ABSTRACT

The purpose of this study was to figure out catfish meat's chemical composition, mineral content, amino acid composition, and fatty acid profile. Moisture, protein, lipid, and ash content were measured at 71.30%, 19.03%, 8.10%, and 1.5%, respectively. Catfish meat had higher levels of calcium, phosphorus, and iron, with 304.82, 279.45 and 17.03 mg/100 g, respectively. The essential amino acid content was 41.81 g/100g protein. Oleic, linoleic, and palmitic acids were the most common fatty acids present in catfish meat. Oleic acid made up more than a third of the fatty acid content in catfish meat. Because of its high oleic acid content, catfish meat should be considered because it has been linked to a lower risk of cardiovascular disease.

Keywords: Catfish; chemical composition; minerals; amino acids; fatty acids.
1. INTRODUCTION

In developing countries, fish has played an important role in resolving the sustainability of people's food and livelihoods. About 2.6 billion people consume 20% of their animal protein from fish, and over 400 million people in Asia and Africa consume at least 50% of their animal protein from fish. However, only 13% of animal protein consumption is provided in developing countries [1]. In the tropics, fish is one of the most essential sources of animal protein, and it has long been recognised as a source of high-quality protein and other essential nutrients [2].

Catfish (Clarias gariepinus) are primarily freshwater fish that are well adapted to confined environments and are resistant to manipulation and disease. It is produced in large quantities alongside the Nile fisheries, particularly Nasser's Lake, as well as fish farming and other freshwater lakes in Wadi El-Rayyan Lake's first pond. Catfish is extremely nutritious, containing a high concentration of unsaturated fatty acids, vitamins, proteins, and minerals [3].

The nutritional value of fish meat is highly valued by consumers. Fish meat is a high-protein source that contains essential amino acids. It also has a high concentration of omega-3 fatty acids and a variety of other nutrients, such as vitamins and fat-soluble and micro-elements. As a result, the demand for fish meat is growing all the time. On the other side, the world's stock of fish and seafood is dwindling. As a result, there has been a surge in interest in aquaculture and fish farming [4].

Fish can be a very nutritious part of the human diet; it contains most of the vitamins he requires, a wide range of minerals, and all of the necessary amino acids are properly proportioned in the proteins. Fish and fish products contain water, proteins and other nitrogen compounds, lipids, carbohydrates, minerals, and vitamins, as do many other animal products. [5]. Consumption of catfish (Clarias gariepinus) has increased rapidly in recent years as a result of its availability, consistency, and health benefits [6].

In fish, the presence of energy depots in the form of lipids indicates the fish's efficiency. Fish oil has a high polyunsaturated fatty acid concentration, which lower serum cholesterol and help to prevent a variety of coronary heart diseases. Fish meat is also high in minerals, with zinc (Zn), iron (Fe), and copper being the most abundant microelements (Cu) [7].

African catfish farming has increased production and has recently gained significant importance in many African countries, transforming it from an undesirable species to a desirable species [8].

2. MATERIALS AND METHODS

2.1 Raw Materials

Ten kg of fresh African catfish (Clarias gariepinus) was obtained from local market in Assuit city, Egypt during August 2020. Fresh fish were transported in ice-box to the Faculty of Agriculture, Department of Food Science and Technology, Al-Azhar University, Assuit, Egypt.

2.2 Methods

2.2.1 Chemical composition

The proximate composition of catfish meat was determined using the [9] method. The crude protein content was determined using the Kjeldahl method, and the crude lipid content was determined using the Soxhlet method. To determine the ash content, the samples were ash overnight at 550°C. The samples’ moisture content was determined by drying them overnight at 105°C.

2.2.2 Mineral content determination

A flame photometer for sodium, a speckoll spectrophotometer for phosphorus, and a perki-Elmer Atomic Absorption spectrophotometer 2380 for calcium, manganese, iron, and zinc were used to determine the mineral content of Catfish meat samples. As stated in [10].

