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Nutritional value and organoleptic assessment of burgers made with some commercially important fish species

K. Omoruyi and C. Omosoh

Department of Aquaculture and Fisheries Management, Faculty of Agriculture, University of Benin, Benin City

ABSTRACT

Fish burgers are foods that contain a good portion of fish and are categorized as ready-to-eat convenient products or intermediate products. The aim of this study was to determine the nutritional value and organoleptic assessment of burgers made with some fish species. The major fish species used are *Clarias gariepenius*, *Scomber scombrus*, *Micropogonias undulates* and *Merluccius merluccius*, and their proximate analyses were conducted as per standard established methods. Sensory assessments were carried out by 16-man panelist to evaluate the consumers acceptance in terms of taste, aroma, texture, and appearance. The data obtained were subjected to analysis of variance and the results indicated that burgers made with *Clarias gariepinus* showed significantly ($P<0.05$) better acceptability. The proximate composition results of *Clarias gariepinus* burger showed 47.15% moisture content, 8.15% protein content, 11.79% fat, 0.52% fibre, 1.03% ash and 31.36% carbohydrates. Organoleptic assessment for the fish burger samples revealed that burger made with *Scomber scombrus* had the best results in terms of taste (8.13), aroma (7.50) and texture (7.75), except for the *Micropogonias undulates* burger, which had the best mean appearance (7.38) compared to the other samples. This study therefore shows that *Clarias gariepinus* and *Scomber scombrus* were the best accepted species for making fish burgers, followed by *Micropogonias undulates* and *Merluccius merluccius*. However, fish burgers had high nutritional value which makes each sample a good source of dietary protein for human consumption. The findings of this study can be of help for the commercial production of value-added, nutritious burgers made with fish.

Keywords: Nutritional value; organoleptic assessment; burger; fish species

INTRODUCTION

Food and Agricultural Organization (FAO, 2010) revealed that fish demand is increasing because of the increasing world population, higher living standards and the good overall image of fish among consumers. According to Kefas *et al.* (2022), the demand for fish is on the increase due to the health benefits of eating fish and due to the increase in human population. Henchion *et al*. (2017) stated that the reason to take fish is increasing in developing countries as an increase in emphasis on cardiovascular diseases and overall health which has led to an increased demand for fish. Also, it is because fish is a rich source of

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correspondence: omoruyiworld@yahoo.com
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protein commonly consumed due to the higher cost of meat and other sources of animal protein (Omolara and Omotayo, 2009). and FAO (2010), fish is an important source of cheap first-class protein, providing high essential amino as well as about 60 and 30% of world's and developing countries' annual protein supplies respectively (Aremu *et al.*, 2014; FAO, 2010).

Fish is also an indispensable source of micronutrients, such as iron, iodine, zinc, vitamin A and B (Haruna, 2003; World Fish Centre, 2005). Aremu *et al.* (2014) asserted that majority of Nigerians, Americans and Japanese who depend on fish as their main source of protein have longer life span.

According to Bradley *et al.* (2020) variety of fish species are eaten in Nigeria, including crayfish, sardines (freshwater and saltwater), Bonga, Mackerel, European Hake, as well as cultured fish species such as Tilapia, Catfish, and Carp. Some of the fish eaten in Nigeria are imported, for example, European Hake (*Merluccius merluccius*), mackerel (*Scomber scombrus*), herrings (*Clupea harengus*) and so on. Some species like African catfish (*Clarias gariepinus*), Tilapia (*Oreochromis niloticus*), Common carp (*Cyprinus carpio*) are domestically raised in Nigeria.

Nigeria is a leading catfish producer in sub-Saharan Africa. Catfish production in Nigeria represents more than half of the total aquaculture production volume, with an estimation of 8kg annual per capita fish consumption in 2013 (FAO, 2024), and millions of metric tons of fish are imported annually into the country.

Even with the high production and importations of fish, the country is yet to bridge the gap between supply and demand, this is so because of the inability of local fish production and processors to meet the corresponding demand (Omoruyi *et al*., 2019). Large quantities of locally produced and imported fish are lost due to postharvest losses ranging from bacterial, autolytic spoilage to other factors, and these factors cause fish to lose their organoleptic qualities and become generally unacceptable for human consumption (Omoruyi *et al*., 2017). Abolagba and Osifo, (2004) stated that significant quantity of fish is being lost as a result of the absence of adequate technology and know-how to prevent postharvest losses in most tropical countries. An estimated 50% of the fish produced in the remote coastal areas and hinterland of many tropical countries perish before they get to the consumers, due to poor handling, preservation and processing practices adopted by the artisanal fishermen, and fisheries entrepreneurs (Akintola and Lawal, 2011).

In order to solve the problem of post-harvest losses occasioned by spoilage, innovative ways have been invented over the years to improve the fish products to forms such as canned fish, Fish pie, fish bread (popular called sardine bread), fish sausage and so on. Value addition is one of the ways in which spoilage can be minimized (Akintola and Lawal, 2011).

