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*(Original Article)*

# Quality Properties of African Catfish *(Clarias gariepinus)* Meat as Affected by its Color

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## Abstract

Nutritional quality (proximate chemical composition, mineral content, amino acid composition, and fatty acid composition), safety quality (some heavy metals content and microbial analysis) as well as sensory quality were investigated for African catfish *(Clarias gariepinus*) meat obtained from black color and gray color catfish. Fillet of catfish constituted 48.15 and 47.41 % of total body weight in black and gray catfish respectively. Catfish meat contained 74.62 and 76.00% protein, 21.17 and 19.81% of fat (on dry wet) in black and gray catfish respectively. Gray color catfish fillet recorded higher contents of K, P, Ca, Na, Mg and Fe compared with the mineral content of black color catfish fillet while, the latter had higher concentrations of Zn, Se and Mn. Essential amino acids (EAAs) to Non-essential amino acids (N-EAAs) ratio ranged from 0.72 to 0.74, while, The polyunsaturated fatty acids/ saturated fatty acids (PUFA/SFA) ratio ranged from 0.89 to 0.93 in catfish meat. The results indicated that, catfish meat had a high nutritional, and safety qualities. Regarding to sensory quality, the panelists relatively preferred the meat of gray color catfish fillet. Moreover, some sensory parameters (color, odor, taste, and overall acceptability) of catfish meat may be need pre-treatments to improve its sensory quality.

***Keywords:*** *Catfish, Color, Nutritional quality, Safety quality, Sensory quality.*

## Introduction

Fish is an important food source in human consumption due to its minerals and fatty acids needed for various body functions (Wijayanti *et al*., 2023). However, the chemical composition of fish varies greatly from one species and one individual fish to another depending on age, sex, environment and season (FAO, 2001). Catfish (*C. gariepinus*) is most important aquaculture freshwater species with tilapia in Egypt. In 2017, the world aquaculture production quantity of farmed catfish species (*i.e.*, freshwater fishes of the order Siluriformes) is 5.5 million tones as percent of 4.93% (FAO, 2019). Catfish is of the lowest price fish in Egypt compared with other species. Generally, Egyptian consumers prefer the

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light color catfish and many of them reject the dark color one. Consumers have a psychological belief that, black color catfish is low nutritional value and more contaminated. So, the present study was conducted to estimate the nutritional value and some quality properties of African black and gray colored catfish.

## Materials and Methods

Twenty kg of live catfish (*Claries gariepinus)* with average weight from 2-3 Kg were purchased from a local market in Assiut Governorate, Egypt during 2022, and transported in icebox directly to the Food Technology Laboratory, Agriculture Research Station (ARC), in Assiut city**.**

Catfish samples were divided according to its color to gray and black catfish as indicated in figure (1). Fish were slaughtered and left to bleed for three minutes, then cut up to main parts. Fillet was minced by a kitchen meat mincer with a 3 mm diameter perforated plate and packaged in polyethylene bags and kept in frozen at-18±1˚C until use for analysis.

**Fig 1. Black and gray catfish.**

## Nutritional quality

Chemical composition (moisture, crude protein, crude fat and ash contents) was determined according to official methods (AOAC, 2000). Carbohydrates were calculated by difference according to Turhan *et al*., (2005), while caloric value was calculated as multiply the content of protein and carbohydrates by 4 and by 9 for fat content.

Minerals content was analyzed. Microwave digestor (Multiwave GO Plus 50 HZ) was used prior to spectrophotometric analysis of the samples by MPAES4210 (Microwave Plasma -Atomic Emission Spectroscopy) (Agilent, Mulgrave, Victoria, Australia). according to Agilent Technologies, Inc. (2021).

Amino acids were determined chromatography using Beckman Amino Acid Analyzer Model 119CL, according to Pellett and Young (1980). Tryptophan was determined using spectrophotometric method as described by Sastry and Tummuru (1985). Fatty acids were determined according to Kates (1972) and Rossell *et al*., (1983).

**Physico-chemical quality**

To determined pH value, homogenized 10 g of prepared catfish meat fillet, then the sample with 90 ml distilled water for 30 seconds, the pH values were recorded, using a pH-meter (Jenway 3010; Jenway Ltd., Essex, UK) at 20ºC, as defined by Fernández-López *et al*., (2006).

Water holding capacity (WHC) was determined according to Hamm (1960).