2.2.3 Amino acid composition

The amino acids were determined using the method described in [11]. With a few changes, which can be summarised as follows: In a closed test tube at 110°C for 24 hours, a known weight of dry, fat-free samples was hydrolyzed with 5 ml of 6 N HCl. Filtration was performed on the hydrolysate. With distilled water, the residue was washed away, and the filtrate volume was increased to 50ml. The filtrate was then evaporated on a water bath at 50°C for 5 ml. In 5 mL loading buffer, the residue was dissolved (0.2 N sodium citrate buffer of pH 2.2). At the National
Research Center Giza-Cairo, amino acids were determined using chromatography and a Beckman Amino Acid Analyzer Model119CL.

2.2.3.1 Chemical score calculation

According to [12], the chemical score (CS) was established. As follows:

\[ CS = \frac{(\text{mg of essential amino acid 1gm test protein})}{\text{(mg of essential amino acid 1gm reference)}} \]

2.2.3.2 Calculating the A/E ratio

According to [13] the following is the relationship between the content of an individual essential amino acid in a food protein (A) and the total essential amino acid content (E).

\[ \text{A/E ratio} = \frac{\text{mg of the individual essential amino acid}}{\text{g of total essential amino acid}} \]

2.2.4 Composition of the fatty acids

2.2.4.1 Preparation of fatty acid methyl esters

As stated in [14], the methyl esters for fatty acids were segregated from total lipids using 5 ml 3 % H2SO4 in absolute methanol and 2 ml benzene. Methanol was used to heat the contents to 90°C for 90 minutes. The methyl esters were extracted with aliquots of 5 ml hexane each after phase separation was performed with the addition of 2 ml water after cooling. The organic phase was separated, and then filtered through anhydrous sodium sulphate before being concentrated with a rotary evaporator.

2.2.4.2 Fatty acid methyl esters gas liquid chromatography

Fatty acid methyl esters were separated using Perkin-Elmar Gas Chromatography (model F22) with a flame ionisation detector and nitrogen as a carrier gas. The separation was performed on a glass column (2 m 60.25 in) packed with diethylen glyco succinate (DEGS) on chromosorb W, 80–100 mesh. The temperature of the injector and detector was 220 °C. The flow rates for nitrogen, hydrogen, and air were 30, 30, and 300 ml/min, respectively. The chart speed was one centimetre per minute. Peak identification was accomplished by comparing the retention times obtained with standard fatty acid methyl esters. Method of angulation [15].

2.2.5 Statistical analysis

The obtained data from three replicates were analyzed by (ANOVA) using the SPSS statistical package program and differences among the means were compared using the Duncan's Multiple Range test [16]. A significant level of 0.05 was chosen.

3. RESULTS AND DISCUSSION

3.1 Grooss Chemical Composition

Table 1 indicates the estimated chemical composition and caloric value of catfish meat. Moisture, protein, fat, and ash were calculated to be 71.30±0.15, 19.03±0.46, 8.10±0.09, and 1.05±0.14, respectively. The moisture content of catfish was lower than that recorded by [17], who stated that the moisture content in catfish (Clarias gariepinus) was (77.2 %). According to [18] in Nile Karmout fish it was 72.9±0.8%. While, [19] found that, in wild and farmed catfish it was 77.2±0.8%. On the other hand, catfish fillets had a moisture content of 68.77±2.21% as reported by [20]. The protein of catfish meat were 19.03±0.46 and fat content of catfish meat were 8.10±0.09. The findings were consistent with those of [19] who found that, the protein content of wild catfish was 19.33±0.25%.

| Parameters       | Catfish                      |
|------------------|------------------------------|
| Moisture %       | 71.30 ± 0.15                 |
| Protein %        | 19.03 ± 0.46                 |
| Fat %            | 8.10 ± 0.09                  |
| Ash %            | 1.05 ± 0.14                  |
| Carbohydrate %   | 0.52±0.12                    |
| Caloric value (kcal/100 g) | 151.1±0.08                  |

