Bioresearch Communications
Volume 05, Issue 01, January 2019
Journal Homepage: www.bioresearchcommunications.com

Original Article

Comparative evaluation of the nutritional quality of male versus female freshwater Mud Eel, *Monopterus cuchia*

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ABSTRACT: The nutritional quality in muscle, focusing on the proximate, amino acids, fatty acids and minerals compositions of *Monopterus cuchia* were analyzed, depending on the sex. No significant differences were observed in proximate compositions between male and female fish. The predominant amino acids were glutamic acid, aspartic acid, lysine, leucine and arginine in both muscles of both sexes and only glutamic acid showed the significant sexual dependency. The ratio of essential and non-essential amino acids was similar (0.67) in both sexes. For fatty acids, the female had the higher percentage of total MUFAs and PUFAs than the male counterpart. The heptadecanoic acid, pentadecanoic acid and palmitic acid were the primary SFAs, which varied significantly between sexes. The most abundant MUFA (i.e. palmitoleic acid) also showed the sexual dependency. No such significant variation was found in eicosapentaenoic acid (dominated fatty acid of PUFAs group) content. Minerals were found in order of K>Na>Ca>Mg> Mn>Zn, with Na/K ratio of 0.20 in male and 0.21 in female. Based on the nutritive values , *M. cuchia* can be considered as a nutritionally enriched food item for the human diet.

Keywords: Proximate composition, amino acids,fatty acids, minerals, ω-3/ω-6 ratio, *Monopterus cuchia*

Article History
Received: 22 August 2018
Accepted: 25 November 2018

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Citation: Md Hasan Faruque, Rabiullah Bhuiyan , Kaniz Fatema Md. Rakibul Hasan ; Comparative evaluation of the nutritional Biores Comm. V5-(1) 627-636.

INTRODUCTION

Fish muscle is considered as an important source of protein for human consumptions (Stansby 1962)[1]. However, the related information about the chemical composition of fish is also essential to ensure that they meet the requirement of human diet (Kindong et al. 2017)[2]. The quality of fish protein is evaluated by the amino acid score, which provides many biologically important substances including nucleotides, peptide hormones, and neurotransmitters (Iqbal et al. 2006)[3]. Amino acids show crucial roles in metabolism, nutritional transportation, cell signaling, regulators of gene expression and protein phosphorylation cascade (Wu 2010; Wang et al. 2013)[4, 5]. Moreover, amino acids like glycine, glutamic acid and aspartic acid have proven their importance in the human diet to speed up wound healing process and must be supplemented externally in the diet as food or by any other means as they can not be synthesized by the human body (Zuraini et al. 2006; Andersen et al. 2016)[6, 7].

Fish is also a well known source of essential fatty acids such as polyunsaturated fatty acids (PUFAs), which are very useful to control prostaglandin

amalgamation (Kryzhanovskii and Vititnova 2009; Zhang et al. 2010)[8, 9]. Essential unsaturated fatty acids provide many preventive and remedial impacts on human disease such as cardiovascular diseases, cancers, inflammation, neurodevelopment in infants, fat glycemic regulate and aggravation (Limbourn and Nichols 2009)[10]. In addition, fatty acids, more specifically the ω-3fatty acids are related to the synthesis of leukotrienes, thromboxanes, and eicosanoids (Inhamuns and Franco 2008)[11]. They cannot be synthesized in the human body and required for the diet (Sushchik et al. 2007)[12]. Considering the numerous health benefits of fish, American Heart Association suggests consumption of any type of fish at least twice a week for the general population (Kris-Etherton et al. 2002)[13]. Though the chemical compositions of fish make the positive effect on the human health, they fluctuate throughout the year due to the availability of food, environmental changes, habitat, seasons, species, and geographic locations (Orban et al. 2003; Rasoarahona et al. 2005)[14, 15].

The primary source of animal protein in Bangladesh is fish, as it provides 60% share to animal protein intake. The country's open water habitats are blessed by the variety of fish species, comprising 260 freshwater and 475 marine water fishes (DoF 2017)[16]. Among those species, freshwater mud eel (*Monopterus cuchia)* locally known as Kuchia or Kuicha under the family Synbranchidae, is one of the most economically viable species that contributes 5% to the annual foreign earning in the export fishery. Due to its high potential in international trade, Bangladesh exports live Kuchia to more than fifteen countries including China, Thailand, Japan, Malaysia, South Korea, Taiwan, Hong Kong and Singapore and earns 25.37 million USD annually (Hasan et al. 2012; DoF 2017)[16, 17]. Generally, this species available all over the country, lives in mud-holes, boro-paddy field, floodplains, swamps, canals, haors, and baors, especially in Bagerhat, Mymensingh, Khulna, Sylhet and Tangail region of Bangladesh. Besides, *M. cuchia* is also occurring in the freshwater of Pakistan, Myanmar, Nepal and throughout India (Siddiqui et al. 2007)[18]. Although *M. cuchia* is highly accepted by the global community as an excellent supplement for the nutrient in the human diet, there is a lack of research that addresses the nutritive values of this species (Dutta and Dutta 2014)[19]. Even though it is proven that nutritional quality of fish flesh differs within the same species depending on its sex (Nair and Gopakumar 1981; Norambuena et al. 2012; Petricorena 2014)[20, 21, 22], but to the best of author's knowledge, no study has ever investigated to evaluate the nutritional compositions of *M. cuchia* in Bangladesh and elsewhere. Therefore, based on the above mentioned research gap, the objective of this study was to assess the nutritional quality concerning proximate compositions, amino acids, fatty acids, and mineral contents of male versus female Kuchia. It is expectedthat this study will provide the fundamental information concerning the nutritional values of *M. cuchia* to its consumers and to the nutritionist working on diet table.

