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Assessment of fish by-products in market environment of Douala and determination of their nutritional value

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Abstract

To assess the fish by-products released, we surveyed 158 fish pre-caterers and 33 structures in 12 markets in Douala. A random sample of these by-products was used for bromatological analysis. Oils extracted from these samples were characterized by determining some chemical indexes. Investigation showed more than 238 tons of by-products are annually released into the environment of the observed markets. Flour Analysis of by-products showed a moisture content of $22.04 \pm 0.03\%$, $50.29 \pm 0.02\%$ proteins, $29.03 \pm 0.15\%$ ash, $20.3 \pm 0.03\%$ lipids, $0.37 \pm 0.15\%$ total carbohydrates, and mineral elements such as calcium (6.08 ± 0.002 g / kg), phosphorus (7.093 ± 0.003 g / kg), and iron (328 ± 2.65 mg / kg). Analyses of chemical indexes of the oil extracted showed that they were within the range of Codex Alimentarius standard values. It can be concluded that Douala market's fish by-products are of good nutritional quality and could therefore be used in animal nutrition.

Keywords: fish pre-caterers, fish by-products, damaged fish, nutritional value

1. Introduction

Recent trends around the world point to a decline in landings from capture fisheries, indicating that fish stocks have reached or even exceeded the point of maximum yield [1]. Faced with this situation, aquaculture becomes the only viable alternative for increasing fish production in order to meet the protein needs of the world population. Aquaculture, possibly the steadily and rapidly growing food production sector, currently provides almost 50% of the fish consumed worldwide. This sector of activity is therefore considered to have the greatest potential to meet the growing demand for aquatic food [2]. However, although aquaculture is a solution, the fact remains that it presents certain limitations because of many difficulties, including feeding the species to be reared. In the case of fish farming, fish require a high protein intake for their growth. Fishmeal is generally the major component of feed in aquaculture, but its high purchase price has directed research towards alternative sources of protein. In addition, using fishmeal and fish oil from wild fish (minority fishing) to produce farmed fish has been a subject of strong controversy for many years [3]. In a somewhat schematic way, we can say that we produce fish with fish. Even though fish are good suppliers of ingested protein, it will readily be agreed upon that the primary objective must be the production of quality animal protein for human nutrition from other protein sources. The yield of fishmeal catches varies from 20 to 25% and the yield of fish oil varies from 5 to 12% [4]. This poses a real problem in the face of the objective of food security for the less well-off local populations, and in terms of employment, the processing sector of the same products targeted by the milling industry is already a source of many jobs, particularly for women [3]. In order to preserve natural resources while allowing a sustainable development of aquaculture, it is therefore imperative to use other types of raw materials. Global fish consumption generates a significant amount of by-products in the form of heads, guts, bones, tails, fins and skins which are left in the wild or in garbage cans. These fish wastes are excellent sources of protein, fat and minerals. The discharge of such wastes represents a major environmental problem because of their high moisture content and unpleasant odor [5].

In Cameroon, to the extent of our knowledge, no study has been carried out on the assessment of these by-products released into the market environment, yet they have a very high nutritional value. The objective of this study is to make an assessment of the typology and quantity of fish by-products released in to the environment of the city of Douala and to determine their nutritional value.

2. Material and Methods

Two types of fish by-products were used for this study. Fish pre-treatment by-products and spoiled fish from the markets. Fishmongers and warehouses in the city of Douala were also included in the study. Two surveys were carried out simultaneously in the city, the main objectives were to identify the fate of the fish by-products. Twelve (12) markets in the city were visited namely Youpwé, New-bell, "Grand Hangar", Essengue, New-Deido, Sandaga, Saker, Bonaberi "Grand Hangar", Bonaberi "Bonassama", Akwa Nord, Bonamoussadi and Cite de Palmier. Two questionnaires were used, the first which provided information on the actors, cleaning practices, the type of pre-treated by-product, the quantities and fate of by-products in the markets and the second, which provided information on the types of factories, the quantity of damaged products and their fates. Because of their proximity to the laboratory, the organization of the actors and the accessibility to by-products, Youpwé and New-bell "Grand Hangar" were used for the evaluation of the quantity of pre-treated by-products. By-products of each market were weighed daily for a period of 21 days using an

electronic scale (Diamond brand, capacity 40kg ± 5g). During this period, samples of by-products collected randomly were dried in an oven at 55 °C for an average time of 15 hours. The dried by-products were crushed with a blender processor until a yellow powder was obtained. Contents of moisture, ash, minerals (Ca, Mg, K, Na, P, Zn, Cu, Mn and Fe), total proteins (Kjeldahl method) were determined by AOAC methods [6] and total carbohydrates was claculated by the method of difference. Lipid contents were determined by Soxhlet method [7]. Lipid was characterized by determination of its peroxide, anisidine, acid and iodine indexes [8], and total oxidation [9]. Statistical analysis of the results was done using Microsoft Excel 2013 and SphinxPlus.V5.TuiTe software.

