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Determination of the minerals of *Galatea schwabi Clench*, 1929 clam from the lower Sanaga Cameroon

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Abstract
The present study was conducted to determine the concentration of minerals in the meat and shell of the *Galatea schwabi* clam exploited in the Lower Sanaga River, Cameroon. The smoked clam samples were collected in Yakalak and Malimba Districts, the fresh meat and shell were collected in the fishing area. The qualitative and quantitative of the minerals were done in the laboratory by Schimadzu EDX-7000. The results showed 19 minerals identified in the samples. 13 in the smoked clam meat from Malimba District with highest values from Fe (20.328%) and Ca (16.016%); 14 in that of Yakalak District with Ca (19. 011%), Si (14.330%) and S (10.065%); 11 in the fresh meat dominated by P (14.586%), Ca (13.112%), S (12.784%) and P (11.203%); and 13 in the shell dominated by 97.716% of Ca. The meat and shell of *G. schwabi* clam are rich in minerals and can be used for human and animal nutrition.

Keywords: Minerals, clam, *Galatea schwabi,* EDX-7000, Lower Sanaga, Cameroon

1. Introduction
The crucial role that food products of aquatic origin play in food security and nutrition is increasingly recognised, not only as sources of protein, but also as unparalleled suppliers of micronutrients [1]. Minerals are inorganic substances, present in all body tissues and fluids, and their presence is necessary to maintain certain physicochemical processes essential for life [2]. Their concentrations in food can vary due to biotic and abiotic factors.
Minerals are usually classified into two groups: major minerals or macro elements, including sodium, potassium, chlorine, calcium, phosphorus and magnesium, and trace elements, including iron, zinc, copper, manganese, iodine, selenium, chromium, molybdenum, fluorine, cobalt, silicon, vanadium, nickel, boron and arsenic. These elements are involved, at very low concentrations, in countless metabolic processes, for example as constituents or activators of enzymes, regulators, stabilisers or co-transporters [3]. The proportions of some minerals and their major roles in the human and animal body have been demonstrated in some studies [4, 5, 6].
In Cameroon, clams are exploited along the Sanaga Delta for meat and shell by local fishermen in the Mouanko District with an estimated production of over 800 tonnes per year [7]. The shells of these clams have been used for decades in animal feed because of their high mineral content. However, few studies on the quantity and quality of macro and micro minerals have been conducted on fresh and smoked clams [8]. Knowing that minerals play an essential role in human health, growth and development of animals, their determination in clams exploited in the Lower Sanaga is of particular interest.
Several methods of mineral analysis are known, but the Schimadzu EDX-7000 spectrometer is increasingly used for the spectroscopic determination of chemical elements in a product [6, 9]. The working principle of EDX analysis is the measurement of wavelength or energy and intensity of the characteristic x-ray photons emitted from the sample. This allows the identification of the elements present in the sample and the determination of their mass or concentration [10].
In view of the danger that human activity may represent on the living environment of bivalves,

with the consequences that this may have for consumers, this study on the determination of minerals by EDX-7000 in the flesh and shell of the clam *G. schwabi* was undertaken in the Lower Sanaga.

2. Materials and Methods

2.1 Sample collection

Samples of smoked clam meat were collected between February and June 2022 in Malimba and Yakalak District for smokers choose at random. Then, the fresh clam meat and shell were collected in the fishing area located downstream of the Sanaga River with the geographical coordinates 03°34'02.2" N - 009°42'20.8" E. These two Districts are located in the Littoral Region, Sanaga Maritime Division, and Mouanko Sub-division in the areas shown in Figure 1. The choice of these study areas is partly due to the availability of the resource, and partly due to the lack of data on the value of minerals in this food.

