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Dynamics of Smoking Practices of Clams *Galatea schwabi* (Clench, 1929) in the Lower Sanaga, Littoral Region (Cameroon)

[1]*Théophile Collins Yelengwe Ndjamou*, [1]*Gabel Essome Bang*, [1]*Felix Besack*, [1]*Audry Constant Mbock Nemba*, [3]*Jaime Anibal*, [4]*Loick Pradel Kojom Foko*, [1,2]*Gordon Nwutih Ajonina*, [1]*Minette Tomedi Eyango and* [1]*François Tchoumbougnang*

[1]*Institute of Fisheries and Aquatic Sciences, University of Douala, P.O. Box 7236 Douala, Cameroon*

[2]*Cameroon Wildlife Conservation Society, Littoral Region, Mouanko, BP 54 Mouanko, Cameroon*

[3]*University of Algarve, Institute of Engineering and CIMA-Marine and Environmental Research Centre, Faro, Portugal*

[4]*Department of Animal Organisms, Faculty of Sciences, University of Douala, P.O. Box 7236 Douala, Cameroon*

ABSTRACT

Background and Objective: Exploitation of clams constitutes a source of income and food for populations in developing countries. The objective of the study was to characterize populations involved in shellfish sector, describe post-smoking storage practices of *Galatea schwabi* clam and identify problems associated with their storage in the Lower Sanaga, Littoral Region, Cameroon. **Materials and Methods:** A total of 142 participants from Malimba and Yakalak Districts practising the activity were registered and the study took place between February and June, 2022. Data of interest were collected from each participant using a structured questionnaire during individual interviews and focus group discussions. **Results:** Participants were mainly represented by females regardless of the districts. Participants from Yakalak were significantly younger than their counterparts from Malimba. The higher proportion of individuals having completed university studies was found in Yakalak. Smoking was the main storage method of *Galatea schwabi* clams in both districts. Further storage methods including freezing/refrigeration and icing were also used at higher rates in Yakalak ($p = 0.001$). The 5 pesticides were locally used viz. leaves of *Alchornea cordifolia*, chili, oil+red palm oil, Rambo and Vitoxy bolus with no obvious environmental implications. There was a difference between districts regarding main constraints to smoking activity. Inappropriate smoking conditions lead to a deterioration of 15.91% of smokers in Malimba, versus 12.96% in Yakalak. **Conclusion:** Lack of financial resources was more given in Yakalak while pest control issues were more frequently reported in Malimba. This study provided insight into management practices and associated problems with the smoking activity of *Galatea schwabi* clams.

KEYWORDS

Clam, *Galatea schwabi*, smoking practices, *Alchornea cordifolia*, Lower Sanaga, rambo

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INTRODUCTION

Consumption of bivalves is encouraged for a healthy diet and health. Its world demand has increased over the past decades, from 1 million tons in 1950 to 17.7 million tons in 2020[1]. Clams are a group of burrowing bivalve mollusks having an important place in fisheries and aquaculture industry globally[2]. Its exploitation is done at low tide and the clams are extracted by hand[3].

In Africa clam collection activity is not negligible, but more structured in the Maghreb States (North Africa). To promote shellfish production in Tunisia for example, new operating permits have been issued since 2017 and 8 shellfish projects have been created for a production capacity of 1,200 tons/year[4]. Its collection occupies an important place in the country"s economy and represents one of the main activities of fisheries and aquaculture[5]. Similarly, shellfish harvesting in estuarine and mangrove ecosystems on the West African coast has shown that it is possible to ensure food and fishery security through the exploitation of molluscs[6].

Several studies have shown clams as a highly economic resource[7], even though the bulk of studies addressed biology and ecology of clams in Sub-Saharan Africa[8,9]. However, the hazards associated with bivalve molluscs can be divided into three categories: Environmental hazards, intrinsic hazards and process-related hazards. The accumulation of hazardous substances in the flesh tends to compromise the nutritional and health benefits derived from their consumption[10].

In Cameroon, clam-related economic activities are focused in Lower Sanaga and Nkam-Wouri watersheds in the Littoral region[11,12]. Taxonomic investigations reported the presence of several clam species in Lower Sanaga including *Galatea schwabi* which is greatly exploited by local people for its meat and shell[13]. Further species such as *Galatea paradoxa* and *Egeria radiata* were also found earlier in Lower Sanaga[14-16].

As a result, the economy around the clam provides the municipality of Mouanko and its surroundings with thousands of direct and indirect jobs given their socio-economic importance to populations from the Sanaga River, clams remain perishable after capture. Populations in developing countries resort to a variety of simple methods like smoking, solar drying and frying to preserve clams and other fisheries products[17-19]. These methods allow the reduction of the water content in the product and have been proven to be effective for their preservation. However, they expose clams to attacks by pests and microorganisms.