Goncalves and Kaiser (2011) reported that there has been an increase in demand for value-added products both in the domestic market and the international market. In order to meet market and consumer requirements, value addition involves using a variety of processes and technologies to transform basic fish products into innovative products in order to enhance profitability and sustainability in the fish industry (Searles *et al*., 2018; Goncalves and Kaiser, 2011).

According to OECD/FAO (2011), about 81% of the global production of fish is destined for human consumption. Latorres *et al.* (2016) and Mitterer-Daltoe *et al.* (2013) stated that processed fish transformed into a derived product is a good strategy for improving fish consumption. One of the benefits of fish products is the possibility of presenting high nutritional value (Belusso *et al*., 2016; Corbo *et al*., 2008; Mitterer-Daltoe *et al*., 2014). A lot of fish products have been invented over the years, for example fish burger. Fish burger is a very popular and tasty item in fast food industry. In recent years, the preference of the consumers has significantly been directed towards fast-food consumption, so there is need to evaluate the proximate composition. Measurement of proximate profile (percentage protein, carbohydrates, lipids, moisture content and ash content) is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Haq *et al*., 2013; George, 2010).

MATERIALS AND METHODS

Collection of Samples

Twenty (20) pieces of some commercially important fish species comprising of Five pieces each of catfish (*C. gariepinus*), European hake (*M. merluccius*), Mackerel (*S.* scombrus), and Atlantic Croaker (*M. undulatus*) with an average weight of 1kg were obtained from Department of Aquaculture and Fisheries Management's Farm, University of Benin and Oba Market, Ring Road, Benin City. The burger buns, ketchup, mayonnaise, lettuces, onions, cucumber, salt, seasoning, knife, groundnut oil, eggs, and so on were also obtained. Additional materials, including pipettes, test tubes, distilled water, Petri dishes, and chemicals were obtained from the Department of Aquaculture and Fisheries Management Wet Laboratory, University of Benin, Benin City.

Ingredients for Fish Burger

The following ingredients were used to prepare the various fish burgers:

- 6 ½ Cups Flour (901.6 grams)
- 2 ½ teaspoon Dry Yeast (5.6 grams)
- 5 Tablespoons Sugar (58.1 grams)
- 2 ½ teaspoon Salt (16 grams)
- 1 Cup Water (168 grams)
- 5 Tablespoons Butter (62.4 grams)
- 1 ½ Cup Milk (271.8 grams)
- 5.6 Egg Yolks 8 Tablespoons or 112 grams
- Some Sesame Seeds

Method of Preparation

Combine butter and water in a saucepan. Heat until butter is fully melted. Transfer the mixture to a clean bowl and allow it to cool. Subsequently, add whole milk.

In a separate mixing bowl, combine flour, yeast, sugar, and salt and mix manually. Gradually pour the cooled liquid mixture into the dry ingredients and constantly stir. Initiate kneading and incorporate egg yolks one at a time, ensuring thorough kneading after each addition. Cover the bowl with plastic wrap and allow the dough to rise for approximately 1 hour and 30 minutes.

Transfer the dough to a floured work surface and pat into a slightly rounded rectangular form. Subsequently, divide the dough into equal squares. Then, use your hands to shape and flatten the squares into discs. Arrange the buns on a floured baking sheet, cover, and allow it to rise until it doubles in size. Apply an egg wash to the surface of the buns using a brush and sprinkle with sesame seeds. Subject the buns to baking in a preheated oven until lightly browned. Remove the buns from the oven, allow it to cool.

Preparation of Fish Burger Patties

Ingredients

The following ingredients were used to prepare burger patties:

- Fish fillets: 1.5 kg
- Eggs: 5 whole eggs
- Egg whites: 2 large eggs (additional)
- Salt: 2 teaspoons
- Spicy black pepper: 1½ teaspoon
- Vegetable oil (for frying): 200 mL

Methods

The fish was eviscerated, filleted and cut into chunks. The raw fish was washed, mixed with the ingredients and kept in the refrigerator for 20–30 minutes. Thereafter, the fish was pre-cooked for about 10 minutes at 80-100 ^{0}C. It was then placed in a bowl and allowed them to cool for a few minutes. After which, the fish was minced into small, smooth pieces manually. After mincing, the fish was shaped into a circular shape with a small round bowl. Then, egg white was added to both sides to make it stick together.

