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RESEARCH PAPER

Fish By-Products Consumption and Discard Pattern in Nigeria

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استهلاك المنتجات الثانوية من الأسماك ونمط التخلص منها في نيجيريا

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Abstract. Significant portions of by-products are generated and discarded throughout the fish supply chain. To reduce the discard of these by-products and ensure their proper utilization, there is a need to ascertain its discard and consumption pattern among fish consumers. The main aim of this study was to investigate the by-products fish consumers in Lagos State, Nigeria regard as waste; discard and consume. Factors which influence the discard and consumption of these by-products were also investigated. Using a Multistage sampling procedure, a structured questionnaire was used to obtain information from 300 respondents in three Local Government Areas (LGAs) in Lagos State, Nigeria and the data collected were analyzed using descriptive and inferential statistics. The results show that the scales (92%) were the most discarded by-product followed by gut (89%), gills and fins (85%). The skin was the most consumed by-product while the gut was the least consumed. The three major reasons given by the respondents for the discard of these by-products were that they considered them uneatable, useless and a waste. Several interrelating factors, such as social factors, type of fish species and socio-demographic characteristics also influenced the by-products respondents in this study regard as waste; discard and consume. The results in this study indicated that the scales, gut, gills, and fins were largely discarded and underutilized by fish consumers in Lagos State, Nigeria. There is a need for research on sustainable ways to recover and utilize discarded by-products for the development of value-added products and for the realization of a sustainable circular economy.

Keywords: Fish by-products; Waste; Fish discard; Consumption; Nigeria.

الملخص:يتم التخلص من الكثير من المنتجات الثانوية في جميع مراحل سلسلة توريد الأسماك. ولتقليل التخلص من هذه المنتجات وضمان الاستخدام السليم لها، هناك حاجة للتأكد من نمط التخلص منها واستهلاكها بين مستهلكي الأسماك. الهدف الرئيسي من هذه الدراسة هو التحقق من مستهلكي المنتجات الثانوية للأسماك في ولاية لاغوس، نيجيريا بشأن اعتبار هذه المنتجات نفايات: سواء التخلص منها أو استهلاكها. كما تم دراسة العوامل التي تؤثر على التخلص من هذه المنتجات واستهلاكها. باستخدام إجراء أخذ العينات متعدد المراحل، تم توزيع استبيان على الفئة المستهدفة (٣٠٠ مستجيب) للحصول على معلومات في ثلاث مناطق حكومية محلية (LGAs) في ولاية لاغوس، نيجيريا وتم تحليل البيانات التي تم جمعها باستخدام الإحصاءات الوصفية والاستنتاجية. أظهرت النتائج أن قشور السمك (٩٢٪) هي عبارة عن منتجات ثانوية يتم في الغالب التخلص منها كنفايات، تليها الأمعاء (٨٩٪)، والخياشيم والزعانف (٨٥٪). كان الجلد هو المنتج الثانوي الأكثر استهلاكًا بينما كانت القناة الهضمية أقل استهلاكًا. إن الأسباب الرئيسية الثلاثة التي قدمها المجيبون على الاستبيان بشأن التخلص من هذه المنتجات هي اعتبارها غير صالحة للأكل وعديمة الفائدة وبالتالي من النفايات. هنالك العديد من العوامل المترابطة، مثل العوامل الاجتماعية، وأنواع الأسماك والخصائص الاجتماعية والديموغرافية التي أثرت على إجابات المشاركون في هذه الدراسة. أشارت نتائج هذه الدراسة إلى أن القشور، والأمعاء، والخياشيم، والزعانف يتم التخلص منها بشكل كبير وغير مستغلة بشكل كافٍ من قبل مستهلكي المنتجات السمكية في ولاية لاغوس، نيجيريا. هناك حاجة للبحث عن الاستخدام الأفضل لهذه المنتجات الثانوية من أجل تحقيق الاستدامة.

الكلمات المفتاحية: منتجات الأسماك الثانوية؛ نفايات؛ التخلص من الأسماك، الاستهلاك؛ نيجيريا.

Introduction

Fish is an important source of livelihood for people in both developing and developed countries. Its contribution to food security is particularly important in Nigeria, where malnutrition, unbalanced nutrition, protein shortage, hunger and serious health problems are widespread (Akinyele, 2009). According to Amao et al. (2006), fish contributes 13.4 kg/person per year of the animal protein consumed in Nigeria, however, this value is below the global average fish consumption level of 20.5 kg/person per year (FAO, 2018). Despite its significant role, fish supply in Nigeria from all its sources (i.e. artisanal fisheries, aquaculture, industrial fishing and importation) have failed to meet the country's domestic demand (Akinrotimi et al., 2011), which is on the increase due to the increasing population growth in Nigeria and changing consumers' preferences (Adewunmi, 2015). Amao et al., (2006) argued that the short fall in fish supply in Nigeria can also be attributed to the non-maximization and sustainable utilization of aquatic resources, some of which include by-products. There is no standard definition for the term 'by-product' (Rustad et al., 2011). It has been defined by Kim and Mendis (2006) as fish leftovers which are not regarded as ordinary marketable products. Ananey-Obiri and Tahergorabi (2018) defined it as the remaining parts of fish left over after processing, which are often not considered as