Previous investigations reported that molds and insects were the main culprits of post-smoking or drying deterioration during storage[20,21] and these organisms are responsible for reduced food value and quality. To combat these pests, insecticides and pesticides are generally used by populations[22].

Indeed, pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds)[23]. But their utilization is not eco-friendly and is associated with increased risks of human intoxication and pest resistance. Although the risk of pesticide poisoning to human health depends on the duration, frequency and dose of exposure, as well as the level of intrinsic toxicity of the product, it has been estimated that 385 million cases of accidental acute pesticide poisoning occur worldwide each year, resulting in around 11,000 accidental deaths per year[24].

Scientists therefore need to develop strategies to reduce exposure to pesticide residues in order to preserve the environment and living beings[25]. Clams harvested in the Sanaga have been shown to have good nutritional results[26]. However, there is little information on how people store clams after smoking them and field investigations have revealed poor handling of smoked products during storage. In this context, the present study was aimed at describing populations involved in shellfish sector, post-smoking storage practices of clams such as *Galatea schwabi*, their conservation implications and identifying problems associated with their storage in the Lower Sanaga, Littoral Region, Cameroon.

MATERIALS AND METHODS

This study was conducted from February to June, 2022 in 2 districts of Mouanko Sub-division, Department of Sanaga Maritime, in the Littoral Region of Cameroon. The geographical coordinates of the study area are between 3°14' and 3°50'N Latitude and 9°34' and 10°03'E Longitude. The sites are located as enclaves or peripheral to Douala-Edea National Park. The surveyed in Yakalak District was made up of the villages Lolbethal (03°38'12.3"N and 009°47'12.6"E) and Nkangansok (03°38'03.5"N and 009°46'27.9"E) and those of Malimba District were Moulongo (03°35'34.1"N and 009°42'28.7"E), Bolounga (03°35'34.1"N and 009°43'56,9"E), Malbengue (03°33'57.7"E and 009°42'28.7"E) and Maldjebou (03°35'15.2"N and 009°44'14.3"E).

The study area is located in the Sanaga Estuary, closer to the giant mangrove forests of Mbiako[26]. The Sanaga River, which rises in the Mandara Mountains at Bamenda, is the longest river in Cameroon, with an estimated surface area of 133,000 km^2 and a length of 1,000 km[27]. The climate of the study area is subdivided into four seasons: Two dry seasons between mid-November and mid-April for the longer one and mid-June to mid-August for the shorter one, two rainy seasons between mid-August and mid-November for the longer one and mid-April to mid-June for the shorter one.

A survey form developed by the Cameroon Wildlife Conservation Society (CWCS), a national non-governmental organization working since 1997 in the area conducting studies and community-based conservation activities to develop a participative management plan, was used to collect data on interest from populations in the various villages. Using random sampling, a total of 142 participants practicing the activity were enrolled in the study during officially authorized collection period (February-June, 2022) of *Galatea schwabi* clam (Fig. 1). They were distributed as follows: 25 in Lobethal, 29 in Nkangansok, 21 in Moulongo, 31 in Bolounga, 17 in Malbengue and 19 in Maldjedou. The participants were approached in smoking and/or storage places, homes and appointment venues. A structured questionnaire form written in French and English language was conceived as proposed by Gunter and Furnham[28] and used to collect information of interest within 10-15 min individual interviews or 30-60 min focus group discussions. The questionnaire constituted of 8 close-ended questions on sociodemographic and occupational information (gender, age, level of education, seniority, marital status, membership of a peasant organization, time of appearance pests on smoked clams in storage and secondary activities of the actors) and 10 open questions on clam characteristics and knowledge/practices of clam storage (name of exploited clam species, duration of smoking, deterioration causes, pest control measures, types of preservation methods, smokehouse used, the quantity of smoked clams by wheelbarrows, smoking frequency and difficulties).

Statistical analysis: Data were keyed, coded and checked for consistency in an Excel spreadsheet (Microsoft Office 2016, USA) and then exported to StatView v5.0 for Windows (SAS Institute, Inc., Chicago,

Fig.1: Photograph of *Galatea schwabi*

Illinois, USA) for statistical analysis. Qualitative variables were summarized as percentages using tables and charts. Fisher's exact and Pearson's independence chi-square tests were used to compare percentages between variables (bivariate analysis). Data were checked with respect to Cochrane's rule before making decision to use Fisher's exact test and Pearson's independence chi-square test. A $p<0.05$ was considered statistically significant.

