Profile of Nutritional and Quality Aspects of Wild African Catfish, *Clarias Gariepinus* (Burchell, 1822) in Assiut, Egypt

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ABSTRACT

The present study aimed at detecting some aspects of the nutritional, physicochemical and bacterial quality of the fresh African catfish (*Clarias gariepinus*) obtained from fish sellers at Assuit city, Egypt. A sum of 65 samples was randomly collected over a period of 2 months. The samples were subjected to sensory evaluation; the proximate composition "dry matter, moisture, protein, fat, and ash %", pH, TVB, and TBARS were estimated; carbohydrate% and gross energy values were calculated; coliforms, fecal coliforms, *E. coli*, *Cl. perfringens*, and *Aeromonas spp.* count was determined. The estimated mean values (%) of dry matter, moisture, protein, fat, ash, and carbohydrates of the examined catfish samples were 23.69±0.39, 76.31±0.39, 17.97±0.16, 3.97±0.35, 1.18±0.02, and 0.57±0.02, respectively. The gross energy values (Kcal/100g) ranged from 70.65 to 187.14 with mean of 109.86±3.20. The mean values of energy (Kcal/100g) derived from fat, protein, and carbohydrates were 35.7±5.12, 71.89±0.63, and 2.27±0.09, respectively. The sensory scores of the samples ranged from 1.67 to 2.9 with mean of 2.79±0.03. The mean values of pH, TVB (mg N/100g fish flesh), and TBARS (mg malonaldehyde/kg fish flesh) were 6.94±0.03, 20.71±0.52, and 1.33±0.11, respectively. The coliforms and fecal coliforms were detected in 93.85% and 23.08% of the examined samples, respectively, while *E. coli* and *Clostridium perfringens* was detected each in only 3.08% of the examined samples. The *Aeromonas* count was recorded in 75.39% of the samples, with a mean count of 1.84±0.08 log cfu/g. All of the examined catfish samples showed TVB and TBARS values within the permissible limits. Coliforms count exceeded the permissible limit in 20% of the examined samples. In conclusion, catfish sold in Assiut fresh fish markets is of good nutritional, sensory and physicochemical quality; however its bacterial quality is suspicious as it may harbor potentially pathogenic or pathogenic bacteria. Thorough cooking is required before consumption to avoid public health hazard.

Key words: *Catfish (Clarias gariepinus), Proximate Composition, Sensory, pH, TVB, TBARS, Bacterial.*

1. INTRODUCTION

Fish occupy one of the foremost places among the food products of animal origin being an excellent source of protein of high biological value, lipids, and many other micronutrients (Eyo, 2001; Darwish et al., 2003). Over decades, there has been an increase in the awareness about the nutritional and health benefits of fish consumption. Consumers individually or collectively, nowadays, become more demand in respect of freshness, microbial safety, and nutritional value (Abul Mansur et al, 2014; Adam et al, 2015).

As the muscle tissue is the main edible portion of fish and responsible of their nutritional value, studies of proximate chemical composition (dry matter, moisture, lipid, protein, and ash) were examined as parameters of fish flesh quality (Periago et al., 2005; Deng et al., 2016). In general, the nutritional composition of fish varies greatly depending on species, age, feed intake, physical and reproductive status, geographic location and season (Silva and Chamul, 2000; Alasalvar et al., 2002). Meat of fish contains insignificant amounts of carbohydrates in the form of glycogen and high percentage of water (60–86%). Fish proteins are considered superior to proteins of other animals. Its high biological value being due to the presence of small content of connective tissue and lack of fascia leading to superior digestibility rate over beef. Fish proteins contain all the essential amino-acids for the human and they can be used as the sole source of protein in the diet.

Lipids of fish are of relatively low saturated fat content, but high in polyunsaturated fatty acids (Vladau et al., 2008; Buchtová et al., 2010; Gamal and Shamery, 2010). The lipid content of fish varies depending on the type of fish, the time of year and what the fish feeds on. Protein and ash content, however, is less influenced by external feeding but is mainly determined by intrinsic factors such as the fish species, and genetic characteristics (Shearer, 1994; Morris, 2001; Guler et al., 2008).

Raw fish is a highly perishable commodity; the spoilage process begins immediately after capture. The human sensory assessment remains the fastest and most accurate way of assessing fish freshness (Lauzon et al., 2010, Can, 2010). The quality of fish is deteriorated, beside microbial activity by chemical and biochemical changes during storage (Kaitaranta, 1982). Knowledge about the pH may give valuable information about flesh condition. The increase of pH is being due to the production of ammonia and amines by microbial and tissue enzymes activity during storage (National Academy of Sciences, 1985). Undesirable compounds such as volatile bases with low molecular weights (TVB) are produced as the result of deterioration processes with degradation of proteins. The TVB level showed high degree of relation with sensory analyses regarding product acceptance, so could be used as an effective indicator of fish deterioration. Increasing of TVB values of the market samples reflected their poor quality and unhygienic market condition. In freshwater fish species the total volatile basic nitrogen (TVB) formation is affected primarily with the activity of microorganisms. It is mainly consists of the formation of ammonia (Massa, 2006; Sharma and Goswami, 2010). Loss of quality, as well, is related in a greater extent to oxidative processes affecting mainly lipids. Fish lipid contains high levels of polyunsaturated fatty acids, and is highly susceptible to oxidative deterioration with the formation of by-products such as aldehydes, ketones and other compounds with an unpleasant odor and flavor. Such by-products can be measured using the thiobarbituric acid reaction (TBA) assay, which quantifies the presence of malondialdehyde (MDA mg/kg) (Fontes et al., 2007, Pacheco et al., 2010). The MDA is of particular concern for human health in view of its well-known mutagenic and carcinogenic effects (Riggins and Marnett, 2001; Del Rio et al., 2005).

In spite of health benefits, fishery products can act as a source of various contaminating microorganisms which is particularly critical for human when they are opportunistic and or pathogenic in nature (Huisint-Veld, 1996; Ghaly et al., 2010; Mhango et al., 2010).The microbial flora associated with fish is usually a reflection of their aqueous environment. Indigenous bacterial pathogens such as *Aeromonas spp* are ubiquitous in the aquatic environment. Non-indigenous pathogenic bacteria such as *E. coli* and *Clostridium perferengines* are most times introduced into water bodies through human or animal feaces. Beside source contamination of fishes, improper handling and environmental organisms from point of sale can as well increase the bacterial loads in fish sold in open markets. When such contaminated fishes are ingested they could pose a great risk to the health of the consumers (Allen et al., 1983; Kvenberg, 1991; Arafat, 2013). The microbiological quality of fish can be measured by using coliform, fecal coliform and *E. coli* counts (Budiati, et al., 2015).

In Egypt fish production are significant locally for supporting food security (Mahmoud et al., 2015). In the year 2013, the annual freshwater fish production was estimated at 1142 thousand tonnes, with annual per capita consumption of 13.92kg that supply consumers with 26 Kcal, 4.16g animal protein, and 0.95g fat/capita/day. The inland capture production was estimated at 250196 tonnes, accounting for 21.91 % of the total freshwater fish production (FAO, 2015; FAOSTAT, 2018).

Fish in Egypt is been a major source of protein and energy for many communities. Egyptian people use fish sometimes as the only source of animal protein throughout the year as substitute for red meat, because of the latest common adulteration and/or higher price. The African catfish, *Clarias gariepinus*, is a commonly consumed species, with great commercial value in Egypt (Ibrahim and

Omar, 2013). It is commonly sold in the fresh state. Its main characteristic is the absence of scales and intramuscular bones, contributes to its popularity. It is a valuable food fish with high nutritional importance, has superior flesh with distinctive taste and texture (Eyo, 2001; Jankowska et al., 2007; Ibrahim and Omar, 2013). Its meat nutritional characterization is very similar to red meat, except for fat content which is considerably varied (Gjedrem et al., 2012). It is a low to medium fat species, with the fat content provides a lower proportion of polyunsaturated fatty acids (PUFA) omega-3 (ω-3); and the ω-6/ω-3 ratio is within the proscriptions of the World Health Organization "WHO" (Ersoy and Özeren, 2009; Chaijan et al., 2010; Casallas et al., 2012).

At the points of harvesting and marketing, catfish (*C. gariepinus*) contamination may occur resulting in its quality deterioration. They may also harbor a variety of bacterial pathogens driven from their aqueous environment or post-harvest contamination (Andy et al., 2018).

The present research was elucidate to determine the proximate composition beside the sensory, some physicochemical and bacteriological quality aspects of wild catfish "*Clarias gariepinus"* harvested and sold in the area of Assiut city, Egypt, with a view to assessing its quality and nutritional value.

