0.6±0.5^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.6±0.0^{d}	06/07
Mouanko	Laskobo	3.4±0.9^{a}	4.6±1.6^{d}	0.0±0.0^{a}	0.0±0.0^{a}	0.8±0.4^{c}	1.0±0.0^{d}	1.4±0.9^{a}	0.8±0.5^{a}	0.6±0.5^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.4±0.1^{a}	1.4±0.5^{d}	1.1±0.5^{d}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{b}	0.0±0.0^{a}	06/05
	Lorenz	1.2±0.8^{a}	3.2±1.3^{a}	0.0±0.0^{a}	0.4±0.1^{a}	0.0±0.0^{a}	0.0±0.0^{a}	2.2±1.0^{c}	0.8±0.4^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.6±0.5^{a}	0.2±0.0^{a}	1.2±1.0^{c}	0.6±0.5^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.8±0.8^{e}	0.0±0.0^{a}	05/06
	Kasalafan	3.8±1.5^{a}	4.2±0.8^{b}	0.0±0.0^{a}	0.6±0.0^{a}	0.6±0.0^{b}	0.0±0.0^{a}	1.0±0.8^{a}	1.4±0.5^{a}	1.4±0.5^{d}	1.4±0.5^{d}	1.6±0.5^{e}	0.0±0.0^{a}	0.4±0.3^{a}	0.6±0.4^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	0.0±0.0^{a}	05/07
	Côte d'Ivoire	4.4±1.1^{c}	2.4±2.2.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	0.0±0.0^{a}	2.2±1.3^{c}	1.0±0.0	1.0±0.0	1.6±0.5^{e}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{b}	0.8±0.4^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.6±0.5^{d}	0.0±0.0^{a}	06/04
	Yoyo 2	4.0±1.6^{b}	4.20±1.3^{b}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	1.0±0.0^{d}	2.0±0.7^{b}	1.0±0.7^{a}	0.0±0.0^{a}	1.4±0.5^{d}	0.0±0.0^{a}	0.0±0.0^{a}	1.2±0.8^{c}	0.6±0.5^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.2±0.1^{a}	0.0±0.0^{a}	05/05
Youpwe	Tyo1	4.2±1.4^{b}	7.0±1.2^{h}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	1.0±0.0^{d}	0.6±0.5^{a}	1.6±0.9^{a}	1.20±0.8^{c}	0.6±0.5^{a}	1.4±0.5^{d}	0.0±0.0^{a}	0.4±0.0^{a}	1.6±0.8^{e}	0.0±0.0^{a}	1.6±1.1^{c}	0.0±0.0^{a}	0.8±0.4^{a}	06/07
	Tyo2	6.6±2.3^{g}	7.2±1.6^{i}	1.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	0.8±0.4^{c}	1.6±0.8^{a}	3.2±1.9^{f}	0.6±0.4^{a}	0.0±0.0^{a}	1.4±0.5^{d}	1.4±0.5^{d}	0.2±0.1^{a}	1.4±0.4^{d}	0.0±0.0^{a}	1.2±0.4^{b}	0.0±0.0^{a}	0.0±0.0^{a}	06/07
	Tyo3	4.6±2.7^{d}	4.2±3.0^{b}	0.0±0.0^{a}	0.6±0.2^{a}	1.0±0.0^{d}	0.6±0.5^{b}	2.6±1.1^{d}	1.2±0.4^{a}	1.0±0.7^{b}	0.6±0.5^{a}	1.4±0.5^{d}	1.0±0.4^{c}	0.8±0.4^{a}	1.0±0.5^{b}	0.0±0.0^{a}	1.4±0.5^{b}	1.2±0.8^{b}	0.0±0.0^{a}	07/08
	Tyo4	6.4±2.1^{f}	6.0±1.6^{e}	0.0±0.0^{a}	0.4±0.3^{a}	1.0±0.0^{d}	1.0±0.0^{d}	1.4±0.5^{a}	2.2±0.4^{c}	1.8±0.4^{f}	0.6±0.4^{a}	0.8±0.4^{b}	0.2±0.1^{a}	0.0±0.0^{a}	1.4±0.8^{d}	0.0±0.0^{a}	1.2±0.8^{b}	1.2±0.4^{b}	0.0±0.0^{a}	08/08
	Tyo5	6.4±2.4^{f}	4.6±2.9^{d}	0.0±0.0^{a}	0.0±0.0^{a}	1.0±0.0^{d}	1.0±0.0^{d}	2.6±1.5^{d}	2.2±0.8^{c}	0.4±0.3^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	1.6±0.5^{e}	1.2±0.0^{c}	1.4±0.5^{b}	0.0±0.0^{a}	1.0±0.0^{b}	0.0±0.0^{a}	05/07
Totals		56.0	64.0	1.0	2.2	13.4	9.2	9.2	24.0	12.0	10.4	11.8	5.6	10.8	14.5	1.4	5.4	9.0	3.8	08/08
F(120; 29)		4.611*		0.943ns		11,881**		3.045*		5.703*		11,881**		3.389*		17.583**		20.366**		

