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Original Research Article

Proximate Composition, Fatty Acid Profile and Total Amino Acid Content in Raw Samples of Asian Swamp Eel (*Monopterus albus*)

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Abstract: Due to the advancement of refining and processing technologies, as well as an increased study on the fish proteins and peptides, a new industry has emerged to produce a fish protein powder for human consumption and medicinal products. In this regard, Asian swamp eel has become a commercially important fish in Eastern and Southeastern Asia due to its high nutritional value and its potential as a new ingredient for marketing protein powder. This study aims to determine the proximate composition and analyse amino acid and fatty acid in two parts of the eel, which are the body and waste (head and tail). The eel was locally bred eel from a farm located in Terengganu. The results showed that swamp eel contained 9.0g/100g ash, 12.2g/100g moisture, 2.3g/100g fat, and 76.5g/100g protein. The total content of fatty acid in the eel's body was found to be 0.11g/100g sample, whereby this is lower than the content in the waste, which is 0.17g/100g sample. The dominant fatty acids in both eel's body and waste are palmitic, lauric, oleic and a-Linoleic. The waste has shown further high fatty for myristic and stearic acids. Meanwhile, the highest amino acid contents in both parts, body and waste, is the glutamic acid (Glu) which is 2.44g/100g for body sample and 1.71g/100g for waste sample. Other dominant amino acids are aspartic acid, glycine, arginine, threonine and leucine. This study provides knowledge on the health values of consuming Asian swamp eel and its potential to produce value-added products from eel farming including the processing of their byproducts for the production of novel food ingredients, nutraceuticals, pharmaceuticals, and other.

Keywords: Asian swamp eel; amino acids; fatty acids, proximate compositions

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1. Introduction

The diversity of nutrients in food is necessary to meet nutritional needs and play a role in the immune system. Foods containing good nutrients will boost the immune system and speed up healing. Fish is an essential source of animal protein as well as other nutrients for human health all over the world. Marine fishes are an exploitable source of efficacious animal-derived medicinal products (ADMPs) (Prokopov *et al.*, 2019). Fish products commercially sold are primarily sourced from marine fish, such as fish liver oils and shark cartilages (Haniffa *et al.*, 2014). On the other hand, freshwater fish are rarely used as ingredients to make food products as they are deemed unfamiliar to consumers. Although they are unfamiliar, their significance and potential should not be overlooked and should be further investigated.

Asian swamp eel, or its specific name *Monopterus albus* or *belut* in Malay, is a commercially important fish due to its nutritional value in Eastern and Southeastern Asia. Asian swamp eels are a widespread type of eel found in Malaysia. These species have a tolerance around pH seven and 28°C temperature and live in muddy ponds, swamps, canals, and rice fields in the tropics (Matsumoto *et al.*, 2010; Khaleel *et al.*, 2019). According to Kamarudin *et al.* (2017), Asian swamp eels are a popular commercial food, fish and medicine, especially in China and Malaysia. It is also stated that from 2010 to 2013, the total production of wild swamp eel in Malaysian public water bodies (rivers, ex-mining pools, dams, lakes, and others) was projected to be 187.6 tonnes, with a retail value of around RM2.3 million (Kamarudin *et al.*, 2017).

The Asian swamp eel is a high-protein food source with a % protein composition of 81.25% (Herawati *et al.*, 2018). They are rich in amino acids and fatty acids. Amino acids and fatty acids are essential nutrients for the body. Amino and fatty acids can accelerate the healing process of several diseases, especially tissue damage such as burns. Besides being used as food, Asian swamp eels can be used in many applications. Some applications include producing fish oil, gelatin, fish hydrolysate and medicines.

The Asian swamp eel specimen used in this study was from an aquamarine farm in Terengganu. The farm carried out all of its operations, from breeding, hatching, and growing to harvesting, while being concerned about the environmental aspects and food resources for their eels. The study of the composition of fish can provide insightful information about its physiological condition, energetic adaptation, habits, nutritional value and commercial applications. Additionally, this data could help develop a high-quality processing method that enables eels to be consumed throughout the year. The present study was therefore conducted to determine the nutritional composition and quantify the fatty acids and total amino acids of locally-breed eel to gain further insights on the potential values in commercial applications.