2. MATERIALS AND METHODS

2.1.Collection and Preparation of Samples:

Of the African catfish (*Clarias gariepinus* "*C. gariepinus*"), 65 samples were randomly collected from fish sellers in Assiut city, Egypt. The samples were immediately transported to the laboratory of Meat Hygiene, Faculty of Veterinary Medicine, Assiut University; washed off to remove external dirties and slime, and kept at 4°C till being soon investigated. Each sample was first inspected organoleptically then was dissected (head and fins removed; gutted and filleted with the skin intact) aseptically and prepared for bacteriological and chemical examinations.

For bacteriological examination, the flesh with the skin intact was aseptically cut and thoroughly mixed in a sterile mortar. For chemical analysis, flesh without skin was cut out and mixed thoroughly in a clean mortar. Prepared samples not used directly for chemical analysis were kept at -20ºC till use.

2.2.Sensory Assessment:

Catfish samples were organoleptically assessed and scored according to FAO (1995) and Hall (1992). Scores of > 2.7 are graded "E", from 2.0 - 2.7 graded "A", from 1.0 – < 2.0 graded "B", and < 1.0 graded "C" (un-official score; fish not used for human consumption).

2.3.Basic Chemical Composition Estimation:

The basic chemical component (moisture, fat, protein and ash) percentages were estimated according to AOAC (2000).
Moisture was determined in 20g sample; protein in 0.5g of the dried sample, with 6.25 nitrogen to protein conversion factor; fat in 1gm dried sample with slight modification (Abd-Allah and Ismail, 2016); and ash in 1gm dried sample.

NB: All estimations on the dry weight basis were converted into the wet weight basis according to the equation of Jurgens and Bregendahl (2007):

$$\text{Nutrient wet basis\%} = \frac{\text{nutrient dry basis\% X dry matter \%}}{100}$$

The dry matter and carbohydrate percentages were calculated by difference:
Dry matter % = 100 – moisture %
Carbohydrate % = 100 – (moisture % + protein % + fat % + ash %)

2.4.Gross Energy Content

The gross energy content (kcal/100g) was calculated according to the equation of Merrill and Watt (1973):

Gross energy value (Kcal/100g) = (protein % x 4) + (fat % x 9) + (carbohydrate % x 4).

2.5.Physico-chemical Quality Assessment

2.5.1. The pH

It was estimated according to Lyhs et al. (1998) using 10g of fish sample flesh. The pH-Meter (Lovibond, SD50) was used for measurement after being calibrated with pH buffer of 7.

2.5.2. Total volatile bases nitrogen (TVB) "mg N/100g fish flesh"

It was determined according to Pearson (1976).
TVB "mg N/100g flesh" = (Titration – Blank) x 14

2.5.3. Thiobarbituric acid reactive substances (TBARS value) "mg malonaldehyde/kg fish flesh"

It was estimated according to Buege and Aust (1978). Spectrophotometer (Unico UV- 2100, USA) at 531nm was used to read the absorbance.

2.6.Bacterial Analysis:

2.6.1. Preparation of dilutions

Of the sample 10g was removed aseptically and stomached (Seward 400) with 90ml sterile 0.1% peptone water for 2 min in a sterile polyethylene bag. Tenfold serial dilutions were then prepared.

2.6.2. Aeromonas spp count

Of the dilutions (1/10, $1/10^3$, and $1/10^5$), 0.1ml was inoculated onto the surface of starch ampicillin agar plates (Palumbo et al., 1985), then incubated at 28ºC for 24-48hrs. Typical colonies are yellow to honey colored, 3-5mm in diameter, show clear zone of starch hydrolysis when the plates is flooded with lugol's iodine solution.

2.6.3. Coliforms, fecal coliforms and E. coli counts (MPN/g)

According to AOAC (1980), most probable number (MPN) three tubes dilution method was used.

2.6.3.1. Coliforms count (MPN/g)

For presumptive count lauryl sulphate broth was used as an inoculation medium; and for confirmatory count brilliant green bile (2%) broth was used. Incubation was at 35ºC for 48hrs for each step.

2.6.3.2. Fecal coliforms count (MPN/g):

EC medium was used for inoculation, incubated in water bath at 45±0.5°C for 48hrs.

2.6.3.3. E. coli count (MPN/g)

Levine Eosin methylene blue "EMB" agar was used as culture medium. Inoculated plates were incubated at 35ºC for 48hrs.Typical colonies are dark centered (nucleated) with metallic sheen.

2.6.4. Clostridium perfringens count (MPN/g)

According to Beerens *et al.* (1980), lactose sulfite broth was used as an inoculation medium, being incubated at 46±0.5°C for 48hrs.

2.7.Statistics

The obtained data were analyzed statistically using Microsoft Excel 2010 version to calculate the means and standard deviations. The data were shown as means± standard error (Mean±SE).

3. RESULTS

Table 1: Proximate composition (%) "wet weight" of the examined African catfish (*C. gariepinus*) samples (n=65)

Parameter	Min	Max	Mean ± SE
Dry Matter	17.92	32.00	23.69±0.39
Moisture	68	82.08	76.31 ±0.39
Protein	14.91	20.16	17.97 ±0.16
Fat	0.28	12.8	3.97 ±0.35
Ash	0.84	1.5	1.18 ±0.02
Carbohydrate	0.21	0.98	0.57 ±0.02

Min= minimum Max= maximum Mean ± SE= mean ± standard error

Table 2: Energy content (Kcal/100g flesh) of the examined African catfish (*C. gariepinus*) samples (n=65)

Parameter	Min	Max	Mean ± SE
Gross Energy	70.65	187.14	109.86 ±3.20
E Fat[1]	2.52	115.2	35.7 ±3.12
E Ptn[2]	59.64	80.64	71.89 ±0.63
E Cab[3]	0.83	3.94	2.27 ±0.09

Min= minimum Max= maximum Mean ± SE= mean ± standard error
[1]Energy derived from fat [2]Energy derived from protein [3]Energy derived from carbohydrate

Table 3: Sensory and chemical quality indices of the examined African catfish (*C. gariepinus*) samples (n=65)

Parameter	Min	Max	Mean ± SE
Sensory	1.67	2.92	2.79 ±0.03
pH	6.37	7.39	6.94 ±0.03
TVB (mg N/100g flesh)[1]	12.6	28	20.71 ±0.52
TBARS (mg MDA/kg flesh)	0.05	3.54	1.33 ±0.11

Min= minimum Max= maximum Mean ± SE= mean ± standard error
[1]n = 62, the other 3 samples was not enough for the estimation

Table 4: Bacterial quality of the examined African catfish (*C. gariepinus*) samples (n=65)

Parameter	Positive samples		Min	Max	Median
	No.	%			
Coliforms count (MPN/g)[1]	61	93.85	3	1100	23
Fecal coliforms count (MPN/g)	15	23.08	3.6	150	3.6
E. coli count (MPN/g)[2]	2	3.08	3.6	-	-
Cl. Perfringenes count (MPN/g)	2	3.08	3.6	20	-
Aeromonas count (log cfu/g)	49	75.39	1.3	3.32	1.84 ±0.08[3]

Min= minimum Max= maximum [3]Mean ± SE
[1]The confirmatory count [2]The 2 positive samples had the same count (3.6 MPN/g for each)

Table 5: Acceptability percentage of the examined African catfish (*C. gariepinus*) samples

Parameter	Samples tested	Permissible limits[1]	Samples (%) within limits	Sample(%) exceed limits
TVB (mg N/100g flesh)	62	30	62 (100%)	0 (0.0%)
TBA (mg malonaldehyde /kg flesh)	65	4.5	65 (100%)	0 (0.0%)
Coliforms (cfu/g)	65	100	52 (80.0%)	13 (20.0%)

[1](E.S., 2005)

The results documented in Table (1) showed that, the minimum, maximum, and mean values (%) of dry matter were 17.92, 32.00, and 23.69±0.39; of moisture 68.0, 82.08, and 76.31±0.39; of protein 14.91, 20.16, and 17.97±0.16; of fat 0.28, 12.8, and 3.97±0.35; of ash 0.84, 1.5, and 1.18±0.02; and of carbohydrate were 0.21, 0.98, and 0.57±0.02, respectively. The gross energy values (Kcal/100g) of the examined catfish samples ranged from 70.65 to 187.14 with mean of 109.86±3.20. The values of energy derived from fat, protein, and carbohydrate per 100 gram sample, were in the range of 2.52 - 115.2, 59.64 - 80.64, and 0.83 – 3.94; with means of 35.7±5.12, 71.89±0.63, and 2.27±0.09, respectively (Table 2). Sensory scores of the examined catfish samples ranged from 1.67 to 2.9 with mean of 2.79±0.03. The values of pH, TVB (mg N/100g fish flesh), and TBARS (mg malonaldehyde/kg fish flesh) ranged from 6.37 to 7.39, 12.6 to 28.0, and 0.05 to 3.54 with means of 6.94±0.03, 20.71±0.52, and 1.33±0.11, respectively (Table 3). Coliforms and fecal coliforms showed count in 61 (93.85%) and 15 (23.08%) of the 65 examined catfish samples, respectively, with minimum, maximum and median values of 3, 1100, and 23 MPN/g for coliforms; and 3.6, 150, and 3.6 MPN/g for fecal coliforms, respectively. *E. coli* was detected only in 2 (3.08%) of the 65 samples with count of 3.6 MPN/g for each. *Clostridium perfringens* was, also, detected in 2 (3.08%) of the 65 samples with count of 3.6 and 20 MPN/g, respectively. *Aeromonas* count was recorded in 49 (75.39%) of the 65 examined samples, with minimum, maximum and mean values of 1.3, 3.23, and 1.84±0.08 log cfu/g, respectively (Table 4). All (100%) the examined catfish samples showed TVB and TBARS contents within the permissible limits of 30mg/100g and 4.5mg/kg, respectively. Coliforms count was within the permissible limit of ≤100 cfu/g in 52 (80%), while exceeded the limit in 13 (20%) of the 65 examined samples (Table 5).

