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Short communication

Proximate and Mineral Compositions of Rice Field Eel Monopterus Albus

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Abstract

Rice field eel (Monopterus albus) is an air breather freshwater fish that can be found extensively in paddy field area in Malaysia. It has high economic value all over Asia and used as folk remedies for various diseases. Mineral compositions play a vital role in various metabolisms though it's required in a minute amount in the human body. Proximate compositions and selected minerals compositions were determined in Monopterus albus. The study found that Monopterus albus was high in protein content (50.07%-74.31%) and low in lipid (2.26%-2.66%), which suggests this fish species suitable to be consumed by various human conditions. The amplest macroelement was Calcium with a concentration of 29127.00 mg/Kg - 50468.50 mg/Kg, followed by Phosphorus and Magnesium, 21290.00 mg/Kg - 32975.50 mg/Kg and 1264.50 mg/Kg - 1638.50 mg/Kg respectively. Zinc was the dominant microelement found in Monopterus albus with a concentration of 44.17±1.20 mg/Kg followed by Iron, Manganese, Copper, and Chromium with concentration range of 32.60 mg/Kg - 38.6 mg/Kg, 3.40 mg/Kg – 22.65 mg/Kg, 0.97 mg/Kg - 1.07 mg/Kg and 0.59 mg/Kg - 0.78 mg/Kg respectively. The results of this study will be further used to promote fish-based medication and remedies benefit to human.

Keywords: *Minerals Composition, Monopterus albus, Proximate Composition, Rice Field Eel*

1. Introduction

Freshwater fish is consumed by most of the world populations as a protein source and low-fat food which provides lots of health benefits. Fish-based medication have been used in the treatment of infectious and parasitic diseases, during pregnancy, childbirth and postpartum and to treat diseases of the different systems in the human body. Fish-based medication is mainly based on nutritional constituents in fish such as proteins, fats, carbohydrates, amino acid, fatty acid, vitamins, flavonoids, and minerals [1]. These components efficiently contribute to health remedies, body metabolism processes and deficiency of elements may affect the proper function of the human body. Previous study shows that freshwater fishes such as Monopterus albus (rice field eel), Channa sp. (snakehead fish), and Anabas testudineus (perch) have high nutritional value that help in maintaining homeostasis in human body and used as traditional remedies by locals [2, 3, 4, 5].
Minerals are one of the main nutritional support components which act as cofactors in numerous enzymes involved during body metabolisms. Although the body requires a very small dosage of minerals, an inappropriate amount can be a disadvantage to the body [6, 7]. Previous studies reported that there are several mineral and trace elements that are essential to human body metabolisms such as Copper (Cu), Chromium (Cr), Phosphorus (P), Iron (Fe), Magnesium (Mg), Manganese (Mn), Zinc (Zn) and Calcium (Ca) [1, 6, 8, 9, 10, 11].
Rice field eel (Monopterus albus) is a freshwater species known as a commercial food product which received high demand both in the local and international market due to its delicious texture and taste [4]. Due to high nutritional value, it is widely used as the traditional medication for various diseases. It is native in most tropical or subtropical Asia including Malaysia [12, 13]. Monopterus albus lives in muddy ponds, swamps, and canals. It is one of the main fish species that can be found in rice field areas [14] and able to survive in harsh environment during drought season without water for a long period [15]. Although rice field eel is a favorable food enjoyed by locals, the nutritional evidence of this species is still lacking and therefore in this study, we investigated the proximate composition and mineral compositions of Monopterus albus.

2. Methodology

2.1 Sample Collection

Monopterus albus were collected from three states of West Malaysia namely Selangor, Perak, and Terengganu respectively. These three areas were chosen because they are paddy plantation areas [16], known as the main habitat for Monopterus albus. Eel samples with approximately body weight of 138.08±2.73 g (mean±S.E) and total length of 54.16±0.24 cm (mean±S.E) were sampled randomly in each area. The sampling activities were conducted from July 2016 to January 2017. All samples were transported back to UniSZA laboratory alive in polystyrene box with air pump system (water temperature of 26°C to 27°C). The body weight (g) and total length (cm) of eel samples were

recorded. Eel samples underwent hypothermia process according to Komilus et al. [17] and Marimuthu et al. [18] method with slight modification by placing eels into ice-cold water (0^oC) for approximately 10 minutes. Internal organs of samples were removed. Eel samples were cut into smaller piece and freeze-dried in freeze dryer [17]. Samples were then stored in freeze dryer for 3 days and then, ground into homogenous powder using a blender then stored in freezer at -80^oC prior to proximate and minerals analysis.