Water holding capacity (%) =% Moisture -% Expressible water

**Color**

Catfish fillet color was measured by chroma meter (Konica Minolta, model CR 410, Japan). Color was expressed using the CIE *L*, a*,* and *b** color system, lightness *L** dark (0) to light (100), the redness *a** values (+) reddish to (-) greenish and the yellowness *b**values (+) yellowish to (-) bluish were estimated according to Commission International de l'E´ clairage, (1978). Samples were analyzed at Cairo University Research Park (CURP)/ Faculty of Agriculture.

Thiobarbituric acid (TBA) values were determined according to the method of Pearson, (1991). The total volatile bases nitrogen (TVB-N) was estimated as described by AOAC (2005). Trimethylamine (TMA) was determined according to Malle and Tao, (1987).

**Microbiological quality**

The total plate bacterial counts were according to procedures by APHA (1976) and Difco- Manual (1984). Yeast and Mould counts (YMC) were determined using Bacto yeast malt (Y.M) according to the methods described by Difco -Manual (1998).

**Sensory quality**

Sensory qualities were done by 10 staff members of Agriculture Research Station in Assiut city. A 10- point hedonic scale (1 being dislike very much to 10 being like very much) was used according to Gelman and Benjamin (1989).

**Statistical analysis**

The data obtained 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 (SPSS, 2020). A significance level of 0.05 was chosen.

**Results and Discussion**

**Body composition of black and gray catfish *(Clarias gariepinus)* fillet**

The data presented in Table (1) showed the body composition of the studied catfish. Data indicated that, there were significant ($p > 0.05$) differences in the fillet, head, frame, viscera, skin and fins between black and gray studied catfish, whereas black catfish had heavier weight for the studied parameters. This difference might be due to the age and feeding conditions as reported by Deng (2018). However, the of catfish fillet constituted 48. 15 and 47.41% of total body weight in black and gray catfish color; respectively. Such results are agreed with Abd-Elfttah (2021) who reported that, the yield of catfish fillet was 48.41%, and Sobczak *et al.,* (2022) showed that, the fillet yield was shown catfish 49.1%. On other hand Abd El-latif (2021) showed that the fillet obtained counted 44.95% of the total body and Abdel-aal (2001) who reported that, the yield of Nile Karmout fish *(Claries lezera)* fillet was 47.0%. *Clarias gariepinus* has 42.74 % fillet and 54.83 % inedible sections. From the body weight composition one can concluded that the net percentage of the flesh compared to the total body was good to use such kind of fish to produce a fast fish product such as fish burger or fish fingers (Abd El-latif, 2021).

**Table 1. Body composition of black and gray catfish *(Claries gariepinus)***

| Component | Blackcatfish | | Gray catfish | |
|---|---|---|---|---|
| | Weight (g) | % | Weight (g) | % |
| **Fillet** | 1178.00±6.504 [a] | 48. 15 | 1157.18±7.549 [b] | 47.41 |
| **Head** | 532.78±3.196 [a] | 21.78 | 531.86±3.329 [b] | 21.79 |
| **Frame** | 308.97±5.839 [a] | 12.63 | 307.17±1.260 [b] | 12.58 |
| **Viscera** | 235.09±5.007 [a] | 9.61 | 234.17±3.746 [b] | 9.59 |
| **Skin** | 122.46±1.823 [b] | 5.98 | 141.97±4.677 [a] | 5.82 |
| **Fins** | 69.07±1.988 [a] | 2.82 | 68.57±2.735 [b] | 2.81 |
| **Whole body(n=3)** | 2446.32±9.065 [a] | 100 | 2440.92±8.401 [b] | 100 |

Different letters in the same row means significantly difference ($p<0.05$)

## Gross Chemical Composition of black and gray catfish fillet

Proximate chemical composition and caloric value of black and gray catfish are shown in Table (2). Moisture, crude protein and fat content had significant differences ($p < 0.05$) between the compared studied colors catfish. However, gray catfish fillet showed the greatest moisture and protein content 74.16 and 76.00 %; respectively. The consumption of catfish could help to prevent some problems due to deficiencies of protein in the diet of people in developing countries (FAO, 2008). On other hand, the black catfish fillet showed highest fat content and caloric value (21.17% and 498.70 kcal/100g on dry weight, respectively). Moreover, there were no significant differences for both ash and carbohydrate content between the two colors studied catfish as shown in Table (2). Similar results were reported by Yelouassi *et al*. (2018); Mahboob *et al*. (2019); Abiodun *et al.* (2021); (Mahmoud *et al*. (2021); Hamad (2021), Mostafa *et al.* (2023) and Zaghloola *et al.* (2023) on catfish fillet composition. Moreover, the main components of fish meat are water (66–81%), protein (16–21%), carbohydrates (<0.5%), lipids (0.2–25%), and ash (1.2–1.5%) in wet weight basis as reported by FAO (1999).