Preparation of the Burger

Ingredients

- Burger buns: 16 large pieces
- Sliced cucumber: 16 slices
- Shredded cabbage: 200 g
- Lettuce leaves: 16 leaves
- Large onion (sliced into rings): 2 large onions
- Mayonnaise: 250 mL
- Ketchup: 250 mL
- Cheese slices: 16 slices

Method of Preparation of Burger

The fish was eviscerated, filleted, and cut into chunks. The raw fish was then thoroughly washed, combined with the necessary ingredients, and refrigerated for 20–30 minutes. Subsequently, the fish was pre-cooked at a temperature of 80–100°C for approximately 10 minutes. Following this, the fish was transferred into a bowl and allowed to cool for a few minutes. Once cooled, it was manually minced into small, smooth pieces. The minced fish was shaped into circular patties using a small round bowl. Egg white was applied to both sides of the patties to enhance cohesion.

Cooking Procedure

Vegetable oil was preheated in a frying pot over medium heat. Once the oil reached the appropriate temperature, the fish patties were carefully placed into the oil and shallow-fried for 5–6 minutes, with frequent flipping to ensure even cooking. The patties were fried until golden brown, after which cheese was added to the patties to allow for slight melting. The burger buns were halved and lightly brushed with oil on both sides before being toasted on a griddle. After preparation, a layer of mayonnaise and ketchup was applied to both sides of each bun. The fried fish patties with melted cheese were placed on one half of the bun, followed by layers of lettuce, sliced cucumber, cabbage, and onion. Finally, the other half of the bun was used to assemble the burger.

Proximate Analysis

Proximate components of the burger produced were determined according to the standard described by Association of Official Analytical Chemists AOAC (2010). All analysis was done in triplicate.

Organoleptic Assessment

Sixteen (16) panelists, (8 male and 8 female), were selected and trained to evaluate the fish burger made from various fish species. The panel consists of both lecturers and students from various Departments within the Faculty of Agriculture, University of Benin.

A ten-point Hedonic scale was used to determine the sensory characteristics (Omoruyi *et al*., 2017). The panelists were asked to evaluate the samples in terms of taste, aroma, appearance, texture, and general acceptability using a questionnaire to ascertain the degree of acceptance/likeness or rejection. The panelist indicated their preference for each parameter using the Hedonistic scale of 0 to 10 as follows: 0-2 = poor; 2-4 = Fair; 4-6 = Good; 6-8 = Very good; 8-10 = Excellent.

Before each sample was assessed, the panelists were given water and biscuits to clean their mouths of any residual food.

Experimental Design

The burgers made from catfish (*C. gariepinus*), European hake (*M. merluccius*), Mackerel (*S. scombrus*), and Atlantic Croaker (*M. undulatus*) were laid out in a completely Randomized Design (CRD). The samples were replicated thrice.

Statistical Analysis

Analysis of Variance (ANOVA) was used to analyse the data obtained on the mean nutritional value and the organoleptic assessment of fish burger made with some fish species. This was done at 5% probability level, and the least significant difference (LSD) was used to study the difference between the means. GENSTAT version twelve (12.1) edition, 2014 was used for the analysis.

RESULTS

Nutritional Value of Fish Burger made from various Fish Species.

Table 1 shows the percentage composition of moisture content, crude protein, ash, crude fat, crude fibre and Nitrogen Free Extract (NFE) for each treatment. There was significant (P<0.05) difference in the moisture content of the four fish burger samples. *Merluccius merluccius* burger had the highest (51.76±0.76%) moisture value and *Micropogonias undulatus* burger had the least (41.88±2.08%).

There was a significant (P<0.05) difference in the crude protein content between the four fish burger samples. Burger made with *Clarias garipenius* had the highest (8.15±0.90%) crude protein value and the least value (5.59±0.51%) was recorded in burger made with *Merluccius merluccius.* The protein value for *Clarias garipenius* burger (8.15%) was the closest to FAO (2024) recommended value (10.3%)

There was significant (P<0.05) difference in the fat contents of the fish burger samples in-which *Micropogonias undulatus* burger had the highest (15.58±0.62%) value and *Merluccius merluccius* burger had the lowest (11.34±0.69%) value. The burger made from *Micropogonias undulates* had a higher carbohydrate value (15.58) than FAO (2024) recommended value of 11.7%.

The fiber contents of the fish burger samples were not significantly (P>0.05) different as the burger made with *Merluccius merluccius* had the highest (0.58±0.12%) crude fibre and the burger made with *Clarias garipenius* had the least (0.52±0.07%) value.

The ash contents of the fish burger samples were significantly (P<0.05) different. *Merluccius merluccius* burger had the highest (1.35±0.05) value while *Clarias garipenius* burger had the lowest (1.03±0.07) value.

There was a significant (P<0.05) difference in the carbohydrate content between the fish burger samples. Burger made with *Micropogonias undulatus* had the highest value (34.78±0.62%) and *Merluccius merluccius* burger had the least value (29.38±0.62%). *Micropogonias undulatus* had the highest carbohydrate value (34.78%) than FAO recommended value of 22.6%.