In two consecutive lines, the values followed by the same letter are not significantly different, P ≤ 0.05.

TYo 1 to TYo 5: Transformer of neighborhoods 1 to 5 of Youpwé

4 DISCUSSION

Fish smoking is a very important activity in the Littoral region of Cameroon and the demand for smoked fish continues to grow. However, the storage conditions can affect its quality, it is important to carry out a socio-sanitary analysis of the smoked fish stored. The gender disparity in activities (Tab. 1) could be explained by the emphasis placed on labor and the physical effort provided which, in fishing activities, thereby limiting women to processing and selling. Indeed, the involvement of women in these activities allows them to avoid idleness and to obtain foreign currency to make them more active in the management of household expenses. Studies done in Benin, Ivory Coast and Cameroon have reported that all fish processors are women and fishermen are men [28]; [29]; [30]. The majority of people are between 19 and 50 years old. This implies that the profession is dominated by very active individuals who have strength and experience. Similar results for people aged 20 to 50 were obtained in Benin [31]. The various actors in the sector in the camps of Mouanko and Manoka were foreigners, in particular of Nigerian and Ghanaian nationalities, unlike Youpwé where trade and processing is strongly dominated by Cameroonian. This will be due to the fact that the Mouanko and Manoka camps are mostly inhabited by these foreign populations and also by their mastery of shad fishing, which is therefore the most predominant; then the transmission of the practices of the sector from generation to generation. A socio-economic and technological study of the production of fermented and dried fish (Guedj) in Senegal, found that only 10% of fish processors were foreigners [32]. This difference could be due to the fact that the majority of fishermen in Cameroon are foreigners, unlike in Senegal, where locals dominate the sector. Many actors have a primary level education. This is also seen in the south-west region of Cameroon, where processors have at least a primary education [30]. This is not the case in all countries, the sector is characterized by high levels of illiteracy 85%, 89% and 95%, respectively [33]; [34]. These results may be due to the Muslim culture of these countries, which may prevent women from going to school. The actors, whatever the locality, have an experience in the activity of 11 to 15 above 41%. The study on the socio-sanitary analysis of fish smoking in Abidjan (Ivory Coast) indicates that in the commune of Abobo, 30% of women had been in the business of selling smoked fish for less than 10 years; 37% of women and 3% of men had between 10 to 20 years of seniority in the profession and 30% of women had practiced this profession for more than 20 years [29].

The great fish diversity observed in the maritime coastal areas (Youpwé, Manoka and Mouanko) (Tab. 2) could be explained by the watershed, the fishing period, the ecology, the reproduction cycle and the collection method. On the other hand, a study carried out on the processing methods, conservation practices and quality attributes of smoked and smoked-dried fish consumed in Benin, and showed

that 32 species of fish were used for the production of smoked fish, the most smoked of which were *S. scombrus* (71%), followed by *Trachurus trachurus* (62.1%) and *E. fimbriata* (12.1%). This could be explained by the types of fish used for the production of smoked fish included fresh fish caught in local water (33.1%) and imported frozen fish (66.9%) [31].

The high rate of infestations by insect pests and molds observed in the different collections of smoked fish (Fig. 2, 3) can be explained by the fact that the actors in the processing and marketing chain use smoking techniques and unsuitable storage tools due to the high cost of smoking techniques and archaic storage tools (Mouanko) or difficult living conditions (Manoka). At all stages of the food system, quantitative and qualitative losses are possible for many reasons: bacteria, yeasts, mites, molds, insects and rodents can degrade products during harvesting, storage, transport and due to defective or unsuitable packaging; temperature, light, oxygen, humidity, drought, natural enzymes are factors that destroy the quality and shelf life of products throughout the food chain; and that beyond biological and physical factors, the state of equipment, road and storage infrastructure, the economic context, hygiene standards and finally the modern lifestyles of households lead to losses [35]. Similarly, these results go in the same direction as those obtained on the storage of smoked and/or dried fish in Madagascar; indeed, they had shown that the infestation could be due to insect pests, molds and poor storage conditions [12]. Natural enzymes are destructive factors for the quality and shelf life of products throughout the food chain; and that beyond biological and physical factors, the state of equipment, road and storage infrastructure, the economic context, hygiene standards and finally the modern lifestyles of households lead to losses.