RESULTS

Distribution of actors involved in the smoking of *Galatea schwabi* according to each district: A comparative analysis of participants by gender, age and level of education between Malimba and Yakalak is presented in Fig. 2. Females were predominant irrespective of district and there was no significant difference in proportion of males and females in the two districts ($p = 0.03$). In contrast, a statistically significant difference was found in distribution by age and level of education. Participants from Yakalak were younger than those from Malimba with a higher proportion of participants aged 30-39 and 40-49 years in Yakalak while those aged 50-59 years were more frequently found in Malimba ($p = 0.03$). Likewise, the proportion of respondents who have completed secondary or university graduates was higher in Yakalak ($p = 0.0001$) (Fig. 2).

Analysis of the *Galatea schwabi* smoking value chain in each district: The dynamics of the chain value of *G. schwabi* smokers in each district is presented in Fig. 3. No significant difference was found between interviewees from Malimba and Yakalak Districts for farming group, matrimonial status and secondary occupations. The proportions of participants with seniority of 0-10 and 10-20 years were significantly higher in Yakalak (Fig. 3).

The actors involved in this activity has secondary occupations (traders, teachers, retailer, fast food, etc.). About 55% of them are associated with serving groups.

Distribution of the different conservation methods for *Galatea schwabi* according to each district: As depicted in Fig. 4, smoking was the predominant method to store *G. schwabi* clams in Malimba and Yakalak. Two additional methods including freezing/refrigeration and icing were also used by participants, with a significantly higher proportion in Yakalak ($p = 0.001$).

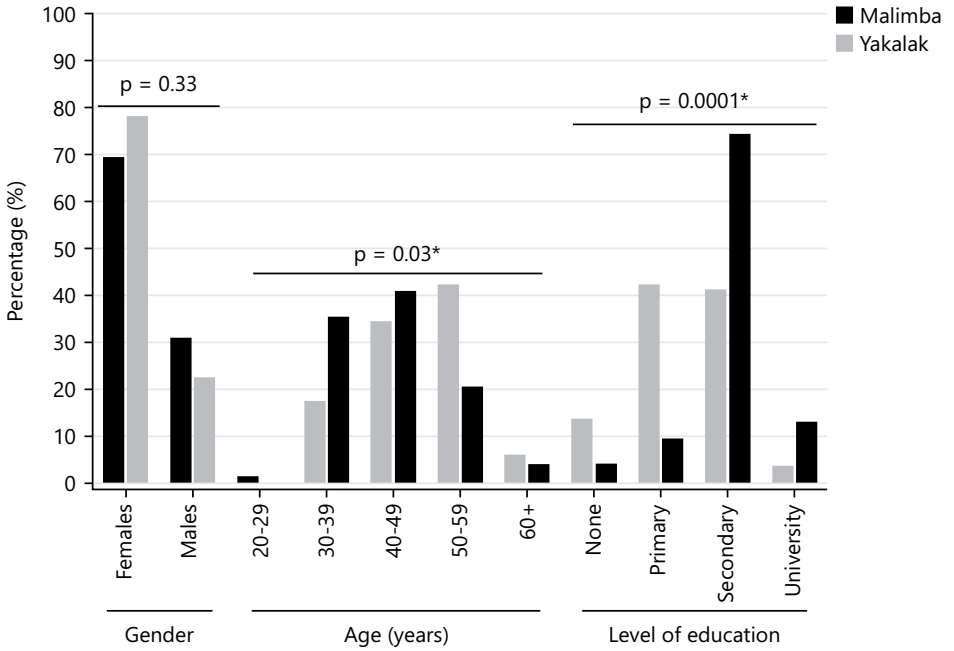

Fig. 2: Distribution of actors involved in the smoking of *Galatea schwabi* according to each district