4. DISCUSSION

Fish is one of the main sources of high quality protein, being consumed by a large percentage of the populace especially in the developing countries because of its availability and palatability. In recent, the quality of fish as a food gets more attention. It includes several physicochemical and microbiological parameters (Ali et al., 1998). The quality assessment of African catfish (*C. gariepinus*) as a common fish species consumed in Egypt is a matter of concern.

4.1.Basic Composition:

Fresh fish is a central point in fish for food utilization. Knowledge of its composition is essential if the fullest use is to be made of it. The processor, nutritionist and the cook all are aware about the fish composition (Silva and Chamul, 2000; FAO, 2001).

Results of the current investigation declared that, dry matter content (%) of *C. gariepinus* samples ranged from 17.92 to 32.00 with mean of 23.69±0.39. These were close to the 23.7±1.0 found by Adam et al. (2015) "catfish, *Clarias lazira*"; and the 24.98±2.09 by Deng et al. (2016) "wild *C. gariepinus*" in Sudan; but lower than the 41.10±0.01 found by Adeosun et al. (2015) "wild *C. gariepinus*" in Nigeria.

Moisture content of food is an important factor that has a functional effect on some quality characteristics such as texture and as well, affects the microbiological stability of the food product. Moisture percentage obtained in the current study for the wild *C. gariepinus* fresh flesh were nearly similar to the findings of Polak-Juszczak (2007) "75.53" for African catfish fillets, Adam et al. (2015) "76.5±0.7" for *Clarias lazira* in Sudan, Chwastowska-Siwiecka et al. (2016) "75.59±0.91" for farmed *C. gariepinus* in Poland, Deng et al. (2016) "75.02±2.09 for wild *C. gariepinus* in Sudan, and El-Lahamy et al. (2018) "75.95±0.26" for wild *C. gariepinus* in Fayoum – Egypt. Lower mean values were recorded by Wimalasena and Jayasuriya (1996) "69.3±2.5" for farmed stinging catfish in Sri Lanka, Adeosun et al. (2015) "58.9±0.01" for wild *C. gariepinus* in Nigeria, and Azuka and Goodnesschinwe (2018) "70.3" for *C. gariepinus* form markets in Nigeria. Lower percentage of 71.7 and 70.35% for *C. gariepinus* fish were also recorded by Olopade et al., (2013) and Oladipo and Bankole (2013), respectively. Higher mean values was reported by the FAO (2001) "78.0" for

catfish, Yanar Yasemen (2007) "77.89±0.17" for wild *C. gariepinus* in Turkey, Miroslav et al. (2011) "78.69±0.12" for farmed Wels catfish (*Silurus glanis*) in Republic of Serbia, Olayemi et al. (2012) "78.7" for farmed *C. gariepinus* in Nigeria, Binsi et al. (2015) "79.54±1.52" for catfish (*Ompok pabda*) in India, Issifu (2018) "77.4±1.94" for farmed *C. gariepinus* in Ghana, and Likongwe et al. (2018) "77.44±0.30 for *C. gariepinus* in Malawi. Fowoyo and Isaac (2018) found moisture range of 72.61-78.18% for farmed *C. gariepinus* in Nigeria. Ersoy and Özeren (2009) and Casallas et al. (2012) recorded variable range of 74-85% for moisture in catfish.

The fish as a source of protein are of immense nutritional benefit to malnourished children and adults. The result of the proximate composition generally showed fish as a good source of protein. Freshwater fish contain 17–22% protein in general (Effiong and Fakunle, 2012). The current obtained values of protein for wild *C. gariepinus* samples were in line with the previous mentioned range. Nearly similar ranges, of 17-19.7, and 12-22 were reported by FAO (2001), and Casallas et al. (2012), respectively, while lower range of 15.71-16.2 was detected by Ersoy and Özeren (2009), of 7.24-16.24 by Olayemi et al, (2012) for *C. gariepinus*, and of 8.23-9.96 by Fowoyo and Isaac (2018) for farmed *C. gariepinus* in Nigeria. Mean values, of 18.6±1.1, 19.7, 17.85±0.12, 17.27±0.1, 18.69±0.98, 17.37±0.48, 16.9±0.17, and 17.58±0.23, were found by Wimalasena and Jayasuriya (1996), Polak-Juszczak (2007), Yanar Yasemen (2007), Miroslav et al. (2011), Binsi et al. (2015), Chwastowska-Siwiecka et al. (2016), El-Lahamy et al. (2018), and Issifu (2018), respectively, which were close to the current result. Chukwu and Shaba (2009), and Adeosun et al. (2015) estimated higher mean values, of 19.75 and 27.3±0.01, respectively.

Fat content in flesh is related with moisture, where fat and water account for approximately the 80% of the total composition (Huss, 1995). Similar percentage (80.28%) was obtained for fresh flesh of *C. gariepinus* in the present study. Fat content of freshwater fish were in a broad range of 2 to 20% depending on type and availability of feed, age, size etc (Binsi et al, 2015). In the present study, fresh meat of the African catfish "*C. gariepinus*" showed a fat content mean value of 3.97±0.35, that categorized it as low fatty fish species (≤5%) according to the Egyptian Standards (E.S., 2005), however in line with the Polish Standards (PN-A, 1999), it was classified into a group of medium-fat fish. In comparison with the obtained data, Yanar Yasemen (2007) and Miroslav et al. (2011) found nearly similar fat content of 3.64±0.03 and 3.43±0.08 for wild *C. gariepinus* in Turkey and Wels farmed catfish "*Silurus glanis*" in Republic of Serbia, respectively. However, the fresh meat of *C. gariepinus* evaluated by Fawole et al. (2007), Polak-Juszczak (2007), Ersoy and Özeren (2009), Olopade et al. (2013), Oladipo and Bankole (2013), Adeosun et al. (2015), Chwastowska-Siwiecka et al. (2016), El-Lahamy et al. (2018), and Fowoyo and Isaac (2018) was characterized by higher fat contents, of 7.8, 5.3, 5.04, 6.55, 8.94, 5.65±0.09, 11.1±0.01, 5.46±1.0, and 14.75-32.26%, respectively. Lower fat contents of 0.3±0.2, 0.4-5.7, 2.67±0.28, and 0.57±0.17 were detected by Wimalasena and Jayasuriya (1996), Casallas et al. (2012), Binsi et al. (2015), and Issifu (2018), respectively. FAO (2001) reported range of 2.1-3.8 for fat in catfish meat. Variations in the fat content can be attributed mainly to variation in the type and availability of feed, the geographical area of catch, season, age, and body weight (Goda et al., 2007; Skałecki et al., 2013). The oil from fish could be a rich source of omega -3- fatty acid which plays significant role in decreasing the risk of heart disease and also helping reduce symptoms of depression, hypertension, and attention deficit hyperactivity disorder (ADHD). Fish oil, as well, aiding the body in weight loss, fertility, pregnancy and increased energy (Khora, 2013).