MATERIALS AND METHODS

Sample collection and measurements

Mature *M. cuchia* (Hamilton, 1822) were collected from Chitalmari upazila (22.7807°N and 89.87390°E) under the Bagerhat district of Bangladesh in the September 2017. The mean water temperature of the Kuchia collection site was 37.00 ± 0.56°C with the dissolved oxygen content of 6.30 ± 0.98 mg/L. The pH and transparency were 7.50 ± 0.13 and 55.50 ± 0.10 cm, respectively. Instantly after collection, fishes were kept alive and transported to the laboratory, where the biometric measurements (wet weight and length) of each of these fish were carried out. Sex (male and female) of the collected fish samples were identified according to Miah et al.(2013)[23]. Finally, one hundred (male=50, female=50) fish were used to assess their nutritional value. The mean (±Standard Deviation) total length and weight of the sampled male fish were 53.00±5.21 cm and 185.85±42.86 g. Mean length and weight of the female fish used in this analysis were 51.22±7.07 cm and 153.13±46.35 g (Table 1).

Table1. Biometric data of male and female *M. cuchia.* Data are expressed as mean ± Standard Deviation.

	Male (n=50)	Female (n=50)
Total Length (cm)		
Mean	53.00 ± 5.21	51.22 ± 7.07
Maximum	67.80	64.60
Minimum	43.00	33.00
Weight (g)		
Mean	185.85± 42.86	153.13± 46.35
Maximum	289.79	260.26
Minimum	92.64	79.80

Sample preparation

After the measurements of length-weight, fishes were beheaded, gutted and finally, edible portions (muscle tissue) were collected for analysis. Afterward, the fish muscles were kept in sterilized plastic bags and stored in the deep freezer at -18°C for 5 days before analysis. For proximate compositions, amino acids, fatty acids and minerals analyze, fish muscles from all fish samples were homogenized to make a pooled sample and final analysis was done from the homogenized pooled sample with six replicates of each of the sex.

Determination of proximate composition

The total moisture and ash content were analyzed by the method of the Association of Official Analytical Chemists (AOAC 2000)[24]. Total nitrogen (N) contents of fish muscle samples were determined by using of Micro-Kjeldhal technique. The crude protein contents were determined by multiplying obtained nitrogen content by 6.25.Total crude lipid from fish muscle tissues was determined with chloroform: methanol (2:1) extraction method.

Amino acids determination

Amino acid determinations were carried out in the Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh. The analysis of amino acids in fish sample was done by High Performance Lipid Chromatography (HPLC) in an amino acid analyzer (SKYAM s4300, Germany). In details, 0.20 g of prepared fish muscle was hydrolyzed with 25 mL of 7N HCl at 120˚ C for 22-24 hours under a nitrogen atmosphere. HCl was neutralized with 7.5N NaOH and the solution was prepared up to 250ml volume with sample dilution buffer (pH 3.4), and the solution was filtered by 0.45 mm membrane filter prior to analysis. Afterward, 100 uL of sample was taken in a vial and added 900 uL sample dilution buffer (pH 3.4) to made to volume of 1 mL. Standard amino acids were analyzed simultaneously and each of the amino acid in the unknown sample was identified based on the retention time and peak area of the standard amino acids. Tryptophan was not estimated in this study as it is destroyed upon acid hydrolysis. In addition, sulfur containing amino acids (methionine and cysteine) were not detected as the sample was not oxidized with performic acid followed by hydrolysis. The amounts of each amino acid were given as g per 100 g protein.

Fatty acids determination

The fatty acids profiling was done following gas chromatographic (GC) method proposed by Chowdhury et al. (2003)[25]. Samples were methylated into fatty acid methyl ester (FAME) using HCl and methanol mixture. The FAME was separated using the mixture of hexane and anhydrous diethyl ether. NaOH was used as a base wash and the upper organic layer was separated. Two µl of sample was injected and analyzed with the capillary column (30 × 0.25mm; film thickness: 0.25 µm) and flame ionization detector. Standard fatty acids were analyzed simultaneously. Every fatty acid within the unknown pattern turned into diagnosed based on the retention time and peak area of the standard fatty acids.The chromatogram was used for the calculation (%) of fatty acids present in the analyzed sample.

Minerals determination

Among 8 minerals, Calcium (Ca), Copper (Cu), Iron (Fe), Magnesium (Mg), Manganese (Mn) and Zinc (Zn) were analyzed by using Atomic Absorption Spectrometer (Model No.: AA-7000, Shimadzu). The instrument was calibrated with chemical standard solutions prepared from commercially available chemicals and all reagents were used for the preparation of samples were of analytical grade and deionized water was used throughout the study. The Phosphorus (P) in the sample was measured with ultraviolet visible spectrophotometry (UV/VIS). The Potassium (K) in the sample was measured with the flame photometer.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) v. 20.0 software package (SPSS, SAS Institute Inc. Gary, USA) and Microsoft Excel 2016 MSO windows program were used for statistical analysis. The data were analyzed to determine the descriptive statistics such as mean, maximum and minimum value, standard deviation (SD) and standard error of mean (SEM). The obtained data were subjected to student t-test at 5% level of significance to compare the means between male and female *M. cuchia*.