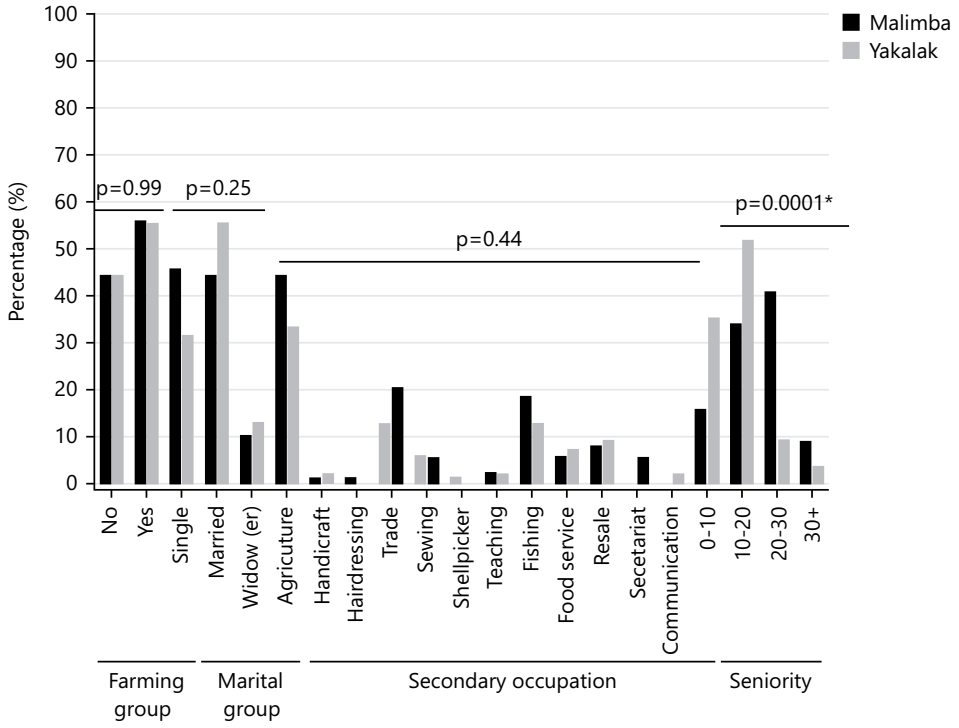

Fig. 3: Value chain of *Galatea schwabi* smoking actors according to each district

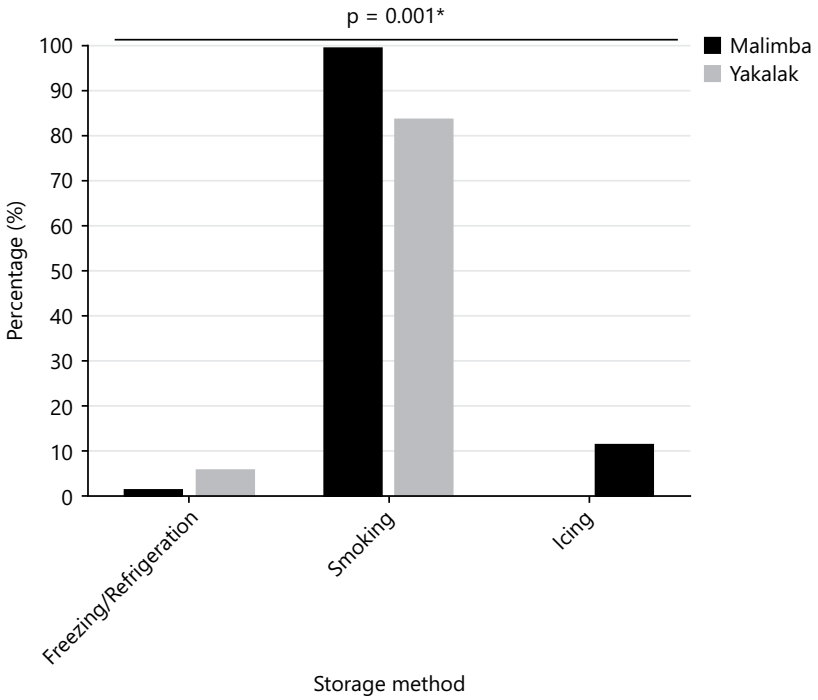

Fig. 4: Distribution of the different conservation methods for *Galatea schwabi* according to each district

Characterization of the smoking activity of *Galatea schwabi* according to each district: The clam commonly called besonda in Yakalah and behonna in Mouanko, is fished from February to June in the Lower Sanaga. The characterization of the smoking activity of *G. schwabi* according to each district is presented in Table 1. Some significant differences were observed in smoking duration, frequency and relationship with suppliers in the two districts studied.