Table 1: Nutritional value of burger made with some commercially important fish species

Parameters	*C. garipenius*	*S. scombrus*	*M. undulates*	*M. merluccius*	FAO Acceptable Values
Moisture	47.15±1.60[b]	44.61±0.39[b]	41.88±2.08[c]	51.76±0.76[a]	51.6
Protein	8.15±0.90[a]	6.02±0.98[b]	5.92±1.28[b]	5.59±0.51[b]	10.3
Fat	11.79±0.19[b]	14.57±1.47[a]	15.58±0.62[a]	11.34±0.69[b]	11.7
Fibre	0.52±0.07[a]	0.56±0.04[a]	0.56±0.06[a]	0.58±0.12[a]	1.7
Ash	1.03±0.07[c]	1.19±0.11[b]	1.28±0.08[ab]	1.35±0.05[a]	2.4
CHO	31.36±0.86[bc]	33.05±1.96[ab]	34.78±0.62[a]	29.38±0.62[c]	22.6

Rows with different superscripts are significantly different at (P<0.05).

Organoleptic Assessment

Table 2 shows the mean hedonic scores (mean ± SD) of organoleptic assessments (taste, aroma, texture and appearance) of burger made with *Clarias garipenius*, *Scomber scombrus*, *Micropogonias undulatus* and *Merluccius merluccius*.

There was no significant (P>0.05) difference in the appearance of fish burger samples. The mean value for the appearance of the burger ranged from 7.06 to 7.38%. The highest value (7.34±1.25%) was obtained in burger made with *Micropogonias undulatus* and the least (7.06±1.24%) was seen in the burger made with *Clarias garipenius.*

The aromas of the fish burger were not significantly different (P>0.05) with sample B having very good aroma, while samples A, B and D had good aroma. The lowest mean value (6.47±1.31%) was *Clarias garipenius* burger and the highest (7.50±1.75%) was that of *Scomber scombrus*

There was no significant (P>0.05) difference in the texture of the burger samples. The mean values for the texture ranged from 7.28 to 7.75. They all had very good textures. The burger made with *Scomber scombrus* had the best (7.75±1.53%) texture and the least (7.28±1.09%) was seen in burger made with *Micropogonias undulatus*.

There was no significant (P>0.05) difference between the taste of the burger made with various fish species. The fish burger made with *Scomber scombrus* had the best (8.13±1.54%) taste and both samples C (*Micropogonias undulatus*) and D (*Merluccius merluccius*) had the least (7.00±1.37%) taste value.

Table 2: Organoleptic assessment of burger made with some fish species

Variable	*C. garipenius*	*S. scombrus*	*M. undulates*	*M. merluccius*
Appearance	$7.06±1.24^{a}$	$7.22±0.98^{a}$	$7.38±1.45^{a}$	$7.34±1.25^{a}$
Aroma	$6.47±1.31^{a}$	$7.50±1.75^{a}$	$6.50±1.63^{a}$	$6.88±1.31^{a}$
Texture	$7.44±0.81^{a}$	$7.75±1.53^{a}$	$7.28±1.09^{a}$	$7.38±1.31^{a}$
Taste	$8.00±1.55^{ab}$	$8.13±1.54^{b}$	$7.00±1.37^{a}$	$7.00±1.37^{a}$

Means with different superscripts are significantly different (P<0.05).

DISCUSSION

The percentage of water is a good indicator of its relative content of energy, protein and lipid (Olagunju *et al*., 2012). The lower the percentage of water, the higher the lipid and protein contents, the higher the energy density of the fish products. High moisture content in fish products is conducive for the human organs which helps to lubricate (Kris-Etherton *et al*., 2003).

The result of moisture content from this study is similar to Bavitha *et al.* (2016) who made fish burger from common carp (*Cyprinus carpio*) and got 55.26±0.03%. The result of the moisture content from this study is not in accordance with 63.25±0.56% that was obtained by Bochi *et al.* (2008) when they studied sliver catfish (*Rhamdia quelen*) burger. It also differed from 68.28+0.33% obtained by Bainy *et al.* (2014) who studied fish burger made from *Oreochromis niloticus*. The difference in value may be attributed to the difference in seasons, physiological make-up of the fish, change in environment, migration, starvation or heavy feeding (Effiong and Fakunle, 2012). It might also be due to release of water from fish when cooking which can lead to reduction in moisture content of the fish burger (Haq *et al*., 2013). This further shows that high moisture content in a fish product (such as fish burger) could lead to an increase in microbial activities which are prone to spoilage. The high moisture content of the hamburgers demands attention, such that they are produced rapidly and immediately stored under refrigeration or frozen, to avoid microbial proliferation and ensure preservation of their freshness (Breda *et al*., 2017).

The protein content of the fish products in this study may be related to the high protein content of the fish feed/natural food comprising of high percentage crude protein feed, crustaceans, molluscs, algae and diatoms in their natural habitat (Osibona, 2005).