The disparity of chemical composition could be attributed to age and feeding conditions as reported by Deng (2018).

**Table 2. Proximate chemical composition of black and gray catfish fillet (dry weight bases)**

| Parameters | Black catfish | Gray catfish |
|---|---|---|
| Moisture | 73.88 ±0.440 [a] | 74.16±1.00 [b] |
| Protein%* | 74.62±0.300 [b] | 76.00±0.240 [a] |
| Fat%* | 21.17±1.00 [a] | 19.81±1.26 [b] |
| Ash%* | 2.99±0.490 [ab] | 3.02±0.020 [a] |
| Carbohydrate %* | 1.23±0.100 [a] | 1.16±0.040[ab] |
| Caloric value (kcal/100g)* | 498.70±1.00 [a] | 486.93±0.966 [b] |

Different letters in the same row means significantly difference ($p<0.05$),*On dry weight bases

## Mineral content of black and gray catfish (*Clarias gariepinus)* fillet

The obtained data in Table (3) revealed that there were eleven minerals in both catfish samples, ten elements as nutritional minerals (Ca, Na, K, P, Mg, Fe, Zn, Mg, Cu, and Cr) and three heavy metals (Hg, Cd and Pb). Gray color catfish fillet was higher content of K, P, Ca, Na, Mg and Fe compared with the mineral content of black color catfish fillet. While black color catfish fillet contains higher concentrations of Zn, Se and Mn. Potassium recorded 4970.09 and 5948.92 ppm in black and gray catfish, respectively. However, potassium supports healthy nerve, muscle, and heart, as well as sugar metabolism, acid-base balance, and brain oxygenation (Rasul *et al.*, 2021). Phosphorous was found as 4119.53 and 5265.27 ppm in black and gray catfish, respectively. On the other hand phosphorous aids in a variety of physiological functions, including phospholipid and adenosine polyphosphate activity (Nair and Mathew, 2001). Black catfish meat had high content of zinc (36.36 ppm) than that in gray catfish meat (29.23 ppm). Moreover, zinc supports the immune system's function, growth and development, and fortifies their defenses against attacks by free radicals (Jónsson *et al*., 2007). Beside, sodium value recorded 783.82 and 880.42 ppm in black and gray catfish meat, respectively. Also, sodium and potassium help in regulating osmotic pressure in the body. However as indicated in Table (3), iron content was 170.07 and 178.98 ppm in black and gray catfish, respectively. Iron helps in transporting oxygen, calcium aids in protecting bone health, and iodine plays a role in controlling normal growth mechanisms, as well as physical and mental development (Prashanth *et al*. 2015; Goff 2018; Alagawany *et al*. 2021). Gray catfish content 479.05 ppm of magnesium while it was 424.87 ppm in black catfish. Mg is an active component of several enzyme systems in which thymine pyrophosphate is a cofactor. Oxidative phosphorylation is greatly reduced in the absence of Mg while Mn is a cofactor of hydrolase, decarboxylase, and transferase enzymes (Murray *et al*., 2000). Also, gray catfish meat recorded higher content of Cu (2.69 ppm) compared to black catfish meat (1.63 ppm). Cupper is a constituent of many enzymes, and plays a role in iron absorption (Chandra, 1990). Chromium content was ranged from 0.20 to 0.22 ppm in catfish meat. Finally, Cr deficiencies may exist, particularly in children suffering from protein-calorie malnutrition (Mertz, 1974). Similar results were reported by Ersoy and Özeren (2009); Adelakun *et al*. (2017); Abd-Elfttah (2021); Abiodun *et al*. (2021) and Wijayanti *et al*. (2023) for different prepared catfish fillet.

The variations in mineral values could be as a result of the environmental conditions, feed, ecological requirements, metabolism and other factors such as salinity, water pollution level, and sediment (Ashraf *et al*. 2012). Moreover, the differences in the mineral content could be attributed to the habitat, type of feeding, type of feeding and age (Abd-Elfttah, 2021 and Abiodun *et al*.,2021).