The great variability of the biotic factors indexed by the populations of Manoka, Mouanko, Youpwé, and emerged from the collections from the field (Fig 4; Tab. 3, 4) would betray the low success of smoking and storing smoked fish in the different localities in the region. Indeed, the storage is successful if at its end, the stored food does not show any qualitative and quantitative depreciation. These infestations are the result of improper treatment or improper storage (Fig. 2, 3). This could be explained by the archaic artisanal processing techniques used by processors as well as poor transport conditions and unsuitable storage tools. Indeed, the presence of mites and beetles has been reported on sun-dried sardines (Dagaa) from Lake Victoria [36]. While in Akwa Ibom State in Nigeria, the fish species: *Clarias gariepinus, Tilapia zilli, E. fimbriata, Gadus morhua* and *Heterotis niloticus* are infested by Insects and Molds [15]. Pest infestations for dried fish from sub-Saharan countries are due to unhygienic processing technique, poor storage facilities, transportation and handling during marketing [12].

The pests from the collections belong to three families of insect pests and two orders: Dermestidae, Cleridae (Coleoptera) and Calliphoridae (Diptera), Mites and Molds (Tab. 3, Fig. 3, 4). Beetles (*Necrobia, Dermestes*) are the main insect pests of smoked fish stocks in the three localities (Tab. 4). Indeed, *N. rufipes* is predominant compared to *D. maculatus,* this would be linked to the high salt content of sea fish. The accidental presence of *D. maculatus* would be explained by the presence of fishes living both fresh and sea water. The number of smoked fish insects is higher in Youpwé than in Manoka and Mouanko, this could be directly related to the storage time of the fish, because fish sellers buy smoked fish in bulk and do not buy new stock until the old stock is completely eliminated. This result can also be explained by the quality of the fish caught, the equipment used for smoking, storage conditions, transport and the sometimes unhealthy sales environment. This result could be explained by the fact that the species *D. maculatus* is particularly fond of smoked freshwater fish. Insect infestation is the cause of significant losses in quantity and quality of stored, smoked or dried fish in Nigeria. These losses result in the physical disintegration of the stored smoked fish leading to economic losses [20]. This observation corroborates the results of the actors, who reported that long storage periods gave insects more time to reproduce and consume the fish [37]. Infestations of smoked fish by *Dermestes* spp and *N. rufipes* are generally associated with *Lardoglyphus* sp, *Calliphora* sp and fungi [16].

The observation of fungal contamination mainly highlights six filamentous smoked fish fungi, distributed differently in the localities surveyed (Tab. 3, 4, Fig. 3). This would be due to the environmental conditions that contribute to fungal growth that are a hot and humid climate, a water content of 16% and more, favorable characteristics of the substrate. The fungi isolated in this study are all opportunistic pathogens of medical and veterinary importance. The presence for example of certain species of *Aspergillus, Penicillium,* in foods as contaminants increases the risk of production of mycotoxins which could induce gastrointestinal and metabolic disorders when contaminated foods such as smoked fish are consumed. 25 species of fungi were found on dried fish products at the market in Zhanjiang China [38]. This result could be due to the fact that the fish were sun-dried and the number of fish (7) used for fungal isolation. Previous studies have shown that fungal contamination of sun-dried fish can be region-specific with *Saccharomyces sp., Mucor sp., Rhodotorula sp., Schizosaccharomyce sp., Acremonium sp., Rhizopus sp., Absidia sp., Aureobasidium sp., Trichoderma sp., Cladosporium sp., Alternaria sp.* and *Candida sp.* isolation in different regions [19].