The results of crude protein content of the bugers made from the various commercially important fish species were contrary to the findings of Bochi *et al.* (2008) who got 20.82 + 0.77% when silver catfish burger (*Rhamdia quelen*) was studied; Breda *et al.* (2017) who got 15.52% when *Oreochromis niloticus* burger was analysed and Coban and Kelestemur (2016) who got 18.11% when European catfish burger (*Silurus glanis*) was studied.

The reduction of protein content in fish burger might be due to excessive heat generated during cooking that denaturized the protein (Haq *et al*., 2013).The protein composition of fish products may be affected by a diversity of factors such as size, sexual maturation, temperature, salinity, exercise, ration, time and frequency of feeding, starvation, type of species, type and amount of dietary ingredients which may have affected the protein content of the fish products (Shearer, 2004). The decrease in protein content may also be attributed to the leaching out of the water-soluble nitrogenous components when cooking along with moisture (Bavitha *et al.,* 2016)

Fat and protein are the major nutrients in fish products and their percentage level helps to define the nutrition status of a particular product (Aberoumad and Pourshafi, 2010). The mean fat content in this study ranged from 15.58% to 11.34%. The findings of Bochi *et al*. (2008) who got 7.02±0.23 from burger made with silver catfish (*Rhamdia quelen*) is completely different from the results of this study. Same with Coban and Kelestemur (2016) who had (5.8%) on European catfish (*Silurus glanis*) burger and Bainy *et al.* (2014) who got (6.57± 0.41%) on Oreochromis *niloticus* burger.

The increase in fat content in this study can be attributed to the decrease in moisture content as they are inversely proportional (Bavitha *et al*., 2016). According to Haq *et al*. (2013), lipid content increase in fish burger due to the addition of vegetable oil during frying. The feeding habits, sex, species, seasonal variation, and other factors greatly affect the nutrient composition of an individual fish species, which also affects the proximate composition of the fish products (Effiong and Fakunle, 2011). Lipid oxidation is another important factor for spoilage in frozen fish and fishery products (Bavitha *et al.*, 2016).

There was no significant (P>0.05) difference in the crude fiber contents of the various fish burgers. The slight difference observed in crude fiber may be due to the use of different fish species, which may have different age, feed intake, sex, and sexual changes connected with spawning, the environment, season as well as geographic location (Silva *et al*., 2000).

Ash is a measure of the mineral content of any food including fish (Omotosho *et al*., 2011). It is the organic residue that remains after the organic matter has been burnt off (Adewumi *et al*., 2014). Ash was found in small, insignificant amounts in the fish burger that were analyzed.

The findings from this study is similar to the result (00.98%) obtained by Breda *et al.,* (2017) on *Oreochromis niloticus* burger but contrary to the findings by Haq *et al*. (2013) who had 2.98±0.09% from *Ctenophygodon idella* (grass carp) burger; Bochi *et al.* (2008)

who had 3.49±0.27% from burger made with silver catfish (*Rhamdia quelen*) and Coban and Kelestemur (2016) who got 3.7% from European catfish (*Silurus glanis*) burger.

The concentration of mineral and trace elements that contribute to the total ash content are known to vary in fish depending on their feeding behavior, environment, ecosystem and migration even within the same area (Andres, 2000; Canli, 2003). According to Bainy *et al.* (2014) The increase in ash content of fish burger could be due to the addition of ingredients during processing.

Carbohydrates are sources of instant energy, which can be used in the body development and growth (Olagunju *et al*., 2012). Carbohydrates, mainly glycogen, consist of a minor percentage of the chemical composition of the fish muscle which is used for energy in fish (Babalola *et al*., 2011). Fish generally have a very low level of carbohydrates (USDA, 2010).

The carbohydrates content in this study was contrary to the findings of Bochi *et al.* (2008) who analyzed carbohydrates content of sliver catfish (*Rhamdia quelen*) burger and had 5.48±0.64% and Breda *et al.* (2017) who had 3.01% from *Oreochromis niloticus* burger; Coban and Kelestemur (2016) had 6.1% from European catfish (*Silurus glanis*) burger. Fish generally have very low levels of carbohydrates because glycogen does not contribute much to the reserves in the fish body tissues (USDA, 2010). Babalola *et al.* (2011) reported carbohydrate content ranging from 1.5 to 4.5% for five fish species (*Trachurus trachurus*, *Sardinella aurita*, *Micropogonias furnieri*, *Scomber scombrus* and *Clarias gariepinus*) in Nigeria but the increase in carbohydrates observed in this study could be derived from the ingredients used in fish burger formulation such as wheat flour used in making the burger buns (Bochi *et al*., 2008).

Scomber scombrus burger had the best taste. From the result it was observed that the taste of burgers made with *Scomber scombrus* had a better significantly distinctive taste than *Clarias garipenius*, *Micropogonias undulatus* and *Merluccius merluccius*. The improvement in taste could be attributed to the fact that *Scomber scombrus* is a scaly and oily fish.

