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RESEARCH ARTICLE

BIOCHEMICAL COMPOSITION OF FISH, SHRIMP AND CRAB POWDERS SOLD ON THE ADJAME MARKET FORUM (ABIDJAN, IVORY COAST)

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ABSTRACT

This essay is a journey Fish, shrimp and crab powders are in certain are as used as a substitute for meat, fish and seafood by populations. The objective of this study was to determine the biochemical composition of these powders in order to check if they cancover the protein and mineral needs of consumers populations. For this, fish, shrimp and crab powdersal ready produced by the women sellers of the Adjamémarkets were taken rand omly, and other powders were made in the laboratory. The composition of macronutrients and minerals was determined by standard methods. The results showed that, with the exception of shrimp powder, fish and shrimp powders collected from the Adjamé markets had humidity percentages lower than 10%. These powders had high protein contents (from 37.59% ± 1.64 to 61.45% ± 1.9) and ash (from 10.47% ± 0.14 to 26.93% ± 0.53).) and low lipids contents (from 4.33% ± 0.19 to 4.77% ± 0.36) and low carbohydrates (from 4.43% ± 2.89 to 9.45 % ± 1.315). Likewise, they had variable contents of all the minerals studied, with high values of phosphorus (from 9.22 ± 0.41 mg/100g to 13.44 ± 0.8 mg/100g), potassium (from 5.45 ± 1.1 mg/100g to 6.84 ± 0.6 mg/100g) and calcium (from 6.79 ± 1.3 mg/100g to 17.29 ± 0.43 mg/100g).Also, all the powders made in the laboratory had humidity percentages less than 10%, high protein and ash contents, and low carbohydrate and lipid contents. However, the powders produced in the markets had higher carbohydrate contents and lower proteins contents, which suggests that the women sellers added carbohydrates or unknown ingredients to the different powders for economic purposes.

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INTRODUCTION

A good diet must be healthy, varied and balanced in order to provide the consumer with all the nutrients essential for the proper functioning of their body (OMS, 2016). It must indeed provide sufficient quality and quantity of essential nutrients such as carbohydrates, lipids, proteins, vitamins and minerals from numerous food sources that are part of the eating habits of populations (Kalala, 2014).At the protein level in particular, for certain reasons such as the increasingly high costs of meat, fish and seafood on the markets or for choices of traditional culinary techniques and seasoning methods, fish, shrimp and crab powders are increasingly used as ingredients by a significant number of households, regardless of social levels (Kimani *et al*., 2022). Some of these households, especially the less well off, use these powders as a total replacement for protein foods in their various menus. Can the biochemical composition of these powders alone cover the protein and certain mineral needs of consuming populations? Are there any risks in replacing protein foods with fish, shrimp and crab powders? To answer these questions, fish, shrimp and crab powders sold in the Adjamé markets, and those produced in the laboratory were analyzed using appropriate methods.

MATERIALS AND METHODS

Powders of fish, shrimp, crab were taken directly from Adjamé markets from sellers chosen randomly in November 2020. Likewise, other powders of fish (herring), shrimp (Penaeus) and crabs (Callinectes) were made in the laboratory, from fresh samples from Abobodoumé, (Ivory Coast) dried over a wood fire before being transformed into powder (Figure 1). Figure 1a: Sardine fish of the genus *culpeaharengus*; Figure 1b : Shrimp of the genus*Penaeus*; Figure 1c : crabof the genus*Callinecte*

Production of fish, shrimp and crab powders: The animal materials used to make the powders produced in the laboratory were purchased fresh then smoked before being transported to the laboratory. All these samples are dried in an oven at 65°C for 72 hours before being reduced to powders and stored in the refrigerator at 4°C. The dry matter (DM), ash (TC) and lipids contents were determined by the AOAC method (1990) and the humidity level according to the AFNOR standard (1991).

Figure 1a Figure 1b Figure 1c

Figure 1. Animal material used to make powders in the laboratory

The protein contents were determined by the method of Kjeldahl (BIPEA, 1976) and those of minerals by atomic absorption spectroscopy. The digestible carbohydrates contents (TGD) and the energy value (VE) were calculated by the FAO method (2002), according to the following formulas:

TGD = 100 – (Proteins (% MS) + Lipids (% MS) + Fiber (% MS) + Ash (% MS))

VE (Kcal/100g) = 4 x Proteins (%) + 9 x Lipids (%) + 4 x Available Carbohydrates (%).