**Table 3. Minerals content of black and gray catfish fillet**

| Minerals | Black catfish | Gray catfish |
|---|---|---|
| **mg /kg (ppm)** | | |
| **Ca** | 1017.21 | 1147.47 |
| **Na** | 783.82 | 880.42 |
| **K** | 4970.09 | 5948.92 |
| **Mg** | 424.87 | 479.05 |
| **Cu** | 1.63 | 2.69 |
| **Fe** | 170.07 | 178.98 |
| **Zn** | 36.36 | 29.23 |
| **P** | 4119.53 | 5265.27 |
| **Se** | 0.20 | 0.00 |
| **Mn** | 0.61 | 2.01 |
| **Cr** | 0.20 | 0.22 |
| **Micro gram/kg** | | |
| **Hg** | <0.1 | <0.1 |
| **Cd** | <0.1 | <0.1 |
| **Pb** | <0.10 | <0.10 |

On the other hand, the heavy metals (Hg, Cd and Pb) were recorded < 0.1 micro gram/kg in black and gray catfish fillet. The European maximum levels of 0.30 mg/kg for Pb and 0.05mg/kg for Cd (FAO, 2003) maximum levels are 0.02 and 0.05; respectively. So, the determined heavy metals in this study were less than this limits in both of catfish colors. This means that the studied catfish fillet is safe for human consumption and cannot impose health hazard to the consumers.

## Amino acid profile of black and gray catfish meat (g/100g protein)

Protein is an important nutrient for growth and development of humans and its quality depends on the types and composition of its amino acids (Oriolowo *et al*., 2020). The amino acid profile of black and gray colors catfish fillet is presented in Table (4). The results indicated that, all the essential amino acids, were presented in the studied catfish fillet proved that its high-quality sources of protein for nutrition. In addition, the meat of African catfish can be classified as protein products. However, there was a slight difference between amino acid compositions of the two studied catfish fillets as indicated in Table (4). The total essential amino acids content ranged from 41.04 to 42.19 g/100g protein. This was similar to 42.5% reported for catfish by Osibona *et al.,* (2009). Also, Abd-Elfttah, (2021) revealed that, total essential amino acids content was 41.81 g/100g protein. On other hand Zaglol and Eltadawy (2009) found that total essential amino acids in crayfish was 55.703%. The ΣEAA in the investigated catfish fillet was higher than in the FAO/WHO standard of (33.9 g/100 g of protein). The, EAAs cannot be produced by the human body, thus they must be obtained directly from food (Schaafsma, 2000). Moreover, lysine and leucine content recorded the highest value among the essential amino acid. lysine is required for tissue growth and repair; helpful for maintaining the nitrogen balance in adults and necessary for growth in children. Leucine is also helpful for the remodeling and synthesis of muscle proteins (Junianto *et al*., 2022).

On other hand, E/NE ratioin black and gray recorded 0.72 to 0.74. This result was lower than 0.82 reported by Ahmad *et al*. (2013) and 0.84 reported by Zaglol, and Eltadawy (2009). In this side Abd-Elfttah (2021) revealed that, E/NE ratio in catfish meat was 0.72. Also, Oriolowo *et al*., (2020) found that the essential to non-essential amino acids ratio was 0.69. Tryptophan recorded 1.08 and 1.09 g/100g protein in black and gray colors catfish fillet: respectively. Tryptophan plays an important biological role in the human body. It takes part in the synthesis of serotonin, which is one of the most important neurotransmitters, which makes.

**Table 4. Amino acid profile of black and gray catfish meat (g/100g protein)**

| Amino acid | Black catfish | Gray catfish |
|---|---|---|
| **Threonine** | 5.06 | 5.08 |
| **Valine** | 5.19 | 5.26 |
| **Methionine** | 2.89 | 2.93 |
| **Isoleucine** | 4.93 | 4.94 |
| **Leucine** | 8.73 | 8.71 |
| **Phenylalanine** | 3.91 | 3.91 |
| **Lysine** | 10.25 | 10.27 |
| **Tryptophan** | 1.08 | 1.09 |
| **Total EAAs** | 41.04 | 42.19 |
| **Histidine** | 2.12 | 2.15 |
| **Arginine** | 5.98 | 5.93 |
| **Aspartic Acid** | 9.85 | 9.88 |
| **Serine** | 3.80 | 3.76 |
| **Glutamic Acid** | 15.89 | 15.91 |
| **Proline** | 3.52 | 3.56 |
| **Alanine** | 6.79 | 6.82 |
| **Cysteine** | 0.75 | 0.75 |
| **Tyrosine** | 3.42 | 3.19 |
| **Glycine** | 5.03 | 5.43 |
| **Total N EAAs** | 57.15 | 57.28 |
| **Total amino acid** | 99 .19 | 99.47 |
| **EAA/ N EA** | 0.72 | 0.74 |

EAA/ N EA= Essential amino acids (EAAs) to Non-essential amino acids (N-EAAs) ratio

It extremely necessary to enter the body in depression, insomnia. Such results are in agreement with that reported by Oriolowo *et al.* (2020) and Abd-Elfttah, (2021) for catfish and Zaglol, and Eltadawy, (2009) for crayfish meat. However, the data given in the Table (4) show that the obtained results of black and gray color catfish fillet indicated that, the N-EAAs presented the highest concentration were glutamic ranging from 15.89 to 15.91, respectively. Glutamic acid turns in the body into glutamate that helps nerve cells in the brain send and receive information from other cells. Similar result was reported by Adeyeye (2009); Oriolowo *et al.* (2020) and Abd-Elfttah (2021) for catfish meat.