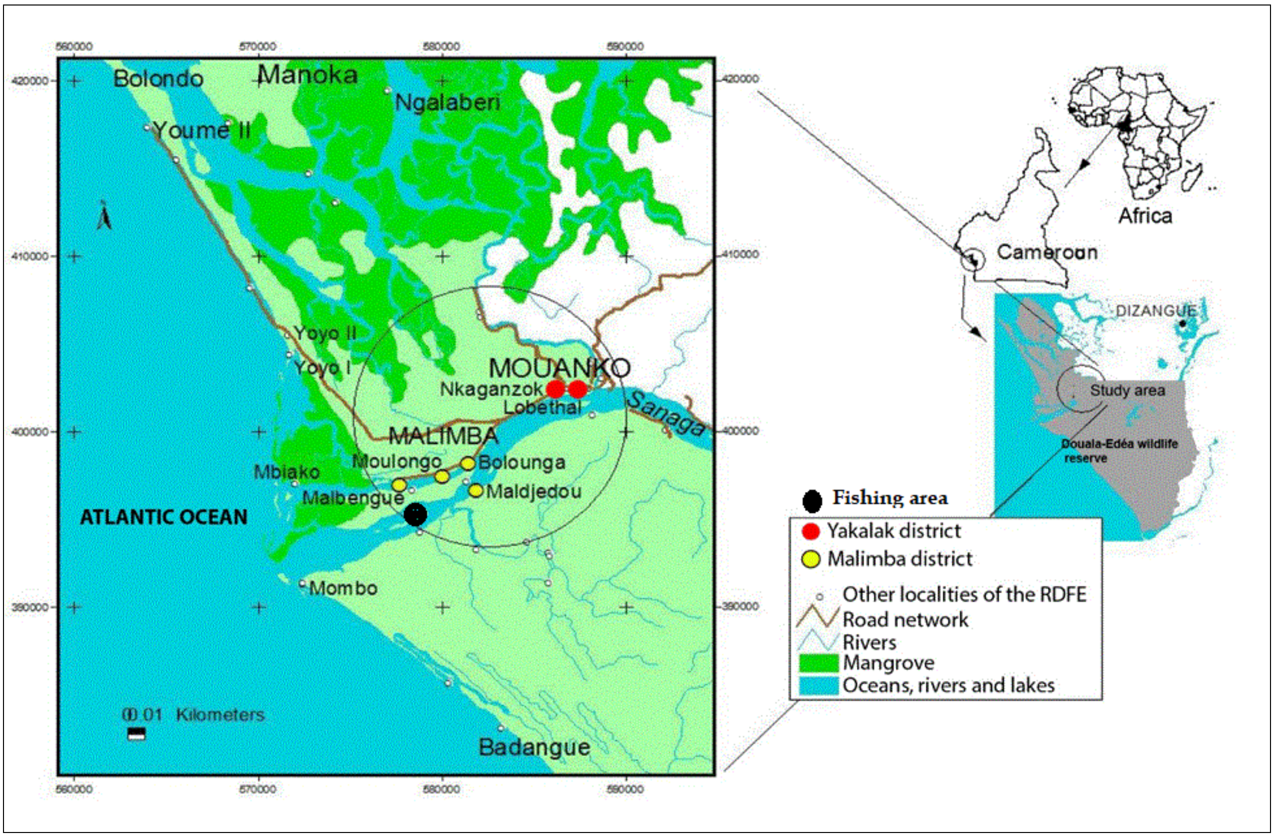


Fig 1: Map of the study area

2.2 Preparation of *G. schwabi* meat and shell powders for analysis

To obtain the powder, clam shells were first separated from the rest of the flesh, then washed thoroughly with clean water and dried in the study at 105°C for 24 hours. After cooling, the shells were ground to powder using an electric blender and sieved to obtain a uniform particle size. The same process was used for the clam meat.

2.3 EDX-7000 analysis of the samples

To assess the concentration of continuous minerals in the shell and meat of *G. schwabi*, measurements were determined using EDXRF on a Schimadzu EDX-7000 spectrometer shown in Figure 2. Indeed, a given amount of powder of our samples was put into the bottom of cell; and covered with plastic film. Then, the cells were placed in the X-ray chamber and analysed.

The EDX-7000 incorporates a new high-performance solid-state detector, which offers excellent sensitivity, resolution and throughput for a wide range of applications, from general screening analysis to advanced materials research in areas such as chemistry. These tools allow the analysis of the various macrominerals and microminerals in any sample between Sodium (Na) and Uranium (U).

Fig 2: Schimadzu EDX-7000 analysis device

3. Results

The fresh, smoked and shell meat of *Galatea schwabi* clams from the Lower Sanaga was analysed for minerals by EDX-7000, and the results obtained are presented in Table 1. The complete mineral content profile of smoked clam from Malimba District is presented in Figure 3, that from Malimba District in Figure 4, the fresh meat in Figure 5 and the shell in Figure 6.