RESULTS AND DISCUSSION

Proximate composition

The proximate compositions of *Monopterus cuchia* are shown in Table 2.

Table 2. Proximate composition of male and female *M. cuchia*. Data are expressed as mean±standard error of mean (SEM). Mean values followed by the same letter indicate no significant difference (P> 0.05).

Proximate compositions	Male	Female
Moisture	81.25± 0.81[a]	80.71 ± 0.66[a]
Ash	1.02 ± 0.12[a]	0.98 ± 0.10[a]
Crude protein	16.42± 0.48[a]	16.80 ± 0.30[a]
Lipid	0.83 ± 0.14[a]	0.71 ± 0.11[a]

It was found that mean moisture contents (mean±SEM)in muscles of male and female Kuchia were 81.25±0.81% and 80.71±0.66%, respectively. The amount of ash was 1.02±0.12 in male and 0.98±0.10% in female. The crude protein content was found to be higher in female (16.80±0.30) than male (16.42±0.48). In contrast, males had a higher proportion of lipid. The proportion of total moisture and ash followed the same trends as protein content. Data also showed that no significant differences (P>0.05) existed between two sexes in terms of principal constituents.

The proximate composition of fish varies impressively within and between species, size, sex, physiological condition and environmental changes (Boran and Karacam 2011)[26]. Bogard et al. (2015) reported that in fish (inland captured, n=34) moisture content varied from 60.20-85.40% with an average 76.89%[27]. The average amount of moisture content in *Anabas*

testudineus throughout the year was 79.11% in male and 78.99% in female (Nargis 2006)[28]. The moisture content of this study is in agreements with the results of moisture composition for *Salmo truttamacrostigma* (Ateş et al. 2013)[29]. Similarly, Nargis (2006) did not show any significant variation in mean values for moisture, ash, protein, and lipid between two tow sexes of Anabas *testudineus*. Additionally, Nargis (2006) recorded the higher protein content in female than male fish[28]. The results of this study for ash content are in parallel with the findings of Kacem et al. (2011)[30].

The range of protein value in fish muscle is between 15-20 percent (Murray and Burt 2001)[31]. Fish is considered as high protein sources when its protein value is higher than 15% (Stansby 1962)[1]. Therefore, *M. cuchia* can be considered as high protein fish since it contains higher than 15% protein in muscles, regardless of sex.

Chandrashekar and Deosthale (1993) indicated that lipid content showed a wide variation between fish species and the range was 0.65-1.3%, which is well corroborated with the present finding for lipid content[32]. However, Özogul et al. (2009) and Bogard et al. (2015) found the higher concentration of lipid for painted eel (4.42%) and barred spiny eel (2.6%), respectively[27, 33]. This could be explained by the fact that, lipid content of fish differs greatly between species and geographical location (Zenebe et al.1998)[34].

Amino acids profile

The profiles of amino acids obtained from the muscle of *M. cuchia* are presented in Table 3.

Table 3. Amino acid profile (g/100g) of male and female *M. cuchia.* Data are expressed as mean ± Standard Error of Mean. Different letters within a row denote significant differences ($P< 0.05$) and the same letter denotes no significant differences ($P> 0.05$).

Amino Acids	Male	Female
Essential Amino Acids (EAAs)		
Threonine	3.74 ± 0.03[a]	3.67 ± 0.04[a]
Valine	4.38 ± 0.02[a]	4.45 ± 0.04[a]
Isoleucine	4.75 ± 0.04[a]	4.69 ± 0.03[a]
Leucine	7.77 ± 0.12[a]	7.71 ± 0.05[a]
Lysine	7.88 ± 0.07[a]	7.90 ± 0.18[a]
Phenylalanine	3.44 ± 0.10[a]	3.46 ± 0.27[a]
Non-essential Amino Acids (NEAAs)		
Aspartic acid	8.31 ± 0.07[a]	8.27 ± 0.12[a]
Serine	2.87 ± 0.05[a]	2.85 ± 0.04[a]
Glutamic acid	14.05 ± 0.09[a]	14.27 ± 0.13[b]
Glycine	3.93 ± 0.10[a]	3.95 ± 0.10[a]
Alanine	4.66 ± 0.05[a]	4.60 ± 0.10[a]
Histidine	2.01 ± 0.07[a]	1.94 ± 0.07[a]
Tyrosine	3.20 ± 0.15[a]	3.05 ± 0.09[a]
Arginine	4.98 ± 0.08[a]	5.08 ± 0.08[a]
Proline	3.54 ± 0.08[a]	3.60 ± 0.05[a]
EAAs/NEAAs	0.67	0.67

Among the fifteen detected amino acids, six amino acids (threonine, valine, isoleucine, leucine, lysine, and phenylalanine) were essential amino acids and nine amino acids (aspartic acid, serine, glutamic acid, glycine, alanine, histidine, tyrosine, arginine, and proline) were non-essential amino acids (Li et al. 2016)[35]. Irrespective of sex, the predominant amino acids in the muscle of Kuchia was glutamic acid (14.05±0.09g/100g in male, 14.27±0.13g/100g in female) followed by aspartic acid, lysine and leucine.According to Gam et al. (2005) and Zuraini et al. (2006), glutamic acid, aspartic acid, lysine, arginine and glycine were the most dominant amino acids in freshwater fishes[6, 36].