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fitting for human consumption. According to Rustad et al. (2011), by-products can be understood as any edible or inedible raw material remaining after the production of the main products. In this study, by-products are defined as any part of fish besides the flesh or fillet. In Nigeria, the term 'discard' and 'waste' refer to two separate terms. The former refers to by-products that are thrown away by consumers or respondents for any reason, while the latter refers to by-products which cannot be used for any application (i.e., by-products considered worthless). By-products are generated during the processing of fish obtained from both capture fisheries and aquaculture (Olsen et al., 2014) and they include scales, heads, viscera, fins, skin, bones, and frames (Ananey-Obiri and Tahergorabi, 2018). There are varying estimates of the volume of by-products generated worldwide (Rustad et al., 2011). Pastoriza et al. (2003) claimed that by-products make up about three-quarter of the total weight of the catch, while Suresh et al. (2018) reported that they can make up about 50-80% of the total catch, depending on the fish species and level of processing. Although some of the by-products have been utilized in the production of low-price ingredients, such as fish meal, fish oil, fish silage, fish fertilizer, fish sauce (Suresh et al., 2018); the bulk of it is discarded (Falch et al., 2006) at seas, rivers or landfills. This creates disposal and pollution problems as well as the underutilization of the nutrients contained in the by-products (Suresh et al., 2018). Fish by-products contain protein, lipid, minerals (Ghaly et al., 2013) as well as other valuable compounds (Rustad et al., 2011). They can be used to produce value added products, such as amino acids, proteins, collagen, gelatin, oil, enzymes, bioactive peptides (Ghaly et al., 2013), which in turn can be used to solve problems related to food security and help in generating additional revenue and employment opportunities in the fisheries industry.

To effectively exploit these by-products generated from the fisheries industry (both from capture fisheries and aquaculture) in the development of value-added products, knowledge about its consumption and discard pattern among Nigerian consumers must be established. Research on the consumption, preferences, and market for by-products in Asia (Tonsberg et al., 1996); Iceland (Arason, 2003) and Norway (Jonsson and Vidarsson, 2016) have been documented. The head of fish makes up the bulk of fish by-product by volume and export from the Icelandic Fisheries. Other by-products, such as the skin is exported to countries like Canada and Spain, but a fraction is also used in the production of leather (Arason, 2003). The Chinese are acclaimed for consuming every part of fish, and the part of fish not eaten are largely used in Chinese traditional medicine. In Taiwan, most fish by-products are used and those not used, such as gall bladder and eyes, are sometimes exported to Japan for fish oil production. Milk fish and eel offal are consumed in Taiwan. Taiwan is also known as Norway's largest export market for Salmon heads which are used in the preparation of fish soup. (Tonsberg et al., 1996). Many Africans show a strong preference to fresh fish in its whole form, and when by-products are generated, they have been used as non-conventional supplementary feed or as ingredients for compounded feed as a source of animal protein and mineral especially in small-scale aquaculture farms in countries such as Kenya (Nyandat, 2007) and Nigeria. According to Ayinla (2007), fish by-products from processing companies were used in the production of fish meal for use as feed in aquaculture farms before the closure of the only fish meal processing plant in Nigeria. There is paucity of information on the consumption and discard pattern of fish by-products among fish consumers in Nigeria. The knowledge of Nigerian consumers' attitude towards fish by-products may increasingly contribute to its improvement in terms of recovery, maximization, and sustainable utilization.

The main aim of this study was to investigate the by-products respondents in Lagos State regard as waste; discard and consume. Furthermore, this study aimed at determining the factors which influence the discard and consumption of by-products in the study area using three indices: Respondents' responses, socio-demography and consumption of fish species. Lagos State was chosen for this study because it is a coastal state and one boasting of major fish markets with a high fish consumption pattern among its inhabitants.

Materials and Methods

Study Area

Lagos State is located in the South-Western part of Nigeria. It is bordered in the North and East by Ogun State; in the West by Republic of Benin, in the South by the Atlantic Ocean and it stretches over 180 km along the Guinea Coast of the Bight of Benin on the Atlantic Ocean. In terms of land mass, it is the smallest state in Nigeria, yet it has the highest urban population (LASG, 2018). About 22% of its total land mass comprises an extensive network of Lagoons, rivers, creeks swamps and estuaries (Olaoye et al., 2014). Lagos which is the 6th megacity in the world is Nigeria's economic, financial, and commercial nerve center. It is dominated by the Yoruba ethic group and is divided into 20 Local Government Areas (LGAs) and 37 Local Council Development Areas (LCDAs) respectively (LASG, 2018).

Sampling procedure and Data Collection

This study used a non-experimental survey design that consisted of the administration of questionnaires to obtain reliable data as well as to document respondent's perceptions of fish by-products. The questionnaire comprised of questions pertaining to the aim of this survey. Information on the socio-demographic characteristics of the respondents; possible factors that affect fish

by-product discard and the most frequently consumed fish species were retrieved. A complete list of all the local government areas, their constituencies and wards were obtained from the Lagos State Government. The target population for this study were male and female adults (18 years and above) who consume fish in Lagos State.

The Multistage random sampling procedure was employed in data collection as shown in Figure 1. A total of three hundred and thirty (330) questionnaires were administered to both male and female fish consumers and a quota of 55 questionnaires were administered per ward to ensure uniformity. In total, information from 300 fully completed questionnaires (50 questionnaires per ward) was used to obtain the data used for this analysis. Informed consent was obtained from all respondents by seeking their approval before proceeding with the questionnaire survey. To satisfy the inclusion criteria for participation in the survey, the respondents were asked whether they consume fish and if they were 18 years and above. On responding in the affirmative, the respondents in the selected buildings/houses were included in the study population. In cases of plural eligibility in a building, all the eligible respondents were selected. Visual aids in the form of pictures were incorporated in the interview process for easy identification of the listed fish by-products.

Statistical Analysis

The data collected for this study were analyzed using descriptive (i.e. frequency distribution and percentages) and inferential statistics (i.e. Chi-square). Chi-square (X^2) test was used to check for statistical significance ($P<0.05$) in the relationship between the respondents' age, sex, income, education, and the by-products they regard as waste; discard and consume.