The ash content of catfish meat was 1.05±0.14, according to the data in Table 1. The results were consistent with those stated by [22] who found that the ash content in Clarias gariepinus was 1.7±0.06%. On the other hand, [19] found that the ash content in wild catfish was (1.40%). Catfish had a carbohydrate content of 0.520.12.On the other hand, [23] found that the
carbohydrate content in catfish minced meat, both unwashed and washed, was 0.38±0.16 wet basis and 1.61±0.66 dry basis in unwashed minced meat and 0.97±0.14 wet basis and 4.64±0.73 dry basis in washed minced meat. [24] found out about the carbohydrate content of C. gariepinus and C. sp1 epidermal mucus was 2.25±1.33 and 0.64±0.23, respectively. Carbohydrate, protein, and fat content decide the nutritional value of catfish meat. The caloric value of the catfish meat analysed was found to be 151.10.08 kcal/100g. Muscle tissue had an energy value of 93.50 to 175.83 kcal/100 g, according to [25]. Though [26] found 105–208 kcal/100 g in cultured sturgeon muscle tissue. Meat from C. gariepinus males and females had a low calorific value, averaging 496.59 kJ/100 g on average [27].

3.2 Minerals Content of Catfish Meat

The data in Table 2 showed that. The calcium content in catfish meat was 304.82 mg/100g, the sodium content was 142.29 mg/100g, the phosphorus content was 279.45 mg/100g, the magnesium content was 11.45 mg/100g, the iron content was 17.33 mg/100g, the manganese content was 1.17 mg/100g, and the zinc content was 2.92 mg/100g (on dry basis).

[28] Calcium and potassium have average means of 1.05±0.19 and 5.31±0.53 mg/g in the dry season and 2.09±0.93 and 4.65±2.54 mg/g in the wet season, respectively, according to the mineral analysis of C. gariepinus for both the dry and wet seasons. The Ca and Fe concentrations in this study were higher than those recorded by [29] (231 mg/100 g to 265 mg/100 g) and (9 mg/100 g). Mineral content differences may be caused by the fish’s age, type, and feed.

On the other hand, [30] studied mineral content in Pangasius hypophthalmus and discovered that sodium had the highest proportion (387.5±135.9 mg kg-1) followed by potassium (335.6±3.42 mg kg-1) with low magnesium levels (12.08±0.15 mg kg-1). In general, [31] reported that calcium is important for bone formation and that fish, particularly small fish, is a good source of this mineral. Calcium intake for adults should range between 1000 and 1300 mg per day.

3.3 Amino Acid Composition of Catfish Meat

The composition and ratio of the various nutrient groups determine the dietary value of meat. The protein content of meat, particularly the content of essential amino acids, is one criterion for evaluating it [32]. Data in Table 3 showed that, that, The total amino acid content per 100g protein is 99.87 g. However, [33] reported that the total amino acid content of fresh clarias gariepinus was 95.03 g/100g protein (without determination of tryptophan). On the other hand, [25] The total amino acid content of the wels catfish(Silurus glanis) was discovered to be 100 g/100 g protein (with determination of tryptophan).

**Table 2. Minerals content of catfish meat (mg/100 g dry weight basis)**

| Minerals     | (mg/100 g) |
|--------------|------------|
| Calcium (Ca) | 304.82     |
| Magnesium (Mg)| 11.45     |
| Sodium (Na)  | 142.42     |
| Phosphorus (P) | 279.45   |
| Iron (Fe)    | 17.03      |
| Zinc (Zn)    | 2.92       |
| Manganese (Mn)| 1.17     |

The essential amino acid content was 41.81 g/100g protein according to the tabulated data in Table 3. This was comparable to the 42.5 % reported by [34] for catfish. While, [35] reported that Catfish had a percentage of essential amino acids of 40.2 %. However, [36] found that, the essential amino acids in crayfish was 55.703%.

The major amino acids in the essential fraction were lysine (10.45%) and leucine (8.34%). These findings are consistent with those of [35] for catfish and [36] for crayfish meat. Furthermore, the data revealed that, Glutamic acid had the highest value of any amino acid (16.38 %). [37] and [35] both reported the same trend for catfish meat. In contrast, the E/NE ratio in catfish meat was 0.72. These values were lower than the 0.82 reported by [38] or the 0.84 reported by [36]. While, [35] discovered that the essential to non-essential amino acid ratio was 0.69.