**Fatty acid profile of black and gray catfish meat**

The fatty acids profile of total lipids of the studied black and gray colors catfish are presented in Table (5). The date revealed that, the total saturated fatty acids of catfish meat was ranged from 29.11 to 29.94% of fatty acids. The dominant saturated fatty acid in catfish fillet was palmitic acid (C16:0) which recorded 22.88-21. 03% while, the total unsaturated fatty acids content was ranged from 69.24 to71.82% of fatty acids. Oleic fatty acid (C18:1) was the dominant unsaturated fatty acid which recoded 35.78-35.89% of total fatty acids content. Moreover, oleic fatty acid constituted more than a third of total fatty acids of catfish meat. Oleic acid is the most important constitute of plasma free fatty acids and could be reported as an anti- inflammatory fatty acid plying a role in the activation of different pathway of immune competent cells (Carrillo *et al.,* 2012).

As indicated in Table (5), linoleic (18:2) comes in the second order of unsaturated fatty acids content of catfish meat and recorded 19.11 to19.37% followed by linolenic acid (18:3) with 2.95 to 3.08% of total fatty acids content. However, unsaturated fatty acids, which the body is unable to produce, are essential to human metabolism. They are precursors of a class of hormones known as prostaglandins, which are crucial for both the appropriate healing of inflammatory processes and muscular contractions (Coultae, 1989). Generally fat of catfish meat contains a considerable amount of omega-3 and omega-6 fatty acids, which are crucial for a child's brain development and for lowering blood pressure to prevent stroke (Junianto *et al*., 2022).

As recommended by WHO (2003) the minimum PUFA/SFA ratio could be 0.4 – 0.5 in foods, this ratio in catfish meat was ranged from 0.89-0.99 which indicated that catfish meat is high quality in this concern. Regarding to catfish color, the gray catfish meat continent a high quantity of unsaturated fatty acid compared to the black one.

However, the slight differences may be due to different factors, such as breed, sex, age, diet, geographical location, environment, may all influence the fatty acid composition (Fernández-López *et al*., 2006).The obtained results for fatty acid composition are the same line with that reported by Ljubojevi´c *et al*. (2013); Yu *et al*. (2017) for wels catfish *(Silurus glanis)*, Chauke *et a*l. (2008); Abd-Elfttah (2021); Hamad (2021) and Sobczak *et al*. (2022 ) for raw catfish *gariepinus* and catfish *heteroclarias* .

**Table 5. Fatty acid profile black and gray catfish meat (as % of total fatty acids)**

| Fatty acid | Carbon chain | Black catfish | Gray catfish | Recommended minimum ratio (WHO,2003) |
|---|---|---|---|---|
| **Myristic acid** | C14:0 | 0.79 | 0.75 | |
| **Tetradecenoic** | C14:1 | 0.13 | 0.11 | |
| **Pentadecanoic** | C15:0 | 0.17 | 0.17 | |
| **Palmitic acid** | C16:0 | 22.88 | 21. 03 | |
| **Palmitoleic** | C16:1 | 6.09 | 6.07 | |
| **Heptadecanoic acid** | C17:0 | 0.16 | 0.23 | |
| **Cis-10- Heprodecenoic** | C17:1 | 0.24 | 0.26 | |
| **Stearic** | C18:0 | 5.75 | 5.63 | |
| **Oleic acid** | C18:1 | 35.78 | 35.89 | |
| **Linoleic acid** | C18:2 | 19.11 | 19.37 | |
| **γ- Linolenic acid** | C18:3n6 | 1.95 | 1.97 | |
| **Linolenic acid** | C18:3n3 | 1.00 | 1.11 | |
| **Stearidonic acid** | C18:4 | 0.26 | 0.28 | |
| **Archidic acid** | C20:0 | 0.19 | 0.21 | |
| **Cis-11- Eicosenoic acid** | C20:1 | 0.34 | 0.40 | |
| **Eicosadienoic acid** | C20:2 | 0.25 | 0.27 | |
| **Eicosatienoic acid** | C20:3n6 | 0.51 | 0.59 | |
| | C20:3n3 | 0.77 | 1.1 | |
| **Eicosapentaenoic acid (EPA)** | C20:5 | 1.14 | 1.29 | |
| **Behenic** | C22:0 | 0.25 | 0.24 | |
| **Docosatetraenoic acid** | C22:4 | 0.57 | 0.63 | |
| **Cludandonic acid (DPA)** | C22:5 | 0.44 | 0.49 | |
| **Docosahexaenoic acid (DHA)** | C22:6n3 | 0.80 | 1.71 | |
| **Lignoceric acid** | C24:0 | 0.14 | 0.13 | |
| **Non identified fatty acid** | | 0.38 | 0.42 | |
| **Total fatty acid** | | 99.71 | 99.93 | |
| **SFA** | | 29.94 | 29.11 | |
| **USFA** | | 69.24 | 71.82 | |
| **MUSFA** | | 42.58 | 42.73 | |
| **PUSFA** | | 26.63 | 28.91 | |
| **PUFA/SFA ratio** | | 0.89 | 0.99 | 0.4 – 0.5 |