Crude ash content, which is the total amount of mineral compounds remaining after incineration, is also an important indicator of meat quality. The range for the ash content gave an indication to what extent the fish are sources of minerals such as calcium, potassium, zinc, iron and magnesium (Andrew, 2001). Ash content of the analyzed *C. gariepinus* samples were close to the 0.86-1.96, 1.1±0.06, 1.32±0.26, 1.22±0.069, and 1.34±0.26% detected by Ersoy and Özeren (2009), Chwastowska-Siwiecka et al. (2016), Deng et al. (2016), El-Lahamy et al. (2018), and Issifu (2018), respectively. Lower mean value, of 0.1±0.0 was found by Wimalasena and Jayasuriya

(1996) in stinging catfish, of 0.98 by Polak-Juszczak (2007) in African catfish fillets, of 0.68±0.02 by Yanar Yasemen (2007) in wild *C. gariepinus*, of 0.89±0.03 by Miroslav et al. (2011) in Wels catfish "*Silurus glanis*", and of 0.83±0.04 by Binsi et al. (2015) in cat fish "*Ompok pabda*". However, higher mean values of 3.06 and 2.3±0.02 were estimated by Chukwu and Shaba (2009), and Adeosun et al. (2015), respectively. Nearly similar ash range, of 0.8-2 was estimated by Casallas et al. (2012) for catfish, while higher range of 4.05-4.51 by Fowoyo and Isaac (2018) for farmed *C. gariepinus* in Nigeria.

The amount of carbohydrate in white fish muscle is generally too small to be of any significance in the diet; usually less than 1% (FAO, 2001). The current obtained result declared that carbohydrate content of fresh *C. gariepinus* meat were in the range of 0.21-0.98 with mean value of 0.57±0.02 which is in line with that reported by FAO (2001). Nearly similar carbohydrate percentage of 0.48% was submitted by Sesugh et al. (2012) for wild *C. gariepinus* in Nigeria, but lower mean value of 0.28±0.2 was estimated by El-Lahamy et al. (2018) for wild *C. gariepinus* in Egypt. Higher values of 7.27-17.27 were recorded by Fowoyo and Isaac (2018) and of 4.45±1.55 by Issifu (2018) for farmed *C. gariepinus* in Nigeria and Ghana, respectively. Wimalasena and Jayasuriya (1996) detected higher mean value of 4.2±0.8 for stinging catfish in Sri Lanka, and Adam et al. (2015), of 5.8±0.3 for *Clarias lazira* in Sudan.

4.2.Energy Content:

The energy value of meat is determined by its fat, protein and carbohydrate content. According to Rosa et al. (2007), the gross energy value of 100 g of fresh muscle tissue of catfish reached 109.39 kcal. Similar result of 109.86±3.2 Kcal/100g on average was noted in the current study for fresh meat of *C. gariepinus*. Slightly higher calorific value of 118.64 kcal/100g on average was found by Chwastowska-Siwiecka et al. (2016) for the meat of farmed *C. gariepinus* in Poland. FAO (2001) reported gross energy value of 410-530 Cal/Lb for catfish meat. The greatest percentage of energy in the current study was found to be derived from fish protein (68.55%), followed by fat (29.28%), while the minor percentage was derived from carbohydrates (2.17%) (Not Tabulated). Vladau et al. (2008) declared that protein accounts for 80 to 90% of the energy content of the fish which support the current finding.

4.3.Sensory:

Despite quality of fish involves nutritional, physicochemical, and microbiological properties; consumers however will decide to buy a fresh fish based solely on its "degree of freshness" (Parisi et al., 2002). Catfish as a perishable food often priced and sold on basic of its freshness criteria, which is seen as the most important attribute of catfish quality (Andy et al., 2018).

In the current study, the sensory scores of the inspected catfish samples ranged from 1.67 to 2.92 with a mean value of 2.79±0.03. All (100%) the examined 65 samples were graded fit for consumption, with 57 (87.69%), 6 (9.23%) and 2 (3.08%) of them were of grades E, A and B, respectively (Not Tabulated). Binsi et al. (2015) in India found nearly similar results; all inspected samples of catfish (*Ompok pabda*) were accepted with high sensory scores (like extremely to like moderately), showing no off-flavors, bright silvery pink color, and firm and elastic texture. Issifu (2018) in Ghana however, mentioned that fresh catfish (*C. gariepinus*) samples collected from markets were of acceptable to moderate acceptable grades.

4.4.Physicochemical:

The pH value is regarded as an important parameter to evaluate fish spoilage. As well, it is a critical determinant of microbial growth (Mazorra-Manzano et al. 2000). The pH of fish flesh after death ranges from 6.7 to 7.0 being related to the amount of muscle glycogen available, which varies according to species, season, feed, exposure to stress and activity levels (Hall, 1992; Linden and Lorent, 1996; Merkin et al., 2010). The boundary value of pH_{24} for fresh fish meat is 6.5 (Marx et al., 1997). In catfish, pH values have been reported ranging between 6 and 7 under different storage

conditions (Lubes, 2005; Rodríguez et al., 2009 and Pacheco et al., 2010). The mean pH value obtained (6.94±0.03) in the current study is within the previous range. However, higher mean value of 7.28±0.038 was recorded by Mousa and Mahmoud (1997) for fresh *Clarias lazera* collected from fish markets in Kafr-Elsheikh, Egypt, while lower mean value of 6.3±0.09 by Chwastowska-Siwiecka et al. (2016) for *C. gariepinus*, 24hrs post-catch, in Poland. Slightly higher pH mean values of 7.07±0.08 and 7.0 were recorded by Chomnawang et al. (2007) and Azuka and Goodnesschinwe (2018), respectively, while slightly lower mean values of 6.78±0.01 and 6.75±0.06 by Yanar Yasemen (2007) and Binsi et al. (2015), respectively. The high pH value for catfish flesh in the majority of samples in the present study could be attributed to measuring of pH in the flesh directly after fish slaughter, leaving little or no chance for rigors to occur.

Total volatile basic amines (TVB), is a general term that includes the measurement of tri-methylamine, di-methylamine, ammonia and other volatile basic nitrogenous compounds associated with seafood spoilage. Estimation of TVB value is one of the most widely used measurements of fish quality (Zhong-Yi et al., 2010). Fish samples with high TVB values are of poor quality and reflected their unhygienic market condition (Sharma and Goswami, 2010).

The concentration of TVB in freshly caught fish is typically between 5 and 20 mg N/100 g flesh (Connel, 1995). Amounts of TVB within 30 and 35 mg N per 100 g of muscles is considered as acceptable limit for fresh fish (Amegovu et al., 2012; EU/EC, 2008). The Egyptian Organization for Standardization set value of 30 mg N/100g flesh as acceptable limit in fresh-water fish (E.S., 2005). In the present study, the maximum TVB value registered for catfish samples was 28 mg N/100 g, indicating that all inspected samples were accepted based on their TVB content which is in agreement with the sensory evaluation of such samples. Massa (2006) reported high degree of relation for TVB level with sensory analyses regarding fish acceptance. The average TVB value in the current study was 20.71±0.52 mg N/100g flesh. Yanar Yasemen (2007) and Binsi et al. (2015) found lower mean values of 15.47±0.22 and 7.18±0.57, respectively. Hassan Azaa and El-Shahat (2011) recorded TVB mean value of 12.3±0.4 in fresh fish obtained from markets in Egypt, while Jianadasa et al. (2014), estimated values in the range of 15-1021mg/100g; with rejection level (exceed allowed limit) of 5-12%, for 3 types of fresh fish collected from retail markets in Sri Lanka. TVB is a product of both autolytic and bacterial degradation, and in freshwater fish it is mainly composed of ammonia, which comes from deamination of amino acids and nucleotide catabolites – thus reducing the quality of the available fish protein (Binsi et al., 2015). The somewhat high TVB values of the samples could be attributed to the freeze storage of the samples before analysis.

TBARS value measures the amount of malonaldehyde formed as a result of lipid oxidation. Once the value crosses the maximum limit of acceptability, it should be taken as a definite indication of fat deterioration (Binsi et al, 2015). In the present study all (100%) inspected samples of catfish (*C. gariepinus*) showed TBARS values below the accepted limit (4.5mg/kg) set for the fresh-water fish (E.S., 2005). TBARS mean value of 1.33±0.11 was recorded for the examined *C. gariepinus* samples. Lower mean value, of 0.45±0.04 was estimated by Yanar Yasemen (2007) in Turkey, of 0.3±0.12 by Chwastowska-Siweicka et al (2016) in Poland, and of 0.309±0.012 by Binsi et al. (2015) in India. Hassan Azza and El-Shahat (2011) recorded TBA mean value of 0.293±0.04 mg/kg for fresh fish from retail markets in Egypt.

4.5.Bacterial:

Apart from the high perishability of fish, consumer safety is an issue to be considered because fish is a good medium for rapid bacteria multiplication particularly when handled under unsanitary conditions (Oladosu-Ajayi et al., 2011). As well, fish is susceptible to a wide variety of bacterial pathogens, most of which are capable of causing illness to humans. Great economic losses have been reported due to foodborne illness resulting from consumption of contaminated fish, and this can be a problem to the immune compromised, children and elderly people (Shinkafi and Ukwaja, 2010). The traditional system of marketing and utilization leaves little opportunity for applying

quality assurance programs on fresh fish entering the domestic market. At the points of harvesting and marketing catfish contamination may occur with a variety of spoilage and pathogenic bacteria (Andy et al., 2018).