The content of alanine, aspartic acid, histidine, isoleucine, leucine, serine, threonineand tyrosine were at higher level in male Kuchia. In contrast, the content of arginine, glutamic acid, glycine, lysine, phenylalanine, proline andvaline were found to be higher in female than in male. Barrento et al. (2010) found that male crabs had usually higher concentration of several amino acids than females like histidine, lysine, tyrosine and arginine[37]. They also found that, in the female the most abundant EAAs (Essential Amino Acids) were leucine, lysine and methionine. The present findings also revealed the high amounts of aspartate, tyrosine and, histidine in male and lysine, arginine, proline in the female.

Of 15 amino acids, only glutamic acid content showed the sexual dependency ($P< 0.05$). The ratio of EAAs/NEAAs (Non-essential Amino Acids) was observed 0.67 in the muscles of both male and female Kuchia. The ratio of essential and nonessential amino acids (EAAs/NEAAs) was found to be on an average 0.73 (range varied from 0.67-82) for 14 fish reported by Iwasaki and Harada (1985)[38]. Similarly, the EAAs/NEAAs ratio was determined as 0.70 for Monkfish (*Lophius piscatorim*), 0.71 for Atlantic cod (*Gadusmorhua*) and Scup (*Stenotomous chrysops*) and 0.72 for Atlantic whiting (*Merluccius bilinearis*) by Jhaveri et al. (1984)[39]. It is evident from the data (EAAs/NEAAs ratio of 0.67 both in male and female fish) obtained that *M. cuchia*, in general, is well balanced with respect to the essential and non-essential amino acids ratio, irrespective of sex, may be considered as a valuable food source in the human diet because of having high quality protein. According to McLarney et al. (1996) the daily requirement of amino acid (g/100 g protein) are as follows; histidine: 1.9, 1.9, 1.6; isoleucine: 2.8, 2.8, 1.8, leucine: 6.6, 4.4, 1.9; lysine: 5.8, 4.4, 1.6; phenylalanine + tyrosine: 6.3, 2.2, 1.9; threonine: 3.4, 2.8, 0.9 and valine: 3.5, 2.5, 1.3 for 2–5 years old children, 10–12 years old young, and mature adults, respectively[40]. Based on the present data, the daily intake (g/day) of *M. cuchia* that can met up the recommended values are as follows; histidine (male): 94.42, 94.42, 79.51; histidine (female): 98.13, 98.13, 82.63; isoleucine (male): 58.90, 58.90, 37.86; isoleucine (female): 59.68, 59.68, 38.37; leucine (male): 84.99, 56.66, 24.47; leucine (female): 85.56, 57.04, 24.63; lysine (male): 73.58, 55.82, 20.30; lysine (female): 73.39, 55.67, 20.25; phenylalanine + tyrosine (male): 77.82, 27.18, 23.47; phenylalanine + tyrosine (female): 78.13, 27.29, 23.56; threonine (male): 90.93, 74.88, 24.07; threonine (female): 92.60, 76.26, 24.51 and valine (male): 79.93, 57.09, 29.69; valine (female): 78.70, 56.22, 29.23 for 2–5 years old children, 10–12 years old young, and mature adults, respectively.

Fatty acids profile

The fatty acid concentrations detected by GC analyses are shown in table 4.

Table 4. Fatty acids profile (%) of male and female *M. cuchia*. Data expressed as mean ± SEM. Ratio of each group (SFAs, MUFAs and PUFAs) of fatty acids in % was calculated as 100% from the total fatty acids determined. Mean values in the same row having the different superscript are significantly different ($P< 0.05$).

Fatty acids	Male	Female
Saturated Fatty Acids (SFAs)		
Caproic acid (C6:0)	0.93 ± 0.06[a]	1.10 ± 0.08[a]
Caprylic acid (C8:0)	1.51 ± 0.16[a]	1.40 ± 0.12[a]
Myristic acid (14:0)	0.80 ± 0.28[a]	0.46 ± 0.07[a]
Pentadecanoic acid (C15:0)	5.51 ± 0.76[a]	9.64 ± 0.91[b]
Palmitic acid (C16:0)	6.28 ± 0.35[a]	3.61 ± 0.45[b]
Heptadecanoic (C17:0)	28.63 ± 0.85[a]	17.70 ± 0.78[b]
Stearic acid (C18:0)	0.94 ± 0.27[a]	0.81 ± 0.12[a]
Behenic acid (C22:0)	1.41 ± 0.23[a]	0.86 ± 0.23[a]
Σ SFAs	46.01	35.58
Unsaturated Fatty Acids (UFAs)		
Monounsaturated Fatty Acids (MUFAs)		
Myristoleic acid (C14:1)	1.38 ± 0.15[a]	1.93 ± 0.30[a]
Pentadecenoic acid (C15:1)	6.70 ± 0.58[a]	5.54 ± 0.30[a]
Palmitoleic acid (C16:1)	14.18 ± 1.88[a]	18.99 ± 0.52[b]
Heptadecenoic acid (C17:1)	3.50 ± 0.19[a]	4.37 ± 0.30[b]
Oleic acid (18:1)	1.30 ± 0.07[a]	2.65 ± 0.44[b]
Erucic acid (C22:1)	3.08 ± 0.53[a]	1.91 ± 0.46[a]
Σ MUFAs	30.14	35.39
Polyunsaturated Fatty Acids (PUFAs)		
Linoleic acid (C18:2 ω 6)	3.68 ± 0.58[a]	4.23±0.57[a]
Linolenic acid (C18:3 ω 3)	3.72 ± 0.54[a]	4.76 ± 0.16[a]
γ-Linolenic acid (C18:3 ω 6)	1.09 ± 0.17[a]	2.40 ± 0.19[b]
Eicosadienoic acid (C20:2 ω 6)	1.99 ± 0.28[a]	2.22 ± 0.09[a]
Eicosatrienoic acid (C20:3 ω 3)	2.56 ± 0.41[a]	2.25 ± 0.14[a]
Dihomo-γ-linolenic acid (C20:3 ω 6)	1.15± 0.13[a]	1.95 ± 0.26[b]
Arachidonic acid (C20:4 ω 6)	3.19 ± 0.34[a]	2.32 ± 0.17[b]
Eicosapentaenoic acid (C20:5 ω 3)	3.91 ± 0.26[a]	5.61 ± 1.05[a]
Docosadienoic acid (C22:2 ω 6)	1.43 ± 0.19[a]	1.88 ± 0.22[a]
Docosahexaenoic acid (C22:6 ω 3)	1.13 ± 0.19[a]	1.41 ± 0.11[a]
Σ PUFAs	23.85	29.03
EPA + DHA	5.04	7.02
ω 3/ω 6	0.90	0.93

