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Amino Acid and Fatty Acid Composition of Wild Climbing Perch (*Anabas testudineus*) from Peatland Drainage Waters in Central Kalimantan, Indonesia

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ABSTRACT

This study aimed to characterize the amino acid and fatty acid composition of the climbing perch (*Anabas testudineus*) collected from peatland drainage waters in Tumbang Nusa Village, Central Kalimantan, Indonesia. Fish samples were analyzed at the Organic Chemistry Laboratory, Gadjah Mada University. Amino acid profiles were determined using High Performance Liquid Chromatography (HPLC), while fatty acid composition was assessed by Gas Chromatography–Mass Spectrometry (GC–MS). The results showed that *A. testudineus* contained nine essential amino acids, with lysine (0.890%) and leucine (0.596%) as the dominant components, followed by arginine, valine, phenylalanine, isoleucine, histidine, methionine, and tyrosine. Non-essential amino acids were also detected, with aspartate (1.048%), alanine (0.598%), and glutamate (0.629%) contributing the highest proportions. Fatty acid analysis revealed that oleic acid (43.24%) and palmitic acid (23.76%) were the most abundant, alongside stearic acid (7.78%), lauric acid (5.05%), and myristic acid (4.37%). Importantly, beneficial long-chain omega-3 fatty acids, including EPA (2.02%) and DHA (1.12%), were identified, although at relatively low concentrations. Overall, the fatty acid composition was dominated by monounsaturated fatty acids (MUFA, 48.82%), followed by saturated fatty acids (SFA, 17.20%) and polyunsaturated fatty acids (PUFA, 1.12%). These findings indicate that *A. testudineus* from peatland habitats represents a valuable nutritional resource, rich in essential amino acids and health-promoting fatty acids. Unlike previous reports from Bangladesh, Thailand, and Malaysia, this is the first study to provide baseline biochemical data for climbing perch from Indonesian peatland drainage waters, highlighting its novelty and relevance for local food security and aquaculture development.

INTRODUCTION

Fish play a critical role in human nutrition, particularly in developing countries where they provide an affordable source of high-quality protein, essential amino acids, and health-promoting lipids. This significance is particularly evident in Southeast Asia, where fish serves as a staple component of the human diet **(Stabili *et al.*, 2013)**. Beyond their caloric contributions, fish also offer bioactive compounds, including polyunsaturated fatty acids (PUFAs), which are essential for human growth and metabolic regulation, as well as for the prevention of chronic diseases **(Tang *et al.*, 2009)**. Insights into the biochemical composition of fish species are vital for evaluating their nutritional value and informing aquaculture practices aimed at enhancing food security **(Út *et al.*, 2020)**.

Anabas testudineus, locally referred to as ikan betok, is a freshwater species found predominantly in South and Southeast Asia. It is notable for its ecological adaptability, thriving in extreme conditions such as hypoxia and acidic waters **(Feary *et al.*, 2007)**. In Indonesia, *A. testudineus* is part of traditional diets and provides significant protein intake for rural households. Despite its ecological resilience and high nutritional potential, research examining its biochemical profile—particularly in terms of amino acid and fatty acid composition—remains limited **(Stabili *et al.*, 2006)**.

Previous studies conducted in regions like Bangladesh, Thailand, and Malaysia have documented the essential amino acids and variable fatty acid profiles in *A. testudineus*, with notable variations attributable to different environmental conditions **(Iwata *et al.*, 2003)**. However, there is a conspicuous research gap regarding this species in Indonesia, especially from unique ecosystems such as peatland drainage waters. These ecosystems, characterized by low oxygen levels and high dissolved organic matter, may significantly impact the feeding ecology and biochemical composition of fish **(Nasef, 2021)**. This reflects the pressing need to explore how specific habitats influence the nutritional characteristics of *A. testudineus*, particularly in terms of its contributions to local food security and the development of aquaculture practices tailored for peatland regions **(Foran *et al.*, 2005)**.

Previous studies in Bangladesh, Thailand, and Malaysia have reported the essential amino acids and variable fatty acid profiles of *A. testudineus*, with differences largely influenced by local environmental conditions **(Iwata *et al.*, 2003; Akter *et al.*, 2021)**. However, no published data are available for Indonesia, particularly from peatland drainage waters, which are characterized by low oxygen levels, acidic conditions, and high dissolved organic matter. These unique environmental factors are likely to influence the feeding ecology and biochemical composition of fish, creating a critical research gap. Therefore, the present study was designed to analyze the amino acid and fatty acid profiles of *A. testudineus* from peatland drainage waters in Central Kalimantan, Indonesia. By addressing this gap, the study provides novel baseline data that may inform

aquaculture practices, enhance understanding of nutritional value, and support strategies for food security in peatland regions. Therefore, the current study aimed to analyze the amino acid and fatty acid profiles of *A. testudineus* collected from peatland drainage waters in Central Kalimantan, Indonesia. This investigation will provide crucial baseline data that may support future research and practical applications in the realms of food security, aquaculture development, and the conservation of peatland aquatic biodiversity.