The present data showed somewhat higher counts of total and fecal coliforms in the investigated fresh catfish (*C. gariepinus*) samples with median values of 23 and 3.6 MPN/g, respectively. Of the samples 20.0% showed coliforms count above the allowed limit (100 cfu/g) set for fresh fish by the Egyptian Organization for Standardization (E.S., 2005).

The previous result disagrees with the findings of Adeosun et al. (2015); could not detect coliforms count in any of the examined wild *C. gariepinus* samples in Nigeria. Omojowo and omojasola (2013), as well, could not find total coliforms count in farmed *C. gariepinus* flesh in Niger State. Likewise, Heever and Frey (1994) could not detect total or fecal coliforms in any of the examined farmed *C. gariepinus* samples in South Africa. However, Budiati et al. (2015) found higher total coliforms counts (2.52-3.75 log cfu/g), but lower fecal coliforms counts (0.94-1.11 log cfu/g) in *C. gariepinus* samples obtained from wet markets in Malaysia. Higher total and fecal coliforms in the range of 1.8-3.3x10^3 and 1.3-1.5x10^3cfu/g, respectively were found by Umana et al. (2017) for wild *C. gariepinus* samples in Nigeria. Issifu (2018) estimated higher total coliforms count, of 8.7x10^2cfu/g and Likongwe et al. (2018), higher count, of 1.5x10^5cfu/g for *C. gariepinus* samples in Ghana and Malawi, respectively. The presence of coliforms confirms that the fishes are readily exposed to fresh human fecal matter, with suggestion of public health hazard (National Academy of Sciences, 1985). Catfish samples with somewhat higher coliforms content could be due to exposure of the fish to contamination from the environment or during marketing (i.e. poor hygiene of handling). Very low numbers of some fecal origin microbial agents could be enough to cause illness (Adeosun et al., 2015).

In the present study, *E. coli* was detected in only 2 (3.08%) samples with a count of 3.6 MPN/g. Heever and Frey (1994) in South Africa and Budiati et al. (2015) in Malaysia could not find *E. coli* count in any of the examined samples of *C. gariepinus* fish, which not comply with the current finding. Likewise, Pyz-tukasik and Paszkiewicz (2018) could not estimate *E. coli* count (< 1 log cfu/g) in the muscles of farmed Wels catfish in Poland. On the other hand, Issifu (2018) found higher *E. coli* count, of 2.3x10^3cfu/g and Likongwe et al. (2018), higher count, of 4x10^4cfu/g for *C. gariepinus* samples in Ghana and Malawi, respectively. Mousa and Mahmoud (1997) isolated *E. coli* at higher percentage (6.61%) from fresh wild catfish (*Calrias lazera*) in Kafr-Elsheikh, Egypt. Similarly, Umana et al. (2017) and Andy et al. (2018) detected *E. coli* at higher percentages, of 7.4 and 9.1%, respectively, in the *C. gariepinus* samples collected from markets in Nigeria, meanwhile, Fowoyo and Isaac (2018) found *E. coli* at nearly close percentage (4.5%) in farmed *C. gariepinus* samples in Nigeria. Oladosu-Ajayi et al. (2011) could isolate *E. coli* from skin of farmed *C. gariepinus*, 24hrs after slaughter, but could not isolate it from the fish flesh. *E. coli* is viewed as a sanitary hazard and represents a health risk to consumers. Its presence even in small numbers will be at risk when food safety is considered (Ganegamaarachchi et al., 2000). Sugita et al. (1997) however, concluded that the skin of freshwater fishes was the natural habitat of the *E. coli* bacteria, as he frequently isolated them from the skin of freshwater fish.

Clostridium perfringens spores can reach fish in their water habitat contaminated with sewage or during handling. Numbers greater than 10^6 are necessary to cause illness. However, such quantities do not reach foods by mere contamination, but accumulate as a result of multiplication of vegetative cells (Bryan, 1980). In the present study *Cl. perfringenes* was detected at low counts (3.6 and 20 MPN/g) in only 2 (3.08%) of the catfish samples, which may suggest fecal contamination of the water habitat of the fish or poor handling during marketing. Binsi et al. (2015) detected low count (0.2 log cfu/g) of sulphite reducing clostridia (SRC) in fresh catfish (*Ompok pabda*) from markets in India. The most important representatives of SRC species are *Cl. perfringens, Cl. bifermentans, Cl. sporogenes and Cl. botulinum* (Dijk and Grootenhuis 2003). Sulphite reducing clostridia are

widely distributed in the environment, because they can withstand harsh environmental conditions, where their presence indicates possibility of fecal contamination. Even though temperature abuse for short period will not permit significant growth of these organisms; cyclic and static temperature abuse for relatively long periods, however, may lead to high and dangerous numbers of SRC (Hill et al. 1993; Horan, 2003).

Aeromonas species are Gram-negative, non-spore forming, facultative anaerobic bacteria, grow at a wide range of temperatures; known as psychrophilic and mesophilic microorganisms that have a broad host spectrum. They are, widely distributed in the aquatic environment being common in warm water aquaculture in Egypt, composing a part of the normal intestinal microflora of healthy fish (Khalil and Mansour, 1997; Aberoum and Jooyandeh 2010; Austin and Austin, 2012). They have been isolated from various food products including seafood (Krovacek et al., 1992; Saleh et al., 2017)

Generally, *Aeromonas* spp are considered serious foodborne pathogens that are associated with septicemia, gastroenteritis, enterocolitis, and wound infections in humans (Altwegg and Geiss, 1989; Janda, 1991). In the current study, *Aeromonas* was counted in 75.39% of the examined samples, with a range of 1.3-3.32 and mean value of 1.84±0.08 log cfu/g. lower rate (25%) of detection was recorded by Wassif (2018) from channel catfish (*Ictalurus punctatus*) in Egypt; while higher rate (82.7%) by Wang and Silva (1999) from channel catfish fillets in Mississippi, USA.

5. CONCLUSION

The present study has shown that wild *Clarias gariepinus* harvested and sold in the area of Assiut city are intensively rich in term of nutritional values; being an excellent source of protein, beside considerable content of fat, and ash. The sensory parameters and the studied biochemical indices of deterioration (pH, TVB, and TBARS); all indicated values well within the prescribed limit of acceptability. The microbiological parameters, however, indicated fish are laden with bacterial contaminants including potential pathogens. High numbers of coliforms, less fecal coliforms, and considerable count of *Aeromonas* spp in the majority of samples; beside low numbers of *Cl. perfringenes* and *E. coli* were found in fish samples. Food poisoning is often associated with some of these detected bacterial species. For that, it is necessary to maintain the proper hygienic condition at every step of catching, landing and transportation, to minimize the contamination level. Fish retailers should be educated on the need for the hygienic conditions during fish handling. Additionally, fish need to be properly processed or cooked before consumption as a safeguard against bacterial hazards.

6. REFERENCES

Abd-Allah, Sh.M.S. and Ismail, H.A.A. (2016): Quality parameters and nutritive value of wild and cultured Nile Tilapia sold in Assiut city, Egypt. Assiut Vet. Med. J., 62 (151): 90-100.

Aberoum, A. and Jooyandeh, H. (2010): A review on occurrence and characterization of the *Aeromonas* species from marine fishes. World J. Fish Marine Sci., 2 (6): 519-523.

Abul Mansur, M.; Shafiqur Rahman, Md.; Absar Khan, Mn.; Shaheed Raza, Md.; Lubaba, Sadia and Wahab, R. (2014): Studies on the quality attributes and safety aspects of semi-fermented fish products. Indian J. Marine Sci., 43 (6): 949-954.

Adam, H.M.Y.; Ahmed, A.M.M.; Ibrahim, A.M.A. and Yousif, F.M. (2015): Comparative study of the body weight characteristics and effect of drying on chemical composition of three Nile fish species (*Oreochromis Niloticus, Labeo Niloticus* and *Clarias Spp.*). Online J. Anim. Feed Res., 5 (6): 175-180.

Adeosun, O.; Olaifa, F.E. and Akande, G.R. (2015): Chemical composition, microbial content and sensory evaluation of smoked farmed catfish *Clarias gariepinus* (Burchell, 1822) raised under different culture systems in Ibadan, Nigeria. Food Sci. Quality Manag., 46: 33-43

Alasalvar, C.; Taylor, K.D.A.; Zubcov, E.; Shahidi, F. and Alexis, M. (2002): Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*): Total lipid content, fatty acid and trace mineral composition. Food Chem., 79: 145–150.

Ali, M.E.; Babiker, S.A. and Tibin, A. (1998): Body characteristics yield indices and proximate chemical composition of commercial fish species of Lake Nubian. FAO Expert Report, AGRIS, 574: 211-214.