Results

Socio-demographic Characteristics of Respondents

The results of the socio-demographic characteristics of the respondents are shown in Table 1. Two-thirds of the respondents were female and about one-third were male. Majority of the respondents (42%) were within the age group 25-35 years. All the respondents had a form of formal education. Only 5% had a Masters' degree while 54% of the respondents had tertiary education (OND/HND and Bachelors' degree). The distribution of respondents by occupation shows that about 82% of the respondents had a source of livelihood. The results further indicate that majority (31%) of the respondents were involved in entrepreneurship. In addition, very few people (1%) were civil servants. Even though all the respondents had formal education and many had a means of livelihood, only about 35% earn above ₦ 50, 000.

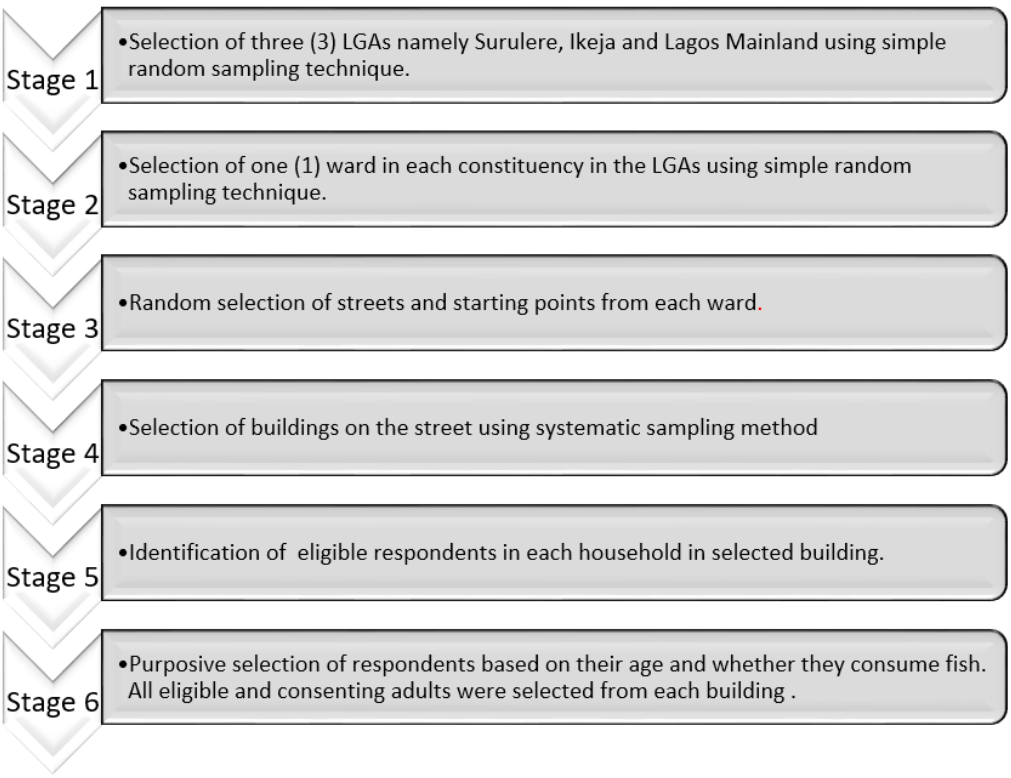

Figure 1. Multi-stage random sampling procedure used in data collection.

Table 1. Percentage distribution of respondents by Socio-demographic characteristics.

Variable	Frequency (n)	Percentage (%)
SEX		
Male	98	33
Female	202	67
AGE GROUPS		
18-24 years	89	30
25-35 years	125	42
Above 35 years	86	29
HIGHEST LEVEL OF EDUCATION	116	39
SSCE	77	26
OND/HND	83	28
Bachelor's degree	15	5
Master's degree	9	3
Others		
OCCUPATION		
Entrepreneur/Business men	94	31
Professional Services	58	19
Artisans	53	18
Students	52	17
Sales representatives/Executives	32	11
Civil Servants	4	1
Clerical workers	4	1
Unemployed	3	1
MONTHLY INCOME (₦)		
Less than 20,000	96	32
20,000-50,000	100	33
Above 50, 000	104	35

Consumers Response on Fish By-products

Fish by-products regarded as waste: The results of respondents' responses on the various by-products they regard as waste is shown in Figure 2. Although there were varying responses from the respondents on the by-products they regard as waste; the results indicated that the scales were the by-products largely considered to be a waste by the respondents while the skin was the by-product least considered to be a waste.

Fish by-products discarded by respondents: As shown in Figure 3, the scales were the by-products mostly discarded as reported by 96% of the respondents. Following the scales; the gut, fins and gills were the by-products largely discarded by more than 80% of the respondents. The skin was the least discarded by-product.

Distribution of Consumers' Responses

Fish by-products consumed by respondents: As shown in Figure 4, the skin was the most consumed by-product. The gut was the least consumed by-product followed by the scales. The respondents' reasons for discarding the various fish by-products are shown in Figure 5. The three major reasons which influenced the respondents' choice for discarding these by-products were because they found them uneatable (54%) of no use to them (30%) and a waste (24%). The respondents also listed other factors which influenced their attitude towards fish by-products consumption some of which include preference, beliefs, family upbringing and other social factors. The fish species consumed by the respondents are shown in Figure 6. Atlantic Mackerel (locally called Titus) was the fish species mostly consumed by the respondents.