However, to solve these storage problems, different treatments are applied by the actors (Fig. 5). In Manoka and Mouanko, the great use of smoking would be due to the availability of firewood, and the most used storage tool, which is the rack. On the other hand, in Youpwé, dry red pepper is used more because it is more available and easier to disseminate in the box, refrigeration and smoking are used for smoked fish that have not lost enough water during the smoking process. Fish smoked at 10-15% moisture content had a shelf life of 3-9 months when properly stored. The study in Nigeria showed that (94.9%) of Warri – South LGA preserved their smoked fish by re-smoking, 5.1% used freezing [13]. This contradicts results that reported the predominant use of synthetic insecticides 60% and waste vehicle oil 25%, peanut oil 15% [39]. To avoid the invasion of predators (87.5%) of the traders surveyed re-dry the smoked/dried fish

under mild heat treatment while some traders expose the product to sun drying (37.5%) [40]. Of the smoke-dried fish traders who mentioned insect attack, 55.5% and 11.1% used insecticide and chili pepper respectively during storage. Many researchers have suggested the use of plants as an alternative to the use of toxic materials such as carrier oil and synthetic chemicals for the protection of dried fish [18]; [19]; [33].

5 CONCLUSION

Smoked fish is consumed by a large population around the world due to its nutrient content. This study revealed that only women are involved in fish processing. The processors and traders were of Cameroonian, Ghanaian and Nigerian nationality, mostly had a primary education, a great experience of 11 to 15 years. Among the 33 inventoried species, *E. fimbriata* and *I. africana* are the most smoked species. The rate of infestation depends on the species of fish and their locality of origin. The main insect pest of stored smoked fish is *N. rufipes*. To prevent the action of these pests, the players resort to physical control (smoking and refrigeration) and biological control (dry red pepper, garlic, dry salting).

COMPETING INTERESTS

The authors declare that they have no competing interests.

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REFERENCES

[1] A. Balić, D. Vlašić, K. Žužul, B. Marinović, andZ. Mokos,«Omega-3 versus omega-6 polyunsaturated fatty acids in the prevention and treatment of inflammatory skin diseases», *International Journal of Molecular Sciences,* vol. 21, no. 3, pp.741-767, 2020.

[2] K. Manz, M. Ndomou, M. Njinkoue, F. Tchoumbougnang, M. Milong, D. Djimbie, O. Soh, M. Nchoutpouen, R. Foumedzo, and I. Gouado, «Antihyperlipidemic potential of oil extracted from *Ilisha africana* on rats». *Scientific African,* pp.1-5, 2020.

[3] M. Nchoutpouen, M. Ndomou, C. Manz, M. Milong, R.A. Dama, R.P.N. Ndombol, V. Nsoga, C. Ngotang, M.T. Youogo, M.J. Peyieno, E. Ngock and F. Tchoumbougnang, «Hylipidemic effects of *Ethmalosa fimbriata* fish extract oil in dyslipidemic rats», *International Journal of Biological and Chemical Sciences,* vol. 14 no. 6, pp. 2193-2203, 2020.

[4] A. M. Atallah, and F. H. Faryal, «Study of the Healthy Effects of Different Fat Ratios Mixtures of Omega-3 to Omega-6 in Male Mice with Alloxan-Induced Diabetes», *Tikrit Journal for Agricultural Sciences,* Vol. 21 no.4, pp.129-138, 2021.

[5] S. P.N. Meke, and N. P. A. Tabet, «Enhancing SMEs Organization in Small Scale Fishing Communities as A Tool for a Better Contribution to Cameroon's Economy», *Scholars Journal of Economics, Business and Management,* Vol. 7 no.11, pp. 386-399, 2020.

[6] FAO, The global situation of fisheries and aquaculture. The sustainability in action. Rome, 2022.

[7] Institut National de la Statistique (INS), *Annuaire Statistique du Cameroun,* Chapitre 14: Elevage et Pêche, pp.209-219, 2020.

[8] S.A.O. Adeyeye, «Traditional fish processing in Nigeria: a critical review», *Nutrition&Food Science,* Vol. 46, no. 3, pp. 321-335, 2016.

[9] M. H. M. Assogba, S. G. Ahounou, G. A. Bonou, C. F. A. Salifou, M. Dahouda, A. Chikou, S. Farougou, and A. K. I. Youssao, «Qualité de la Chair des Poissons: Facteurs de Variations et Impacts des Procédés de Transformation et de Conservation», *International Journal of Progressive Sciences and Technologies,* Vol.10 no.2, pp. 333-358, 2018.

[10] J. V. F. Nsoga, M. C. S. Milong, N. M. Nchoutpouen, K. J. C. Manz, M. N. Ekwalla, S. R. Tuem, F. Tchoumbougnang, and M. Ndomou, «Characterization of Smoking Activity and Perception of Smoked Fish by Households in the City of Douala (Cameroon)», *International Journal of Nutrition and Food Sciences,* Vol.10 no.6, pp. 159-166, 2021.