Twenty-four fatty acids were identified in both sexes. The total saturated fatty acids (SFAs) contents of the fish muscles were 46.01% in male and 35.58% in female. The dominant SFA was heptadecanoic acid (C17:0) (28.63±0.85% in male and 17.70±0.78% in females) followed by pentadecanoic acid (C15:0) and palmitic acid (C16:0), these values are varied significantly between sexes.

It has been reported in the literature (Zuraini et al. 2006; Fallah et al. 2013; Cieślik et al. 2018) that fish oil is characterized by high level of palmitic acid (C16:0) and stearic acid (C18:0)[6, 41,42]. However, in this study, heptadecanoic (C17:0) and pentadecanoic acid (C15:0) acids were found to be higher in comparison to above mentioned fatty acids of saturated fatty acid group in *Monopterus cuchia*, which is consistent with the findings of Dutta and Dutta (2014)[19].

For MUFAs, female (35.39%) fish had higher amount than male (30.14%). Palmitoleic acid (C16:1) was the major constituent of MUFAs with the values of 14.18±1.88% in male and 18.99±0.52% in female. Palmitoleic acid (C16:1), heptadecenoic acid (C17:1) and oleic acid (C18:1) of MUFA group showed sexual dependency.

The erucic acid concentration was considerably found to be higher in both male (3.08 g/100g) and female (1.91g/100g) Kuchia than the value reported by Dutta and Dutta (2014)[19]. The concentration of fatty acids can differ based on the catching season (Öksüz and Özyılmaz 2010)[43]. Although the erucic acid has the negative health effect (i.e. myocardial lipidosis and hearth lesions) in animals, but such kind of association between the dietary erucic acid and adverse human health effect is not documented. Considering the adverse health effect in animals induces by erucic acid, Food Standards Australia New Zealand (2003) recommended the value of 500mg as tolerable daily intake (TDI) for the average adult[44]. Therefore, about 17 g flesh of male and 27 g flesh of female Kuchia can exceed the TDI. Moreover, the further study is required to make a concrete conclusion about the erucic acid concentration in *M. cuchia* based on seasonal variation.

Data obtained in our study also indicated that the total polyunsaturated fatty acids (PUFAs) contents of fish muscles were 23.85% in male and 29.03% in female. The most abundant PUFAs was eicosapentaenoic acid (C20:5; ω-3) with the mean value of 3.91±0.26% in male and 5.61±1.05% in female followed by linolenic acid (C18:3) (3.72±0.54% in male and 4.76±0.16% in female) and linoleic acid (C18:2; male=3.68±0.58 and female=4.23±0.57%). Among all PUFAs, the γ-Linolenic acid (C18:3), dihomo-γ-linolenic acid (C20:3) and arachidonic acid (C20:4) varied significant between male and female fish. The values of EPA+ DHA were found to be higher in females (7.02%) than males (5.04%).

The primary group of fatty acid in freshwater carp (*Chanodichthys erythropterus*) is SFA (Kindong et al. 2017)[2]. Dutta and Dutta (2014), documented that the heptadecanoic acid (C17:0) and the palmitoleic acid (C16:1) was the most dominant fatty acid in freshwater mud ee[l9]. Our study also showed the similar results. Akpinar et al. (2009) found that the palmitoleic acid (C16:1) content in brown trout was higher in male than female, while the arachidonic acid (C20:4 ω 6) was higher in male (3.00%) than female (2.34%)[45]. They also reported that oleic acid, arachidonic acid and few others fatty acid significantly varies between two sexes. These results are well coincided with our present investigation.

The ratio of ω-3and ω-6 fatty acids were to be calculated as 0.90 in male and 0.93 in female *M. cuchia*.The ω-3/ω-6 ratio is considered as a suitable index to compare the nutritional value of fish oils (Guler 2007)[46]. The ω-3/ω-6 ratio in our present study was notably lower (0.90 in male and 0.93 in female) than the value documented by Akpinar et al. (2009) for male (2.59 ± 0.37) and female (2.26 ± 0.22) *Salmo trutta macrostigma*[45]. Their results could be discussed with the fact that, in general, marine fish contains comparatively higher percentage of ω-3 acids than the freshwater fish (Nakamura et al. 2007)[47]. As our recorded value was lower than the maximum value of 4.0 (which may cause chronic diseases), therefore, we may conclude that *M. cuchia* can be consumed as a healthy and safe food, irrespective of sex.