3. Results and Discussion

3.1.1 Assessment of types and quantities of fish by-products

3.1.1.1 Pre-treatment and by-products

3.1.1.1.1 Actors

The survey was carried out in 12 markets of the city of Douala. 158 fish pre-caterers were identified and questioned. This activity was shown to be carried out only by Cameroonians, and was highly dominated by males (98.7%) against 1.3% female. Christians were predominant (78.5%), followed by muslims (8.9%) and others religions (12.7%). Figure 1 show the percentage of pre-caterers according to their nationality, gender and religion.

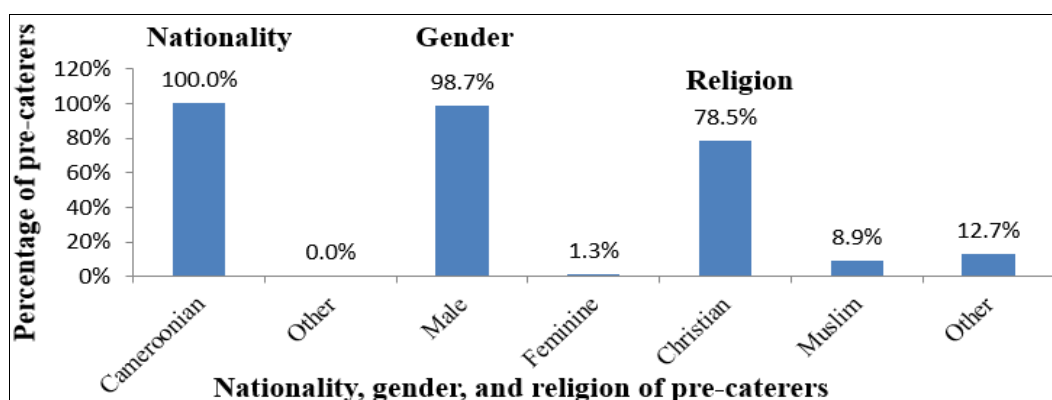


Fig 1: Percentage of pre-caterers according to their nationality, gender and religion

Young adults (20 to 40 years old) were more present in the market environment (84.8%) than older people (2.5%). Many were high school drop-outs (57%) and 1.3% were illiterate. Matrimonial status consisted of 36.7% single, 29.1% married

and 1.3% widowers. Figure 2 shows the percentage of pre-caterers according to their age, educational level, and marital status.

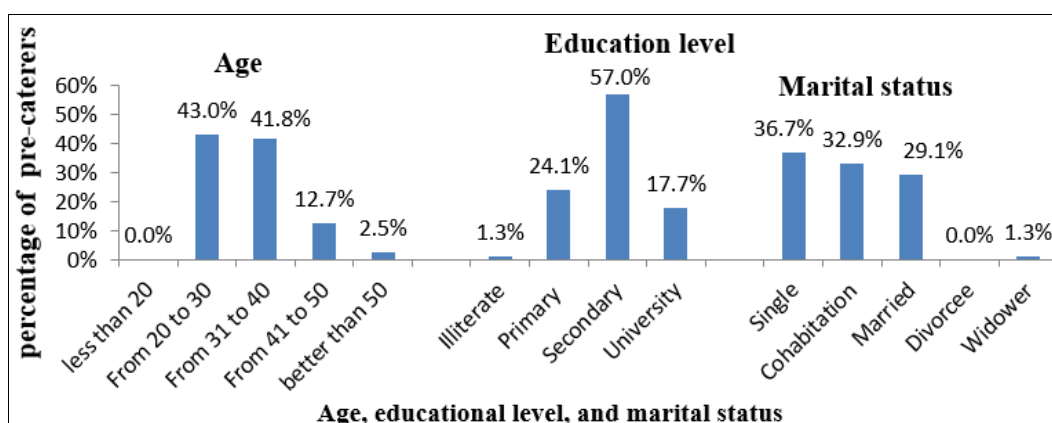


Fig 2: Percentage of pre-caterers according to their age, educational level, and marital status

Amongst these individuals 67.1% practiced pre-treatment of fish as a main occupation against 32.9% who did it as a temporary or secondary occupation. 53.2% did not have a secondary job, 35.4% worked in the informal sector highly dominated by fish dealers and deliverers in restaurants, hotels and individual homes. We also found that 3.8% worked in the formal sector strongly represented by teachers, security

guards, 6.3% students and some pupils (1.3%). Figure 3 shows the percentage of pre-caterers according to the perception of the profession of fish pre-caterers.