The results were analyzed using the Sphinx plus V5 software. The comparison of means was based on analysis of variance (ANOVA) followed by the Newman-Keuls test, at the 5% threshold.

RESULTS

Macronutrients contents in fish, shrimps and crabs powders sold at the Adjamé markets: Table I presents the macronutrient contents of the powders sold in the Adjamé markets. Fish powders (5.47 ± 0.06%) and crab powders (7.08 ± 1.80%) have low humidity percentages, less than 10%. However, shrimp powder has a high moisture percentage (11.03% ± 1.82).All of these powders have high protein and ash contents. The values vary respectively from 37.59±1.64% (crab powder) to 61.45±1.90 %(shrimp powder) for protein contents, and from 10.47±0.14 % (fish powder) to 26.93±0.53% (crab powder) for ash contents. However, these powders have low lipids and carbohydrates contents. The values vary respectively from 4.33±0.19% (shrimp powder) to 4.77±0.36% (fish powder) for lipids contents and from 4.43±2.89% (shrimp powder) to 9.45±1.15% (crab powder) for carbohydrates contents. The energy value of fish powder is normal (204.914±7.51 Kcal/100g), that of shrimp powder is lower (201.995±4.29 Kcal/100g) and that of crab powder is lower (164.209± 2.0Kcal/100g).

Macronutrient contents in laboratory-produced fish, shrimp and crab powders: Table II presents the macronutrient contents of the powders produced in the laboratory. All of these powders have low moisture, lipid and carbohydrate contents. The values vary respectively from 3.87±1.33% (crab powder) to 5.00± 1.82% (shrimp powder) for the humidity percentage, 5.73 ±0.59% (crab powder) at 4.83 ±0.55% (shrimp powder) for lipid contents and from 3.34 ±0.95 % (shrimp powder) to 7.22 ±2.52%(crab powder) for carbohydrates contents. However, these powders have high protein, ash and energy contents. The values vary respectively from 44.92± 1.64 % (crab powder) to 78.23 ± 4.55 % (fish powder) for protein contents, from 6.67 ± 0.42 % (fish powder) to 36.93% ±0.46(crab powder) for ash contents and from 183.78 ± 1.59 Kcal/100 g to 268.61 ± 3.45 Kcal/100 g for energy contents.

Mineral contents of fish, shrimp and crab powders sold at the Adjamé markets: The average mineral values of fish, shrimp and crab powders are recorded in Table III. Fish, shrimp and crab powders have high levels of phosphorus (from 9.22±0.41 mg/100g to 13.44±0.8 mg/100g), potassium (from 5.45± 1.1 mg/100g to 6.84±0.6 mg/100g) and calcium (from 6.79±1.3 mg/100g to 17.29±0.43 mg/100g).On the other hand, the sodium contents are between 2.91 ±1.5 mg/100g and 4.00 ±0.56 mg/100g. Likewise for chlorine contents which is between 1.89 ± 0.5 mg/100g and 2.87 ± 0.4 mg/100g. As for the other trace elements, namely magnesium, sulfur, iron, copper and zinc. The levels of zinc are between 0.09 ± 0.00 mg/100g and 1.85 ± 0.22 mg/100g). The sodium, chlorine, potassium and calcium contents arenot statistically differentin fish and shrimp powders, but higher than those in crab powder. The phosphorus content of fish powder is higher than that of shrimp powder which is significantly equal to that of crabs. There is no significant difference between the copper contents in shrimp and crab powders.