Mineral content

The minerals content obtained from the muscle of *M. cuchia* are presented in Table 5.

Table 5. Mineral contents (%) of male and female *M. cuchia*. Data expressed as mean ± SEM. Values in the same row having the different superscript are significantly different (P<0.05).

Mineral content	Male	Female
Sodium (Na)	0.15 ± 0.003^a	0.15 ± 0.002^a
Potassium (K)	0.75 ± 0.009^a	0.73 ± 0.029^a
Magnesium (Mg)	0.06 ± 0.001^a	0.06 ± 0.002^a
Manganese (Mn)	0.002 ±0.000^a	0.002 ± 0.000^a
Calcium (Ca)	0.07 ± 0.002^a	0.15 ± 0.003^b
Zinc (Zn)	0.01 ± 0.000^a	0.01 ± 0.000^a
Na/K ratio	0.20	0.21

Six minerals were detected. The mineral contents of *M. cuchia* muscle were decreased from potassium (K) to manganese (Zn) as follows: K>Na>Ca>Mg>Mn>Zn. The predominant mineral in the muscle of Kuchia was potassium with mean value as 0.75±0.009% in male and 0.73±0.029% in female. The ratio of Na/K was almost similar in male (0.20) and female (0.21) *M. cuchia*. A significant variation was observed only in calcium content between two sexes.

Minerals are necessary for the growth and development of living organisms, which influences the metabolic and physiological activities of human body (Abdulkarim et al. 2015)[48]. Njinkoue et al. (2016) found that the most abundant mineral was potassium in the muscle of *Pseudotolithus typus*, also found the Na/K ratio of 0.19[49]. Besides, Bu et al. (2012) and Perez and Chang (2014) recommended that to prevent the cardiovascular diseases the Na/K ratio in food should be less than 1[50, 51]. The current values were lower than that prescribed value for both male and female Kuchia, the lower concentration of Na and higher of K makes *M. cuchia* a good meal for human health.

CONCLUSIONS

This study has provided the basic information about nutritional values including proximate, amino acids, fatty acids and minerals compositions of *M. cuchia*, which has a great potential in international market, based on sex. The proportion of total moisture, ash and lipid were higher in male than in females, except in crude protein content. Among all amino acids only glutamic acid shows significant sexual dependency. On the other hand, 9 fatty acids showed quantitative differences (P<0.05) depending on sex. No such variation was found for minerals contents between sexes, except the calcium content. Based on the EPA+DHA value and ω-3/ω-6 PUFA ratio, it can be concluded that muscle tissue of female *M. cuchia* is nutritionally enriched than that of the male fish. However, further research is required on the seasonal variations of the nutritional composition of male and female *M. cuchia.*

ACKNOWLEDGEMENT

Authors would like to acknowledge Ministry of Science and Technology (MOST), Government of the People's Republic of Bangladesh for funding this work. We also would like to acknowledge Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh for providing the laboratory facilities.

REFERENCES

1. Stansby M.E. 1962. Proximate composition of fish. Fish in Nutrition. Bd. By Brik Heen and Rudolf Kronzer. Fishing News (Books). Ltd.
2. Kindong, R., Prithiviraj, N., Apraku, A., Ayisi, C.L and Dai, X. 2017. Biochemical composition of Predatory carp (*Chanodichthyserythropterus*) from Lake Dianshan, Shanghai, China. Egyp. J. Basic. Appl. Sci. **4(4)**, 297-302.
3. Iqbal, A., Khalil, I.A, Ateeq, N. and Khan, M.S. 2006. Nutritional quality of important food legumes. Food chem. **97(2)**, 331-335.
4. Wu. G. 2010. Functional amino acids in growth, reproduction, and health. Adv.Nutr. **1(1)**, 31-37.
5. Wang, W., Wu, Z., Dai, Z., Yang, Y., Wang, J. and Wu, G. 2013. Glycine metabolism in animals and humans: implications for nutrition and health. Amino acids. **45(3)**, 463-477.
6. Zuraini A, Somchit MN, Solihah MH, Goh YM, Arifah AK, Zakaria MS. … and Mat Jais A.M. 2006. Fatty acid and amino acid composition of three local Malaysian *Channa spp.* fish. Food Chem. **97(4)**.674-678.
7. Andersen, S.M, Waagbo, R. andEspe, M. 2016. Functional amino acids in fish nutrition, health and welfare. Front.Biosci. **8**, 143-169.
8. Kryzhanovskii, S.A. andVititnova, M.B. 2009. ω-3 polyunsaturated fatty acids and the cardiovascular system. Hum. Phys. **35(4)**, 491-501.
9. Zhang, Z., Wang, S., Diao, Y., Zhang, J. and Lv, D. 2010. Fatty acid extracts from *Luciliasericata* larvae promote murine cutaneous wound healing by angiogenic activity. Lipids Health Dis. **9(1)**, 24.
10. Limbourn, A.J. and Nichols, P.D. 2009. Lipid, fatty acid and protein content of late larval to early juvenile stages of the western rock lobster, *Panuliruscygnus*. Comp.Biochem. Physiol. **152(3)**, 292-298.
11. Inhamuns, A.J. and Franco, M.R.B. 2008. EPA and DHA quantification in two species of freshwater fish from Central Amazonia. Food Chem. **107(2)**, 587-591.
12. Sushchik, N.N., Gladyshev, M.I. andKalachova, G.S. 2007. Seasonal dynamics of fatty acid content of a common food fish from the Yenisei river, Siberian grayling, *Thymallusarcticus*. Food Chem. **104(4)**,1353-1358.
13. Kris-Etherton, P.M., Harris, W.S. and Appel, L.J. 2002. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circulation.**106(21)**, 2747-2757.
14. Orban, E., Nevigato, T., Lena, G.D., Casini, I. and Marzetti, A. 2003. Differentiation in the lipid quality of wild and farmed seabass (*Dicentrarchuslabrax*) and gilthead sea bream (*Sparusaurata*). J. Food Sci. **68(1)**, 128-132.
15. Rasoarahona, J.R., Barnathan, G., Bianchini, J.P. andGaydou, E.M. 2005. Influence of season on the lipid content and fatty acid profiles of three tilapia species (*Oreochromis niloticus*, *O. macrochir* and *Tilapia rendalli*) from Madagascar. Food Chem. **91(4),** 683-694.
16. DoF 2017. Yearbook of fisheries statistics of Bangladesh 2016-17. Fisheries resources survey system (FRSS), Department of Fisheries. Bangladesh: Director General, DoF, Dhaka. p. 129.
17. Hasan, M.M., Sarker. B.S., Nazrul,K.S,. Rahman, M.M. and Mamun, A.A. 2012. Marketing channel and export potentiality of freshwater mud eel (*Monopterus cuchia*) of Noakhali region in