Allen, D. A.; Austin, B. and Colwell, R. R. (1983): Numerical taxonomy of bacterial isolates associated with a freshwater fishery. J. Gen. Microbiol., 129: 2043– 2062.

Altwegg, M. and Geiss, H. K. (1989): *Aeromonas* as a human pathogen. CRC Crit. Rev. Microbiol., 16: 253–286.

Amegovu, A.K.; Sserunjogim, M.L.; Ogwok, P. and Makokha, V. (2012): Nucleotide degradation products, total volatile basic nitrogen, sensory and microbiological quality of Nile perch (*Lates niloticus*) fillets under chill storage. J. Microbiol. Biotech. Food Sci., 2: 653–666.

Andrew, A.E. (2001): Fish Processing Technology, University of Ilorin Press, Ilorin, Nigeria.

Andy, I. E.; Bassey, I. U.; Lennox, J. A. and Obo, V. U. (2018): Assessment of the bacteriological quality of cat fish (*Clarias gariepinus*) sold at 8 miles market, cross river State, Calabar. Int. J. Scientific Res Publ., 8 (11): 130-134.

AOAC "Association of Official Analytical Chemists" (1980): Official Methods of Analysis of the Association of Official Analytical Chemists. 13th Ed. Horwitz, W. (edit). Washington, DC.

AOAC "Association of Official Analytical Chemists" (2000): Official Methods of Analysis of the Association of Official Analytical Chemists. 17th Ed. AOAC International, Gaithersburg. MD.

Arafat, M. G. (2013): Microbiological assessment of three types of fresh fish (*Tilapia niloticus*, *Labeo niloticus* and *Hydrocynus spp.*) sold in Ed Dueim, Sudan. N. Y. Sci. J., 6 (4): 49-54.

Austin, B. and Austin, D.A. (2012): Aeromonadaceae representatives (motile aeromonads). In: Austin, B., Austin, D.A. (Eds.), Bacterial Fish Pathogens, Diseases of Farmed and Wild Fish. 5th ed. Springer, New York, London. Pp. 119-146.

Azuka, I.W. and Goodnesschinwe, U. (2018): Microbial and chemical evaluation of parts of fresh and smoked Tilapia (*Oreochromis niloticus*) and Catfish (*Clarias gariepinus*). *The Pharmaceutical and Chemical Journal*, 5(2):119-128.

Beerens, H.; Romond, Ch.; Lepage, C. and Criquelion, J. (1980): A liquid medium for the enumeration of *Clostridium perfringens* in foods and faeces.

Binsi, P. K.; Viji, P.; Visnuvinayagam, S.; Ninan, G.; Sangeeta, G.; Triveni, A. and Ravishankar, C.N. (2015): Microbiological and shelf life characteristics of eviscerated and vacuum packed freshwater catfish (*Ompok pabda*) during chill storage. Food Sci. Technol., 52(3):1424–1433.

Bryan, F.L. (1980): Epidemiology of foodborne diseases transmitted by fish, shellfish and marine crustaceans in the United States, 1970-1978. J. Food Prot., 43 (11): 859-876.

Buchtová, H.; Svobodová, Z.; Kocour, M. and Velíšek, J. (2010): Chemical composition of fillets of mirror crossbreds common carp (*Cyprinus carpio* L.). Acta Veterinaria Brno, 79: 551–557.

Budiati, T.; Rusul, G.; Wan-Abdullah Wan Nadiah, Ahmad Rosma and Mat Arip Y. (2015): Microbiological quality of catfish (*Clarias gariepinus*) and tilapia (*Tilapia mossambica*) obtained from wet markets and ponds in Malaysia. J. Aquac. Res. Develop., 6 (1): 1-5.

Buege, J.A. and Aust, S.D. (1978): Microsomal lipid peroxidation. Methods Enzy., 52: 302-310.

Can, Ö. P. (2010): Evaluation of the microbiological, chemical and sensory quality of carp processed by the sous vide method. Inter. J. Agri. Biol. sci., 1 (2): 99-104.

Casallas, N.E.C.; Casallas P.E.C. and Mahecha H.S. (2012): Characterization of the nutritional quality of the meat in some species of catfish: A review. Rev. Fac. Nal. Agr. Medellín, 65 (2): 6799-6809.

Chaijan, M.; Jongjareonrak, A.; Phatcharat, S.; Benjakul, S. and Rawdkuen, S. (2010): Chemical compositions and characteristics of farm raised giant catfish (*Pangasianodon gigas*) muscle. LWT - Food Sci. Tech., 43 (3): 452-457.

Chomnawang, C.; Nantachai, K.; Yongsawatdigul, J.; Thawornchinsombut, S. and Tungkawachara, S. (2007): Chemical and biochemical changes of hybrid catfish fillet stored at 4 °C and its gel properties. Food Chem., 103 (2): 420-427.

Chukwu O. and Shaba I.M. (2009): Effects of drying methods on proximate compositions of catfish (*Clarias gariepinus*). World J. Agri. Sci., 5 (1): 114-116.

Chwastowska-Siwiecka, I.; Skiepko, N.; Pomianowski, J. F.; Kubiak, M.S.; woźniak, M. and Maryczka, M. (2016): Gender differences in the chemical composition and selected properties of African catfish *(Clarias gariepinus* burchell, 1822*)* meat. Ital. J. Food Sci., 28: 391-401

Connel, J.J. (1995): Control of fish quality, fishing new books. Blackwell Science Ltd., Cambridge, London, p 241.

Darwish, A.M.; El-Mossalami, M.K. and El-Bassuony, R.A. (2003): Quality assurance of some fatty fishes. Assuit Vet. M. J., 49 (98): 79 - 96.

Del Rio, D.; Stewart, A.J. and Pellegrini, N. (2005): A review of recent studies on malondialdehyde as toxic molecule and biological marker of oxidative stress. Nutr Metab Cardiov Dis, 15: 316-328.

Deng, O.O.; Mohamed, A.H.; Agib M.A.; El- faki F.E. and Ali M.E. (2016): Comparative studies on nutritive value of wild and farmed African catfish *Clarias gariepinus.* Int. J. Fish. Aquatic Studies, 4 (3): 327-329.

Deng, O.O.; Mohamed, A.H.; Agib M.A.; El- faki F.E. and Ali M.E. (2016) Comparative studies on nutritive value of wild and farmed African catfish *Clarias gariepinus.* Int. J. Fish. Aquatic Studies, 4 (3): 327-329.

Dijk, R. and Grootenhuis, A. (2003): Microbiologie van voedingsmiddelen; methoden, principes en criteria. Keesing Noordervliet BV, Houten, pp 433–561.

E.S. "Egyptian Standards (2005): Chilled fish, ES: 3494/2005. ICS: 67.120.30. Egyptian Organization for Standardization and Quality Control, Arab Republic of Egypt.

Effiong, B. N. and Fakunle, J. O. (2012): Proximate and mineral content of traditional smoked species from Lake Kainji, Nigeria. Bull. Env. Pharm. Life Sci., 1: 43-45.

El-Lahamy, A.A., Khalil, Kh.I., El-Sherif, Sh.A. and Mahmud, A.A. (2018): Effect of smoking methods (hot and cold) and refrigeration storage on the chemical composition of catfish fillets (*Clarias gariepinus*). J. Food Process Technol., 9 (10): 1-4

Ersoy, B. and Özeren, A. (2009): The effect of cooking methods on mineral and vitamin contents of African catfish. Food Chem., 115 (2): 419-422.

EU/EC (2008): Amending regulation (EC) No 2074/2005 as regards the total volatile basic nitrogen (TVB-N) limits. In: Communities, T. C. O. T. E. (ed.) 1022/2008. Official J. Europ. Union.

Eyo, A.A. (2001): Fish Processing Technology in the Tropics. National Institute for Freshwater Fisheries (NIFFR), New Bussa, pp. 1-39.

FAO "Food and Agriculture Organization" (1995): Quality and Quality Changes in Fresh Fish. Huss, H. H. (edit). FAO Fisheries Technical Paper No. 348.

FAO "Food and Agriculture Organization" (2001): The composition of fish. Murray J. and Burt J. R. (edit), Torry Advisory Note No.38, http://www.fao.org/wairdocs/tan/x5916e/x5916e00.htm. pp 1-80.

FAO "Food and Agriculture Organization" (2015): FAO Global Capture Production Database, Fisheries and Aquaculture Department.

FAOSTAT (2018): http://www.fao.org/faostat/en/#data/FBS. Accessed (23 Sept. 2019)

Fawole, O.O; Ogundiran, M. A.; Ayandiran, T. A. and Olagunju, O.F. (2007): Proximate and mineral composition in some selected fresh water fishes in Nigeria. Internet J., 9: 52-55.