Another criterion is the protein chemical score (CS), which is defined as the lowest ratio of essential amino acid content in the test protein to each amino acid content in muscle protein, or to the EAA necessary level when the EAA requirement has already been determined. According to the CS hypothesis, whole egg protein has the highest biological value (BV) and thus is best for growth, and that growth would be limited by the critical amino acid in the diet with the lowest ratio to its content in whole egg protein [39]. As evidenced by the data in Table 4.
The first limiting amino acid in catfish meat, according to the chemical score, was tryptophan, and the second limiting amino acid was valine.

According to the data in Table 5, the A/E ratio of amino acids in cattfish meat was higher than the FAO recommendation for school children and adults. With the exception of methionine and phenylalanine for school-age children, the amino acids in catfish meat met or exceeded the recommendations for the most important amino acids for school-aged children and adults. In addition, tryptophan levels in catfish meat were lower than recommended.

### Table 3. Catfish meat amino acid composition (g/100 g protein)

| Amino acid   | Catfish meat | Amino acid   | Catfish meat |
|--------------|--------------|--------------|--------------|
| Threonine    | 5.04         | Glutamic Acid| 16.38        |
| Valine       | 5.21         | Proline      | 3.55         |
| Methionine   | 2.92         | Alanine      | 6.90         |
| Isoleucine   | 4.94         | Cysteine     | 1.28         |
| Leucine      | 8.34         | Tyrosine     | 1.30         |
| Phenylalanine| 3.84         | Glycine      | 5.19         |
| Lysine       | 10.45        | Non-Essential amino acids (N-EAA) | 57.56 |
| Tryptophan   | 1.07         | Total amino acid | 99.37 |

### Table 4. Catfish meat chemical score and limiting amino acid

| EAA              | Egg(E) | score (A / E × 100) |
|------------------|--------|---------------------|
|                  | E.A.A mg /g protein | Catfish |
| Threonine        | 51     | 98.82               |
| Valine           | 76     | 68.55               |
| Methionine       | 32     | 84.06               |
| Isoleucine       | 56     | 91.25               |
| Leucine          | 83     | 100.48              |
| Phenylalanine    | 51     | 75.29               |
| Lysine           | 63     | 165.87              |
| Tryptophan       | 18     | 59.44               |
| First limiting amino acid | Tryptophan |                |
| Second limiting amino acid | Valine |                |

A = mg amino acid /g protein tasted material,  E = mg amino acid /g protein for egg

### Table 5. A/E ratio of catfish meat in comparison to FAO [13]

| EAAs            | Catfish | FAO [13] |
|-----------------|---------|----------|
|                 | School children | Adult |
| Threonine       | 120.54  | 126      | 81     |
| Valine          | 124.61  | 112      | 117    |
| Methionine      | 69.83   | 99       | 53     |
| Isoleucine      | 118.18  | 126      | 117    |
| Leucine         | 199.47  | 198      | 171    |
| Phenylalanine   | 91.84   | 99       | 171    |
| Lysine          | 249.94  | 198      | 144    |
| Tryptophan      | 25.95   | 40       | 45     |

FAO [13], \( A/E \) ratio = \( \frac{mg \ of \ individual \ essential \ amino \ acid}{g \ of \ total \ essential \ amino \ acids} \)
3.4 Fatty Acid Content of Catfish Meat

One of the most important health benefits of eating fish is its complex fatty acid profile [40]. Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) are defined. Table 6 shows the fatty acid composition of total lipids in catfish meat. The data discovered that four fatty acids influence the lipid profile of catfish: oleic (C18:1), linoleic (C18:2), palmitic (C16:0), and steric (C16:1) [25] made the same observation about wels catfish, and [41] made the same observation about catfish. On the other hand, these fatty acids together accounted for 64.40 percent of the total lipid content of catfish meat. It was nearly identical to the 76.67 percent reported by [25] for wels catfish meat. Geographical location, Breed, sex, age and diet environment can all have an impact on fatty acid content [42].