Qualitative analysis of concentrations expressed as a percentage of wet matter yielded thirteen (13) minerals in smoked clam meat from Malimba District, fourteen (14) from Yakalak District, eleven (11) in fresh meats, and thirteen (13) in shells. The macro elements recorded in the samples (flesh and shell) are composed of Ca, P, K et S, and the micro minerals are made up of Fe, Zn, Cu, Ho, Ba, Mn, Si, Cr, Co, Sr, Br, Zr, Rb, Mo et Ni.

In terms of quantitative analysis of each product, two minerals were predominant, namely Iron (20.328%) and Calcium (16.016%) in the smoked clam from Malimba District, and three from Yakalak District, mainly Calcium (19.011%), Silicon (14.330%) and Sulphur (10.065%). On the other hand, four minerals predominate in the fresh meat which has not undergone any prior treatment, especially Phosphorus (14.586%), Calcium (13.112%), Sulphur (12.784%) and Potassium (11.203%). As for the clam shell, Calcium represents the major element with a concentration of 97.716%.

The results obtained also show a difference between the mineral composition of fresh and smoked meat on one hand. In fact, the P mineral contained in fresh clam meat is entirely absent in the smoked products of the two Districts, while the Si, Ti, Zr and Cr appears there. On the other hand, the microelements Ba, Ho, Ni, Co, Cr and Ti present in the shell of *G. schwabi* are entirely absent in the fresh flesh.

Table 1: Mineral content (%) in the meat and shell of *G. schwabi* clams before and after smoking in the Lower Sanaga.

Elements	Smoked flesh from Malimba District	Smoked flesh from Yakalak	Fresh meat before smoking	Shell
	(%)			
P	*	*	14.586	0.006
Si	9.171	14.330	*	*
Ca	16.016	19.011	13.112	97.716
S	8.839	10.065	12.784	0.619
Fe	20.328	7.145	0.943	0.1
K	2.790	3.684	11.203	0.266
Ti	0.689	0.694	*	0.035
Mn	0.712	0.466	0.149	*
Zn	0.506	0.372	0.471	*
Cu	0.224	0.203	0.325	0.04
Sr	0.179	0.128	0.076	0.586
Br	0.088	0.082	0.084	*
Zr	0.065	0.039	*	*
Rb	0.051	0.037	0.081	*
Cr	*	0.062	*	0.065
Ba	*	*	*	0.399
Ho	*	*	*	0.128
Ni	*	*	*	0.011
Co	*	*	*	0.028

*not detected

P (Phosphorus), Si (Silicon), Ca (Calcium), S (Sulphur), Fe (Iron), K (Potassium), Ti (Titanium), Mn (Manganese), Zn (Zinc), Cu (Copper), Sr (Strontium), Br (Bromine), Zr (Zirconium), Rb (Rubidium), Cr (Chromium), Ba (Barium), Ho (Holmium), Ni (Nickel) and Co (Cobalt).