2. Materials and Methods

2.1. Samples

The whole eels were cleaned, and the entrails were removed. Then, the samples were packed in three vacuum bags with an average weight of 700 g eels per bag, which brings the total to 2100 g of eels. Then, the eels were stored at -20℃ until further use. Before the analysis, the frozen eel was defrosted at 4^{o}C in a refrigerator and then homogenized using a Waring BB300SE high-speed blender for about 2 minutes.

2.2. Proximate Analysis

Moisture, ash and protein content were determined as described in AOAC methods (AOAC, 2016). Moisture was determined by drying the sample at 105°C until a constant weight was achieved. The total ash was determined by burning the fish at high temperatures (550°C) in a muffle furnace, leaving only inorganic matter (ash). The weight of leftover inorganic materials is used to calculate the ash content. The Kjeldahl method determined the nitrogen (N) content of fish samples, and the value was multiplied by 6.25 as an estimate of the crude protein content. The fat content was determined using the Soxhlet solvent extraction procedure with petroleum ether as solvent. Samples are extracted with ether in a Soxhlet-type extractor for 16 hours, then the lipid extract is evaporated to dryness at 95–100°C and weighed.

2.3. Fatty Acid Analysis

Fatty acids in Asian swamp eels were esterified using the transesterification method to form Fatty Acids Methyl Esters (FAMEs) before being analyzed using Gas Chromatography, GC (Razak *et al.*, 2001). Gas chromatography-mass Spectrometer Agilent 6890 instrument coupled to an Agilent 5973 mass spectrometer was employed to determine and identify the fatty acids content. A 100 mg sample was weighed in a 20 ml vial and dissolved in 10 ml hexane. Potassium hydroxide (100 µl, 2 N) was added in methanol followed by vortex for 30 s. The sample was centrifuged for 10 min, and the clear supernatant was transferred into a 2 mL autosampler vial bottle. FAMEs were separated using a capillary gas chromatography column with a highly polar stationary phase based on chain length, degree of unsaturation, and geometry and position of the double bonds. Identification of fatty acids is done by injecting 1 µl of the standard solution and 1 µl of the sample solution in the

GC tool. The operation conditions were an oven temperature of 35°C, an inlet temperature of 250oC, and a flame ionization detector of 300°C.

2.4. Amino Acid Analysis

The hydrolysis was done by adopting the method from Febriyenti *et al*. (2016). The determination of amino acids was done using precolumn derivatization with 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate (AQC). Ten microliters of filtrate of acid hydrolysis above was added with 70 µl of AccQ Fluor Borate Buffer (Waters Corporation, USA). The sample tube was vortexed briefly before adding 20 µl of reconstituted AccQ Fluor Reagent to the sample tube. After vortexing for several seconds, the sample tube was left to stand for 1 minute at room temperature and then heated in an oven at 50 C for 10 min. The mixture was transferred to the LVI vial before being injected into the HPLC tool.

3. Results and Discussions

3.1. Proximate Compositions

Generally, fish contains 2–25% fat, 15-30% protein and 50-80% moisture content (Deepika *et al.*, 2014). Some freshwater and marine Thai fishes in the raw state were reported to have their protein contents ranging from 17 to 22 g/100 g (Puwastein *et al.*, 1999). Table 1 shows the proximate composition of the Asian swamp eel. The protein content of the eel body and waste was 18.2 g/100 g (18.2%) and 18.3 g/100 g (18.3%) respectively. The resulting amount of protein content in both the body and waste part is found to be higher than usual finding in other studies, which was around 15–17 g/100 g (Wijayanti & Susilo, 2017; Wijayanti & Susilo, 2018) in cultured and wild eel (*Anguilla bicolour*). It is also reported that the protein content between large and small eels was not significant, which ranged from 19.20 to 19.62% (Gomez-Limia *et al.*, 2021) and for some fish species, increases slightly or remains relatively stable as the body weight increases (Ramseyer, 2002). In general, it can also be reported that there is no significant difference between the protein content in the body and the waste part of the eel.

The lipid content of the eel for each part was low (0.2–0.3 g/100g). Heinsbroek *et al.* (2007) reported that dry matter, lipids and energy were closely related and increased with the body weight, which was between 10 and 130 g for the European eel. Van Ginneken *et al.* (2018) reported that as the fish grow, lipids accumulate in eels before spawning migration and the lipid contents increase.