SFA= saturated fatty acids, USFA= unsaturated fatty acids, MUSFA= mono unsaturated fatty acids, PUSFA= Poly unsaturated fatty acids, PUFA/SFA= Poly unsaturated fatty acids: saturated fatty acids,

## Physicochemical properties of black and gray catfish fillet

Some physicochemical properties of black and gray catfish fillet are presented in Table (6). Black catfish meat recorded significantly ($p \leq 0.05\%$) higher values of pH and TBA contents compared with gray color catfish meat, while the later was significantly ($p \leq 0.05\%$) higher of WHC and there were no significant of total volatile bases nitrogen ($p \leq 0.05\%$) of total volatile bases nitrogen TVB-N and trimethylamine (TMA) contents between the two studied catfish meats. However, pH of catfish meat ranged from 6.50 to 6.54. Generally, the pH value of meat is considered the main quality indicator through processing technologies and storage. (Cawthorn *et al*., 2018). Since the pH value is not enough index used alone to determine the quality of fish, it can be used as a guideline to control the quality of fish when joined with other quality parameters (Ozogul *et al*., 2011). Similar results were reported by Mahboob *et al*. (2019); Abd-Elfttah (2021) and (Mahmoud *et al*. (2021) for catfish fillet. The obtained results indicated that WHC of gray catfish meat was 71.18% while it was only 70.81% in black catfish meat and that may be due to the relatively high content of protein as indicated in Table (2). However, measuring the ability of the muscle to hold water is one of many ways to describe quality of fish. This is an extensive characteristic for many reasons: From the point of economical view, weight reduction due to water loss is of very importance (Olsson *et al*., 2003), The accumulation of discharge is unattractive to consumers and loss of water is negatively affected the muscle texture (Abd El-latif, 2021). The obtained results agreement comparatively with that of Paleckaitis *et al.* (2018); Abd-Elfttah (2021) and Mahmoud *et al.* (2021) for catfish fillet. According to data in Table (6), the TBA value in both black and gray catfish fillet was 0.85 mg malonaldehyde / kg, while it was 0.80 mg malonaldehyde / kg gray color catfish fillet and that reflect the relatively high fat content in black catfish meat. Moreover, the maximum TBA value, in good quality fish, is 5 mg (MDA/ kg) as reported by Ozogul *et al*. (2011). Besides Gahruie *et al*. (2017) mentioned that fresh catfish contain 3-5 mg MDA/ kg sample) but if the values increased to 5-8 mg (MDA/ kg sample) it limits the product acceptability.

As indicated in Table (6) TVB-N contents was ranged from 7. 91to 7.93 mg/100g sample while TMA was ranged from 2.01 to 2.02 mg/100g. Moreover, the concentration of TVB-N in freshly caught fish is normally between 5 and 20 mg/100g, while 30-35 mg/100g of flesh is generally considered to be the maximum level of acceptability for cold water fish reported by Muhammet and Sevim (2007).