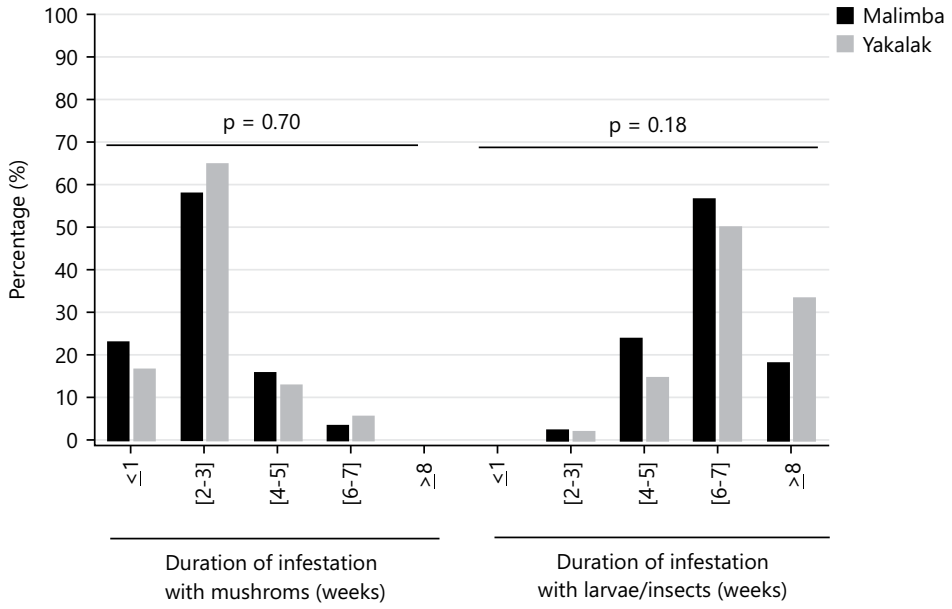

Fig. 5: Frequency of occurrence of *Galatea schwabi* pests according to storage duration in each district by moulds and larvae/ insects

However, the traditional smokehouse system ("Bandas") was used for clam smoking in the 2 districts. It's made from wood and recycled materials such as canvas and jute sacks on top of which is placed a wire mesh. The amount of clam smoked is measured per barrow equivalent to three "Cappeaux". From Table 1, the smoking time varied from 10-48 hrs in the two communities. However, most of the actors smoked their products within a day (24 hrs). The smoking capacities of the participants varied from 5 to 12 wheelbarrows. The frequency with which this action was repeated in a week varied from 1-4 times. This depended on the actor-network of distribution, supply and availability. It was also noted from these results that, the actors were linked to their suppliers through family and ethnic relationships the spreading of the activity.

Agents responsible for spoilage of smoked *Galatea schwabi* and duration of pest appearance during storage by district: During the surveys, all (100%) actors identified molds and insects as the main pests of smoked *G. schwabi* after long storage. Figure 5 shows the values obtained for the duration of appearance of smoked clam pests. Most participants in both districts reported that molds (fungi or mushrooms) and insects/larvae were more frequently observed between post-smoking 2-3 and 6-7 weeks, respectively. Again, no statistically significant difference was found between districts. As soon as the storage bags are opened, larvae and insects can be observed as shown in Fig. 6.

Distribution of substances used to neutralize spoilage agents of smoked *Galatea schwabi* during storage by district: The majority of participants were not using pesticides to control the infestation of smoked *G. schwabi* clam by an insect (Fig. 7). The 5 pesticides were locally used in the districts namely leaves of *Alchornea cordifolia*, chilli, oil+red palm oil, Rambo powder and Vitoxy bolus. These pesticides were more frequently used by participants in Malimba ($p = 0.009$). How to use Rambo powder and Vitoxy bolus are mentioned on the product label and the leftovers are used according to the experience of each actor.

Difficulties of actors related to the smoking activity of *Galatea schwabi* in Lower Sanaga: Table 2 presents the various constraints that hinder the development of the smoking activity of *G. schwabi* according to each district. This result shows that the major constraints of the populations of the Yakalak

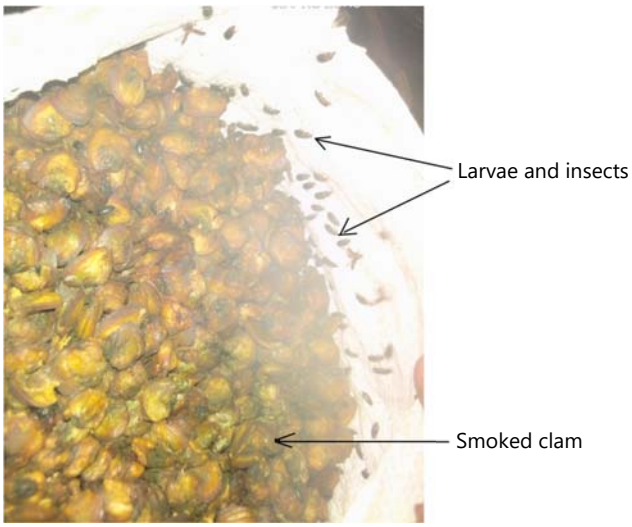

Fig. 6: Smoked clam infected by larvae and insects

Table 1: Distribution of the inventory of the smoking activity by the actors, according to each district