Inferential Statistics

Chi-Square test was used to check for significant differences and to gain a deeper understanding of the relationship between the socio-demographic characteristics: age, sex, income and education (re-categorized) of the respondents and the by-products they discard, consume and regard as waste. There was no statistically

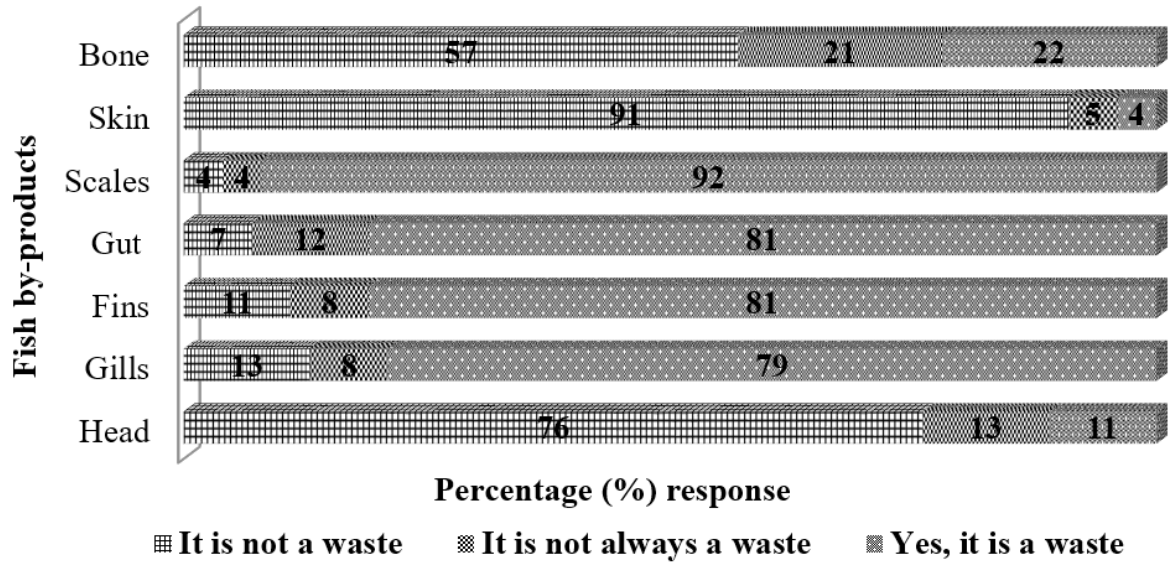

Figure 2. Percentage frequency of fish by-products regarded as waste.

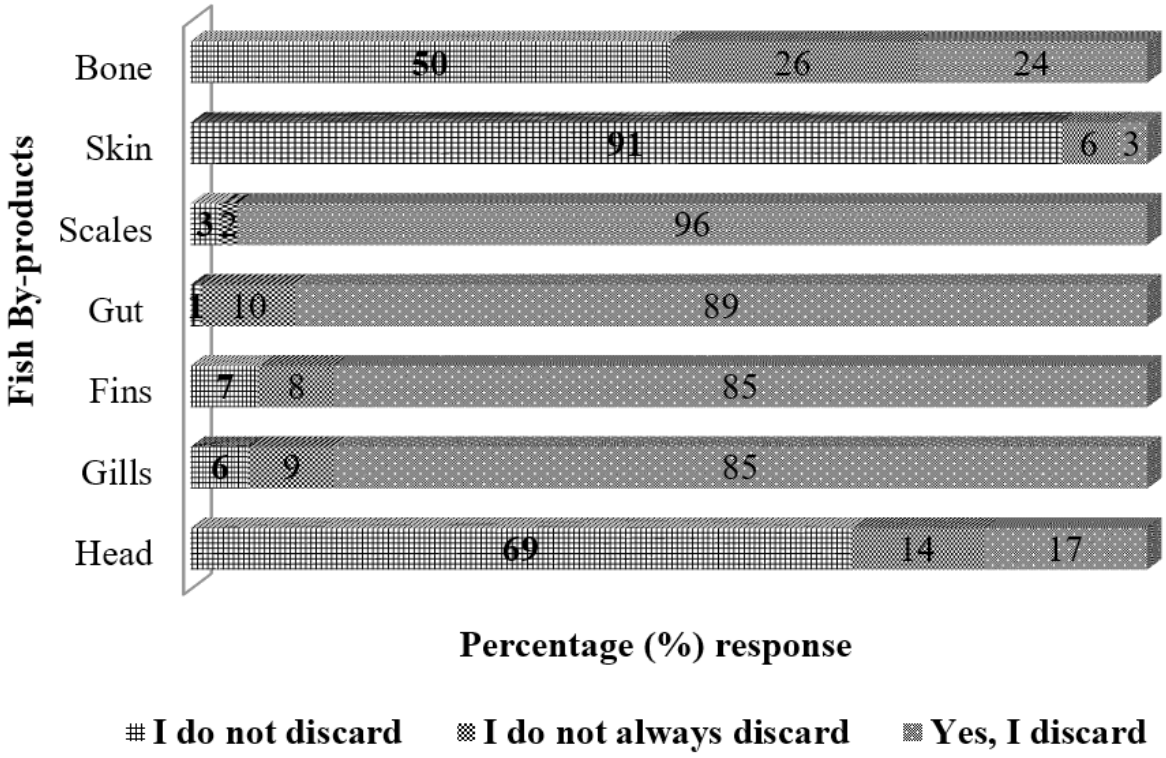

Figure 3. Percentage distribution of respondents who discard fish by-products.

significant relationship (P>0.05) between the respondents' age and the by-products evaluated. There was a statistically significant relationship (P<0.05) in the sex of respondents and certain by-products they discarded and regarded as waste.