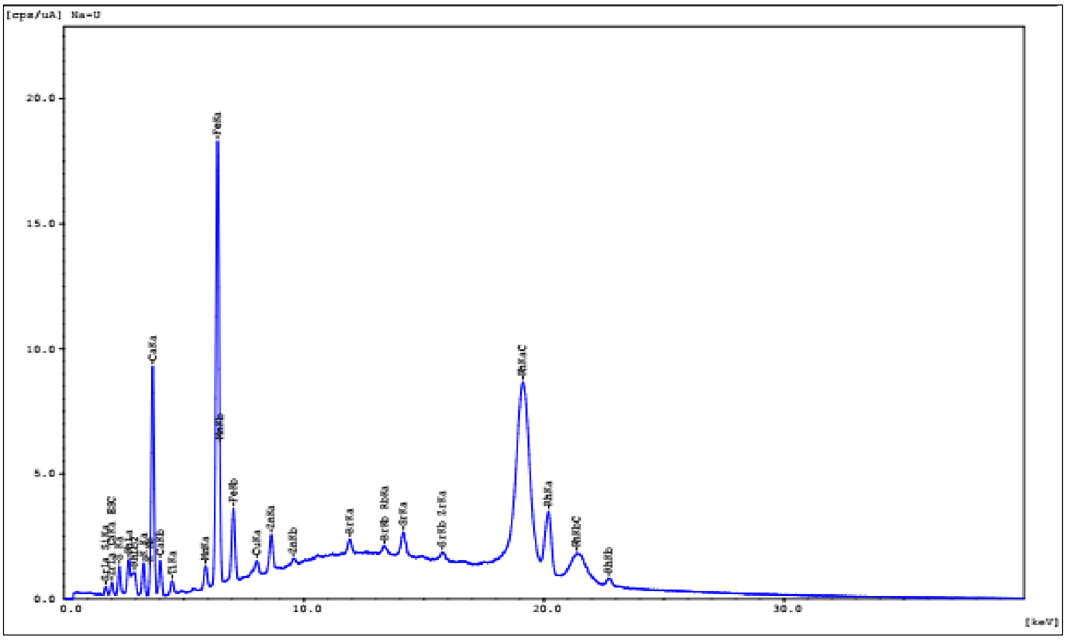


Fig 3: Mineral profile of smoked clam meat from Yakalak District

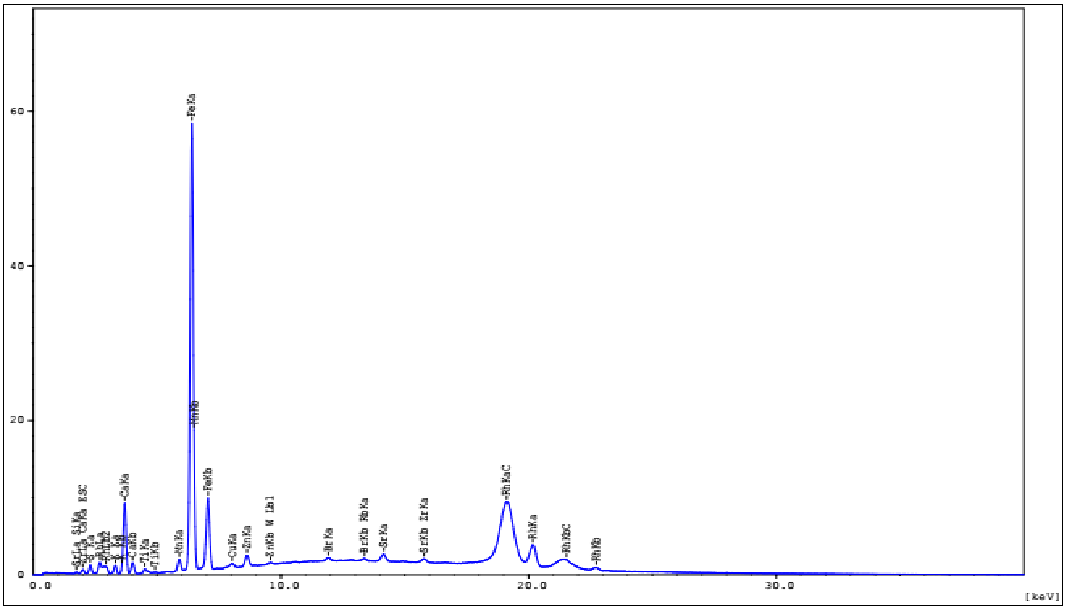