Mineral contents of fish, shrimp and crab powders produced in the laboratory: Table IV presents the mineral contents of the powders produced in the laboratory. The results show that the sodium content is higher in fish powder (4.62 ± 0.5 mg/100g) than in shrimp powder (4.05 ± 0.2 mg/100g), which is significantly higher than that of crab powder (1.31 ± 0.7 mg/100g). The level of magnesium is statistically higher in fish powder (2.21 ± 0.2 mg/100g) compared to shrimp and crab powders which have statistically identical levels.Concerning phosphorus, the content is higher in fish powder (14.32 ± 0.7 mg/100g) than in shrimp powder with a value of 10.33 ± 0.6 mg/100g. The lowest content is determined at the level of crab powder (2.97 ± 1.24 mg/100g). In terms of sulfur content, crab powder has a significantly higher content (0.47 ± 0.9 mg/100g) than shrimp powder (0.43 ± 0.4 mg/100g), which is even higher than that of fish powder (0.40 ± 0.3 mg/100g). Fish and crab powders have statistically the same chlorine contents (1.61 ± 0.9 mg/100g and 1.64± 0.5mg/100g) which are significantly lower than the chlorine content of shrimp powder (2.82 ± 0.2 mg/100g). There is a significant difference between the potassium contents of the different powders studied. Fish powder has the highest value (15.81 ± 0.8 mg/100g) followed by shrimp powder (7.21 ± 0.45 mg/100g) and finally crab powder (1.26 ± 0 .61 mg/100g). The same is true for iron with values of 0.28 ± 0.1 mg/100g, 0.17 ± 0.7 mg/100g and 0.05 ± 0.03 mg/100g respectively for fish powder, crab and shrimp. The results show that fish and crab powders have significantly identical copper contents but lower than that of shrimp powder. Calcium contents are statistically higher in crab powder (29.67 ± 10.62 mg/100g) followed by shrimp powder (16.34± 0.81 mg/100g) then fish powder (5.34 ±0.52 mg/100g).

DISCUSSION

The interest of this study was to evaluate the biochemical characteristics of fish, shrimp and crab powders sold at the Adjamé markets in comparison with those produced in the laboratory, according to the process indicated by the sellers. The humidity percentages of all these flours are low, less than 10% with the exception of the shrimp powder sold at the Adjamé market which was 11.03%. This is beneficial because the reduction of fish and shellfish to powder generally aims for better preservation through minimizing the risks of deterioration and growth of harmful microorganisms (Echendu *et al*., 2009). The low lipid contents of the powders studied are justified by the fact that the lipid content of fish flesh varies from one species to another because the preferential lipid storage organs (liver, subcutaneous adipose tissues, tissues perivisceral adipose, muscle tissue) differ depending on the species. Thus, for lipids in fish flesh, the contents vary from less than 1 g/100 g to more than 18 g/100 g depending on the capacity of the species to store them as energy reserves in its muscle tissues (Vincent *et al*., 2020). In addition, even within the same species, the lipid content of the flesh increases with the size of the animals but can also vary depending on the season, the reproduction and feeding cycle (Médale, 2010). These fluctuations are more marked for fatty species from fishing. For example, in sardines, the lipid content of the muscle varies from 1.2 g/100 g in March, after spawning, to 18.4 g/100 g in September (Bandara*et al*., 1997). The species used to produce the powders is lean herring with lipid contents ranging from 3.7 to 4.5 g/100 g. The results corroborate those published by FAO/INFOOD (2019). As for shrimp and crab powders, our results reveal that they are richer in lipids than those in FAO (1979) on crustaceans (4.63 to 5.73%). Fish and shrimp powders are generally richer in protein than those from crabs. All three types of powders studied were found to be richer in protein (44 to 78 g/100 g of dry matter) than fresh fish (18 to 27 g/100 g of fresh matter) depending on the species.

Table I. Macronutrient contents, humidity and energy value of fish, shrimp and crab powders sold in the Adjamé markets

Biochemical parameters	Type of powders		
	Fish	Shrimp	Crabs
Humidity (%)	05,47±0,06[c]	11,03±1,82[a]	07,08±1,80[b]
Ash (%)	10,47±0,14[c]	13,40±0,23[b]	26,93±0,53[a]
Lipids (%)	04,77±0,36[a]	04,33±0,19[a]	04,63±0,59[a]
Proteins (%)	59,03±4,55[a]	61,45±1,90[a]	37,59±1,64[b]
Carbohydrate (%)	05,87±4,67[b]	04,43±2,89[b]	09,45±1,15[a]
Energy value (Kcal/100g)	204,914±7,51[a]	201,995±4,29[b]	164,209±2,0[c]

Each mean ± standard deviation are fromtests performed in triplicate. Analysis of variance followed by the Newman-Keuls multiple comparison test at the 5% threshold. The letters a, b, c in super script follow the means from the Newman-Keuls mean ranking test; on the same line, means followed by different letters are significantly different (P ≤0.05).