Variables	Settings	Yakalak (%)	Malimba (%)	χ^2	df	p
Type of smokehouse	Traditional "Bandas"	90.74	96.59	-	-	0.25
	Improved "Bandas"	9.26	3.41			
Smoking time (hour)	5-10 hrs	16.67	5.68	10.65	4	0.03*
	10-24 hrs	42.59	54.55			
	24-48 hrs	27.78	35.22			
	>48 hrs	12.96	4.55			
Quantity of clams smoked	>4	9.26	1.14	7.35	4	0.11
(in wheelbarrow)	[5-8]	33.34	40.91			
	[9-12]	50.00	50.00			
	[13-16]	3.7	6.81			
	>17	3.7	1.14			
Smoking frequency	1 times/day	0.00	1.14	19.16	3	0.0003*
	1-2 times/week	42.59	12.50			
	3-4 times/week	53.7	70.46			
	5-6 times/week	3.71	15.90			
Links with uppliers	Family	44.44	61.36	6.36	2	0.04*
	Ethnic group	20.37	21.60			
	Regular customers	35.21	17.04			

Chi-square test was used for comparisons and *Statistically significant at $p<0.05$

Table 2: Distribution of some major constraints of the smoking activity of *Galatea schwabi* according to each district

Major constraints	Yakalak (%)	Malimba (%)
Decline of the clam	27.78	6.82
Non-adequate smoking equipment	18.52	15.91
Lack of a market for sale	9.26	11.36
Deterioration of the state of health of the actors	12.96	15.91
Restricted access to other buyers	11.11	14.77
Pest control issues	14.81	23.86
Weak supervision by public authorities	5.56	11.36

D istrict are the decline of the clam resource (27.78%) and the use of non-adequate or traditional smoking equipment (18.52%). On the other hand, those of the Malimba District have problems with pest control (23.86%), the use of derisory smoking equipment (15.91%) and the deterioration of the state of health of the actors (15.91%). Although, Nigerian foreigners are the main buyers of smoked clams in the field, stakeholders note limited access to other buyers (11.11% in Yakalak Townships and 14.77% in Malimba).

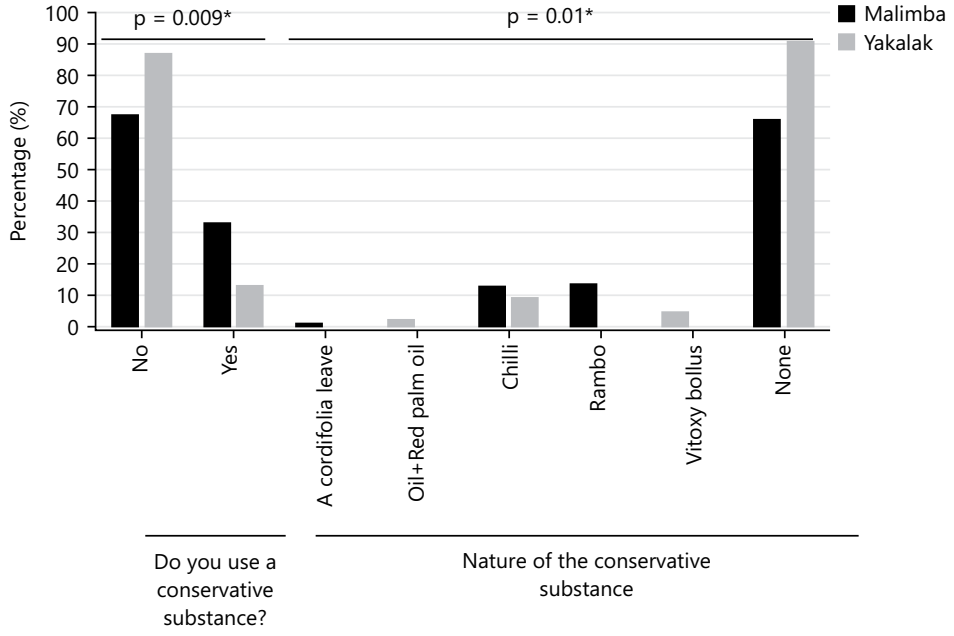

Fig. 7: Distribution of pesticides used by actors to control smoked *Galatea schwabi* pests during storage by district

DISCUSSION

In this study characteristics of local actors and analyzed practices and problems associated with storage of *Galatea schwabi*, a clam species greatly exploited by populations from Mouanko Division for income and food were described. Women were mainly involved in smoking activity of *G. schwabi* clam and this finding was in line with earlier studies[7,29]. Likewise, smoking activity was more frequent in Malimba District compared to Yakalak District. The presence of a large individual wharf in Malimba District facilitates smoking activity while subsistence activities are more seen in Yakalak District due to its geographical proximity with administrative regions.