**Table 6. Physicochemical properties of black and gray catfish fillet**

| Parameters | Black catfish | Gray catfish |
|---|---|---|
| **pH value** | 6.54±0.0.03 [a] | 6.50±0.020 [b] |
| **WHC (%)** | 70. 81±0.810 [b] | 71.18±0.080 [a] |
| **TBA mg MDA/ kg** | 0.85±0.020 [a] | 0.80±0.070 [b] |
| **TVB-Nmg/100g** | 7. 93±0.445 [a] | 7.91±0.360 [ab] |
| **TMAN mg/100g** | 2. 02±0.100 [a] | 2. 01±0.050 [a] |

Different letters in the same row means significantly difference (p<0.05)

Moreover, the acceptability recommended limit (35mg/ 100g of fish flesh) for fish as defined by EOS (2005). While the acceptability recommended rate for TMA values in fish are 10-15 mg/100g of fish as suggested by Lakshmanan (2000). According to the (EOS, 1991), 30 mg/100g sample is the allowed upper limit of TVB-N and 10 mg/100g sample is the allowed upper limit of TMA. The above mentioned results are in agreement with those obtained by Hamad, (2021), who reported that TVBN and TMAN in raw catfish fillets (*Clarias gariepinus)* were 13.40 and 1.02 mg/100g and (Mahmoud *et al*. (2021) showed that, frozen catfish fillet during the storage period up to 12 months, the TVB-N value increase from 22.02 to 24.27 mg/100g. Moreover, Mohamed (2016) showed that, the total volatile basis nitrogen (TVB.N) and trimethylamine (TMA) value for fresh Catfish were 6.55 and 3.696 mg/100g; respectively. Abd-Elfttah, (2021) found that, the TVB-N in catfish meat was 5.97± 0.58 mg/100g.

## Color values (L*, a*, and b*) of black and gray colors catfish fillet

The first thing that catches the consumer's attention in seafood is its color, thus color has an inevitable effect on the food products' acceptability and marketability (Li *et al.* ,2013). Pigmentation is highly valued in some fish, such as salmon and trout, and ornamental fish, while in others, such as channel catfish, *Ictalurus punctatus*, it is highly undesirable (Li *et al*., 2007).

Date in Table (7) indicates the color values (L, a*, and b*) of black and gray catfish fillet. Gray catfish fillet was significantly higher than black catfish in L* value (lightness), which recorded 52.99 and 51.61, respectively. Whereas the obtained result of a* value (redness) of black catfish revealed that it was more redness compared with gray catfish fillet (21.05 and 19.40; respectively). On other hand, b* values (yellowness) recorded 17.04 in gray color catfish and 18.92 in black color catfish. From such results, gray catfish meat seemed to be lighter than the meat of black color catfish. These results agree with Sobczak *et al*. (2022) showed that, (L*) and (WI), as well as lower a* and b* parameters mentioned in the fillets of *heteroclarias* compered than *C. gariepinus*.

**Table 7. color values (L*, a*, and b*) of black and gray catfish fillet**

| Parameters | L* | a* | b* |
|---|---|---|---|
| **Black catfish** | 51.61±0.815 $^{b}$ | 21.05 ±0.767 $^{a}$ | 18.92±0.692 $^{a}$ |
| **Gray catfish** | 52.99±0.605 $^{a}$ | 19.40±0.423 $^{b}$ | 17.04±0.416 $^{b}$ |

Different letters in the same row means significantly difference ($p<0.05$)

## Microbial evaluation of black and gray catfish fillet

Microbial activity is generally responsible for the deterioration of fish, total bacterial count is used as an acceptability index for fish fillets and its products due to the impact of bacteria on fish spoilage (Mahmoud *et al*., 2021).

The mean values of the total bacterial count (TPC) and yeast and mould counts (YMC) per g of catfish fillet are presented in Table (8). The total plate count recorded 4.60 log cfu/g in black catfish fillet which it higher than that of the gray catfish fillet (4.47 log cfu/ g). The results come in agreement with International Commission on Microbiological Specification for Foods (ICMSF, 1986) and stated that the maximum recommended bacterial counts for good quality product is $5 \times 10^5$ (5.7 log10 cfu/g). Moreover, the maximum limit of 6 (log CFU/g) is acceptable in fresh fish as reported by Zhu *et al*. (2015). As shown in Table (8), yeast and moulds recorded 2.17and 2.08log cfu/g, respectively in black catfish fillet which it higher than that of the gray catfish fillet recorded 2.08 and 1.82log cfu/g. Mostafa *et al.* (2023) showed that, the raw *Pangasius* fish fillets and Indian mackerel had total plate bacterial counts (TPC) of $3.8x10^4$ and $2.5x10^3$ CFU/ g; respectively. While yeast and mold counts were $6.2x10^2$ and $0.97x10^2$ CFU/g;

respectively. On other hand these results of total bacterial counts are less than the Egyptian standard (ESO, 2005) acceptable limit of fish (105 CFU/g).