MATERIALS AND METHODS

Sample collection

Climbing perch (*Anabas testudineus*) samples were collected from peatland drainage waters in Tumbang Nusa Village, Pulang Pisau Regency, Central Kalimantan, Indonesia, which are part of the former Peatland Development Project (PLG) area. Freshly caught fish were immediately placed in ice boxes and transported to the laboratory for further analysis.

Sample preparation

Fish were cleaned, filleted, and homogenized using a sterile blender. The homogenized samples were stored at –20°C until biochemical analysis was conducted.

Amino acid analysis

Amino acid profiles were determined following acid hydrolysis using 6 N HCl at 110°C for 24h under nitrogen atmosphere to prevent oxidation. The hydrolyzed samples were neutralized and filtered before analysis. Amino acid quantification was performed using High Performance Liquid Chromatography (HPLC) equipped with a fluorescence detector after pre-column derivatization with o-phthalaldehyde (OPA). Identification and quantification were conducted by comparing retention times and peak areas with those of known amino acid standards.

Fatty acid analysis

For fatty acid analysis, total lipids were extracted from homogenized fish samples using the Bligh and Dyer method with chloroform–methanol (2:1 v/v). Extracted lipids were converted into fatty acid methyl esters (FAMEs) through transesterification using methanolic HCl. The resulting FAMEs were analyzed using Gas Chromatography–Mass Spectrometry (GC–MS). Identification of fatty acids was based on comparison with standard FAME libraries, and quantification was expressed as a percentage of the total fatty acids.

Data analysis

All analyses were performed in triplicate, and results were expressed as mean ± standard deviation (SD). Amino acid and fatty acid compositions were presented as percentages of dry weight basis and total fatty acids, respectively.

RESULTS

Amino acid profile

The analysis of amino acid composition in the climbing perch (*Anabas testudineus*) from Tumbang Nusa, Central Kalimantan, revealed the presence of both essential and non-essential amino acids (Table 1). Among essential amino acids, lysine (0.890%) and leucine (0.596%) were found in the highest concentrations, followed by arginine (0.564%), valine (0.290%), phenylalanine (0.273%), isoleucine (0.270%), histidine (0.192%), methionine (0.140%), and tyrosine (0.161%). For non-essential amino acids, aspartate (1.048%) and alanine (0.598%) dominated the composition, while glutamate (0.629%), glycine (0.566%), and serine (0.260%) were also present.

Table 1. Amino acid composition of climbing perch (*Anabas testudineus*) expressed as % dry weight (mean ± SD, n = 3)

Amino Acid	Concentration (%)
Essential Amino Acids	
Histidine	0.192 ± 0.21
Arginine	0.564 ± 0.23
Methionine	0.140 ± 0.32
Valine	0.290 ± 0.22
Phenylalanine	0.273 ± 0.12
Isoleucine	0.270 ± 0.22
Tyrosine	0.161 ± 0.31
Leucine	0.596 ± 0.23
Lysine	0.890 ± 0.24
Non-Essential Amino Acids	
Aspartate	1.048 ± 0.35
Glutamate	0.629 ± 0.23
Serine	0.260 ± 0.12
Glycine	0.566 ± 0.23
Alanine	0.598 ± 0.22

Note: Amino acid concentrations are expressed as percentage of dry weight basis (% DW).

Fatty acid profile

The fatty acid composition of *A. testudineus* is presented in Table (2). Oleic acid (C18:1, 43.24%) was the most abundant fatty acid, followed by palmitic acid (C16:0, 23.76%) and stearic acid (C18:0, 7.78%). Other notable fatty acids detected included lauric acid (C12:0, 5.05%), myristic acid (C14:0, 4.37%), and palmitoleic acid (C16:1, 3.56%). The presence of polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA, 2.02%) and docosahexaenoic acid (DHA, 1.12%) was also confirmed. The overall fatty acid groups consisted of saturated fatty acids (SFA, 17.20%), monounsaturated fatty acids (MUFA, 48.82%), and polyunsaturated fatty acids (PUFA, 1.12%).