The chi-square analysis in Table 2 also shows a statistically significant relationship (P<0.05) between respondents' income and their response to whether they discarded the fins and considered it a waste. Their response to the other listed by-products were not statistically

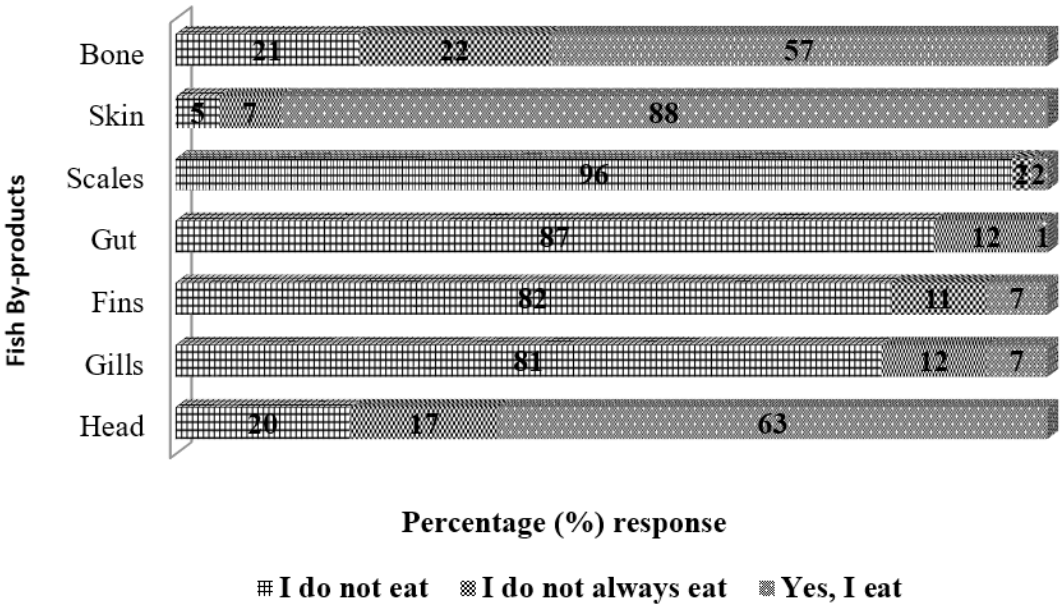

Figure 4. Percentage distribution of respondents who consume fish by-products.

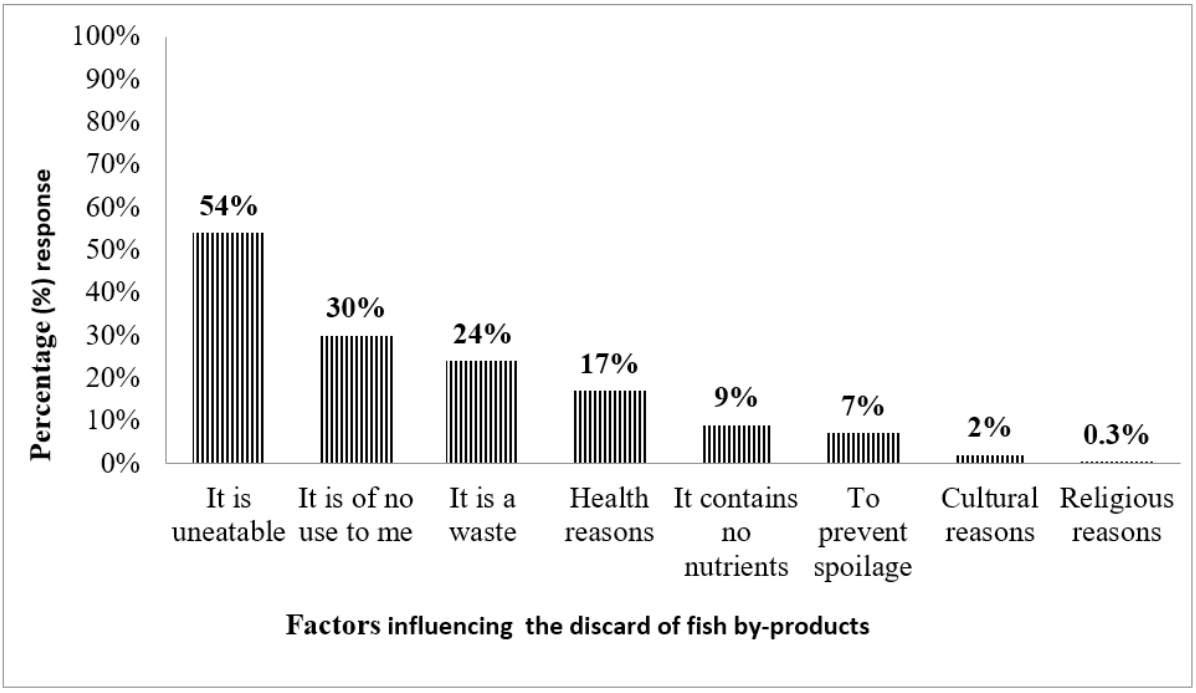

Figure 5. Respondents' reasons for discarding fish by-products fish species consumed.

significant (P>0.05). There was no association between the education of respondents and the by-products they discarded but a statistically significant (P<0.05) relationship was observed in their views on whether they regarded the bone as waste and whether they consumed the fins, skin and bones.

Discussion

Knowledge of fish by-products consumers regard as waste; discard and consume is essential if these resources are to be harnessed and utilized effectively. In this study, the term waste and discard refer to two different terms. The scales were the by-products largely regarded as waste followed by the gut, fins, gills bone, head and skin as shown in Figure 2. A similar trend was observed