[11] B. R. Tamgno, P. J. Chegue, F. Tchoumbougnang, and T. L. Ngamo, «Evaluation of factors of loss on stocks of smoked fish in three subdivisions of the Cameroon maritime coastal zone in Littoral region», *Journal of Entomology and Zoology Studies,* Vol. 9, no.3, pp. 37-44, 2021.

[12] E. N. Ndrianaivo, J. Cornet, M. Cardi, L. Razanamparany, and J. Berge, «Stocking of smoked and or dried fish: the case of Malagasy *Oreochromis niloticus* »Fish asaly«, *African Science,* Vol. 12, no. 2, pp. 254-265, 2016.

[13] K. Omoruyi, and E. Oghoje,«Comparative analyses of fish processing, marketing and distribution in Warri-South and sapele local government areas of Delta state, Nigeria», *International Journal of Fisheries and Aquatic Studies,* Vol. 4, no. 6, pp. 425-433, 2016.

[14] B. R. Tamgno, N. H. Tekou, T. N. Nyamsi, M. Mouamfon, and T. L. Ngamo, «Insect pests of smoked fish during storage and damage caused in the northern loop of the Dja Biosphere Reserve (East Cameroon)», *International Journal of Chemical and Biology Sciences,* Vol. 14, no.2, pp.528-538, 2020.

[15] E. O. Ayotunde, F.B. Ada, G. N. Udeh, andV. O. Out,«Weevils and fungi infestation of dried fish: A case study of Uyo local government area, Akwalbom state, Nigeria», *International Journal of Fisheries and Aquatic Studies,* Vol. 4, no.4, pp.359-367.2016.

[16] M. S. Singh, B. Ravikant, A. Abdul, P. Subir, C. Bhagchand, andK. Narinder,«Insect infestation in dried fishes», *Journal of Entomology and Zoology Studies,* Vol.6, no.2, 2720-2725, 2018.

[17] H.O.O. Jackson, and V. O. O. Ayub, «Effect of Salting on Houseflies (*Musca domestica*) and Beetles (*Necrobia rufipes* and *Dermestes maculatus*) Infestation of Fish from Lake Victoria, Kenya», *International Journal of Research in Pure and Applied Microbiology,* Vol. 3, no.1, pp. 30-35,2013.

[18] Peyieno, Antifungal potential of essential oils and emulsion of *Petroselinum hortense* and *Ocimum gratissimum*, against *Aspergillus flavus* agent associated with the deterioration of *Ilisha africana* (Bloch, 1795). Memoire. University of Douala, 95 p, 2020.

[19] D. N. Nganou, E. S. Tchinda, A. T. Sokamte, F. K. Ngoualem, S. F. Nodem, M. T. Beumo, and N. L. Tatsadjieu, «Mycotoxins Content of Smoked Fishes Sampled on Market Stalls of Ngaoundere and Antifungal Activity of Essential Oils of *Cymbopogon citrates* and *Ocimum basilicum* against Mycotoxin Producing Strains», *European Journal of Medicinal Plants,* Vol. 31, no.13, pp.36-47, 2020.

[20] A. A. Ayeloja, F. O. A. George, W. A. Jimoh, and G. L. Adebisi, «Effect of insect infestation on the economic value of smoked fish sold in selected markets in Nigeria», *Agricultural Science and Technology,* Vol. 12, no. 1, pp. 82-86, 2020.

[21] N. Benkerroum, «Chronic and Acute Toxicities of Aflatoxins: Mechanisms of Action», *International Journal of Environnemental Researh and Public Health,* Vol.10, no.17, pp. 423-431, 2020.

[22] Mbega and Teugels, Guide to the Determination of Fish in the Lower Ogooué Basin, Namur University Press, 165 p, 2003.

[23] M. Stiassny, G. G. Teugels, and C. Hopkins,«Freshwater and Brackishwater Fishes of Lower Guinea», *Tropical Fauna and Flora Collection,* Vol. 42, no. 1, 2, pp. 805-622, 2007.

[24] D. G. H. Halstead, «Keys for the identification of beetles associated with stored products. Introduction and key to families», *Journal of Stored Products Research,* Vol. 22, no. 4, pp. 163-203, 1986.

[25] Delobel and Tran, Les Coléoptères des Denrées Alimentaires Entreposées dans les Régions Chaudes. ORSTOM/CTA (Faune tropicale XXXII): France, 424 p, 1993.