RAS: Unique profession exercised; **A:** Informal sector; **B:** Formal sector

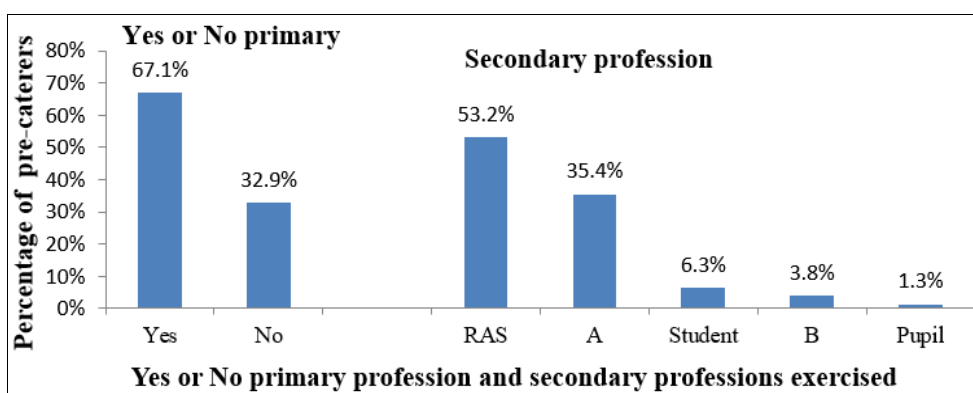


Fig 3: Percentage of pre-caterers according to the perception of the profession of fish pre-caterers.

3.1.1.1.2 Typology and fate of fish pre-treatment by-products

Amongst the fish by-products produced in these markets, scales were always present (100%) followed by viscera, gills

(97.5%) and heads (94.9%). Figure 4 shows the percentage of pre-caterers based on the probability of the presence of a type of fish by-product in these markets.

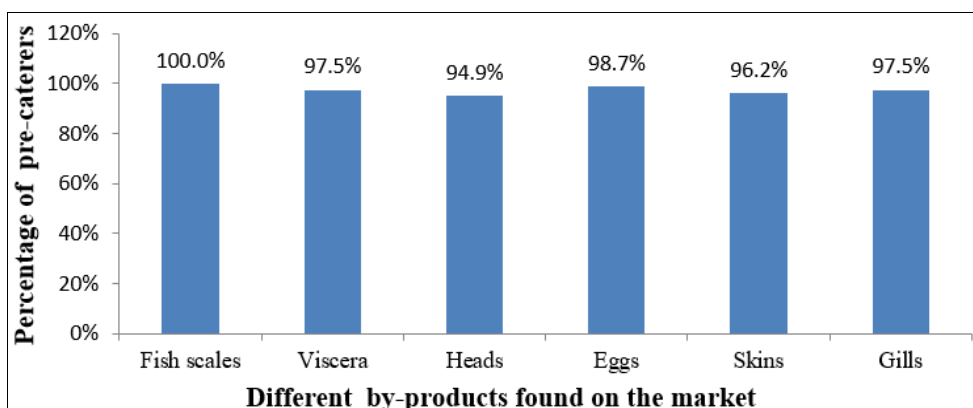


Fig 4: Percentage of pre-caterers based on the probability of the presence of a type of fish by-product in these markets Some by-products are valuable in these markets, and they are shown in Table I.

Table 1: The different by-products valued in these markets

By-products	Sold	Consumed	Used	Sale price	Purpose
Swin Bladder	X			80 to 210 thousand CFA francs per kg	To produce sutures and objects in medicine and purchased by nigerians
Gills	X	X		5000 FCFA the 10L bucket	For marine mammal fishing
Bibs	X	X		100 to 2000 FCFA	To housewives and Chinese
Hoses	X	X			
Egg	X	X	X	500 FCFA	For treatments or rituals
Heart	X	X	X		
Carcass (skins, heads, and stops)	X	X		2000 to 15000 FCFA	To housewives or fish sellers

As shown in table I, the quantity to price ratio of bibs, casings, eggs, hearts and carcasses is highly different. Swim bladder sizes ranged from smallest to largest depending on the size of the fish. The most popular came from *Polydactylus quadrifilis* and *Pseudotolithus* spp. Bibs are located along the abdomen of *Pseudotolithus* spp. Casings from large fish were mixtures of lungs, stomach and long intestines that were bought by chinese and housewives from the fish pre-processors in new-bell market.

Swim bladders and carcasses were the two types of by-products regularly sold or consumed in these markets. As for the other by-products, the sales are done according to customer needs. Regardless of the value of the by-products in these markets, there is always an important amount of waste poured into the environment because the collection of by-products in these markets is done by sorting. Figure 5 shows the percentage of pre-caterers according to the perception of the fate, exploitation, selling price and

recipients of fish by-products. The predominant fate (43%) of fish byproducts in these markets was throwing, selling and eating. At least 16.5% released by-products into the

environment. Nearly 60.8% did selling after sorting against 22.8% who sold the entire products Figure 5 shows the percentage of pre-caterers according to the perception.