The most commonly stored form of carbohydrate in fish is glycogen, which can be mobilized to satisfy energy demands (Wijayanti & Susilo, 2018). A significant difference was found in the carbohydrate content between the body and the waste part of the eel. The carbohydrate content in the waste part of the eel was 1.4 g/100 g compared to the body, 0.6 g/100g.

Ash content can be described as mineral content absorbed by the fish in the water through their gills and skin. The ash content in the waste part was significantly higher, with 4.5 g/100g, than the body part, 2.8 g/100g. This is likely due to the mineral content of the head part being in the form of calcium. It was in agreement with the study by Wijayanti and Susilo (2018) that the ash content in the head and tail were significantly higher than in the body.

Table 1. Proximate composition of Asian swamp eel's body and waste (head and tail)

Parameter, Unit	Body	Waste
Protein, g/100g	18.2	18.3
Total fat, g/100g	0.3	0.2
Total carbohydrate, g /100g	0.6	1.4
Ash, g/100g	2.8	4.5
Moisture, g/100g	78.1	75.6
Energy, kcal/100g	78 (328 kJ)	81 (340 kJ)
Crude fiber, g/100g	<0.1	<0.1

3.2. Fatty acid compositions

Fatty acids could be categorized into two groups: saturated fatty acids and unsaturated fatty acids, where the difference lies in the chemical bond. Table 2 shows the fatty acid contents expressed as a percentage of the total fatty acids of the eel sample. Fifteen fatty acids, ranging from caprylic acid (C8:0) to eicosapentaenoic acid (EPA) (C20:5n3), were identified. The most abundant fatty acid in the eel's body is palmitic acid (C16:0), followed by eicosapentaenoic acid (EPA) (C20:5n3) and arachidic acid (C20:0). In eel's waste, the dominant fatty acids are palmitic acid (C16:0), oleic acid (C18:1n9c) and lauric acid (C12:0). Palmitic acid was the primary saturated fatty acid (SFA) in both body and waste followed by lauric and stearic acid. These fatty acids have beneficial physiological effects when integrated with skincare products (topical application). Palmitic acid is used as raw material for shampoo, soap and soft cream (Sajna *et al.*, 2015). The pharmaceutical industry commonly uses Lauric acid from fish as an anti-bacterial, anti-viral and anti-protozoon (Lin *et al.*, 2017). Oleic acid was the primary monounsaturated fatty acid (MUFA) detected in eel's body (8.96%) and waste (14.94%). Oleic acid is also known as omega 9, and these acids have protective power in the body that can reduce levels of LDL cholesterol (Low-Density Lipoprotein) cholesterol and increase levels of HDL (High-Density Lipoprotein) (Sidhu, 2013).

Linoleic acid was the only polyunsaturated fat (PUFA) in the eel's body and waste, with a low percentage of 6.81% and 2.88%, respectively. Linoleic acid, which can be found in Asian swamp eel, is one of the omega-6 fatty acids that play an essential role in wound healing processes. Omega 3 and omega six fatty acids, which are linoleic acid (C18:3n-3), eicosapentaenoic acid or EPA (C20:5, n-3) and docosahexaenoic acid or DHA (C22:6, n-3) are the most beneficial fatty acids and were dominated in fish fat (Razak *et al*., 2001). These fatty acids are essential in the wound healing process, where omega-6 is required to produce prostaglandin while omega-3 is required to decrease the production of prostaglandin (Calder, 2005). Prostaglandin could induce inflammation in the early phase of the wound healing process, but too much omega-6 could prolong the inflammatory phase and prolong the wound healing process. It is also reported that the level of EPA increased according to the size of the fish (Endinkeau & Tan, 1993; Gomez-Limia *et al*., 2021). A similar result regarding fat content was also found in this study. The decrease in EPA and DHA occurred because complex unsaturated fatty acids were easily oxidated, and the oxidation rate increased with the processing time. EPA and DHA were easily oxidated by oxygen and light and produced degradation products (Barrow *et al*., 2009). In general, the fatty acids of the eel examined in this study showed a higher saturated rather than unsaturated acid content. However, differences in concentrations and amount of minerals among fish may be due to diet and breeding environmental conditions, such as temperature and pH, size, and age, as highlighted by Gomez-Limia *et al*. (2021).