Table II. Macronutrient contents, humidity and energy value of fish, shrimp and crab powders produced in the laboratory

Biochemical parameters	**Type of powders**		
	Fish	**Shrimp**	**Crabs**
Humidity (%)	4,07±0,12[b]	5,00 ± 1,82[a]	3,87±1,33[c]
Ash (%)	6,67±0,42[c]	10,93±0,23[b]	36,93±0,46[a]
Lipids (%)	5,17±0,06[a]	5,73±0,59[a]	4,83±0,55[a]
Proteins (%)	78,23±4,55[a]	73,80±1,90[b]	44,92±1,64[c]
Carbohydrate (%)	4,23±1,07[b]	3,34±0,95[c]	7,22±2,52[a]
Energy value (Kcal)	268,61±3,45[a]	243,85±5,27[b]	183,78±1,59[c]

Each mean ± standard deviation are from tests performed in triplicate. Analysis of variance followed by the Newman-Keuls multiple comparison test at the 5% threshold. The letters a, b, c in super script follow the means from the Newman-Keuls mean ranking test; on the same line, means followed by different letters are significantly different (P ≤0.05).

Table III. Average value of fish, shrimp and crab powders sold at the Adjamé market

Trace elements (mg/100g)	Types of powders		
	Fish	Shrimp	Crab
Sodium	4,00±0,56[a]	3,70±0,7[a]	2,91±1,5[b]
Magnesium	1,34±0,05[c]	1,85±0,22[b]	0,49±0,09[a]
Phosphorus	13,44±0,8[a]	9,22±0,41[b]	10,52±1,4[b]
Sulfur	0,15±0,4[c]	0,48±0,5[b]	0,72±0,2[a]
Chlorine	2,83±0,3[a]	2,87±0,4[a]	1,89±0,5[b]
Potassium	6,61±0,5[a]	6,84±0,6[a]	5,45±1,1[b]
Iron	0,19±0,5[a]	0,14±0,2[b]	0,19±0,1[a]
Copper	nd	0,29±0,3[a]	0,32±0,01[a]
Calcium	17,29±0,43[a]	16,78±0,7[a]	06,79±1,3[b]
Zinc	0,10±0,6[b]	0,14±0,6[a]	0,09±0,0[c]

Each mean ± standard deviation are from tests performed in triplicate. Analysis of variance followed by the Newman-Keuls multiple comparison test at the 5% threshold. The letters a, b, c in super script follow the means from the Newman-Keuls mean ranking test; on the same line, means followed by different letters are significantly different (P ≤0.05).

Table IV. Average value of minerals in fish, shrimp and crab powders prepared in the laboratory

Trace elements(mg/100g)	Types of powders		
	Fish	Shrimp	Crab
Sodium	4,62± 0,5[a]	4,05±0,2[b]	1,31±0,7[c]
Magnesium	2,21±0,2[a]	1,56±0,1[b]	1,76±0,8[b]
Phosphorus	14,32±0,7[a]	10,33±0,6[b]	2,97±1,24[c]
Sulfur	0,40±0,3[c]	0,43±0,4[b]	0,47±0,9[a]
Chlorine	1,61±0,9[b]	2,82±0,2[a]	1,64±0,5[b]
Potassium	15,81±0,8[a]	7,21±0,45[b]	1,26±0,61[c]
Iron	0,28±0,1[a]	0,05±0,3[c]	0,17±0,7[b]
Copper	0,07±0,01[b]	0,23±0,06[a]	0,06±0,01[b]
Calcium	5,34± 0,52[c]	16,34±0,81[b]	29,67±10,62[a]
Zinc	nd	0,22±0,2	nd

Each mean ± standard deviation are from tests performed in triplicate. Analysis of variance followed by the Newman-Keuls multiple comparison test at the 5% threshold. The letters a, b, c in super script follow the means from the Newman-Keuls mean ranking test; on the same line, means followed by different letters are significantly different (P ≤0.05).

These high values could be explained by the fact that the fish, shrimp and crabs were dried before the dosage. Furthermore, given that the proteins measured could be myofibrillar proteins, they are more concentrated in fish flesh (70 to 80%) than in meat (FAO/INFOODS, 2019). In fact, fish contain less insoluble protein (3 to 10%) than meat, the content of which varies from 16 to 28% (Haard, 1995). These high protein contents make powdered fish an excellent source of protein, necessary for the growth of children and the maintenance of adults. In addition, fish proteins are richer in essential amino acids and more digestible than those from meat (Médale*etal*., 2003).