Furthermore, the data revealed that more than a third of the lipid content in catfish meat was accounted for by oleic acid. According to [44] oleic acid (C18:1) has a beneficial effect on decreasing plasma cholesterol and has been reported to reduce the risk of coronary heart disease by 20-40%, primarily by lowering LDL cholesterol. As a result of its high oleic acid content and ability to prevent heart disease, catfish meat should be considered.

Table 6 shows that catfish meat contained a trace of vaccinic acid (2.10%). Vaccinic acid is a type of fatty acid that belongs to the omega 7 family. According to [44] the presence of Omega 7 in epithelial cell membranes protects the body by inhibiting bacterial growth and promoting tissue regeneration and healing. Palmitic acid (C16:1) was responsible for 21.59% of the saturated fatty acids (SFA) in catfish meat, had the highest content. This result was consistent

### Table 6. Fatty acid content of total lipids in catfish meat % of total fatty acids

| Carbon chain | Fatty acid | Catfish | Recommended minimum ratio [43] |
|--------------|------------|---------|---------------------------------|
| C12:0        | Lauric acid| 0.66    |                                 |
| C14:0        | Myristic acid| 0.46   |                                 |
| C15:0        | Pentadecanoic acid| 0.12 |                                 |
| C16:0        | Palmitic acid| 21.59  |                                 |
| C16:1u9      | Palmitolic acid| 0.54 |                                 |
| C16:1u7      | Palmitolic acid| 4.68  |                                 |
| C17:0        | Heptadecanoic acid| 0.36 |                                 |
| C18:0        | Stearic acid| 6.46    |                                 |
| C18:1u9      | Oleic acid| 36.35   |                                 |
| C18:1u7      | Vaccinic acid| 2.10   |                                 |
| C18:2u7      | 6-Octadecosanoic acid| 0.14 |                                 |
| C18:2u6      | Linoleic acid| 19.76  |                                 |
| C18:3u6      | Gamma linolenic acid| 1.94 |                                 |
| C18:3u3      | Linolenic acid| 1.08   |                                 |
| C18:4u3      | Stearidonic acid| 0.18  |                                 |
| C20:0        | Arachidonic acid| 0.11 |                                 |
| C20:1u9      | Gondoic acid| 0.36    |                                 |
| C20:2u6      | Eicosatrienoic acid| 0.27 |                                 |
| C20:3u6      | Eicosatrienoic acid| 0.75 |                                 |
| C20:4u6      | Arachidonic acid| 1.07  |                                 |
| C20:5u3      | Eicosapentaenoic acid| 0.10 |                                 |
| C22:4u6      | Docosatetraenoic acid| 0.21 |                                 |
| C22:5u3      | Cludandonic acid (DPA)| 0.24 |                                 |
| C22:6u3      | Docosahexaenoic acid (DHA)| 0.31 |                                 |

Non identified fatty acid 0.16

EFAs 20.95

SFA 29.92

UFA 70.08

MUFA 44.17

PUFA 25.91

PUFA/SFA ratio 0.86 0.4 – 0.5
with the findings of [25] for wels catfish and [34] for fresh and processed catfish. *Clarias gariepinus* is a species of Clarias.

Catfish meat had a total saturated fatty acid content (SFAs) of 29.92%. According to [46] wels catfish has a higher SFA content (30.22%). In contrast, [26] discovered SFA level in sturgeon (25.99%). According to [34] (SFAs) were found to be 38.61% in fresh catfish. While, [25] reported that wels catfish content 16.32% of SFAs.