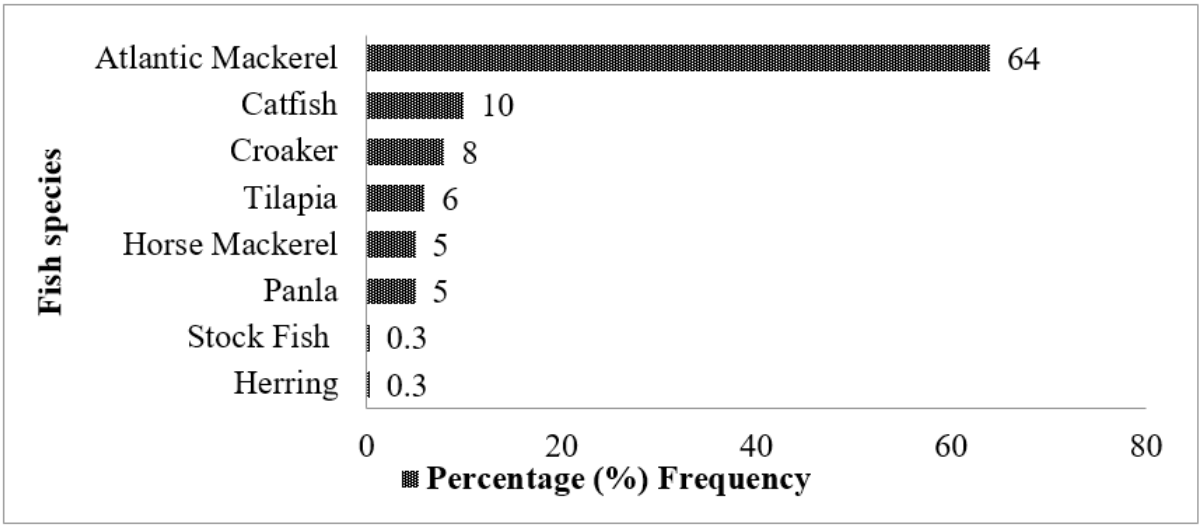

Figure 6. Fish species mostly consumed by respondents Inferential Statistics .

Table 2. Chi-Square test result on the socio-demographic characteristics and the by-products respondents regard as waste, discard and consume.

Statements	Age	Sex	Education	Income
By-products regarded as waste				
Head	4.968	2.478	1.557	2.804
Gills	8.471	14.116**	2.629	4.428
Fins	4.235	6.895*	5.868	11.282*
Gut	2.854	11.775**	1.134	1.124
Scales	0.324	9.345**	2.614	8.738
Skin	4.827	1.472	2.375	3.806
Bones	0.097	8.111*	7.462*	1.146
By-products discarded				
Head	7.643	0.636	4.903	6.042
Gills	0.793	7.222*	0.098	2.172
Fins	6.159	10.589**	4.237	10.378*
Gut	1.937	0.498	1.854	4.055
Scales	6.791	3.178	3.116	5.811
Skin	1.585	4.926	2.192	1.498
Bones	3.290	5.737	2.809	0.687
By-products consumed				
Head	6.828	1.069	2.338	8.184
Gills	0.933	2.772	0.532	6.341
Fins	0.622	2.312	8.316*	8.638
Gut	1.940	2.870	4.433	2.524
Scales	3.316	1.498	0.984	6.085
Skin	2.408	5.178	9.129*	6.321
Bones	0.401	2.606	15.136**	1.538

Note: *= Significant at 5% (P<0.05) and ** = Significant at 1% (P< 0.01)

in the by-products discarded by the respondents. As shown in Figure 3, 96% of the respondents discarded the scales, thus making it the most discarded by-products followed by the gut (89%), fins and gills (85%). The skin (3%) was the least discarded by-product. A possible reason why the respondents in this study discarded certain by-products such as the scales, gut, gills and fins more than the bone, head and skin may be because they regard them as inedible and worthless. This was further confirmed from the distribution of responses on the factors influencing the discard of by-products as shown in Figure 5. where the most discarded by-products were those considered uneatable, of no use or a waste. This finding is in agreement with Caruso (2016) who reported that more than 50% of fish by-products were discarded because they were considered a waste. Malaweera and Wijesundara (2014) also reported that certain by-product, such as the scales are discarded because they are largely considered to be worthless. These by-products: scales, gut, gills, fins, bones, head, and skin are not worthless or a waste because they have potential applications in various industries such as the food, feed and pharmaceutical industries owing to their nutritional or chemical composition. Fish scale is a rich source of collagen, the most abundant protein in the body of animals and one which has a vital role in the formation and maintenance of various parts of the body like the bones, ligaments, hair, nails and skin (Jonsson and Vidarsson, 2016). Collagen can be utilized in cosmetic and skin care products owing to its moisturizing, regenerating and film-forming properties (Sionkowska et al., 2020). Type I collagen obtained from the scales of Sea bream were used in the hydrolysate form and it demonstrated Angiotensin converting enzyme (ACE) inhibitory activity, which can be further used in the treatment of hypertension (Fahmi et al., 2004). Kandyliari et al. (2020) recorded varying concentrations of proteins, lipids, fatty acids, and minerals in the head, skin, bones, trimmings, gut and gills of large Gilthead seabream. When compared to the skin and head, the most consumed by-products in our study, Kandyliari et al. (2020) found out that the bones had a higher mineral or ash value. The gills (37.46%) and intestines (43.19%) proved to be good sources of lipids and their values were higher than the lipid content in the head (37.08%) and bones (30.56%). All the by-products had high protein values greater than 30% thus, they can be considered as potential sources of bioactive peptides and for use in the development of functional foods. Falkenberg et al. (2014) recorded radical scavenging activity in gill extracts from Salmon fish. The skin of cod fish has been used in the development of wound patches and tissue regeneration solutions (Jonsson and Vidarsson, 2016). Research on the production of enzymes from fish intestines are being carried out for potential use in food, pharmaceutical, cosmetic, health and industrial applications (Arason, 2003).