**Table 8. Microbial evaluation as log cfu/g of black and gray catfish fillet**

| Parameters | TPC | YMC | |
|---|---|---|---|
| | | Yeast | Mould |
| **Black catfish** | 4.60±0.05 [a] | 2.17±0.06 [a] | 1.95±0.02 [a] |
| **Gray catfish** | 4.47 ±0.08 [b] | 2.08±0. 03[b] | 1.82±0.05 [b] |

Different letters in the same row means significantly difference (p<0.05), TPC =Total plate count, YMC= yeast and mold counts

## Sensory evaluation of the black and gray fillet

The sensory characteristics of food items are the main keys for consumer's acceptance, fish and fish products are unique food items especially concerning color, odor and texture properties (Mahmoud *et al*., 2022). According to the means given by the panelists of grilled samples, sensory scores for studied parameters (Table,9) such as taste, flavor, color, texture and overall acceptability revealed that, there were significant differences observed (p>0.05) amongst the catfish fillet for all the studied parameters. However, the panelists relatively preferred the meat of gray catfish fillet. Besides, the scores of panelists for tested parameters were relatively low. So, catfish meat may be needing some pre-treatments to improve its consumers acceptability. This result was in the same line with Sobczak *et al.* (2022), they showed that, the sensory assessment of, *heteroclarias* meat received better notes than *C. gariepinus.*

**Table 9. Sensory evaluation of the black and gray catfish fillet**

| Sample Parameter | Black catfish | Gray catfish |
|---|---|---|
| **Color** | 6.85±0.150 [b] | 7.71±0.31 [a] |
| **Odor** | 6.46±0.411 [b] | 7.80±0.537 [a] |
| **Taste** | 6.29±0.296 [b] | 7.50±0.408 [a] |
| **Texture** | 7.10±0.409[b] | 7.45±0.471[a] |
| **Overall acceptability** | 6.58±0.632 [b] | 7.50±0.437 [a] |

Different letters in the same row means significantly difference (p<0.05)

## Conclusion

From the obtained results, it could be concluded that catfish meat had high nutritional values, good safety quality in the two studied colors catfish, but may be need pre-treatments to improve its sensory quality.

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# خصائص جودة اللحم وعلاقتها بلون القرموط الأفريقي

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الملخص

تم دراســـة الجودة التغذوية (محتوى الرطوبة، البروتين، الدهن، الرماد، الكربوهيدرات، العناصـــر المعدنية، محتوى الأحماض الأمينية، تركيب الأحماض الدهنية) والجودة الصـــحية (محتوى بعض العناصر الثقيلة والمحتوى الميكروبي) بالإضافة إلى الجودة الحسية للحم القرموط المتحصـــل علية من القرموط ذو اللون الرمادى والقروط ذو اللون الأســـود. شـــكل الجزء القابل للأكل (الفيليه) 48.15، 47.41 ٪ من إجمالي وزن الجسم في سمك القرموط الأسود والرمادي على التوالي. وقد احتوي لحم ســـمك القرموط الأســـود والرمادي على 74.62 76.00 %من بروتين، 21.17، 19.81%من دهن خام (على أساس الوزن الجاف)، في سمك القرموط الأسود والرمادي على التوالي. كما تبين أن لحم القرموط الرمادي يحتوي على نســـب أعلى من البوتاســـيوم، الفوسفور، الكالسيوم، والصوديوم، والمغنيسيوم والحديد مقارنة بمحتواها المعدني في لحم القرموط ذو اللون الأســـود، في حين كان الأخير يحتوي على تركيزات أعلى من الزنك، الســـيلينيوم والمنغنيز. وتراوحت نســـبة الأحماض الأمينية الأســـاســـية (EAAs) إلى الأحماض الأمينية غير الأســـاســـية (N-EAAs) من 0.72 إلى 0.74، بينما تراوحت نســـبة الأحماض الدهنية عديدة عدم التشبع الى الأحماض الدهنية المشبعة (PUFA / SFA) من 0.89 إلى 0.93 في لحم سمك القرموط تحت الدراســـة. ومن أوضـحت النتائج المتحصـــل عليها تبين أن لحم كلا النوعين من القراميط ذو خصـائص جودة تغذوية وصـحية عالية لكليهما. وفيما يتعلق بالجودة الحسـية (لون اللحم، الرائحة، الطعم، ودرجة التقبل العام) فإن لحم القرموط يحتاج الى بعض المعاملات المبدئية لتحسـين الجودة الحسية سواء للحم القرموط ذو اللون الرمادى أو الأسود.