Bangladesh. Int. J. Life Sci. Biotech. Pharma. Res. **1(3)**, 226-233.
18. Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.T., Hassan, M.A., Khondker, M. and Rahman, M.M. (eds.). 2007. Encyclopedia of flora and fauna of Bangladesh. Asiatic Society of Bangladesh, Dhaka, p. 175-176.
19. Dutta, M. and Dutta, P. 2014. A study of the fatty acid profile in the muscle of *Monopterus cuchia*. Ori. J. Chem. **29(4)**, 1501-1505.
20. Nairs K.G.R. andGopakumar, K. 1981. Influence of sex, spawning, starvation and water temperature on fatty acid composition in *Tilapia mossambica*. Fish Techol. **18**, 123-127.
21. Norambuena, F., Estevez, A., Bell, G., Carazo, I. and Duncan, N. 2012. Proximate and fatty acid compositions in muscle, liver and gonads of wild versus cultured broodstock of Senegalese sole (*Solea senegalensis*). Aquaculture, **356**, 176-185.
22. Petricorena, Z.C. 2014. Chemical Composition of Fish and Fishery Products. In Handbook of Food Chemistry. Springer Berlin Heidelberg. p. 1-28.
23. Miah, M.F., Haque, F., Mia, M.R., Jannat, E., Ali, H., Quddus, M.M.A. and Ahmed, K. 2013. Molecular identification and sexual differentiation of freshwater mud eel, *Monopterus cuchia*. Universal J, Agric, Res. **1(3)**, 54-58.
24. AOAC 2000. Official methods of analysis of the association of official analytical chemists, in: 17th (Eds.), Edited by Patricia Cunniff. Arlington, VA, USA.
25. Chowdhury, M.B., Sirajee, A.A., Bhuiyan, H.R., Huq, M.A. and Ismail, K.M. 2003. Studies on fatty acid profile of three commercial fishes of the Bay of Bengal. Ban. J.Scit.Indust. Res. **38(1-2),** 49-54.
26. Boran, G. andKaracam, H. 2011. Seasonal changes in proximate composition of some fish species from the Black Sea. Turk. J. Fish.Aquat. Sci. **11(1)**, 1-5.
27. Bogard, J.R., Thilsted, S.H., Marks, G.C., Wahab, M.A., Hossain, M.A., Jakobsen, J. andStangoulis, J. 2015. Nutrient composition of important fish species in Bangladesh and potential contribution to recommended nutrient intakes. J. Food Compos. Anal. **42**,120-133.
28. Nargis, A. 2006. Seasonal variation in the chemical composition of Body flesh of Koi Fish *Anabas testudineus* (Bloch) (Anabantidae: Perciformes). Ban. J.Scit.Indust. Res. **41(3)**, 219-226.
29. Ateş. M., Çakıroğulları, G.Ç., Kocabaş, M., Kayım, M., Can, E. andKızak, V. 2013. Seasonal variations of proximate and total fatty acid composition of wild brown trout in Munzur River, Tunceli-Turkey. Turk. J. Fish.Aquat. Sci. **13(4)**, 613-619.
30. Kacem, M., Sellami, M., Kammoun, W., Frikha, F., Miled, N. and Ben Rebah, F. 2011. Seasonal variations in proximate and fatty acid composition of viscera of *Sardinella aurita*, *Sarpasalpa*, and *Sepia officinalis* from Tunisia. J.Aquat, Food Prod. T. **20(2)**, 233-246.
31. Murrays, J. and Burt, J.R. 2001. The Composition of Fish. Ministry of Technology, Torry Research Station (No. 38). Torry advisory note. Available from http://www.fao.org/wairdocs/tan/x5916e/x5916e00.htm
32. Chandrashekar, K. andDeosthale, Y.G. 1993. Proximate composition, amino acid, mineral, and trace element content of the edible muscle of 20 Indian fish species. J. Food Compos. Anal. **6(2)**, 195-200.
33. Özogul, Y., Özogul, F.H., Çiçek, E., Polat, A. andKuley, E. 2009. Fat content and fatty acid compositions of 34 marine water fish species from the Mediterranean Sea. Int. J. Food Sci.Nutr. **60(6)**, 464-475.
34. Zenebe, T., Ahlgren, G. andBoberg, M. 1998. Fatty acid content of some freshwater fish of commercial importance from tropical lakes in the Ethiopian Rift Valley. J. Fish Bio. **53(5)**, 987-1005.
35. Li,X,M,, Yuan, J,M., Fu, S.J. and Zhang, Y.G. 2016. The effect of sustained swimming exercise on the growth performance, muscle cellularity and flesh quality of juvenile qingbo (*Spinibarbussinensis*). Aquaculture. **465**, 287-295.
36. Gam, L.H., Leow, C.Y. andBaie, S. 2005. Amino acid composition of snakehead fish (*Channastriatus*) of various sizes obtained at different times of the year. Malays. J. Phar. Sci. **3(2)**, 19-30.
37. Barrento, S., Marques, A., Teixeira, B., Mendes, R., Bandarra, N., Vaz-Pires, P. and Nunes, M.L. 2010. Chemical composition, cholesterol, fatty acid and amino acid in two populations of browncrab *Cancer pagurus*: Ecological and human health implications. J. Food Compos. Anal. **23(7)**, 716-725.
38. Iwasaki, M. and Harada, R. 1985. Proximate and amino acid composition of the roe and muscle of selected marine species. J. Food Sci. **50(6)**, 1585-1587.
39. Jhaveri, S.N., Karakoltsidis, P.A., Montecalvo, J. andConstantinides, S.M. 1984. Chemical composition and protein quality of some southern New England marine species. J. Food Sci. **49(1)**, 110-113.
40. McLarney, M.J., Pellett, P.L. and Young, V.R. 1996. Pattern of amino acid requirements in humans: an interspecies comparison using published amino acid requirement recommendations. J.Nutr. **126(7)**, 1871-1882.