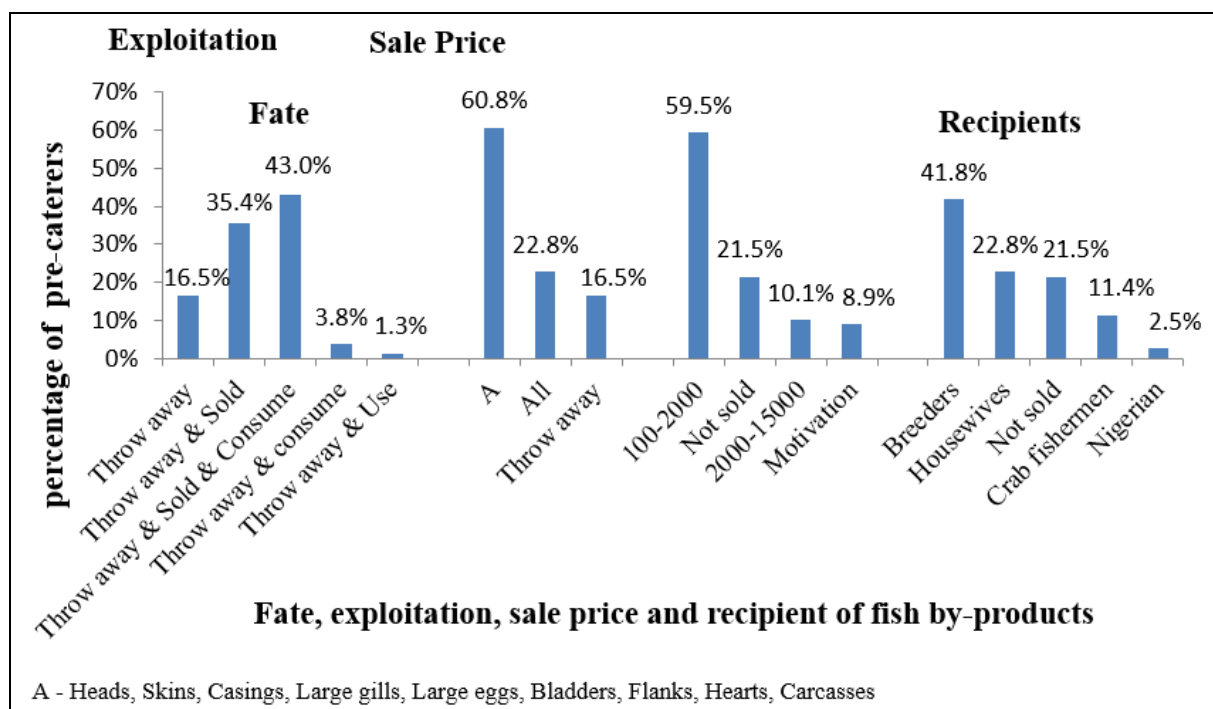


Fig 5: Percentage of pre-caterers according to the perception of the fate, exploitation, sale price, and recipients of these fish by-products

3.1.1.1.3 Quantity of by-products

We found that about 13.16 ± 12.28 kg of by-products were generated by each pre-processor per day and 40.5% produce

less than 10 kg/day. Only 2.5% produced more than 50 kg/day. Figure 6 shows the percentage of pre-caterers based on the amount of fish by-products produced per day.