Fig 4: Mineral profile of smoked clam meat from Malimba District

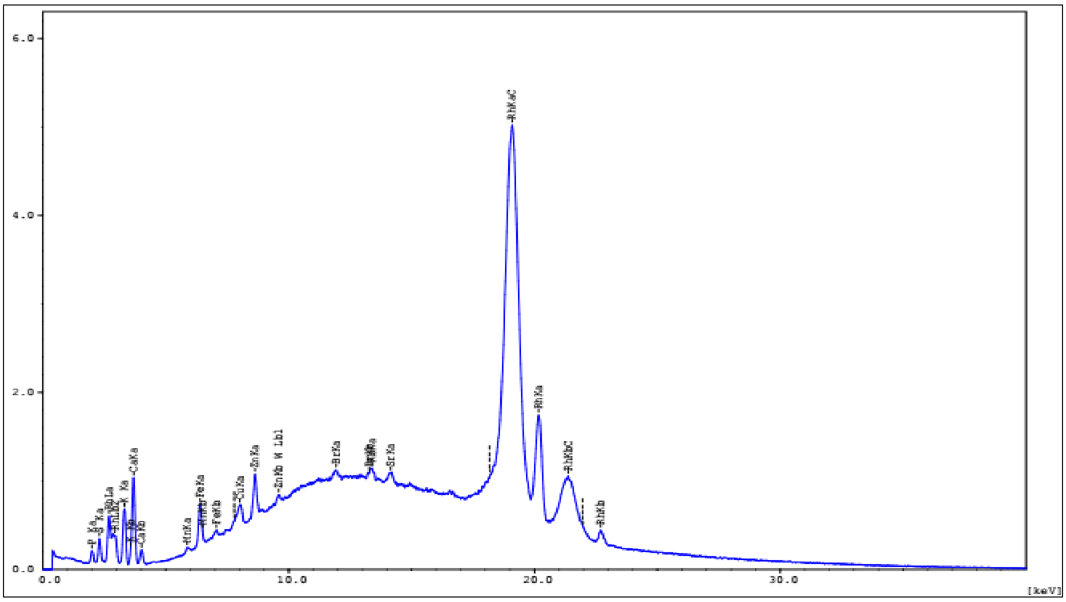
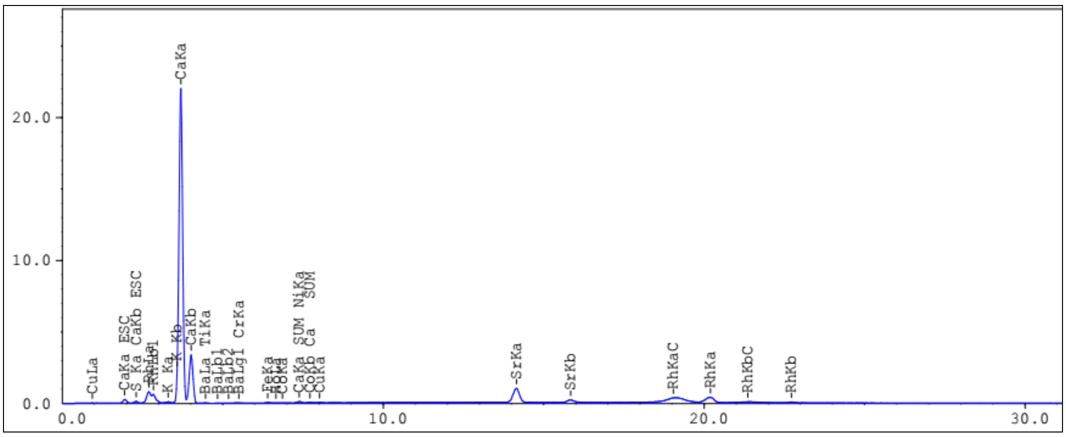