Fontes, M.C.; Esteves, A.; Coldeira, F.; Saraiva, C.; Vieira-pinto, M. and Martins, C. (2007): Freshness and hygienic quality of fish sold in a Portuguese town. Arquivo Brasileiro de Medicina Veterinariae Zootecnia, 59 (5): 1308-1315.

Fowoyo, P.T. and Isaac, M.E. (2018): Microbiological quality, proximate composition and heavy metal contamination of pond-raised catfish (*Clarias gariepinus*). J. Adv. Microb., 13 (4): 1-10.

Gamal, E. D. and Shamery, M. R. (2010): Studies on contamination and quality of fresh fish meats during storage. Egyp. Acad. J. Boil. Sci., (2): 65-74.

Ganegamaarachchi, G. J.; Ariyadasa, K. G. C.; Perera, W. M. K. and Jayasinghe, J. M. P. K. (2000): Investigations on quality aspects of tuna catches of multi-day boats at the Negombo fish landing site, in Sri Lanka. Sri Lanka J. aquatic sci., 5: 97-104.

Ghaly, A.E.; Dave, D.; Budge, S. and Brooks, M.S. (2010): Fish spoilage mechanism and preservation techniques review. American J. Appl. Sci., 7 (7): 859-877.

Gjedrem, T.; Robinson, N. and Rye, M. (2012): The importance of selective breeding in aquaculture to meet future demands for animal protein: A review. Aquaculture, 350 (353):117-129.

Goda, A.M.; El-Haroun, E.R. and Kabir Chowdhury, M.A. (2007): Effect of totally or partially replacing fish meal by alternative protein sources on growth of African catfish *Clarias gariepinus* (Burchell, 1822) reared in concrete tanks. Aquacult. Res., 38: 279-87.

Guler, G. O.; Kiztanir, B.; Aktumsek, A.; Citil, O. B. and Ozparlak, H. (2008): Determination of the seasonal changes on total fatty acid composition and ω3/ω6 ratios of carp (*Cyprinus carpio* L.) muscle lipids in Beysehir Lake (Turkey). Food Chem., 108: 689–694.

Hall, G. M. (1992): Fish Processing Technology 1st Ed.; Chapman and Hall, USA.

Hassan Azza, E.A. and El-Shahat, A.F. (2011): Chemical evaluation of some fresh and frozen fish. Assiut Vet. Med. J., 57 (130): 97-106.

Heever, D.J. van den and Frey, B.J. (1994): Microbiological quality of the catfish *(Clarias gariepinus)* kept in treated waste water and natural dam water. Water SA, 17 (2): 113-116.

Hill, R.T.; Knight, I.T.; Anikis, M.S. and Colwell, R.R. (1993): Benthic distribution of sewage sludge indicated by *Clostridium perfringens* at a deep-ocean dump site. Appl Environ Microb., 59: 47–51.

Horan, N.J. (2003): Fecal Indicator Organisms. In: Mara D., Horan N.J. (eds) The Handbook of Water and Wastewater Microbiology. Academic, London, pp 105–112.

Huisint-Veld, J. H. (1996): Microbial and biochemical spoilage of foods, an overview.

Huss, H.H. (1995): Quality and Quality Changes in Fresh Fish. FAO fisheries technical paper 348. Food and Agriculture Organization of the United Nations, Rome, Italy.

Ibrahim, A.Th.A. and Omar, H.M. (2013): Seasonal variation of heavy metals accumulation in muscles of the African catfish *Clarias gariepinus* and in River Nile water and sediments at Assiut Governorate, Egypt. J. Biol. Earth Sci., 3 (2): B236-B248.

Issifu, K. (2018): Nutritional composition, bacterial load and organoleptic quality of farm-raised catfish (*Clarias gariepinus*, burchell, 1822) from the Dormaa Municipality, Ghana.

Janda, J. M. (1991): Recent advances in the study of the taxonomy, pathogenicity, and infectious syndromes associated with the genus *Aeromonas*. Clin. Microbiol. Rev., 4: 397–410.

Jankowska, B.; Zakęś, Z.; Żmijewski, T.; Ulikowski, D. and Kowalska A. (2007): Slaughter value and flesh characteristics of European catfish *(Silurus glanis)* fed natural and formulated feed under different rearing conditions. Eur. Food Res. Technol., 224: 453-459.

Jianadasa, B.K.K.K.; Ginigaddarage, P.H. and Ariyawansa, S. (2014): A comparative quality assessment of five types of selected fishes collected from retail market in Sri Lanka. American J. Food Sci. Tech., 2 (1): 21-27.

Jurgens, M.H. and Bregendahl, K. (2007): Animal feeding and nutrition. 10th Ed. Kendall/Hunt Publishing Company, Iowa, USA.

Kaitaranta, J.k. (1982): Hydrolytic changes in the lipid of fish roe products during storage. J. Food Technol., 17: 78-98.

Khalil, A.H. and Mansour, E.H. (1997): Toxicity of crude extracellular products of *Aeromonas hydrophila* in *Tilapia Nilotica*. Lett. Appl. Microbiol., 25: 269-273.

Khora, S.S. (2013): Therapeutic benefits of Ω-3 fatty acids from fish. Int. J. Drug Develop. Res., 5 (2): 55-65.

Krovacek, K.; Faris, A.; Baloda, S. B.; Peterz, M.; Lindberg, T. and Mansson, I. (1992): Prevalence and characterization of *Aeromonas* spp. isolated from foods in Uppsala, Sweden. Food Microbiol., 9: 29–36.

Kvenberg, E.J. (1991): Non-indigenous bacterial pathogen. In: Donn R., Cameron H., Van Nostrand R. (Eds). Microbiology of Marine Food Products. New York, pp. 263-291.

Lauzon, H. L.; Margeirsson, B.; Sveinsdóttir, K.; Guðjónsdóttir, M.; Karlsdóttir, M. G. and Martinsdóttir, E. (2010): Overview on Fish Quality Research. Impact of Fish Handling, Processing, Storage and Logistics on Fish Quality Deterioration. Iceland: Matis ohf, Report 39-10. 73p.

Likongwe, M.Ch,; Kasapila, W.; Katundu, M. and Mpeketula, P. (2018): Microbiological quality of traditional and improved kiln smoked catfish (*Clarias gariepinus*; Pisces; Clariidae) in Lake Chilwa Basin.

Linden, G. and Lorent, D. (1996): Los productos del mar. Bioquı´mica agroindustrial. Acribia, Zaragoza, Spain, pp. 189–212.

Lubes, C.A. (2005): Efecto del tiempo de retardo en la refrigeración sobre los cambios microbiológicos, físicos, químicos y sensoriales en el bagre yaque (*Leiarius marmoratus*). Trabajo de Grado. Facultad de Ciencias, Universidad Central de Venezuela, Caracas. 31 p.

Lyhs, U.; Hatakka, M.; Maki-Petays, N.; Hyytia, E. and Korkeala, H. (1998): Microbiological quality of Finnish vacuum-packaged fishery products at retail level. Archiv fur Lebensmittelhygiene, 49 (6): 146-150.

Mahmoud, H.H.; Teh, L.; Khalfallah, Myriam and Pauly, D. (2015): Reconstruction of Marine Fisheries Statistics in the Egyptian Mediterranean Sea, 1950-2010. Fisheries Centre, University of British, Working Paper Series, No 85.

Marx, H.; Brunner, B.; Wenzierl, W.; Hoffmann, R. and Stolle, A. (1997): Methods of stunning freshwater fish: Impact on meet quality and aspects of animal welfare. Z. Lebensm. Unters. Forsch. A., 204A: 282-286.

Massa, A.E. (2006): Cambios bioquímicos post-mortem en músculo de diferentes especies pesqueras. Determinación de la vida útil de las mismas en frío. Tesis Doctorado en Ciencias. Facultad de Ciencias Exactas y Naturales. Universidad Nacional del Mar del Plata, Mar del Plata. 236 p.

Mazorra-Manzano, M.A.; Pacheco-Aguilar, R.; Díaz-Rojas, E.I. and Lugo-Sánchez, M.E. (2000): Postmortem changes in black skipjack muscle during storage in Ice. J. Food Sci., 65 (5): 774–779.

Merkin, G.V.; Roth, B.; Gjerstad, C.; Dahl-Paulsen, E. and Northvedt, R. (2010): Effect of pre-slaughter procedures on stress responses and some quality parameters in seafarmed rainbow trout (*Oncorhynchus mykiss*). Aquacul., 309: 231-235.

Merrill, A.L. and Watt, B.K. (1973): Energy value of foods, basis and derivation. Agriculture Handbook No. 74.Washington, DC, Unites States Depart Agricul.