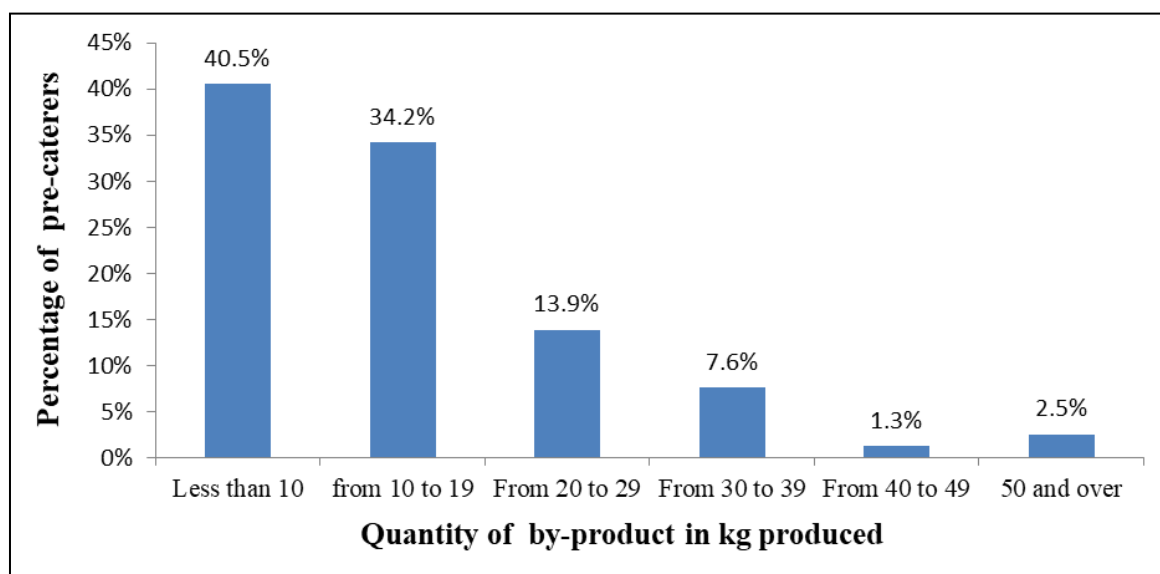


Fig 6: Percentage of pre-caterers based on the amount of fish by-product produced per day

The differences between individuals depend on the seniority of pre-caterers and their confidence towards clients. Senior master fishing processing technics such as filleting and trimming? So some customers choose pre-caterers based on

the quality of cleaning, the ability to detect fish of good quality and the rate of home services. Results of by-product weighings are shown in Table II.

Table 2: Average value (kilograms) of by-products collected per day in two markets of Douala city

	Average waste In kg	Average of co-products In kg	Total by-products In kg
Youpwe market	63.85±24.23	26.25±10.37	90.09±34.59
Central market	121.37±24.64	24.64±7.12	146.01±44.28

Each value is the mean ± standard deviation (n = 21 days)

By-products are mainly recovered by cattle breeders, but due to the lack of conservative methods, purchase of these products is irregular. Housewives also collect it for domestic consumption, fishermen for fishing activities. Nigerian traders use bladders to make surgery sutures. Heart and fat are used in traditional medicine.

3.1.1.1.4 Quantitative estimate of by-products released into the environment of the markets

The average daily waste produced by each fish pre-caterer was 13.16 ± 12.28 kg. At least 16.5% (n=158) dumped their by-products in the environment. The average waste weight for the two markets is shown in table III.

Table 3: Quantitative estimation of fish by-products released into the environment of the markets

	Day/T		Month/T		Year/T	
	Min	Max	Min	Max	Min	Max
Surveys	0.023	0.663	0.688	19.897	8.259	238.759
Youpwe market	0.039	0.088	1.188	2.642	14.263	31.709
Central market	0.096	0.146	2.902	4.380	34.823	52.564

Over 8 to 238 tons of by-products are released into the environment each year. At Youpwe market up to 31 tons of fish waste and over 52 tons at New-Bell market were released into the environment each year.

fish shops, supermarkets, and warehouses opened between 1990 and 2018.

Most of the people (72.73%) purchased fish daily and 9.09% each three months. Meanwhile fish wastes are produced throughout the year with a monthly percentage of 36.36%. Figure 7 is the frequency of fish supply and occurrence of damaged fish in the structures surveyed.