2.2 Proximate Analysis

Proximate composition analysis was determined according to the Association of Analytical Communities (AOAC) Methodology. This analysis was conducted to analyze moisture content, ash content, crude protein content, and lipid content of rice field eel, *Monopterus albus* [19]. Moisture content was determined by oven drying at 105^oC up to constant weight. Ash content was determined by heating samples in the muffle furnace at 550^oC up to constant weight. The crude protein was determined by the Kjeldahl method while lipid content was determined by the Bligh and Dyer method [20]. All analyses were performed in duplicates [21, 22, 23].

2.3 Mineral Elements Analysis

Samples were prepared for mineral elements analysis according to [24, 25] with slight modifications. All glasswares used in the preparation were soaked in 5% (v/v) HNO_3 overnight and rinsed with deionized water. 10mL acid mixture of 65 % HNO_3 and 37 % HCl (in the ratio of 1:3) were then prepared and added with 1g sample. Samples were placed on hotplate for approximately 15 minutes (until completely dissolved) before cooled and filtered into 50mL volumetric flask. Deionized water was added up to 50mL before transferring 10mL from it into 15mL polypropylene test tube for injection into the inductively-coupled plasma-optical emission spectrometer (ICP-OES) (Varian Vista Pro, USA).

2.4 Statistical Analysis

The proximate and potential wound healing minerals composition of *Monopterus albus* were analyzed using one-way analysis of variance (ANOVA) and the significant differences between means were determined by post hoc Tukey HSD (Honesty Significant Difference) test. Differences were considered to be significant when $p<0.05$. Data were analyzed using IBM SPSS package version 22.

3. Results and Discussion

Table 1: Proximate Composition of *Monopterus albus* in the Different States

Proximate (%)	Selangor	Perak	Terengganu
Moisture	81.22 ± 0.02^b	80.86 ± 0.03^a	83.90 ± 0.06^c
Ash	14.13±0.87	11.32±0.16	12.16±0.36
Protein	71.81 ± 1.14^b	50.07 ± 2.88^a	74.31 ± 1.53^b
Lipid	2.45±0.79	2.66±0.08	2.26±0.30

Values are mean ± SE; Different letters in the same column show a significant difference at $p<0.05$
(Tukey Post-Hoc Test). No letters are included in case of no significant difference ($p>0.05$)

Table 2: Selected Macro Minerals Concentration of Monopterus albus in the Different States

Mineral (mg/Kg)	Selangor	Perak	Terengganu
Magnesium (Mg)	1638.50 ± 52.50^b	1264.50 ± 5.50^a	1287.00 ± 28.00^a
Calcium (Cu)	50468.50 ± 2907.50^b	29127.00 ± 1174.00^a	34987.00 ± 859.00^a
Phosphorus (P)	32975.50 ± 1463.5^b	21290.00 ± 208.00^a	23890.50 ± 529.5^a

Values are mean ± SE; Different letters in the same column show a significant difference at $p<0.05$
(Tukey Post-Hoc Test). No letters are included in case of no significant difference ($p>0.05$)

Table 3: Selected Micro Minerals Concentration of Monopterus albus in the Different States

Mineral (mg/Kg)	Selangor	Perak	Terengganu
Copper (Cu)	1.07±0.06	0.97±0.01	0.97±0.04
Manganese (Mn)	22.65 ± 1.55^c	3.40 ± 0.10^a	13.05 ± 0.15^b
Zinc (Zn)	48.20 ± 0.30^b	39.95 ± 0.45^a	45.55 ± 1.25^b
Chromium (Cr)	0.78 ± 0.02^b	0.56 ± 0.03^a	0.59 ± 0.02^a
Iron (Fe)	32.60±0.10	38.65±1.55	36.00±1.23

Values are mean ± SE; Different letters in the same column show a significant difference at $p<0.05$
(Tukey Post-Hoc Test). No letters are included in case of no significant difference ($p>0.05$)

3.1 Proximate Composition

The proximate composition of *Monopterus albus* was shown in Table 1. The result shows there were no differences between lipid and ash content between the locations, Selangor, Perak, and Terengganu. However, there were slight differences in moisture and protein content, from the results; Terengganu eel samples have slightly higher moisture and protein content.