Unsaturated fatty acids (UFAs) made up 70.08% of the total fatty acid content in catfish meat. The obtained results are slightly higher than the 61.39% reported by [34]. While [25] discovered that the wels catfish contained 80.39 percent unsaturated fatty acids (UFAs). In catfish meat, monounsaturated fatty acids (MUFAs) accounted for 44.17% of total fatty acid content. Polyunsaturated fatty acids (PUFAs) made up 25.91% of the total fatty acids found in catfish meat. On the other hand, Many studies have shown that freshwater fish have a lower proportion of n-3 PUFA than marine fish, and evidence in the literature has shown that the fatty acid composition of lipids from tissue and eggs represents the fatty acid content of the lipid in the diet fed to the brood stock; the fatty acid composition of tissue and egg lipids in farmed fish can really vary from that of wild fish [45].

While, [46] reported that, the monounsaturated fatty acids in wels catfish is higher (41.43%). According to [25] the PUFA and MUFA content of wels catfish was 26.31% and 54.08%, respectively. The ratio (P: S) is an effective indicator of the relative risk factor of a food's cholesterol content when SFAs and PUFAs are eaten together [47]. On the other hand, [48] reported that values greater than the maximum are harmful to health and may contribute to the development of cardiovascular diseases. The maximum n-6 to n-3 ratio recommended by the UK Department of Health is 4.0 [49]. Catfish meat had a PUFA/SFA ratio of 0.86. This ratio was lower than the 1.61 reported for wels catfish by [25]. In addition, [50, 51] reported that the PUFA to SFA ratio in freshwater is in the 0.66–1.56 range.

4. CONCLUSION

Catfish meat had higher levels of protein, Fe, and Zn, according to the findings. Catfish meat is high in essential amino acids, with oleic, linoleic, palmitic, and stearic acids dominating the fatty acid profile. Also, the data revealed that oleic acid accounted for more than a third of the lipid content in catfish meat.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO. FAO Fisheries And Aquaculture-Chemical Ele- Ments Of Fish; 2008 Available:http://www.fao.org/fishery/topics/14820/en
2. Gomma RA. Studies on producing sausage from some fish types. M. Sc. Thesis, Fac. of Agric., Al-Azhar Univ; 2005.
3. Nelson JS, Grande TC, Wilson MVH. Fishes of the world. Animal Science and Zoology. John Wiley and Sons Inc. 5th Edition; 2016.
4. B Runner EJ, Jones PJS, Friel S, Bartley M. Fish, human health and marine ecosystem health; Policies in collision. Int. J. Epi, 2009;38:93–100.
5. FAO. Example of successful in agriculture and rural development in the south. Sharing Innovative Experience. 2001;5:240-254.
6. Hoke ME, Jahncke ML, Silva JL, Heamsberger JO, Suriyaphan O. Stability of washed frozen mince from channel catfish frames. J.Food Sci. 200065:1083-1086.
7. Saadettin G, Barbaros D, Nigar A, Ahmet C, Mehmet T. Proximate composition and selected mineral content of commercial fish species from the Black sea. J Sci Food Agric. 1999;55:110-116.
8. Dadebo E, Aemro D, Tekle-Giorgis Y. Food and feeding habits of the African catfish *Clarias gariepinus* (Burchell, 1822) (Pisces: Clariidae) in Lake Koka, Ethiopia. John Wiley and Sons Ltd. African Journal of Ecology. 2014;52(4):471-478.
9. AOAC. Official methods of analysis. 17th Ed. Washington, D.C: Association of Official Analytical Chemist; 2000.
10. AOAC. Official methods of analysis, 16th Ed. Association of Official Analytical Chemists International, Arlington, Virginia, USA; 1995.
11. Pellett PL, Young VR. Nutritional evaluation of protein foods; report of a working group sponsored by the
12. Bhanu V, Ranacha G, Monteiro P. Evaluation of protein isolate from cassia uniflora as a source of plant protein. J of Sci Food and Agric. 1991;54:659-662.

13. FAO. Food and agriculture organization of united nations protein requirements, FAO Nutrition Meetings Report Series, No. 37, Rome; 1985.

14. Rossell JB, King B, Downes MJ. Detection of Adulteration. J. Am. Oil. Chem. Soc. 1983;60:333.

15. Kates M. Techniques of Lipidology. Isolation, Analysis and Identification of Lipids. North Holland Publishing Co, Amsterdam; 1972.