Table 2. Fatty acid profile of Asian swamp eel

Fatty acids	**(Expressed as % of the total fatty acids)**	
	Body	**Waste**
C8:0 (Caprylic)	0.95	2.05
C10:0 (Capric)	0.85	1.67
C12:0 (Lauric)	8.37	14.83
C14:0 (Myristic)	5.09	8.47
C15:0 (Pentadecanoic)	8.62	3.73
C16:0 (Palmitic)	14.80	39.86
C18:0 (Stearic)	4.29	8.31
C20:0 (Arachidic)	8.96	nd
C24:0 (Lignoceric)	5.18	nd

Fatty acids	(Expressed as % of the total fatty acids)	
	Body	**Waste**
Total	**57.10**	**78.92**
C15:1 Cis-10-(Pentadecenoic)	1.64	1.19
C17:1 Cis-10-(Heptadeconoic)	5.08	2.08
C18:1n9c (Oleic)	8.56	14.94
C24:1 (Nervonic)	9.13	nd
Total	**24.40**	**18.21**
C18:3n3 (a-Linoleic)	6.81	2.88
C20:5n3 (EPA) Cis-5,8,11,14,17- (Eicosapentaenoic)	11.71	nd
Total	**18.51**	**2.88**

nd = not detected

3.2 Amino Acid Compositions

Fish protein is an essential source of nutrients and is rich in essential amino acids such as lysine, methionine, cystine, threonine and tryptophan (Mohanty *et al.*, 2014). Amino acid helps the human body to grow and function properly; it consists of essential and non-essential substances that cannot and cannot be produced by the human body. It is essential for fish metabolism and plays an essential role as a flavour and taste component. The method used in this study has allowed the analysis of seventeen amino acids. The values of amino acid compositions of the Asian swamp eel expressed as g/100 g fish sample are shown in Table 3. Glutamic acid was the most abundant amino acid, with 2.44 and 1.71 g/ 100 g for body and waste, respectively, followed by arginine (1.45 and 1.31 g/100 g) and leucine (1.42 and 1.29 g/100 g), relative to other amino acids. These amino acids are known to play an essential role. Glutamic acid is used by the inflammatory cells within the wound for proliferation and as an energy source (De Bandt & Cynober, 2006). Fibroblasts use glutamine for protein and nucleic acid synthesis. Arginine is essential for efficient wound repair and immune function (De Bandt & Cynober, 2006), while glycine is a major component of collagen. A comparison of amino acid contents with four farmed freshwater eel species of two temperature eel (*Anguilla japonica* and *A. rostrata*) and two tropical eels (*A. bicolour pacifica* and *A. marmorata*) shows a similar pattern in overall amino acid composition. However, slight differences in the compositions of some amino acids were observed. The total amount of amino acid contained in Asian swamp eel is slightly higher, which is 16.94 g and 16.22 g in 100 g extract for body and waste, respectively, compared to 14.60–15.41% from four farmed freshwater eel (Ahn, *et al.*, 2015).

Table 3. Amino acid composition of Asian swamp eel in g/100g

Type of amino acid	Amino acid contents (g /100 g)	
	Body	**Waste**
Histidine	0.51	0.53
Threonine	1.22	1.08
Valine	0.68	0.70
Methionine	0.55	0.25
Isoleusine	0.76	0.65
Leucine	1.42	1.29
Phenylalanine	0.64	0.62
Lysine	0.96	0.83
Total essentials (E)	**6.74**	**5.95**
Hydroxyproline	0.49	0.75
Aspartic acid	1.55	1.28
Glutamic acid	2.44	1.71
Serine	0.86	0.85
Glycine	1.10	1.53
Arginine	1.45	1.31
Alanine	0.97	0.99
Proline	0.76	0.91
Tyrosine	0.59	0.93
Total non-essentials (NE)	10.21	10.26
TOTAL	16.95	16.21
E/NE	0.66	0.58

4. Conclusions

The findings of this study showed that the local breed Asian swamp eel is a source of high-quality lipids and protein, with a well-balanced composition of essential fatty acids and amino acids. The results of this study could be beneficial in providing knowledge on the health values of consuming freshwater fish, specifically the Asian swamp eels. This study also indicates the opportunities to produce value-added products from eel farming, including processing their byproducts, such as health supplements, flavour enhancers, and topical medication.

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