There were no significant differences ($p>0.05$) in lipid content among eel samples from Selangor Perak and Terengganu with the value of 2.45±0.79%, 2.66±0.08%, and 2.26±0.30% respectively. Fish can be grouped into three categories depending upon the level of lipids in the fish muscles which are; lipid fish with more than 8% average lipid content, average lipid fish with lipid content vary between 1% and 8% and lean fish with lipid content of less than 1% [26]. As lipid content in samples is between 2.26% to 2.66%, *Monopterus albus* can be considered as average lipid fish. In comparison to a study on freshwater fish in Thailand, eel has the lowest lipid content compared to Common silver barb (*Puntius gonionotus*), Nile tilapia (*Oreochromis niloticus*), Spotted featherback (*Notopterus chitala*), Snakeskin gourami (*Trichogaster pectoralis*), Striped catfish (*Pangasius sutchi*), Striped snakehead fish (*Channa striatus*), and Walking catfish (*Clarias macrocephalus*) [27]. Since *Monopterus albus* have average lipid content, it is suitable to be consumed by people who practice a low-fat diet, cardiovascular patient and hyperlipidaemia patient. The lipid content in *Monopterus albus* also contributes to its organoleptic property, texture, and flavor [28]. The juicy taste derived from almost all edible parts from its body can be an important precursor of flavor compounds since fatty acid autoxidation produces volatile compounds characterizing the fish flavour [29]. These features gave *Monopterus albus* an appealing taste that is enjoyed by people as a delicious savoury dish.

There is a wide variation in moisture content between freshwater species (raw) ranging from 65% to 80% [30]. According to FAO, water in fish muscles is responsible in bonding the protein structure so that it will be rigid and not ready to be destroyed [31]. For *Monopterus albus*, samples from Terengganu have slightly higher ($p<0.05$) moisture content with the value of 83.90±0.06% followed by Selangor and Perak 81.22±0.02% and 80.86±0.03% ($p>0.05$) respectively. However, *Monopterus albus* moisture content from this study was considerably higher in comparison with *Clarias gariepinus* (African catfish) at 72-74% and marine fish *Pagrus major* (Red seabream) at 72-75% [17, 32]. Low lipid fish have higher moisture content and suggested a reverse correlation between the fat and moisture content, which is common in many fish species [33]. *Catla catla* (Major carp) has 76.05% moisture with 2.57% fat while low moisture was found in *Labeo rohita* (Rohu) at 72.10% with high 3.11% fat content [33]. A similar reverse trend is also resulted from this study.

This study suggests that although there is no significant differences of ash content ($p>0.05$) in *Monopterus albus* sampled from these respective states, Selangor shows the highest ash content with 14.13±0.87% followed by Terengganu, and Perak with the value of 12.16±1.53%, and 11.32±0.16% respectively. In comparison with other freshwater fish, the ash content in *Monopterus albus* was the highest compared to *Clarias batrachus* (Walking catfish), and *Channa striata* (Snakehead fish) with the value of 2.4%, 1.4%, and 1.3%, respectively [34]. Ash content is generally recognized as a measure of quality for the assessment of the functional properties of foods [26]. The percentage ash content in the fishes analyzed is also an indication of ample mineral content in fish in these three areas in Malaysia.