Table 2. Fatty acid composition of climbing perch (*Anabas testudineus*) expressed as % of total fatty acids (mean ± SD, n = 3)

Fatty Acid	Concentration (%)
Lauric acid (C12:0)	5.05 ± 0.12
Myristic acid (C14:0)	4.37 ± 0.10
Palmitoleic acid (C16:1)	3.56 ± 0.08
Palmitic acid (C16:0)	23.76 ± 0.54
Oleic acid (C18:1)	43.24 ± 1.12
Stearic acid (C18:0)	7.78 ± 0.20
Eicosapentaenoic acid (EPA)	2.02 ± 0.06
Docosahexaenoic acid (DHA)	1.12 ± 0.05
Total SFA	17.20 ± 0.42
Total MUFA	48.82 ± 1.05
Total PUFA	1.12 ± 0.06

Note: Fatty acids are expressed as percentage of total fatty acids (% of TFA).

The results indicate that *A. testudineus* is a valuable source of essential amino acids, particularly lysine and leucine, as well as non-essential amino acids such as aspartate and alanine. In terms of fatty acid profile, the species is rich in oleic acid and palmitic acid, with moderate levels of beneficial long-chain omega-3 fatty acids (EPA and DHA). Values are presented as percentages of dry weight for amino acids and as percentages of total fatty acids for lipid profiles, ensuring comparability with previous studies. Triplicate analyses are expressed as mean ± SD. Statistical comparison with published data was qualitative due to differences in reporting formats; however, observed ranges are consistent with those reported in the climbing perch from Bangladesh and Malaysia **(Akter *et al.*, 2021)**.

DISCUSSION

The present study provides a comprehensive profile of amino acids and fatty acids in climbing perch (*Anabas testudineus*) harvested from peatland drainage waters in

Central Kalimantan. The findings highlight the nutritional importance of this freshwater species and its potential role in supporting local food security, particularly in regions where fish remains a primary source of animal protein.

Amino acid profile and nutritional significance

The amino acid profile of *Anabas testudineus* (commonly known as the climbing perch) reflects a favorable composition of both essential and non-essential amino acids, indicating its nutritional viability as a protein source. In particular, lysine (0.890%) and leucine (0.596%) were the most abundant essential amino acids in this species. Lysine plays a crucial role in protein synthesis, calcium absorption, and collagen formation, while leucine is essential for muscle growth and repair **(Khemis *et al.*, 2019)**. These values are comparable to those reported in Bangladesh (lysine: 0.92%, leucine: 0.60%) **(Akter *et al.*, 2021)**. This amino acid composition of *A. testudineus* is reported to be comparable to that of other freshwater fish species like tilapia and catfish, which are recognized for their high nutritional quality **(Abdelhamid *et al.*, 2021)**. This highlights the potential of *A. testudineus* as a viable source of protein in both aquaculture feed formulations and human diets.

Despite the favorable amino acid balance, the relatively low concentration of methionine (0.140%)—a common limiting amino acid in freshwater fish that can affect the overall protein quality index of *A. testudineus* **(Khemis *et al.*, 2019)**—is notably lower than the 0.22% reported in Malaysian populations **(Priyatha & Chitra, 2022)**. Supplementation with methionine-rich feed ingredients, such as soybean meal or fishmeal, is therefore recommended in aquaculture systems to improve protein quality and growth performance. Because of this limitation, it is suggested that supplementary dietary sources may be necessary when utilizing this fish extensively in aquaculture or as a staple food; deficiencies in specific amino acids may require dietary complementation for optimal health benefits **(Lau *et al.*, 2021)**.

In terms of non-essential amino acids, *A. testudineus* contains notable levels of aspartate (1.048%) and alanine (0.598%), both of which contribute to the umami flavor profile associated with this fish **(Khemis *et al.*, 2019)**. The presence of these amino acids may enhance the sensory appeal of *A. testudineus*, making it potentially more appealing in culinary applications. Additionally, the high concentrations of these and other amino acids may be an adaptive response to the nutrient-poor environments typical of the species' habitat in nutrient-limited ecosystems.

To conclude, the nutritional analysis of *A. testudineus* suggests it holds promise as a protein source, particularly through its favorable amino acid profile. However, careful consideration of its methionine content informs the need for dietary strategies to ensure nutritional completeness when incorporating this fish into aquaculture or human diets. This relation to the ecological context of the species further underscores its potential and highlights avenues for further research into sustainable fish farming practices.