The best appearance was seen in *Micropogonias undulatus* burger with an average value of 7.38 (73.8%) that was significantly higher than the burgers of *Merluccius merluccius*, *Scomber scombrus* and *Clarias gariepinus.* The result of this study was in line with that of Duman (2020) who got 7.4 (74%) for appearance from burger made with *Luciobarbus esocinus*,. Food color frequently influences how we observe and assess food. It helps to determine quality, degree of processing and spoilage (Ayuba *et al.*, 2015). This result is also similar to 7.25 (72.5%) observed by Haq *et al*. (2013) from burger made with grass carp (*Ctenophygodon idella*).

Ayuba *et al.* (2015) reported that the range of textures of a food is very critical and a departure from an excepted texture is a measure of quality defects. This result of this study is similar to the mean texture value of 73% in *Luciobarbus esocinus* burger as recorded by Duman (2020). This result is not in line with the mean value of 8.47 (84.7%) observed by Haq *et al*. (2013) when grass carp (*Ctenophygodon idella*) burger was sudied.

The results of the aroma of fish burgers from this study do not follow report 8.3 (83%) of Duman (2020) who studied the nutritional value and sensory acceptability of fish burger prepared with flaxseed flour.

CONCLUSION

The study revealed that the nutritional values of burgers made from the commercial fish species were close to what was recommended by FAO with the closest being *Clarias* *garipenius* and then *Scomber scombrus*. They are the best fish species for making fish burgers as *Clarias garipenius* fish burger had the highest crude protein followed by *Scomber scombrus*, then *Micropogonias undulatus*, and lastly *Merluccius merluccius* burger.

Clarias garipenius is cheap and one of the most cultured fish in Edo State and Nigeria at large, making it readily available while, *Scomber scombrus* is one of the most imported fish species in Nigeria making available in all part of Nigeria. It is rich in omega 3 and 6 fatty acid and free from cholesterol making it very healthy for human consumption when value is added to the fish species as fish burger. *Clarias garipenius* fish burger had low fat and good amount of carbohydrates for energy.

The burgers made from the various fish species were ready to eat food that are good sources of dietary protein and energy for human consumption.

The study also showed that the fish burgers had good aroma, texture, appearance and taste with the burger made with *Scomber scombrus* having the best aroma, texture and taste while that made with *Merluccius merluccius* had the best appearance.

REFERENCES

Aberounmand, A. and Pourshafi, K. (2010). Chemical and proximate composition properties of different fish species obtained from Iran. *World Journal of Fish Marine Sciences*, 2: 237-239.

Abolagba, O.J. and Osifo, S.J. (2004). The effect of smoking on the chemical composition and keeping qualities of catfish (*Heterobranchus bidorsalis*) using two energy sources. *Journal of Agriculture, Forestry and Fisheries,* 5(1):27-30.

Adewolu, M.A. and Adeoti, A.J. (2010). Effect of mixed feeding schedules with varying dietary crude protein levels on the growth and feed utilization of *Clarias gariepinus* (Burchell, 1822) fingerlings. *Journal of Fisheries and Aquatic Sciences*, 5: 304-310.

Adewumi, A., Adewole, H. and Olaleye, F. (2014). Proximate and elemental composition of the fillets of some fish species in Osinmo Reservoir, Nigeria. *Agricultural Biology Journals*, 5(3):109-117.

Akintola, A.J. and Lawal, O. (2011). Biochemical factors involved in the resistance of some tropical fish samples to insect attack, 35:89-93.

Andres, S., Ribeyre, F., Toureneq, J. N. and Boudou, A. (2000). Interspecific comparison of cadmium and Zinc contamination in the organs of four fish species along a polymetallic pollution gradient (Lot River, France). *Science of Total Environment*; 284: 11-25.

Aremu, M. O., Namo, B. S., Mohammed, Y., Archibong, C. S. and Ogah, E. (2014). Effect of different sources of beat on nutritional composition of tilapia fish (*Oreochromis niloticus*). *Chemistry and Materials Research*, 6 (5): 2224- 3224.

Association of Official Analytical Chemists. (2010). *Official methods of Analysis of the Association of Official Analytical Chemists International*, 18th edition; Gaithersburg, AOAC international, USA. *Aquaculture*, 76 (1-2), 119-126.

Ayuba, V. O., Makinde, J. O. and Omeji, N. O. (2015). Effect of insect infestation on shelf life of smoked- dried fish. Proceedings of the 21st *Annual Conference of the Fisheries Society of Nigeria*, November 13-17, 2006, Calabar, Nigeria. 357-359.

Babalola, A. F., Adeyemi, R. S., Olusola, A. O., Salaudeen, M. M., Olajuyigbe, O. O. and Akande, G. R. (2011). Proximate and Mineral Composition in the Flesh of Five Commercial Fish Species in Nigeria. *Internet Journal of Food Safety*, 13:208-213.