Samples from Selangor and Terengganu have significantly higher ($p<0.05$) protein content (71.81±1.14% and 74.31±1.53% respectively) compared to those from Perak with the value of 50.07±2.88%. It was higher compared to marine species such as *Pagrus major* (Red seabream), *Scomber scombrus* (Atlantic mackerel), *Scomber australasicux* (Blue mackerel), and *Scomber japonicus* (Chub mackerel) with protein content ranging 18.05% to 22.20% [17, 28]. However, it was considered lower when compared to *Perca fluviatilis* (Yellow perch) with protein content 92.1% to 94.3% [53]. The high protein content is an indicator that eel can be a good candidate as protein source for human consumption. Protein content in the fish muscle contributes organoleptic quality of the fish. The water-protein interaction and reduced connective tissue protein muscle in fish resulting light texture when the fish was cooked [29]. Hence, eel have high protein and good tender texture which is a seek-for characteristics in many cuisines. Although there are differences in protein build-up pattern in samples between locations, it is important to understand that crude protein content in fish flesh varies depending on the species, the nutritional condition, and the productive cycle of animal as well as the parts of the organism [30].

3.2 Mineral Compositions

The macro minerals content of *Monopterus albus* from different locations is shown in Table 2. From the result, Calcium was the highest element content in the samples while Magnesium was the lowest macro mineral content of *Monopterus albus*. Eel samples from Selangor have significantly higher macro mineral content compared to Perak and Terengganu. In Table 3, zinc was the utmost abundant micro mineral element in *Monopterus albus* whereas; chromium was the lowest element concentration in the samples. Selangor shows similar pattern of indistinctly higher micro minerals content compared to samples from both Perak and Terengganu. Results indicated that different location does not have a big impact on the mineral compositions and this observation is similar to another observation on Thailand freshwater fish species that were collected from different locations [35].

Magnesium and calcium content in *Monopterus albus* sampled from Selangor were significantly higher ($p<0.05$) compared to other samples with 1638.50±52.50 mg/Kg and 50468.50±2907.50 mg/Kg respectively while magnesium and calcium content of *Monopterus albus* from Perak and Terengganu show no significant differences ($p>0.05$). Magnesium content from Perak and Terengganu are 1264.50±5.50 mg/Kg and 1287.00±28.00 mg/Kg respectively whereas the calcium content of sample from Perak and Terengganu were 29127.00±1174.00 mg/Kg and 34987.00±859.00 mg/Kg respectively. It was found that calcium content of *Monopterus albus* in this study was tremendously higher compared to *Channa striatus* (Snakehead fish) and *Channa marulius* (Great snakehead) with the calcium content of 5279.00 mg/Kg and 165 mg/Kg respectively [36] and *Chirocentrus dorab* (Dorab wolfherring) *Gymnura spp.* (Long-tailed butterfly ray) with the value of 1166.3 mg/Kg and 1275.9 mg/Kg respectively [37]. Calcium functions as a wound healing secondary messenger involved in signaling cascades critical to wound healing [11]. In addition to that, calcium is also an essential element for body growth and development [38, 39]. According to World Health Organization (WHO), daily intake of calcium for adult human is 1000mg and these amounts increase up to 1200mg per day for both aging and pregnant women. Deficiency of calcium may lead to muscle and abdominal cramp, tetany, rickets, and other bone-related diseases [40].

Magnesium has the highest concentration in all samples compared to other minerals analysed in many studies [34] and shows higher concentration compared to this recent study value ranging between 6183.8 mg/Kg and 15348.0 mg/Kg. However, *Monopterus albus* have higher magnesium content compared to *Anabas testudineus* (Climbing perch), *Channa marulius* (Great snakehead), and *Channa striatus* (Snakehead fish) with the value of 210 mg/Kg, 230 mg/Kg, 270 mg/Kg respectively [41]. A similar pattern can be seen with *Channa striatus* (Snakehead fish) and *Channa marulius* (Great snakehead) with magnesium concentration of 276 mg/Kg and 216 mg/Kg respectively [36]. Many enzymes involved in protein and collagen synthesis needed magnesium as a co-factor [10]. The daily requirement of magnesium is 400mg and deficient in magnesium intake can induce hypocalcemia, which leads to lower calcium absorption in the intestine and thus may lead to a deficiency of calcium [42, 43].