Mhango, M.; Mpuchane, S. and Gashe, B. (2010): Incidence of indicator organisms, opportunistic and pathogenic bacteria in fish. African J. Food, Agri. Nutr. Develop., 10 (10): 4202-4218.

Miroslav, Ć.; Dejana, T.; Dragana, L. and Vesna, Đ. (2011): Meat quality of fish farmed in polyculture in carp ponds in Republic of Serbia. Tehnologija mesa 52 (1):106–121

Morris, P.C. (2001): The Effects of Nutrition on the Composition of Farmed Fish, In: Farmed Fish Quality, Kestin S.C. and Warris P.D. (Eds.). Fishing News Books, London, pp. 161-179.

Mousa, M.M. and Mahmoud, Y.E. (1997): Hygienic quality of newly caught fresh fish. Assiut Vet. Med. J., 37 (73): 219-227.

National Academy of Sciences (1985): An Evaluation of the Role of Microbiological Criteria for Foods and Food Ingredients. National Academy Press, Washington, D.C.

Oladipo, I.C. and Bankole, S.O. (2013): Nutritional and microbial quality of fresh and dried *Clarias gariepinus* and *Oreochromis niloticus*. Int. J. Applied Microb. Biotech., 1: 1-6

Oladosu-Ajayi, R.N.; George, F.O.A.; Obasa, S.O.; Ajayi, A. A. and Bankole, M.O. (2011): Bacterial load, composition and succession in the African catfish, *Clarias gariepinus* (Burchell, 1822) held at ambient temperatures. Researcher, 3 (7): 67-73.

Olayemi, F.F.; Raji, A.O. and Adedayo, M. R. (2012): Microbiological quality of catfish (*Clarias gariepinus)* smoked with Nigerian Stored Products Research Institute (NSPRI) developed smoking kiln. Int. Res. J. Microb., 3(13): 426-430.

Olopade, O.A.; Taiwo, I.O. and Agbato, D.A. (2013): Effect of traditional smoking method on nutritive values and organoleptic properties of *Sarotherodon galilaeus* and *Oreochromis niloticus*. Int. J. Applied Agri. Api. Res., 9 (1-2): 91-97.

Omojowo, F.S. and Omojasola, P.F. (2013): Microbiological quality of fresh catfish raised in ponds fertilized with raw and sterilized poultry manures. Proceedings of 28th Fison Annual Conference, Nov. 25-30, 2013.

Pacheco, J.; Núñez, A.L. and Espinoza, Y.A. (2010): Estabilidad fisicoquímica durante el almacenamiento refrigerado de filetes de bagre dorado (Brachyplatystoma rousseauxii) ahumados y empacados con y sin vacío. Revista Científica UDO Agrícola, 10 (1): 123-132.

Palumbo, S.A.; Maxino, F.; Williams, A.C.; Buchanan, R.L. and Thayer, D.W. (1985): Starch ampicillin agar for the quantitative detection of *Aeromonas hydrophila*. Appl. Environ. Microbiol., 50 (4): 1027-1030.

Parisi, G.; Franci, O. and Poli, B.M. (2002): Application of multivariate analysis to sensorial and instrumental parameters of freshness in refrigerated sea bass (*Dicentrarchus labrax*) during shelf life. Aquaculture, 214: 153-167.

Pearson, D. (1976): The analysis of Foods. 7th Ed. Longman Inc. USA.

Periago, M.J.; Ayala, M.D.; Lo´pez-Albors, O.; Abdel, I.; Martı´nez, C.; Garcı´a-Alca´zar, A.; Ros, G. and Gil, F. (2005): Muscle cellularity and flesh quality of wild and farmed sea bass, *Dicentrarchus labrax* L. Aquaculture, 249: 175– 188.

PN-A (1999): Terminology. PN-A Standard 86770:1999. Fish and fish products. Polish Committee for Standardization, Warsaw, Poland.

Polak-Juszczak, L. (2007): Chemical characteristics of fishes new to the Polish market. Acta Sci. Pol., Piscaria., 6 (2): 23-32.

Pyz-Łukasik, R. and Paszkiewicz, W. (2018): Microbiological quality of farmed grass carp, bighead carp, Siberian sturgeon, and Wels catfish from Eastern Poland. J. Vet. Res., 62: 145-149.

Riggins, J.N. and Marnett, L.J. (2001): Mutagenicity of the malondialdehyde oligomerization products 2-(3-oxo-1 propenyl) malondialdehyde and 2, 4-dihydroxymethylene -3- (2,2 – dimethoxyethyl) glutaraldelyde in Salmonella. Mut Res., 497: 153-157.

Rodríguez, D.; Barrero y, M. and Kodaira, M. (2009): Evaluación física y química de filetes de bagre (*Pseudoplatystoma* sp.) salados en salmuera empacados al vacío y almacenados en refrigeración. Archivos Latinoamericanos de Nutrición, 59 (2): 206-213.

Rosa, R.; Bandarra, N.M. and Nunes, L.M. (2007): Nutritional quality of African catfish *Clarias gariepinus* (Burchell 1822): A positive criterion for the future development of the European production of Siluroidei. Int. J. Food Sci. Technol., 42: 342-351.

Saleh, E. A.; Morshdy, A.M.A.; Mohamed, A.M. and El-sobary Basma, F. (2017): Prevalence of *Aeromonas* species and their herbal control in fish. Global Veteri., 18 (4): 286-293.

Sesugh, A.; Luter, L.; Ishaq E. and Sunday Y. (2012): Proximate analysis of smoked and unsmoked fish (cat and tilapia) in Ombi River Lafia Nasarawa State Nigeria. Elixir Food Sci., 53: 11801-11803.

Sharma, P.J. and Goswami, U.C. (2010): Quality of commercially dried fresh water fish of Assam Source. Environ. Ecology, 28 (2A): 1163-1165.

Shearer, K.D. (1994): Factors affecting the proximate composition of cultured fishes with emphasis on Salmonids. Aquaculture, 119: 63–88.

Shinkafi, S.A. and Ukwaja, V.C. (2010): Bacteria associated with fresh Tilapia Fish (*Oroechromis niloticus*) sold at Sokoto central market in Sokoto, Nigeria. Nigerian J. Basic Appl. Sci., 18 (2): 217-221.

Silva, J.J. and Chamul, R.S. (2000): Composition of Marine and Fresh Water Finfish and Shellfish Species and Their Products. In: Martin R.E., Carter E.P., Flick E.J. and Davis L.M. (Eds.), Marine and Fresh Water Products Handbook, Lancaster, Pennsylvania, U.S.A: Technomic Publishing Company, Pp. 31-46.

Skałecki, P.; Florek, M.; Litwińczuk, A.; Staszowska, A. and Kaliniak, A. (2013): The nutritional value and chemical composition of muscle tissue of carp (*Cyprinus carpio* L.) and rainbow trout (*Oncorhynchus mykiss* Walb.) obtained from fish farms in the Lublin region. Rocz. Nauk. PTZ. (PL), 9 (2): 57-62.

Sugita, H.N.; Matsuo, Y.; Hirose, M., Iwato, Y. and Deguchi, A. (1997): *Vibrio* species strain NM10 with an inhibitory effect against *Pasteurella piscicida* from the intestine of Japanese coastal fish. Appl. Environ. Microb., 63 :4986-4989.

Umana, S.I.; Okon, U.C.; Uko, M.P. and Bassey M.P. (2017): Occurrence of bacterial contaminants in fin-fishes (*Clarias gariepinus* and *Coptodon guineensis*) from humic freshwater ecosystem of Eniong River, Itu, Akwa Ibom State, Nigeria. J. Adv. Microb., 6 (1): 1-12.

Vladau, V.V.; Bud, I. and Stefan, R. (2008): Nutritive value of fish meat comparative to some animals meat. Bull. UASVM Animal Sci. Biotech., 65 (1–2): 301–305.

Wang, Ch. and Silva, J.L. (1999): Prevalence and characteristics of *Aeromonas Species* isolated from processed channel catfish. J. Food Prot., 62 (1): 30–34.

Wassif, I.M. (2018): Biochemical and molecular characterization of *Aeromonas* species isolated from fish. Alex. J. Vet. Sci., 57 (1): 32- 39.

Wimalasena, S. and Jayasuriya, M.N.S. (1996): Nutrient analysis of some fresh water fish. J. Nat. Sci. Coun. Sri Lanka, 24 (1): 21-26.

Yanar Yasemen (2007): Quality changes of hot smoked catfish (*Clarias gariepinus*) during refrigerated storage. J. Muscle Foods, 18 (4): 391-400.

Zhong-Yi, L.; Zhong-Hai, L.; Miao-Ling, Z. and Xiao-Ping, D. (2010): Effect of fermentation with mixed starter cultures on biogenic amines in bighead carp surimi. Int. J. Food Sci. Tech., 45: 930-936.