41. Fallah, A.A., Nematollahi, A. andSaei-Dehkordi, S.S. 2013. Proximate composition and fatty acid profile of edible tissues of *Capoetadamascina*(Valenciennes, 1842) reared in freshwater and brackish water. J. Food Compos. Anal. **32(2)**, 150-154.
42. Cieślik, I., Migdał, W., Topolska, K., Mickowska, B. andCieślik, E. 2018. Changes of amino acid and fatty acid profile in freshwater fish after smoking. J. Food Process.Preserv. **42(1)**, e13357.
43. Öksüz, A. andÖzyılmaz, A. 2010. Changes in fatty acid compositions of Black Sea anchovy (*Engraulisencrasicolus*L. 1758) during catching season. Turk. J. Fish Aquat, Sci. **10(3)**,381-385.
44. Food Standards Australia New Zealand 2003. Erucic acid in food: A toxicological review and risk assessment. Technical report series no. 21, Food Standards Australia New Zealand, Canberra BC, ACT 2610.
45. Akpinar, M.A., Gorgun, S. andAkpinar, A.E. 2009. A comparative analysis of the fatty acid profiles in the liver and muscles of male and female *Salmo truttamacrostigma*. Food Chem. **112(1)**: 6-8.
46. Guler, G.O., Aktumsek, A., Citil, O.B., Arslan. A. andTorlak, E. 2007. Seasonal variations on total fatty acid composition of fillets of zander (*Sander lucioperca*) in Beysehir Lake (Turkey). Food Chem. **103(4)**, 1241-1246.
47. Nakamura, Y.N., Ando, M., Seoka, M., Kawasaki, K.I. andTsukamasa, Y. 2007. Changes of proximate and fatty acid compositions of the dorsal and ventral ordinary muscles of the full-cycle cultured Pacific bluefin tuna *Thunnusorientalis* with the growth. Food Chem. **103(1)**, 234-241.
48. Abdulkarim, B., Bwathondi, P.O.J. and Benno, B.L. 2015. Seasonal variations in the mineral composition of some commercially important fish species of Lake Victoria- Tanzania. Int. J. Agr. Sci. **5**, 426-434.
49. Njinkoue, J.M., Gouad,o I., Tchoumbougnang, F., Ngueguim, J.Y., Ndinteh, D.T., FomogneFodjo, C.Y. andSchweigert, F.J. 2016. Proximate composition, mineral content and fatty acid profile of two marine fishes from Cameroonian coast: *Pseudotolithustypus* (Bleeker, 1863) and *Pseudotolithus elongatus* (Bowdich, 1825). NFS J. **4**, 27-31.
50. Bu, S.Y., Kang, M.H., Kim, E.J. and Choi, M.K. 2012. Dietary intake ratios of calcium to-phosphorus and sodium-to-potassium are associated with serum lipid levels in healthy Korean adults. Prev.Nutr. Food Sci. **17(2)**, 93-100.
51. Perez, V. andChang, E.T. 2014. Sodium-to-potassium ratio and blood pressure, hypertension, and related factors. Adv.Nutr. **5(6)**, 712-741.