Several authors have reported that clam fishing is an almost female activity[4,6,30]. The FAO[1] observed that the harvesting of wild bivalves is practised in coastal communities in Africa by women. On the other hand, Ajonina *et al.*[7] obtained inferior results in their work in the Lower Sanaga. They observed a female dominance of 52.5% in clam processing, in contrast to the results obtained in this study. This difference could be explained by the fact that the activity would have evolved and men would have been more interested in shells which are burned and then sold to the feed mill and would certainly bring in more money than smoked flesh.

The actors involved in this activity have secondary occupations (teachers, retailer, fast food, etc.). About 55% of them are associated with serving groups. This diversity of occupations may be responsible for the reduction time of smoking (less than 24 hrs) observed in the majority of actors in the two localities. Since they may be rushing to exploit very high quantities within a shorter time before going back to other occupations. This was confirmed by their belonging to jangui houses (serving association) where each would like to serve more money.

Concerning the distribution of the different conservation methods of *G. schwabi* in the study area, a significant difference ($p<0.05$) exists between the methods used and the two districts. This result was not surprising given the geographical position and the development of the infrastructures of the clam smoke in each district. It is well-known in the literature that smoking is a simple method of preserving fish

products in coastal areas. The work of previous studies[18,21] showed that smoking is a widespread technique in many developing countries, of which 80% of fish catches are smoked or dried to limit spoilage. Smoking also adds flavour to the product[29].

The most important rule for smoking "etak" in Malaysia is that the smoker must ensure that the product is cooked but that the shell is not opened. clam smoking therefore varies according to the technique used and the type of product required. Ajonina *et al*.[7], obtained a rate of 58.30% for the smoking of *G. schwabi* in the same study locality. However, several factors would favor the smoking of clams. The first factor would be the high availability of the resource (clams) with significant catches during fishing periods. About 32.5 ton of *Galatea schwabi* clams per month had been caught at the start of the resource collection activity[5]. Second, the problem of the instability of electricity to preserve food in the refrigerator or freezer has led people of the municipality of Mouanko to other preservation techniques such as refrigeration and freezing, or the use of ice to preserve meat fresh clam. Similarly, the availability of fuel in the study area is a significant factor and constitutes an opportunity for smoking clams. It should be noted that the flavor brought by the smoke could also be a significant reason why other actors prefer to consume smoked clams than fresh. It's also worth noting that some of the fresh meat that isn"t smoked is used in other ways, such as in the catering industry and the production of clam meatballs and skewers for sale and family consumption.

The results concerning the agents responsible for the deterioration of *Galatea schwabi* during storage were similar to those reported by many authors on smoked fish. The damage caused by moulds and insects was in agreement with that of Ndrianaivo *et al*.[19], Hissein *et al*.[20] and Tamgno *et al*.[21] which showed the main causes of biochemical changes and physical losses during storage of smoked and dried fish. Indeed, the storage of smoked clams in traditional kitchens does not prevent the appearance of these two groups of pests. The work of Ndrianaivo *et al*.[19], also showed that at the start of storage, smoked and dried fish in the wet season contain significantly more molds and no insects yet. Contamination of these smoked products by molds and insects would certainly indicate non-compliance with hygiene rules during handling, poor conservation and storage conditions.

A large proportion of the actors (more than 65% in Malimba and 85% in Yakalak) do not use pesticides or insecticides to conserve their products. This could be due to poor access to the products, lack of finance in their purchasing and limited knowledge about its utilization. The substances used in the preservation of smoked *G. scwhabi* during storage have been listed. All these different products used are available on Cameroonian soil, apart from Vitoxy bolus which would be supplied to smokers by Nigerian buyers. Various studies have been carried out to research insecticides and pesticides used in food preservation during storage and their impacts on health and the environment[22-25,31]. However, the use of pesticides for the conservation of the smoked clam *G. schwabi* by the actors of Lower Sanaga, was the same as those listed by the above authors.

In Burkina Faso for example, it is Rambo powder that is precisely used for the conservation of cowpea at a rate of 32%. It is the second most used pesticide in the Malimba District after *Pimenta* sp. Rambo powder would therefore be perceived as an effective insecticide against pests in preserved dry products thanks to its active ingredient permethrin 0.60 and 99.40% of inert carriers. It would have an abrasive role on the insects and cause their dehydration. The low rate of Vitoxy bolus 500 mg with its basic molecule oxytetracycline HCl bolus in food preservation is ignorance by the actors. This is why its low rate compared to Rambo powder was noticed. With regard to the biological products listed in Mouanko, similar studies have been carried out demonstrating the effectiveness of the plants listed in food preservation or having antifungal or photochemical properties[32-34]. In view of the hazardous nature of pesticides, it is necessary for stakeholders to turn their attention to more holistic, sustainable, natural and safe product conservation, storage and management practices[23].