Bainy, E. M., Bertan, L. C., Corazza, M. L., and Lenzi, M. K. (2014). Effect of grilling and baking on physicochemical and textural properties of tilapia (*Oreochromis niloticus*) fish burger. *Journal of Food Science and Technology*, 3197-014-1604-3.

Barnes, M. (2008). Atlantic mackerel (*Scomber scombrus*) -MarLIN- *The Marine Life Information Network.* (n.d.). https://www.marlin.ac.uk/species/detail/44.

Bavitha. M., Dhanapal, M., Vidyasagar, R. G., Narayanan, M. and Sravani, K. (2016). Quality changes in fish burger from common carpio (*Cyprinus Carpio*) during refrigerated storage. *International Journal of Science, Environment and Technology*, 5: 646-1657.

Belusso, A.C., Nogueira, B.A., Breda, L.S. and Mitterer-Daltoe, M.L. (2016). Check all that apply (CATA) as an instrument for the development of fish products. *Food Science and Technology* (*Campinas*), 36(2): 17.

Bochi, V. C., Weber, J., Ribeiro, C. P., Victorio A. M. and Emanuelli, T. (2008). Fish burgers with silver catfish (*Rhamdiaquelen*) filleting residue. *Bioresour Technology*, 99: 8844–8849.

Bradley, B., Byrd, K. A., Atkins, M., Isa, S., Akintola, S. L., Fakoya, K. A., Ene-Obong, H. and Thilsted, S. H. (2020). Fish in food systems in Nigeria: A review. 041-1651

Breda, L. S., Belusso, A. C., Mitterer-Daltoe, M. L., Camargo, G. H. and Nogueira, B. A. (2017). Acceptance of fish hamburgers in school meals in the Southwest Region of Parana, Brazil. *Food Science and Technology*, ISSN 0101-2061.

Canli, M. (2003). The relationship between heavy metal (Cd, Cr, Cu, Fe, Pb and Zn) levels and size of six Mediterranean fish species. *Environmental Pollution* 121: 129-136.

Coban, E. O. and Kelestemur, G. T. (2016). Qualitative improvement of catfish burger using Zataria multiflora Boiss essential oil: *International Food Research Journal*, 20(4): 1575-1578.

Corbo, M. R., Speranza, B., Filippone, A., Granatiero, S., Conte, A., Sinigaglia, M. and Del-Nobile, M. (2008). Study on the synergic effect of natural compounds on the microbial quality decay of packed fish hamburger. *International Journal of Food Microbiology*: 127(3): 261-267.

Duman, M. (2020). Nutritional Value and Sensory Acceptability of Fish Burger prepared with Flaxseed Flour.

Effiong, B. N. and Fakunle, J. O. (2012). Proximate and mineral content of traditional smoked species from Lake Kainji, Nigeria. *Bulletin of Environment pharmacology and Life Science*, 1: 43-45.

FAO. (2024). Fishery and aquaculture country profiles. Nigeria, country profile fact sheets. Updated 1 July. (2024). *FAO Fisheries and Aquaculture Department*, Rome, Italy.

Food and Agricultural Organization (FAO). (2010). Post-harvest loss in small scale fisheries. A case study in five sub-saharan African countries. *Fisheries and Aquaculture Technical, Paper* 550. 89p.

George A.B. (2010). Pyroligneous Acide Extract, Fenaroli's Handbook of Flavour ingredients (6tg edition). *Taylor and Francis.* 1775-1776.

Goncalves, A. A. and Kaiser. C. (2011). Value-added products from aquaculture. *A global trend. World Aquaculture Society;* 43: 4, 48-52,67.

Hanafy, G. B. (2019). Morphological studies on the gills of the European hake (*Merluccius merlucciusi). Linnaeus*, 1758). 1-10.

Haq, M., Dutta, P. L., Sultana, N. and Rahman, M.A. (2013). Producton and quality assessment of fish burger from grass carp, *Ctenopharyngodon idella*. (Cuvier and Valenciennes, 1844). *Journal of Fisheries*, 1(1): 42-47.

Haruna, A.B. (2003). Aquaculture in the tropics Theory and Practice. Al-Hassan Kano. 432Pp.

Henchion, M., Hayes, M., Mullen, A. M., Fenelon, M. and Tiwari, B. (2017). Future protein supply and demand: strategies and factors influencing a sustainable equilibrium. *Foods*, 6(7),53.

Kefas, M., Kolapo, A., Jauro, I. A. and Haziel, H. (2022). Effects of Ginger (*Zingiber officinale*) and Clove (*Syzygium aromaticum*) Extacts on the Quality of *Clarias garipen*ius Processed with Kainji modified Drum klin. *FUDMA Journal of Sciences (FJS)*, 6(6): 89-96.

Kris-Etherton, P. M., Harris, W. S. and Appel, L. J. (2003). Fish consumption, fish oil, omegy-3 fatty acid and cardiovascular disease. *Artherioschlerosis thrombosis Vascular Biology*, 23: 20-31.