16. SPSS®, Statistical Packages for the Social Sciences Statistical Software For Windows Version 11.0. Micro -Soft, Chicago, IL, USA; 2001.

17. Adeyemi RS, Akande GR. Thermophysical properties of farmed African freshwater catfish (Clarias gariepinus) fillet for process design and optimization. Nigerian Food Journal. 2011;29(1).

18. Abdel-Aal HA. Using antioxidants for extending the shelf life of frozen Nile karmout (Clarias lazera) fish mince. Journal of Aquatic Food Product Technology. 2001;10(4):87-99.

19. Nubia E, Cruz-Casallas, Pablo E, Cruz-Casallas, Héctor Suárez-Mahecha. Quality of catfish meat Learius marmoratus during frozen storage. Universidad de los Llanos - Villavicencio, Meta, Colombia. 2014;18(1).

20. Zhu Y, Zhang K, Ma L, Huo N, Yang H, Hao J. Sensory, physicochemical and microbiological changes in vacuum packed channel catfish (Clarias lazera) patties during controlled freezing-point storage. Food Science and Biotechnology. 2015;24(4):1249-1256.

21. Oladipo IC, Bankole SO. Nutritional and microbial quality of fresh and dried clarias gariepinus and oreochromis niloticus. International Journal of Applied Microbiology and Biotechnology Research. 2013;1(1):1-6.

22. Deng OO. Evaluation on nutritive value of four commercial fish species in River Nile; 2018.

23. El-Shennawy ESA, Ez-El-Rigal AI, Sulieman AM, Elbadwi AA. Improving quality properties of catfish mince. Zagazig Journal of Agricultural Research. 2017;44(6):2641-2647.

24. Hussin NM, Shaarani SM, Sulaiman MR, Ahmad AH, Vairappan CS. Chemical composition and antioxidant activities of catfish epidermal mucus. Journal of Advanced Agricultural Technologies. 2017;4(1).

25. Pyz-Lukasik R, Paszkiewicz W. Species variations in the proximate composition, amino acid profile and protein quality of the muscle tissue of grass carp, bighead carp, siberian sturgeon, and wels catfish. Journal of Food Quality; 2018.

26. Badiani A, Anfossi P, Fiorentini L, Gatta PP, Manfredini M, Nanni N, Tolomelli B. Nutritional composition of cultured sturgeon (Acipenser spp.). Journal of Food Composition and Analysis. 1996;9(2):171-190.

27. Rosa R, Bandarra NM, Nunes ML. Nutritional quality of African catfish Clarias gariepinus (Burchell 1822): A positive criterion for the future development of the European production of Siluroidei International journal of food science and technology. 2007;42(3):342-351.

28. Adelakun KM, Mustapha MK, Amali RP, Mohammed N. Seasonal variation in nutritional quality of catfish (Clarias gariepinus) from Upper Jebba Basin, Nigeria. Journal of Nutrition and Food Science. 2017;7:5-9.

29. Pervin K, Nayeem MA, Newaz AW, Kamal M, Yeasmine S, Nurullah M. Production and quality assessment of fish pickles from mola (Amblypharyngodon Mola) Fish. Bangladesh Journal of Fisheries Research. 2010;14(1-2):87-96.

30. Orban E, Nevigato T, Lena GD, Masci M, Casini I, Gambelli L, Caproni R. New trends in the seafood market. Sutchi Catfish (Pangasius hypophthalmus) fillets from Vietnam: Nutritional quality and safety aspects. Food Chemistry. 2008;110(2):383-389.

31. Mogobe O, Mosepele K, Masamba WR. Essential mineral content of common fish species in Chanoaga, Okavango Delta, Botswana. 2015;9(9):480-486. DOI: 10.5897/AJFS.1307.