3.1.1.2 Damaged fish

3.1.1.2.1 Presentation of the prospected sites

Thirty-three (33) companies were visited for the study namely

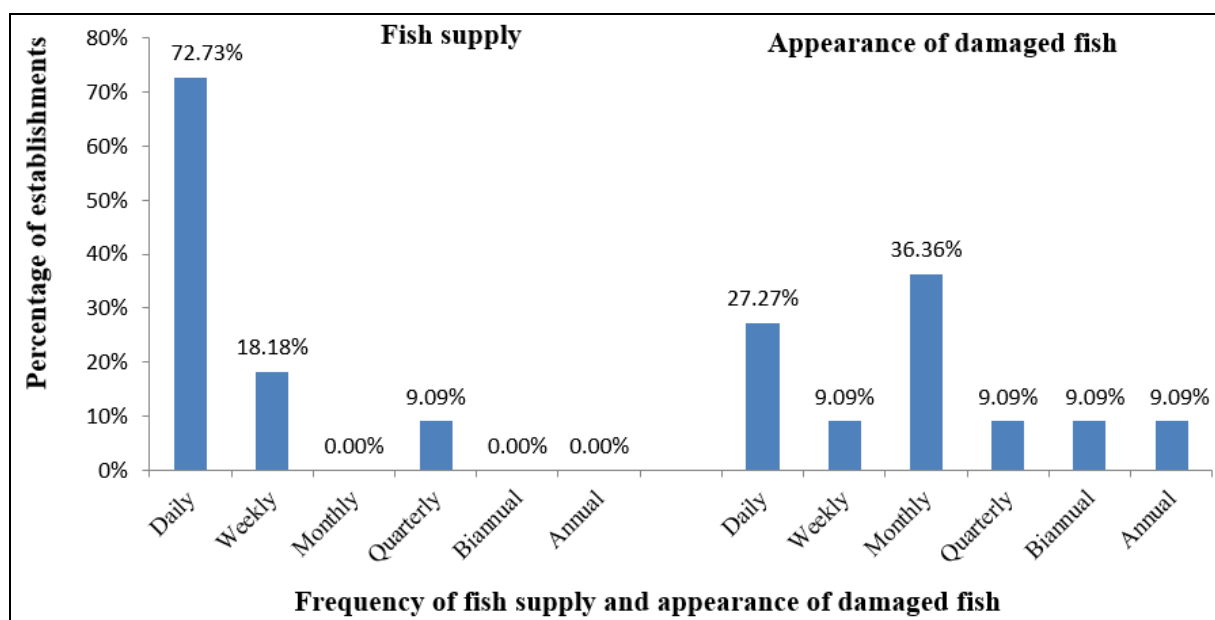


Fig 7: Frequency of fish supply and occurrence of damaged fish in the structures surveyed

Amount of fish supply ranged from 35 kg to 1.500 tons per day and the quantity of waste released per year varied from 0.5 to 2000 kg with 63.64% of companies producing less than 100 kg of damaged fish. A large majority of these companies (72.73%) claimed to throw away this damaged fish against 27.27% who still do selling in spite of the poor quality, either directly or in the form of smoked fish.

About 81.82% of the visited companies were able to value damaged fish against 18.18% who thought it unnecessary. This was the case of some supermarkets or poor fish shops which at certain moments offer such damaged fish to their staff. Figure 8 gives the frequency of the fate of damaged fish and perception of valuation at the level of the establishments surveyed.

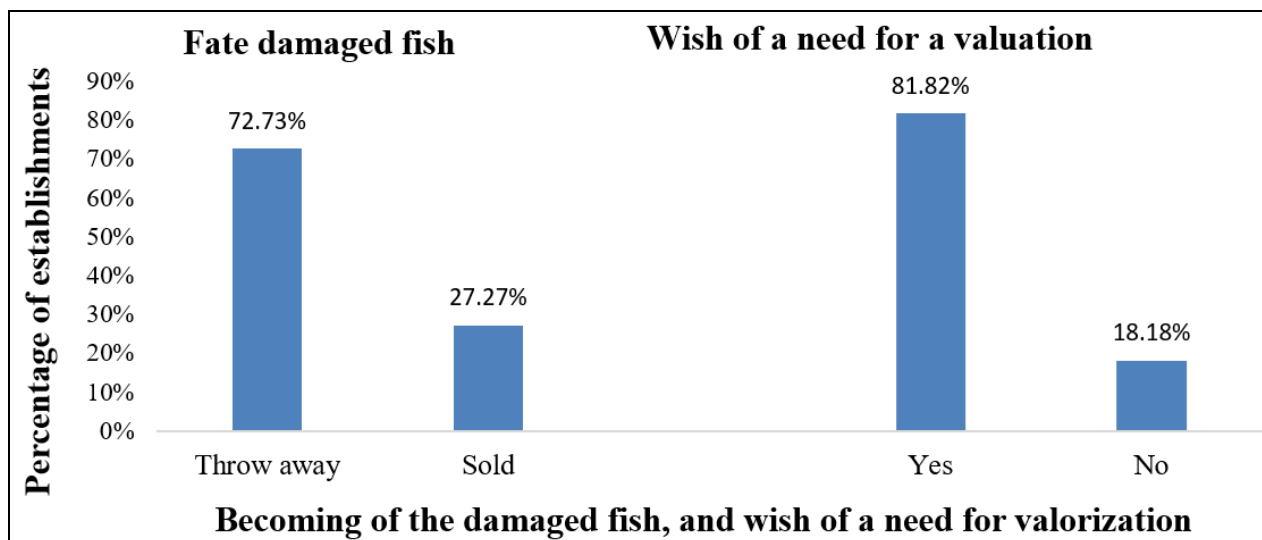
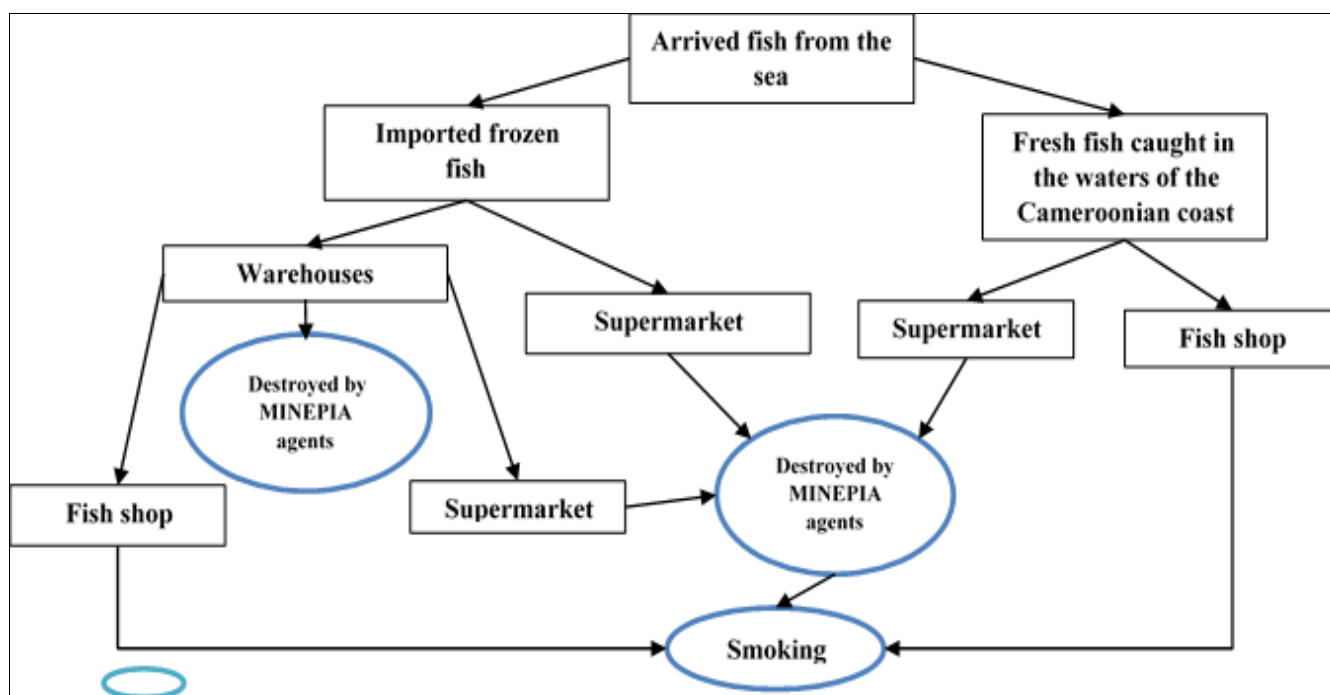