The results of the by-products consumed by the respondents indicated that the by-products least consumed were those frequently discarded and regarded as waste. Olsen (2004) opined that taste (positive effect), distaste (negative effect) and nutrition are factors that influence consumers preference for particular foods. Certain attributes, beliefs and social norms may also contribute to the negative effect of food attitudes. Social norms or factors which can be defined as the expectations from people in one's family, locality or immediate social circle, play a role in determining fish consumption among people all over the world (Olsen, 2004; Rozin, 1995). During the field survey, the respondents in this study further expressed certain social bias which influenced their consumption of by-products. According to them, social factors such as family upbringing (i.e. watching their mothers discard certain by-products), beliefs (i.e. bones can choke a person to death; gills and guts contain a lot of dirt), social norms (such as the cutting off of the fins of fish by fish mongers in the markets even without being asked to do so) positively contributed to why a large proportion of certain by-products such as the scales, gut, gills and fins were considered uneatable. The social bias stated by respondents in this survey was similar to the findings of Gomna and Rana (2007). The authors observed that women in various households in Niger and Lagos State Nigeria, could not give certain by-products such as the head and tails to their husbands to consume. According to the women, serving their husbands these by-products to consume may embarrass them owing to the 'perceived societal expectations', which saliently infer that consumption of certain parts of fish, indicate the poverty level of a person. The fact that more than 50% of the respondents consumed the skin, head and bone showed that these by-products were considered edible by many Nigerians. This can explain why majority of the respondents did not regard the skin, head and bone as waste nor discard them as shown in Figures 2 and 3 respectively. Jonsson and Vidarsson (2016) affirmed that dried cod heads in Iceland are mostly exported to Nigeria. This is in agreement with the findings of this study where the head of fish was the second most consumed fish by-product among the respondents.

The kind of fish species may also influence consumers' attitude toward by-products. This may be the reason why few respondents agreed that the various by-products (i.e. bone, head, gut, fins, gills and scales) may not always be consumed, discarded or regarded as waste. If the fish is of low value, it is also possible that its by-products may not be regarded as valuable hence, may be discarded and/or regarded as waste. The hypothesis that the kind of fish species may play a role in determining the consumption and discard pattern of its by-products was affirmed by the findings of Falch et al. (2006) who reported that liver and roe from relatively large Cod (*Gadus morhua*) are the by-products utilized for human consumption in Northern Europe. According to Jonsson and Vidarsson (2016), Cod is the most important species in Iceland and its salted by-products, such as the tongues and cheeks from big cod heads are the most sought after in Southern Europe.

Although the fish species consumed by the respondents was not correlated with their response on the by-products they regard as waste, discard and consume; the results in Figure 6 show that Atlantic Mackerel (a frozen fish locally called Titus) was the most consumed fish species followed by Catfish (*Clarias gariepinus*). The result is in agreement with the findings of Oluwaniyi and Dosumu (2009) who reported that *Scomber scombrus* (Atlantic Mackerel) and two other forms of frozen fish namely *Clupea harengus* (Herring) and *Trachurus trachurus* (Horse Mackerel) were the most consumed and readily available marine fish species in South-Western Nigeria. Dauda et al. (2016) also reported that Atlantic Mackerel was the most preferred frozen fish in Kastina State, Nigeria. According to Oluwaniyi and Dosumu (2009) Atlantic mackerel being one of the most imported fish species in Nigeria; is one of the major sources of animal protein for the average individual and family in Nigeria because it is readily available and affordable. The reason for the lower consumption of Catfish when compared with Atlantic Mackerel may be because of its relatively high cost. This is in agreement with Oyewole and Amosu (2012) who observed that the consumption of Catfish in many parts of Nigeria was often regarded as a delicacy for the upper class. The texture of the by-products in each fish species may also contribute to whether their by-products can be consumed or not. This is in agreement with Oyewole and Amosu (2012) who observed that 47.1% of respondents in South-Western affirmed that the texture of Catfish (*Clarias gariepinus*) which they considered too soft and sometimes nauseating made them averse to Catfish consumption. According to Malde et al. (2010), bone structure in fish varies between species. The head and fins of Mackerel are soft thus can be chewed safely without the fear of the bones choking or wounding the buccal cavity of consumers. The soft texture of its by-products such as the head and bones may be the reason why more than 50% of the respondents in this study consume the head and bones.

The Chi-square analysis of the socio-demographic characteristics of the respondents show that only sex, education and income were found to be statistically significantly ($P<0.05$) related to the by-products respondents regarded as waste and those discarded. The Chi-square analysis in Table 2 show a statistically significant ($P<0.05$) relationship between the sex of respondents and certain by-products regarded as waste (gills, fins, gut, scales and bone) and those discarded (gills and fins). The results further indicated that the female respondents regarded the gills, fins, gut, scales and bone as waste when compared to the male respondents. The same pattern was also observed in their discard of gills and fins. In Nigeria, females are more directly involved in the preparation of

meals in the family and as a result, by-products which they do not consume or those they regard as waste may be discarded. If this happens, such by-products may never be consumed by other members of their household. This may be the possible reason for the variation in responses between the male and female respondents.

The findings from this study showed that education was the sole socio-demographic characteristic which was observed to have a statistically significant ($P<0.05$) relationship in the by-products (fins, skin and bone) consumed by the respondents. Respondent's knowledge of the nutritional benefits of certain by-products may also have an influence on the by-products they consume. This may explain why the respondents who had a tertiary education consume the fins and bones more than those having lower educational degrees (as shown in Appendix 2). The positive relationship observed between education and the by-products consumed by the respondents implies that an improvement in the educational status of Nigerians on the health benefits of these by-products may lead to an increase in their consumption. This is in agreement with Dauda et al. (2016) who observed a positive correlation between education and fish demand among consumers.