There are no significant differences ($p>0.05$) in phosphorus concentration in eel samples sampled from Perak and Terengganu, which were 21290.00±208.00 mg/Kg and 23890.50±529.50 mg/Kg while Selangor eel samples were significantly higher ($p<0.05$) with 32975.50±1463.50 mg/Kg compared to Perak and Terengganu eels. *Monopterus albus* have approximately 30% higher phosphorus content compared to previous study done on other freshwater fish such as *Tilapia zilli* Tilapia (5516 mg/kg to 9476 mg/kg), *Chrysichthys nigrodigatatus* (Catfish) (7398 mg/kg to 9988 mg/kg) and *Labeo rohita* (Rohu) (3828 mg/kg to 6794 mg/kg) respectively [44]. Similar outcome is also observed with the phosphorus content of *Oncorhynchus mykiss* (Rainbow trout) which only 3378.78 mg/Kg [45]. Phosphorus is an important component in numerous cellular functions and along with calcium; it was also a vital element for bone structure. Both calcium and phosphorus are the main elements in skeletal system maintenance and stability by the formation of calcium phosphate [46, 47]. The daily intake of calcium and phosphorus were similar and can be found in a lot of common food such as milk, cereals, and nuts, therefore phosphorus deficiency is occasional event only [40].

Zinc is a trace mineral that forms a component of many enzymes, including DNA and RNA polymerases and is required for protein synthesis, DNA synthesis, mitosis, and cell proliferation. Zinc is also important for proper functioning for approximately 300 enzymes; in which many of these zinc-dependent processes, such as collagen synthesis and cell division [8]. From the study, the concentration of Zinc in samples of Selangor and Terengganu at 48.20±0.30 mg/Kg and 45.52±1.25 mg/Kg respectively are slightly higher ($p<0.05$) compared to Perak sample with zinc content of 39.96±0.45 mg/Kg. Zinc is also the highest mineral content in the body of *Monopterus albus* with concentration ranging between 59.31 mg/Kg to 69.34 mg/Kg [48]. Results obtained differed from reports on concentration of zinc in *Micropterus salmoides* (Largemouth Bass) and *Morone saxatilis* (Striped Bass), in which it was reported that the concentration of zinc in both species was noticeably lower compared to *Monopterus albus* with 3.45mg/Kg and 3.76mg/Kg respectively [49]. Zinc content of *Monopterus albus* was also still higher compared to *Tilapia zillii* (Red belly tilapia) and *Cyprinus carpio* (Common carp) with value of 23.9 mg/Kg and 32.8 mg/Kg respectively *Liza abu* (Mullet) and *Barbus grypus* (Shabout) at 12.21 mg/Kg and 15.23 mg/Kg respectively [50, 51]. In comparison, the zinc content of *Monopterus albus* obtained from this study was lower in comparison to *Perca fluviatilis* (Yellow perch) with the value of 52.92 mg/Kg [52]. Although *Monopterus albus* from the study shows high concentration of zinc, it was still

below the permissible limits set by Malaysian Food Regulation (1985) and limit set by FAO/WHO (1984), 100 mg/Kg and 1000mg/Kg respectively.

There are no significant differences ($p>0.05$) in copper content in all *Monopterus albus* samples from different location of Selangor, Perak and Terengganu with value 1.07±0.06 mg/Kg, 0.97±0.01 mg/Kg and 0.97±0.04 mg/Kg respectively. Nevertheless, results were slightly higher than a previous study conducted on the same species [48]. The recent study also shows that copper content of *Monopterus albus* was almost twice-fold higher compared to the copper content of *Perca flavescens* (yellow perch), which was approximately 0.38mg/Kg to 0.45mg/Kg [52]. The study shows a similar result pattern of copper content in *Polynemusindicus sp.* (Indian threadfin), *Trachinotus blochii* (Moonfish), and *Chirocentrus dorab* (Dorab wolfherring) which were between the values ranges of 0.95mg/Kg to 1.01mg/Kg [37]. Copper was a prime factor in homeostasis and a necessary cofactor for antioxidant activity [8]. All samples in the study contained copper lower than the permissible limit set by FAO/WHO (1984), which is 10mg/Kg and Malaysian Food Regulations (1985); which is 30mg/Kg food.