Fig 8: Frequency of fate of damaged fish and perception of valuation at the level of the establishments surveyed.

3.1.1.2.2 Fate of damaged fish

Figure 9 shows that damaged fish had two fates: destruction

by MINEPIA sanitary control agents near the warehouses or smoking which is widely used by the majority of fishmongers.



MINEPIA: Ministry of Livestock, Fisheries and Animal Industries

Fig 9: Fate of damaged fish in the markets of Douala

3.1.2 Chemical analysis of by-products

By-products collected and analyzed were mainly gills and viscera. The following results were obtained from a powder of

the by-products. Table IV shows their macronutrient and micronutrient contents.

Table 4: Chemical composition of fish by-products

Macronutrients	Moisture	Protein	Fat	Ash	Total Carbohydrates		
Content (% DM)	22.04±0.03	50.29±0.02	20.3±0.03	29.03±0.15	0.37±0.15		
Macroelements (g/kg)	Ca	Mg	K	P	Na	Ca/P	Na/K
Content	6.08±0.002	0.93±0.0025	1.37±0.0006	7.093±0.003	0.351±0.004	0.857	0.256
Microelements (mg/kg)	Zn	Mn	Cu	Fe			
Content	75.15±0.02	17.67±0.02	39.39±0.03	328±2.65			

The values presented are means and their standard deviation (\bar{x} , δ). n = 3; DM: Dry Matter

They are rich in proteins (50.29 ± 0.02%), followed by ash and lipids respectively. Carbohydrate content was low. Phosphorus was the most abundant mineral (7.093 ± 0.003%)

followed by calcium. Sodium content was low. Calcium/phosphorus ratio was high (0.857) and that of sodium/potassium (0.256) was low. Iron content was the

highest (328 ± 2.65 mg/kg) followed by zinc and copper. Table V shows the values of some chemical indices of the by-products used in this study. Acid number was high ($78.95 \pm$

0.42 mg KOH/kg of oil) when compared to other indices such as peroxide and anisidine indexes.

Table 5: Values of the indices of the by-products studied

Indices	Pi (mg / kg of oil)	An.i (mg / kg of oil)	TOTOX (mg / kg of oil)	Ai (mg KOH/kg of oil)	Ii (mg / kg of oil)
Content n=3	0.79±0.02	0.52±0.008	2.10±0.03	78.95±0.42	66.83±1.78