Fig 5: Mineral profile of fresh clam meat from the fishing area



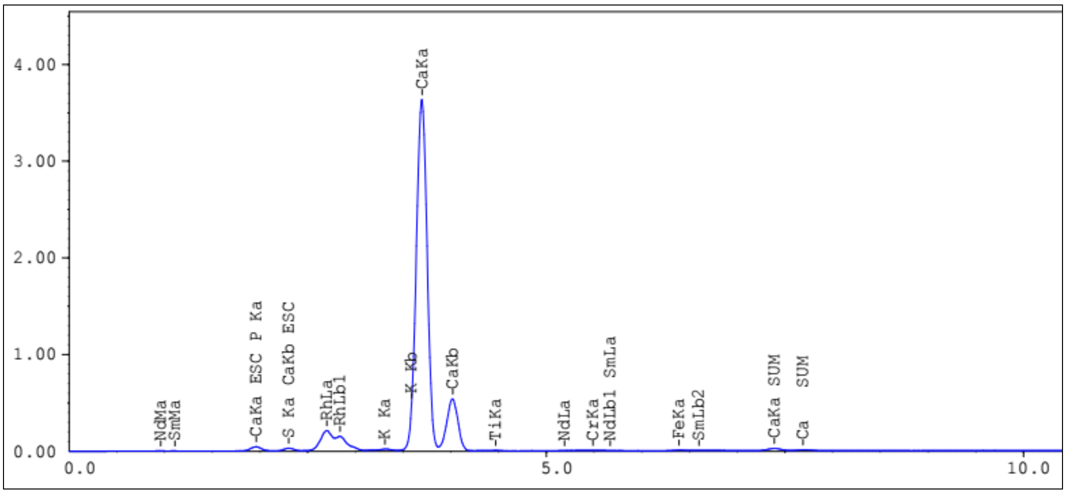


Fig 6: Mineral profiles of clam shell from the fishing area

Discussion

The *G. schwabi* clam is exploited as a source of income and food for local residents. In the present study, the results of EDX analysis indicate that the mineral content of clams from the Lower Sanaga River varies according to the quality of the product. According to Ogidi *et al*, 2020, clams are beneficial to human health as they are a rich source of important nutrients such as phosphorus, calcium, potassium, protein, iron and other vitamins needed by the body [11]. The results obtained in this study, allowed to record the same minerals as stated by these authors. Indeed, the work of ANSES (2010), has revealed that the flesh of aquatic animals contains more than 60 microelements, both essential and not [3]. These micro-elements are stored mainly in the skeleton and also in the muscles. This is why the phosphorus content observed in fresh meat was high, and very low in the shell, but absent in the smoked products. Phosphorus is a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It serves buffering action (phosphate), the formation of high energy compounds (Adenosine Triphosphate) and is involved in the synthesis of phospholipids and phosphoproteins [12].

Some variations in the minerals Ca, Fe, S and K are observable between the smoked products in both District and the fresh meat. These variations are due to the smoking process, which reduces the water content of the clam meat, thus favouring an increase or decrease in water-soluble minerals. This is why after smoking, there is an increase in Fe and Ca content, and a decrease in S and K content. Akinyele (1998) carried out a study on the safety of processed street foods in Nigeria, and showed that nutrient losses are limited to those observed during washing, rinsing and heating [13]. Similar results were obtained by Dikoume, 2020 on fresh and smoked *Egeria radiata* clams in the Lower Sanaga [8]. This author obtained in the samples of fresh and smoked clam respectively in milliequivalents per 100g of dry matter Ca (3680 and 3920), K (83 and 109), Fe (15.91 mg/kg and 24.14 mg/kg) and P (5206 mg/kg and 5294 mg/kg). In fact, potassium lowers blood pressure, protects against loss of muscle mass, preserves bone mineral density, and reduces the formation of kidney stones; and our body needs calcium to build and maintain strong bones. Our heart, muscles and nerves also need calcium to function properly [10]. It should also be noted that the flesh of mollusks is very rich in iron. Iron is present in heminic form, well absorbed by the human body [3]. According to Martin (2001), the recommended dose of iron is up to 30mg/day in pregnant women, 30 to 65 µg/day for potassium and between 800 to 850 mg/day for phosphorus [14].

The smoked products from each District show new elements such as Silicon (high concentration) and Chromium (low concentration) as shown in Table 1. The presence of these minerals is believed to be due to migration of the used material into the clam meat during the smoking process. Xiuxian *et al*. 2023 carried out work showing the reduction of Chromium toxicity in Chinese cabbage due to the synergistic effect of silicon and selenium. These authors noted that heating could lead to a variation in the Chromium and silicon content in the product [15].

Concerning the mineral content in *G. schwabi* shells, the value obtained for Ca by EDX-7000 analysis was 97.716%. The rest of the microelements analysed are characterised by a mineral content of less than 1% for the P, S, Fe, K, Ti, Mn, Zn, Cu, Sr, Br, Zr, Rb, Cr, Ba, Ho, Ni. Soaten *et al* (2010) has made works where they present the role of each microelement in the organism or animal [2]. According to ANSES (2010) 99% of the calcium is contained in the non-consumed part, notably the skeleton, scales, shells, [3]. However, there are strong variations between species and according to the method of conservation and consumption. The results obtained in this study are comparable to several other authors who have determined the concentration of minerals in mollusc shells [16, 17]. Indeed, bivalve shells can be transformed into calcium carbonate or calcium oxide, two very versatile chemical compounds that have broad industrial applications. In addition, shells are also used in the manufacture of cosmetics and traditional medicines, as a calcium supplement in animal feed (shell powder), in handicrafts and in jewellery [1]. The rest of the twelve other microelements contained in the shell have low levels. They are also thought to participate in combination with calcium in many other functions of the body [12].

Conclusion

An EDXRF method was used to determine the concentration of macros and microelements contained in the flesh and shell of the *Galatea schwabi* clam exploited in the Lower Sanaga River because of its richness in nutrients. The results of the analysis of the meat showed a richness in calcium, sulphur, iron, and phosphorus unlike the shell which consists mostly of calcium. Clam meat, whether eaten fresh or smoked, is an excellent source of minerals for consumers. Further studies on the meat and shells are needed to look for major minerals that cannot be identified by EDX-7000.

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