Fatty acid profile and health implications

The fatty acid profile of *Anabas testudineus* exhibits significant nutritional characteristics, including high levels of oleic acid (31.69%) and palmitic acid (23.76%). It is essential to note that the dominance of monounsaturated fatty acids (MUFAs) at approximately 48.82% is particularly beneficial, as MUFAs have been associated with improved cardiovascular health and a reduced risk of metabolic syndrome **(Lee *et al.*, 2019)**. The fatty acid profile was dominated by oleic acid (43.24%) and palmitic acid (23.76%), consistent with values reported in Bangladesh where oleic acid ranged from 40–45% and palmitic acid from 22–24% **(Akter *et al.*, 2021)**. Oleic acid, as a key component of the Mediterranean diet, underscores the potential of *A. testudineus* as a functional food source in rural communities **(Lee *et al.*, 2019)**. This aligns with findings that highlight the beneficial effects of MUFAs on various health metrics, including lipid profiles and cardiovascular outcomes **(Lee *et al.*, 2019)**.

Furthermore, while the measured levels of polyunsaturated fatty acids (PUFAs) in *A. testudineus* are relatively low, it is noteworthy that this species does contain long-chain omega-3 fatty acids such as eicosapentaenoic acid (EPA, 2.02%) and docosahexaenoic acid (DHA, 1.12%) **(Akter *et al.*, 2021)**. Although these concentrations are lower than what is typically found in marine species such as mackerel or sardines, their presence in a freshwater fish is significant, suggesting a unique ecological adaptability. This may stem from the species' feeding habits in nutrient-rich peatland habitats, where microalgae and detritus serve as dietary sources of these omega-3 fatty acids **(Akter *et al.*, 2021)**. Fish species like *A. testudineus* illustrates the biodiversity of freshwater ecosystems and the beneficial nutritional qualities they can offer.

Research on the fatty acid profiles of various fish suggests that the ecological context plays a crucial role in determining their nutritional composition **(Akter *et al.*, 2021)**. In this vein, the fatty acid profile of *A. testudineus* sheds light on the ecological uniqueness of fish from peatland drainage systems, as these environments may differ significantly from conventional freshwater habitats, affecting not only their amino acid but also lipid profiles through the dietary sources available to them **(Akter *et al.*, 2021)**.

In conclusion, the fatty acid profile of *Anabas testudineus* shows promising nutritional value due to its favorable presence of MUFAs and beneficial omega-3 fatty acids. This profile can contribute positively to human diets and public health, particularly in developing rural communities. However, it emphasizes the significance of understanding the ecological factors that influence these nutritional compositions, paving the way for future studies on sustainable aquaculture and the potential for *A. testudineus* as a health-promoting food source.

Ecological and comparative perspectives

When *Anabas testudineus* is compared to other freshwater species such as the Nile tilapia (*Oreochromis niloticus*) in Southeast Asia, it distinctly demonstrates a unique

biochemical profile, particularly in terms of lipid metabolism. Studies show that *A. testudineus* exhibits different levels of fatty acids compared to the Nile tilapia; however, specific comparisons of monounsaturated (MUFAs) and polyunsaturated fatty acids (PUFAs) between these species are not well-supported in the literature. While it is noted that different species exhibit varied fatty acid profiles due to ecological factors such as habitat conditions, nutritional availability, and metabolic pathways, further research is needed to allow definitive claims about specific ratios of MUFAs and PUFAs in *A. testudineus* compared to the Nile tilapia **(Priyatha & Chitra, 2022)**.

The presence of MUFAs in *A. testudineus* may relate to its adaptation to the challenging environments of peatland waters, which are characterized by acidity and low oxygen levels. This adaptation allows the species to thrive in waters where many fish might find it difficult to survive, thus linking its biochemical profile to specific ecological conditions **(Hanafie *et al.*, 2023)**. Conversely, any claims regarding the lower levels of PUFA in *A. testudineus* and their implications for protein and essential fatty acid intake must be substantiated with direct evidence from relevant studies assessing dietary intake and fatty acid biosynthesis **(Veettil *et al.*, 2024)**.

Continued exploration into the trophic ecology of the climbing perch, including its feeding habits and the context of its biochemical profiles as influenced by peatland aquatic systems, remains essential. While existing literature indicates that fish in nutrient-limited ecosystems can exhibit variable diets, the specific role of PUFA in their diets, particularly for *A. testudineus*, requires further elucidation to clarify its ecological significance **(Shi *et al.*, 2024)**.

In summary, the biochemical profile of *Anabas testudineus* potentially reveals significant ecological and metabolic adaptations compared to other freshwater species like the Nile tilapia. A critical examination of these relationships, incorporating robust empirical data, may illuminate broader implications for maintaining fish health in aquaculture systems and enhancing understanding of species adaptation in challenging habitats. The findings underline the necessity for continued research that evaluates the complex interactions between this species and its unique peatland ecosystem.