[26] F. Oyebamiji, and F. Oyebimpe, «Microbial Identification of Smoke-Dried Fish (*Clarias gariepinus*) from Some Local Markets in Ibadan Metropolis Wudpecker», *Journal of Agricultural Research,* Vol. 2, no. 4, pp. 294-298, 2013.

[27] Chabasse D, Bouchra J, De Gentile L, Brun S, Cimon B, Penn P. *Molds of Medical Interest*. Training booklet N° 25, Bioforma: Paris, 160 p, 2020.

[28] B. T. A. Sonangnon, K. A. C. Aboudou, C. Goudjinou, and M. M. Soumanou,«Analysis of production practices and quality of smoked fish sold in southern Benin», *European Scientific Journal,* Vol. 18, no. 17, pp. 154-177, 2022.

[29] U. Y. Monney, V. Diaby, B. K. Bla, A. G. Konan, and A. F. Yapo,«Socio-sanitary analysis of fish smoking in the city of Abidjan (Côte d'Ivoire)», *International. Journal Biological Chemical Science,* Vol. 15, no.6, pp. 2337-2348.2021.

[30] K. Jiazet, «Potential Impact of Fish Smoking on Mangrove Resources in Southwest Cameroon», *Tropical Conservation Science,* Vol. 12, pp.1–13, 2019.

[31] M. F. Assogba, D. G. Anihouvi, H. I Afe, and Y. E. Kpoclou, «Processing methods, preservation pratices and quality attributes of smoked and smoked-dried fishes consumed in Benin», *Food Science and Technology,* Vol. 5, 2019.

[32] N. G. Fall, L. T. Tounkara, M. B. Diop, O. T. Thiaw, and P. Thonart, «Etude socio-économique et technologique de la production de poisson fermenté et séché (Guedj) au Sénégal», *International Journal of Biological and Chemical Sciences,* Vol. 8, no.6, pp. 2523-2538, 2014.

[33] R. G. Degnon, A. N. Faton, E. S. Adjou, F. P. Tchobo, E. Dahouenon, M. N. Soumanou, and D. C. Sohounhloue, «Comparative efficacy of essential oils of two aromatic plants in the post-smoking preservation of horse mackerel (*Trachurus trachurus*)», *Animal Plant Science Journal,* Vol.19, no. 1, pp. 2831-2839, 2013.

[34] N. W. Chabi, C. T. Konfo, P. D. Emonde, M. T. C. Chichi, K. J. C. Sika, Y. Alamou, and L. S. Baba,«Performance of an improved smoking device (Chorkor furnace) on the quality of smoked fish in the commune of Aplahoue´ (South-East of Benin)», *International Journal of Innovation and Applied Studies,* Vol.9, no.3, pp.1383-1391, 2014.

[35] S. Mustafa, and U. Imran,«Food spoilage and Microorganisms», *Turkish Journal of Agriculture - Food Science and Technology,* Vol.9, no.10, pp. 1921-1924, 2021.

[36] T. Ally, G. Mhamphi, and H. Lamtane, «Efficiency of Different Storage Facilities in Reduction of Insect Pest in Sun-Dried Sardines (Dagaa) From Lake Victoria», *Journal of Agricultural Sciences,* Vol.17, no.1, pp.11-16, 2018.

[37] T. H. Katamssadan, E. N. Nukenine, M. Stahler, and C. Adler, «Bio-efficacy of *Azadirachta indica* A. Juss oil extracted from sun- and shade-dried seeds against two stored product beetles», *International Journal of Biosciences,* Vol.7, no.2, pp.135-151, 2015.

[38] Y. Deng, Y. Wanga, Q. Deng, L. Suna, R. Wang, L. Yea, S. Tao, J. Liao, and R. Gooneratne, «Fungal diversity and mycotoxin contamination in dried fish products in Zhanjiang market, China», *Food Control,* pp. 0956-7135, 2021.

[39] M. A. Adeyemi, O. O. Segun and O. S. Barakat, «*Dermestes maculatus* Degeer infestation impact on market loss of dried fish in Kwara State, Nigeria», *Aquaculture and Fisheries,* no.3, pp. 170-173, 2018.

[40] M. F. Assogba, D. G. Anihouvi, H. I. Afe, and Y. E. Kpoclou, «Processing methods, preservation pratices and quality attributes of smoked and smoked-dried fishes consumed in Benin», *Food Science and Technology,* no.5, 2019.