32. Genchev A., Mihaylova G, Ribarski S, Pavlov A, Kabakchiev M. Meat quality and composition in Japanese quails. Trakia Journal of Sciences. 2008;6(4):72-82.
33. Oluwaniyi OO, Dosumu OO, Awolola GV. Effect of cooking method on the proximate, amino acid and fatty acid compositions of Clarias gariepinus and Oreochromis niloticus. Journal of the Turkish Chemical Society Section A: Chemistry. 2017;4(1):115-132.

34. Osibona AO, Kusemiju K, Akande GR. Fatty acid composition and amino acid profile of two freshwater species, African Catfish (Clarias gariepinus) and Tilapia (Tilapia zillii). African Journal of Food, Agriculture, Nutrition and Development. 2009;9(1):608-621.

35. Oriolowo OB, John OJ, Mohammed UB, Joshua D. Amino acids profile of catfish, crayfish and larva of edible dung beetle. Ife Journal of Science. 2020;22(2):9-16.

36. Zagl NF, Eldadawy F. Study on chemical quality and nutrition value of fresh water crayfish (Procambarus clarkii). Journal of the Arabian Aquaculture Society. 2009;4(1):1-18.

37. Adeyeye EI. Amino acid composition of three species of Nigerian fish: Clarias Anguillaris, Oreochromis Niloticus and Cynoglossus Senegalensis. Food Chemistry. 2009;113(1):43-46.

38. Ahmad SM, Birnin-Yauri UA, Bagudo BU, Sahabi DM. Comparative analysis on the nutritional values of crayfish and some insects. African Journal of Food Science and Technology. 2013;4(1):9-12.

39. Hepher B. Nutrition of pond fishes. Cambridge University Press, Cambridge, UK; 1988.

40. Okomoda VT, Tiamiyu LO, Ricketts AO, Oladimeji SA, Agbara A, Ikwanuddin M, Abol-Munafi AB. Hydrothermal processing of clarias gariepinus (Burchell, 1822) filets: Insights on the nutritive value and organoleptic parameters. Veterinary Sciences. 2020;7(3):133.

41. Chauke E, Cukrowska E, Thaela-Chimuka MJ, Chimuka L, Nsengimana H, Tutu H. Fatty acids composition in South African freshwater fish as indicators of food quality. Water; 2008;34(1):119-126.

42. Fernández-López J, Jiménez S, Sayas-Barberá E, Sendra E, Pérez-Alvarez JA. Quality characteristics of ostrich (Struthio camelus ) burgers. Meat Science. 2006;73(2):295-303.

43. WHO. World Health Organization, diet nutritional and prevention of diseases Geneva – Switzerland. Food and Agriculture Organization of the United Nations. 2003;4:101.

44. Koff A. Omega 5 and 7 are they in you?, 2010. Available:https:llashly Kaff . word press. com/2010/07/20/ Omega-5-and-7-%62%80%93-are-they-in-you.

45. Hossain MA. Fish as source of n-3 polyunsaturated fatty acids (PUFAs), which one is better-farmed or wild. Advance Journal of Food Science and Technology. 2011;3(6):455-466.

46. Ljubojević DM. Cirković V. Dordević etal. Fat quality of marketable fresh water is h species in the Republic of Serbia. Czech Journal of Food Sciences. 2013;31(5):445-450.

47. Hoffman LC, Laubscher LL, Leisegang K. Nutritional value of cooked offal derived from free-range rams reared in South Africa. Meat Science. 2013;93(3):696-702.

48. Cengiz E. Unl¨u, M. Bas¸han. Amino acids composition of total lipids in muscle tissues of nine freshwater is from the River Tigris (Turkey).” Turkish Journal of Biology. 2010;34(4):433–438.

49. HMSO. “Nutritional aspects of cardiovascular disease. Report on Health and Social Subjects No. 46) London; 1994.

50. Ljubojević DM, Cirković V, Dordević et al. Fat quality of marketable fresh water is h species in the Republic of Serbia. Czech Journal of Food Sciences. 2013;31(5):445-450.

51. Ozogul F, Ozogul, Alag`oz S. Fatty acid profiles and fat contents of commercially important seawater and fresh water is species of Turkey: A comparative study. Food Chemistry. 2007;103(1):217–223.

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