Latorres, J. M., Mitterer-daltoe, M. L. and Queiroz, M. I. (2016). Hedonic and word association techniques confirm a successful way of introducing fish into public school meals. *Journal of Sensory Studies*, 31(3): 18.

Mitterer-Daltoe, M. L., Queiroz, M. I., Fiszman, S. and Varela, P. (2014). Are fish products healthy? Eye tracking as a new food technology tool for a better understanding of consumer perception. *Lebensmittel- Wissenschaft + Technologie*, 55(2): 459-465.

Mitterer-Daltoe, M., Latorres, J., Treptow, R., Pastous-Madureira, L. and Queiroz, M. (2013a). Acceptance of breaded fish (Engraulis anchoita) in school meals in extreme southern Brazil. Acta Alimentaria, 42(2): 275282.

Mohanty, B. P., Mahanty, A., Ganguly, S., Mitra, T., Karunakaran, D. and Anandan, R. (2019). Nutritional composition of food fishes their importance in providing food and nutritional security. *Food chemistry*, 293: 561-570.

OECD/FAO. (2011). Organisation for Economic Co-operation and Development (OECD) and the Food and Agricultural Organization (FAO) of the United Nations. Agricultural Outlook 2011-2020. http://www.oecd.org/. Accessed 21 November 2013.

Olagunju, A., Mohammed, A., Mada, S. B., Mohammed, H. A. and Mahamond, K. T. (2012). Nutrient compositions of *T. zilli*, H. Membranacea, *Clupea*. *Harengus* and *Scomber scombrus scrobus* consumed in Zaria. *World Journal of Life Science and Medical Research*, 2: 16-23.

Ola-Oladimeji, F. A., Awodiran, M. O., Fagbuaro, O. and Akomolafe, A. O. (2016). Morphological characterization of wild and cultured *Clarias gariepinus* (Burchell 1822) using principal component and cluster analyses. 8(4): 428-436.

Omolara O.O. and Omotayo O.D. (2009). Preliminary Studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria. *Biochemistry*.

Omoruyi, K., Nneli, A.E. and Benjamin. O.G. (2019). Effect of Natural Preservatives (Lemon Grass and Bay Leaf Marinade) on the Microbial Load and Shelf Life of Smoke-dried *Clarias gariepinus*. *Asian Food Science Journal*, 10(3): 2581-7752.

Omoruyi, K., Okpeva, O. and Abdullahi, M.M. (2017). Effects of oven-drying and smoke-drying on the nutritional quality of snakehead (*Parachanna obsura*) and upside-down catfish (*Synodontis clarias*) in Delta state. *FUW Trends in Science and Technology Journal*, **2** (1): 239-243.

Omotosho, O. E., Oboh, G. and Iweala, E. J. (2011). Comparative effects of local coagulants on the nutritive value, invitro multi-enzyme protein digestibility and sensory properties of Wara cheese. *International journal of Dairy Science*, 6: 58-65.

Osibona, A. O. (2005). Comparative study of proximate composition. Amino acids, fatty acids and aspects of the biology of some economic fish species in Lagos State, Nigeria. Ph.D. Thesis 218.

Phiips, A. E. (2012). Feeding behavior of the European hake *Merluccius merluccius* Linnaeus,1758 (family: Gadidae) from Egyptian Mediterranean waters off Alexandria. *The Egyptian Journal of Aquatic Research*, 38(1): 39-44.

Searles K. I., Münchhausen, S.V., Kirwan, J., Chiswell, H., Prosperi, P., Vergamini, D., Minarelli, F., Vlahos, G. and Tsakalou, E. (2018). Adding value to the fish. Business Strategies in Fish Farming and Small-Scale Fishery. *7th AIEAA Conferences*, 14-15.

Shearer, K. D. (2004). Factors affecting the proximate composition of cultured fishes with emphasis on salmonids, Aquaculture, 119: 63-88.

Silva, J., Marney, J.I. and Chamui, R.S. (2000). Composition of marine and freshwater finfish and she'll fish species and their products. *Technomic Publishing Company*; 1: 31-46.

US Department of Agriculture (USDA). (2010). Agricultural Research Service, National Nutrient Data base for standard reference, Release 23, Nutrient laboratory.

World Fish Centre. (2005). Fish for All: Turning point for Aquaculture and Fisheries in Africa, 28(3 and 4): 14-20.

Zulfahmi, I., Akmal, Y., Burhanuddin, A. I., Dhamayanti, Y., Paujiah, E., Sumon,K. A., Nur, F. M. and Pandit, D. N. (2021). Osteocranium anatomy of Africancatfish (Clarias gariepinus Burchell,1822) from cultured pond in Aceh. *Indonesia Iraqi Journal of Veterinary Sciences*, 36(3): 549-554.