Implications for food security and aquaculture

From a nutritional perspective, *Anabas testudineus* is indeed a valuable dietary resource for rural populations in Central Kalimantan, due to its amino acid profile and fatty acid composition, which contribute significantly to both protein quality and lipid nutrition. The amino acid profile provides a basis for evaluating protein quality, and amino acid scores (AAS) are commonly used to express nutritional value **(Öztekin *et al.*, 2020)**. However, the deficiencies in methionine and the relatively low levels of polyunsaturated fatty acids (PUFAs) suggest that reliance solely on this fish may be insufficient for meeting all dietary needs. Therefore, a diversified diet or

supplementation—possibly with oilseed meals or other PUFA-rich sources—could enhance nutritional outcomes **(Derbyshire *et al.*, 2024)**.

Additionally, while *A. testudineus* shows promise in small-scale aquaculture due to its robust nutritional properties and adaptability to diverse environments, specific challenges must be addressed. The methionine deficiency necessitates the formulation of feeds that compensate for this essential amino acid and enhance the PUFA content—critical for fish health and consumer nutritional needs **(Pratama *et al.*, 2020)**. Incorporating PUFA-rich ingredients could optimize the biochemical profile of *A. testudineus*, leading to better growth rates and health outcomes in cultured populations **(Lutfi *et al.*, 2022)**.

The ecological context of *A. testudineus* also plays a significant role in its biochemical composition. The nutrient availability in peatland systems, characterized by limited PUFA precursors, suggests a unique feeding ecology that impacts the overall lipid profile of the fish **(Ren *et al.*, 2022)**. Understanding this ecological specificity could guide strategies for improving the nutritional quality of *A. testudineus* for aquaculture, thus supporting rural communities that rely on this fish as a staple protein source. Further research into the trophic ecology of climbing perch and the dynamics of their biochemical profiles in peatland habitats is warranted to enhance our understanding of their nutritional benefits for aquaculture initiatives. In summary, the nutritional assessment of *Anabas testudineus* indicates its suitability as a dietary resource; nevertheless, it emphasizes the necessity for dietary diversification and supplementation in aquaculture programs. By addressing the biochemical challenges and leveraging its ecological adaptations, *A. testudineus* can significantly contribute to food security in rural populations. Future research should not only expand biochemical assessments of *A. testudineus* across different habitats and seasons but also consider the ecological pressures arising from non-native species introductions. The recent documentation of the Midas Cichlid (*Amphilophus citrinellus*) on Bangka Island **(Islamy *et al.*, 2025a)** and the first record of *Xiphophorus helleri* in the same region **(Islamy *et al.*, 2025b)** highlight the growing concern of invasive fishes in Indonesian inland waters. Monitoring the establishment, distribution, and ecological impacts of these species is essential, as they may compete with native fishes, disrupt trophic interactions, and indirectly influence the nutritional availability of local resources. Integrating nutritional studies of native species with ecological evaluations of invasive species will provide a more comprehensive framework for sustaining fisheries and food security in peatland and other vulnerable ecosystems.

Critical considerations

While this study provides valuable insights, several limitations must be acknowledged. First, the analysis was based on fish collected from a single location, and biochemical profiles may vary seasonally or across different peatland habitats. Second, the study quantified amino acids and fatty acids as percentages but did not assess total

protein or lipid content, which are important for evaluating the overall nutritional yield. Finally, the ecological drivers of biochemical variation in peatland fishes remain poorly understood, highlighting the need for integrative studies combining nutritional biochemistry, ecology, and aquaculture.

CONCLUSION

This study demonstrated that the climbing perch (*Anabas testudineus*) inhabiting peatland drainage waters in Central Kalimantan possesses a favorable nutritional profile characterized by a balanced composition of essential and non-essential amino acids, alongside beneficial fatty acids. Lysine and leucine were the dominant essential amino acids, while aspartate and alanine were the major non-essential amino acids, supporting its role as a high-quality protein source. The fatty acid profile was dominated by oleic and palmitic acids, with significant proportions of monounsaturated fatty acids (MUFAs), and detectable though modest levels of long-chain omega-3 fatty acids (EPA and DHA).

Importantly, this is the first report describing the amino acid and fatty acid composition of *A. testudineus* from Indonesian peatland drainage waters, thereby filling a critical regional knowledge gap. These findings provide baseline biochemical data that can guide aquaculture development in peatland regions, inform dietary enrichment strategies to address methionine and PUFA deficiencies, and contribute to food security initiatives for rural communities. Future studies should investigate seasonal variations, habitat influences, and feed interventions to further optimize the nutritional potential of this ecologically resilient species.

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