Income plays a role in shaping consumer's food choices (Dauda et al. 2016). The result of the inferential statistics as shown in Table 2 indicate that there was a statistically significant ($P<0.05$) relationship between the respondents' income and whether they discard and/or regard the fins as waste. In this study, it was surprising to note that a higher number of respondents who earned the least (Below ₦ 50, 000) regarded the fins as waste and discarded them when compared to respondents who earned above ₦ 50, 000. The findings in this study therefore contradicts those of Adeniyi et al. (2012) who reported that an increase in income, result in a shift of consumers preference towards more expensive sources of animal protein. Consumer preference for certain by-products may be the reason why respondents with higher incomes (Above ₦50, 000) consumed the fins when compared with those with lower incomes. This is in agreement with Albert and Tasie (2016) who observed that the consumption of frozen fish among respondents in Rivers State, Nigeria, was solely dependent on their preference and not their income. Attitudes and preference are suggested to play a major role in explaining food consumption behavior in humans (Olsen, 2001). Food consumption pattern of humans is an extremely complex issue, and it varies significantly across countries, cultures, families, and individuals. It is influenced by many interrelating factors such as the food's quality, sensory attributes, and availability; consumers preference, personality, knowledge (Olsen, 2004), social norms and socio-demographic characteristic of the respondents (Verbeke and Vackier, 2005). The result in this study indicates that several interrelating factors, such as social factors, type of fish species and socio-demographic characteristics determine the by-products respondents in the study area regard as waste; discard and consume.

Conclusion

The results of this study have shown that the scales, gut, gills and fins are the by-products mostly discarded and underutilized in the three LGAs used in this study; while the skin, head and bones are the most consumed by-products. There is a need to educate the public on the benefits of utilizing these by-products to reduce the deleterious effects their discard will have on the environment. To prevent their discard, further research on ways these by-products can be developed into value-added products for both economic and environmental benefits as well as for the realization of a sustainable circular economy is needed. It is hoped that the findings of this study will be of interest to policy makers, research institutions, fish companies, current and future importers of fish by-products and all concerned about attaining the United Nations sustainable development goals (SDGs) especially those which deal with ending hunger, poverty and promoting the conservation and sustainable utilization of fisheries resources.

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Appendix 1: Percentage distribution of Socio-demographic characteristics (Sex) and by-products discarded and regarded as waste.

Socio-demographic characteristics	Percentage responses (%)			Percentage responses (%)		
	It is not a waste	It is not always a waste	Yes, it is a waste	I do not discard	I do not always discard	Yes, I discard
SEX						
Head						
Male	72.4	17.3	10.2	66.3	15.3	18.4
Female	77.2	10.9	11.9	70.8	12.9	16.3
Gills	13.3	16.3	70.4	5.1	15.3	79.6
	12.4	4.0	83.7	6.9	5.9	87.1
Fins	14.3	13.3	72.4	7.1	15.3	77.6
	9.4	5.9	84.7	7.4	4.5	88.1
Gut	12.2	17.3	70.4	1.0	11.2	87.8
	4.0	9.9	86.1	1.5	8.9	89.6
Scales	9.2	5.1	85.7	1.0	3.1	95.9
	2.0	3.0	95.0	3.5	1.0	95.5
Skin	87.8	7.1	5.1	85.7	10.2	4.1
	92.1	4.5	3.5	93.1	4.0	3.0
Bone	50.0	30.6	19.4	41.8	33.7	24.5
	59.9	16.3	23.8	54.5	21.8	23.8

Appendix 2: Percentage distribution of Socio-demographic characteristics (Education) and by-products consumed.

Socio-demographic characteristics	Percentage responses (%)		
	I do not eat	I do not always eat	Yes, I eat
Education			
Head			
SSCE and Others	20.8	12.8	66.4
Tertiary Education	20.0	19.4	60.6
Gills	84.8	10.4	4.8
	81.7	12.0	6.3
Fins	90.4	6.4	3.2
	77.7	14.9	7.4
Gut	84.8	12.8	2.4
	88.6	11.4	0.0
Scales	96.8	2.4	0.8
	95.4	2.3	2.3
Skin	4.8	1.6	93.6
	5.7	10.3	84.0
Bone	30.4	14.4	55.2
	14.3	28.0	57.7

Appendix 3: Percentage distribution of Socio-demographic characteristics (Income) and by-products discarded and regarded as waste.

Socio-demographic characteristics	Percentage responses (%)			Percentage responses (%)		
	It is not a waste	It is not always a waste	Yes, it is a waste	I do not discard	I do not always discard	Yes, I discard
Income Head						
Less than ₦ 20,000	79.2	10.4	10.4	75.0	9.4	15.6
₦ 20,000–₦50,000	77.8	13.1	9.1	72.7	13.1	14.1
Above ₦ 50, 000	70.5	15.2	14.3	61.0	18.1	21.0
Gills	17.7	6.3	76.0	6.3	12.5	81.3
	11.1	7.1	81.8	6.1	7.1	86.9
	9.5	10.5	80.0	6.7	7.6	85.7
Fins	8.3	2.1	89.6	6.3	3.1	90.6
	10.1	9.1	80.8	5.1	7.1	87.9
	14.3	13.3	72.4	10.5	13.3	76.2
Gut	8.3	13.5	78.1	3.1	10.4	86.5
	5.1	12.1	82.8	0.0	10.1	89.9
	6.7	11.4	81.9	1.0	8.6	90.5
Scales	0.0	3.1	96.9	1.0	2.1	96.9
	7.1	2.0	90.9	2.0	3.0	94.9
	5.7	5.7	88.6	4.8	0.0	95.2
Skin	88.5	5.2	6.3	91.7	5.2	3.1
	93.9	5.1	1.0	90.9	7.1	2.0
	89.5	5.7	4.8	89.5	5.7	4.8
Bone	60.4	17.7	21.9	53.1	25.0	21.9
	54.5	22.2	23.2	48.5	25.3	26.3
	55.2	22.9	21.9	49.5	26.7	23.8