Monopterus albus samples from Selangor show significantly higher ($p<0.05$) manganese (Mn) content with 22.65±1.55 mg/Kg, followed by those from Terengganu (13.05±0.15 mg/Kg) while Perak samples have a significantly low ($p<0.05$) concentration of 3.40±0.10 mg/Kg. Enzymes that are involved in Krebs cycle required manganese to be activated. Besides that, lipoprotein lipase, an enzyme required in protein synthesis also needs manganese as the activator [8]. *Monopterus albus* have exceptionally higher concentration of manganese compared to *Micropterus salmoides* (Largemouth Bass), *Morone saxatilis* (Striped Bass) at 0.12 mg/Kg and 0.14mg/Kg respectively [49], and *Perca flavescens* (Yellow perch) with concentration between 0.16 mg/Kg to 0.29 mg/Kg [52]. *Anabas testudineus* (Climbing perch) (5.2 mg/Kg) and *Channa striatus* (Snakehead fish) (10.0 mg/Kg) have higher manganese content compared to *Monopterus albus* from Perak but slightly lesser than samples from Selangor and Terengganu [41].

Chromium is the least micro mineral content found in *Monopterus albus* in this study. Selangor eel samples have higher chromium concentration ($p<0.05$) compared to Perak and Terengganu eel samples with the concentration of 0.78±0.02 mg/Kg, 0.56±0.03 mg/Kg and 0.59±0.02 mg/Kg respectively. *Monopterus albus* have slightly higher chromium content compared to *Amblypharyngodon mola* (Mola carplet) and *Macrobrachium malcolmsonii* (Freshwater prawn) with very low concentrations of chromium of 0.27 and 0.22 mg/Kg respectively [41]. Besides that, *Monopterus albus* have almost 20 fold higher concentration compared to *Channa striatus* (Snakehead fish) and *Channa marulius* (Great snakehead) at only 0.01 mg/Kg and 0.03 mg/Kg respectively [36]. However, *Labeo rohita* found in the polluted area of Indus River, showed chromium content range between 0.13mg/Kg - 1.76mg/Kg which was considerably higher compared to *Monopterus albus* [54]. Although chromium may be classified as the heavy metal element, it still plays an important role in insulin action and actively involved in carbohydrate, protein and lipid metabolism [42, 55].

Iron is the second most abundant microelement found in *Monopterus albus* after Zinc. There are no significant differences ($p>0.05$) in iron content of eel samples in the three selected areas. The concentration of iron in Selangor, Perak and Terengganu eel samples were 32.60±0.10 mg/Kg, 38.65±1.55 mg/Kg, and 36.00±1.23 mg/Kg respectively. *Monopterus albus* have the highest iron content compared to *Clarias batrachus* (Walking catfish) and *Channa striatus* (Snakehead fish) with the concentration of 49.7mg/Kg, 26.8mg/Kg, and 17.0mg/Kg respectively [34]. The iron concentration of the recent study was similar to same species study that ranged from 38.56mg/Kg - 50.40mg/Kg [56]. However, these values were approximately 25% lower compared to *Misgurnus ansguillicaudatus* (Loach), with iron content ranging from 51.04mg/Kg - 219.47mg/Kg from the same study. This may due to the feed habit of loach, which consumes sediment and mud that may have resulted in high mineral content in this fish [56]. In contrast, the iron content of *Monopterus albus* was enormously greater than *Channa sp.* (Snakehead species) which only contains 4.93 mg/Kg to 6.40 mg/Kg [18, 36]. Iron was essential for oxygen transportation from tissues and it plays a vital role as a cofactor in collagen synthesis [57]. The recommended daily allowance (RDA) for iron intake is different depends on sex and age. For the adult male, the daily intake of iron is approximately 8mg per day while for the woman, are ranging from 8mg-27 mg per day. Iron deficiency may cause loss of energy, instability of the digestive tract and loss of appetite [58].

4. Conclusion

From the overall study, *Monopterus albus* is a freshwater fish that have good nutritional value and suitable to be consumed daily or for traditional medicinal purposes. Result from this study may contain higher proximate and mineral compositions compared to the previous studies as this study used whole body except internal organ as an approach to zero waste application and optimization of total yield of mineral available in *Monopterus albus*. This study shows that *Monopterus albus* is a good freshwater fish source and suitable as food source for human consumption. Further study needs to be undertaken to develop health supplement product from this freshwater fish species to promote fish-based medication and healing remedies to human.

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