The wild stocks of bivalves have been over-exploited[1] and the difficulties of the *G. schwabi* clam smoking activity in Lower Sanaga were similar to those encountered in most camps. Hamdaoui *et al*.[4] reported similar results during a sensitive value chain analysis of the clam sector in Tunisia. These authors noted the absence of an organized market and the presence of only foreign buyers (Nigerians in our case) in the production areas, resulting in door-to-door sales. This situation induces a decentralization of supply and consequently a vague, non-transparent sale at very low prices.

François *et al*.[18] during a study on the perception of fish smoking activity in Douala, noted the constraints related to the physical condition of smokers and the improvement of workspaces. Although the wood used for smoking clams comes from the fields and forest, the smoking activity in the municipality of Mouanko would be part of the factors of non-negligible deforestation. This pressure of the actors on the fauna in search of firewood confirmed that the work of Ajonina *et al*.[7] showed the impact of bivalve-related activities on forest resources in Mouanko. Activity constraints observed in the localities studied could also influence the quality of the finished product. Ndjamou *et al*.[26] found significant differences between the proximal chemical meat quality of smoked clams from the two districts.

Smoking is an operation that allows the fuel to release large quantities of particles into the air. Smoke is composed of solid and liquid particles suspended in a gaseous phase. These particles come from the pyrolysis (decomposition under the effect of heat) of wood constituents (cellulose, hemicellulose and lignite). The analysis of particles emitted during the kindling and burning phases of hard and soft woods has been the subject of several studies[35]. However, the polycyclic aromatic hydrocarbons (PAH) produced whenever wood is burned are a potential risk to human health[36]. Although, tobacco smoke is the main risk factor for Chronic Obstructive Pulmonary Disease (COPD), air contamination by wood smoke is also a major concern, as almost half the world's population uses this type of combustion for cooking and heating Aghaeimeybodi *et al*.[37]. "Bandas", the traditional smoke stoves used in the two study areas, release important wood-burning substances into the air. Sanaga clam smokers who do not protect themselves from the smoke while smoking are exposed to various diseases.

This work, which constitutes a pilot study, has highlighted smoking as a clam preservation technique. However, the study has certain scientific and technical limitations. With regard to the technical limitation, the study needs to be extended to take into account all the players involved in the clam value chain, in particular traders, fishermen and wholesalers and then to assess the socio-economic aspects of the resource in the area. With regard to the scientific limitation, the absence of scientific data on clam smoking should be noted here, which further limits the discussion of the results obtained with those of other authors. To overcome the weaknesses and minimize the threats faced by players in the Lower Sanaga clam value chain, it is recommended that the government strengthen players" capacities through seminars and training sessions on processing techniques and environmental protection.

CONCLUSION

This study was carried out to present an inventory of the exploitation of the smoked clam *Galatea schwabi* by local actors in the Malimba and Yakalak Districts in Lower Sanaga, in order to better exploit the resource. The surveys carried out revealed that the smoking activity is more intense in the Malimba District, with a dominance of women. In addition, agriculture, fishing and trade are the secondary activities of the people surveyed during the closure period. Although, molds and insects are the main constraints in the conservation and management of smoked clams for a long storage period, the actors use pesticides to eliminate them, which could constitute a danger to consumers and the environment. This study has therefore highlighted the smoked clam management practices in the Lower Sanaga in Cameroon. Other work should be established in particular on the physico-chemical quality and the identification of the species of molds and insects of the smoked clam, but to seek effective bio preservatives for the

conservation of *Galatea schwabi* during storage. After the above investigation, this income source activity should be promoted and extended out of the Littoral region of Cameroon since it could be used to fight against poverty in other localities. Water content and microbiological studies should be carried out to increase the knowledge available in this fishery activity, as this is necessary to increase the storage duration. More interest should also be given to associated income sources such as shell exploitation and the domestication of clam should be encouraged.

SIGNIFICANCE STATEMENT

Clams caught in the Lower Sanaga are smoked and little information is available on the activity. This study aims to present the players involved and their storage practices for the finished product. Surveys carried out in the Malimba and Yakalak Districts revealed that the activity is dominated by women. Smoking is poor, resulting in the use of pesticides during storage. Rambo powder is the main insecticide used. The use of inadequate smokehouses exposes players to various illnesses and deteriorating health. This work, which constitutes a pilot study in the locality, provides a wealth of information on clam farming. Improving smoking will guarantee a quality product and ensure good management of the resource.

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