Pi: Peroxide index

An.i: Anisidine index

TOTOX: Total oxidation index

Ai: Acid index

Ii: Iodine indice

4. Discussion

Results showed that fish by-products are released into the market environment of Douala as waste. This waste can be used to fill the gap in the local need of fish for Humans or animals [10]. Meat flour from slaughterhouse waste is one of the best sources of protein for domestic animals [11]. It is also used in the human diet, and for cosmetics [12]. Wastes produced by fish processing are increasingly used in human and animal diets. Animal food and fish flour are mainly being produced using these by-products. Fish flour is the first source of protein used in animal breeding because of its high protein content [13]. Producing flour from fish waste is a good example of valorization of fishing by-products. Valorisation of waste has a positive effect on the environment and contributes significantly to fish feeding [14]. The main concern is to make the waste a renewable and recoverable resource that can be introduced as much as possible as a secondary raw material in fish feeding [15]. This fits with the circular economy which is based on the flow of materials and requires respect of ecological principles and a rational use of natural resources to ensure sustainable development¹⁶. Damaged fish practically follows two pathways, both of which have consequences. The first pathway is consumers who buy these products in smoked form and can be victims of poisoning, as a result of bacterial toxins [17]. The second pathway is linked to importers because destruction of tons of products by the sanitary control agents of the MINEPIA cause serious investment costs [18]. Meanwhile, access to such damaged fish is only possible if a valuable treatment method is used. Chemical composition of by-products showed protein content lower than that of commercial fish flour (68 to 70%) and a greater fat content (8 to 11% and 14 to 16%) [19]. The same results were obtained on the *Pseudolithus senegalensis* fillet with a protein content of 66.75%, higher than those of the by-products [20]. By-products of *Pseudolithus typus* showed protein ($59.81 \pm 0.17\%$) and total carbohydrate ($0.75 \pm 0.46\%$) contents higher than those of by-products [21]. Protein and carbohydrate contents found are within the range of values defined by Stansby [22] and Love [23], making these by-products good sources of nutrients for humans. The mean value of the calcium/phosphorus ratio is higher than those found by Ndômbôl [21] and Bayong [24] on the edible part of *Polydactylus quadrifilis* (Fresh captain 0.150 ± 0.188), but the values were lower than that found by Nyemb [25] on the edible part of *Pseudolithus typus*. The Sodium/Potassium ratio is lower than that of Bayong²⁴ on the edible part of *Polydactylus quadrifilis* (Fresh captain 2.010 ± 0.000). The contents of iron, magnesium, phosphorus, calcium and zinc found in this study show that these fishery by-products can be a good source of minerals for humans or animals [26]. The zinc content is higher than that obtained by Yanga [27] in the edible parts of some fish from the Cameroon coast including

Pseudolithus typus (12.4 mg / kg dry weight), *Pseudolithus elongatus* (14.7 mg/kg and *Pseudolithus senegalensis* (14.8 mg / kg). But the values were lower than those obtained by Ndômbôl [21] on the by-products of *Pseudolithus typus* (86.15 ± 6.81 mg / kg). The iron contents show higher values than those of Njinkoue *et al.* [28] in *Pseudolithus typus* (18.9 mg / kg dry weight), *Pseudolithus elongatus* (24.0 mg/kg dry weight) and *Pseudolithus senegalensis* (23.7 mg / kg). Similarly, the calcium content was higher in *Pseudolithus typus* (139 mg/kg dry weight), *Pseudolithus elongatus* (125 mg / kg dry weight) and *Pseudolithus senegalensis* (137mg/kg) as well as phosphorus in *Pseudolithus elongatus* (123 mg/kg) and *Pseudolithus typus* 112 mg/kg [28]. The iodine number provides information on the degree of unsaturation in oil and makes it possible to classify non-drying (II <100), semi-drying (100 <II <130) and drying (II > 130) oils. Therefore oils in our by-products would be non-drying. The acid number measures the amount of free fatty acid present in a fatty substance. These results are lower than the standard (4 mg KOH/g) recommended by the Codex Alimentarius [29]. This could be explained by a low hydrolytic activity [30]. The peroxide number measures the primary oxidation products in an oil. However, this index is only an indicator of the onset of oxidation [31]. The higher it is, the more the fat is oxidized. Our results comply with the standard values, which must be less than or equal to 5 milliequivalents. The anisidine number measures the by-products of oil oxidation and takes into account non-volatile aldehyde compounds. The values obtained in our study are lower than that recommended by the Codex Alimentarius [29] which stipulates that for virgin fats and oils, the anisidine index must be less than [20]. The total oxidation index gives a better evaluation of the oxidation state of the fat, taking into account the different forms of fatty acid oxidation. The values obtained are lower than those recommended by the Codex Alimentarius, ≤ 26 oil for virgin fats and oils [29]. It is possible to find a high peroxide index in a fat which has not yet shown obvious signs of rancidity such as the smell of rancidity, attributable to volatile aldehyde compounds. Conversely, a low peroxide number does not mean that a fat is not altered. Results show that the iodine number is lower than that obtained on the by-products of *P. typus* and a higher value for the other indices [21].

5. Conclusion

The assessment of fish by-products released into the market environment of Douala shows that certain by-products are valued in these markets. They are rich in macro and micronutrients available for human and animal nutrition. Recovery cannot however significantly reduce the great amount of fish waste thrown each year in the environment of Douala City.

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