The digestibility of fish proteins presents an advantage for the nutrition of people with a failing digestive system. Animal products are the main source of animal proteins, hence their high protein contents, as shown by Tokpa (2020) working on the heads and headed parts of fish consumed in Côte d'Ivoire. Due to their peptides which promote their high digestibility, these proteins constitute an important resource in animal and human nutrition (Heu*et al*, 2003). In human food, peptides are of particular interest due to the fact that they have functional properties, which allow them to play a role in the organoleptic characteristics of foods or in their shelf life.

One of the main reasons for carrying out enzymatic hydrolysis of fish powders and other co-products of marine origin is the search for peptides with functional properties. Thus, for example, the hydrolyzate of herring co-products presents a solubility, lipid binding and emulsifier property (Sathivel*etal*., 2003). The three protein sources from fish, shrimp and crab powders have low carbohydrate contents. However, the fish powders collected from the markets of Adjamécontained more important source of carbohydrates than those produced in the laboratory.As a fact, the very high carbohydrate content of the powders collected from the Adjamé markets is believed to be due to fraudulent mixtures made by the producers. In fact, they would use less expensive carbohydrate sources such as corn, millet, etc. to have large quantities of powders in order to increase their income. In fact, carbohydrates being the majority components of cereals (Cruz *et al*., 2019), they would surely be the basis of this increase in carbohydrate levels. The consumption of these powders purchased on the Adjamé markets, a priori very rich in carbohydrates accompanied by carbohydrate foods, could make the meal very unbalanced and be a nutritional risk (Smith *et al*., 2013). The dosage of these ashes made it possible to detect the presence of thirteen mineral substances: sodium, magnesium, phosphorus, sulfur, chlorine, potassium, carbon, iron, copper, oxygen, calcium, zinc and aluminum (Coward-Kelly *et al*., 2006). Overall, these minerals are present but all in small quantities regardless of the origin of the powder. Despite the minimal quantities, these minerals are essential to humans because they play an important role in strengthening the bone system of children, in controlling water balance (osmotic pressure), in establishing acid base balance. In addition, minerals are part of the composition of enzymes and hormones and catalyze numerous metabolic reactions (Schapira, 1981). In the marine environment, calcium is in the form of calcite ($CaCO_3$) or divalent ion (Ca^{2+}). Fish bones and skeletons as well as crustacean exoskeletons are potential sources of calcium. To incorporate it into fortified foods, calcium must be converted into a form that is more assimilable by the body. Treatments with hot water or hot acetic acid were carried out (Jung *et al*., 2007). A study also showed that hydrolysis with Pepsin and acetic acid leads to the dissolution of mineral and organic elements in fish bones (Bhushan and Jung, 2006).

Overall, the fish, shrimp and crab powders produced in the laboratory have practically the same compositions as those reported in the literature. However, the powders taken directly from the Adjamé markets present some differences, notably a greater richness in carbohydrates and low contents of some minerals. Furthermore, the moisture, lipid and mineral content of the powders also varied depending on the species considered. These differences could be explained by dietary diversity between species (Calado*et al*., 2005), but also by biological diversity between species and environments (Karakoltsidis*et al*., 1995; Luzia e*t al*., 2003; Sampaio*et al*., 2006). The shrimp used for the production of shrimp powder in the laboratory consist mainly of a single species *Penaeusmonodon*, raised in tanks, with an environment and a diet controlled so as to obtain maximum growth.All species of fish, shrimp and crabs can be described as wild because they come from the sea with an uncontrolled diet. The biochemical and morphological characteristics of the three species studied (fish, shrimp, crabs) justify the significant differences at the threshold of 5% in the composition of their tissues and therefore in the variability of living organisms. So for proper use of these powders for food fortifications in industry, it is necessary to know these compositions before carrying out certain operations such as obtaining flour, drying and evaluating certain nutritional properties for supplementation.

CONCLUSION

The fish, shrimp and crab powders studied represent a real source of proteins and mineral elements, which makes them essential foods for the growth of children and the proper functioning of the body. However, the carbohydrate concentration of the powders taken directly from the Adjamé market forum indicates inappropriate practices such as mixing powders and other ingredients (corn flour, etc.).

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