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NUTRITIONAL PROPERTIES AND FATTY ACID PROFILE OF COCONUT CRAB *BIRGUS LATRO* (DECAPODA: ANOMURA: COENOBITIDAE) FROM NORTH MALUKU, INDONESIA

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Abstract

The Coconut Crab or Robber Crab (*Birgus latro*, Linnaeus, 1758) is a terrestrial giant hermit crab belonging to a monospecific genus within the Coenobitidae (Anomura). Research on nutritional properties and amino acid composition of this species in the Luwo Island region is still very limited. This study presents a comprehensive analysis of the proximate and fatty acid compositions of coconut crabs (*B. latro*) at different developmental stages, namely juvenile, adolescent, and adult. Proximate analysis reveals variations in moisture content, protein, fat, ash, and carbohydrates, providing insights into the nutritional profile of these crustaceans. Fatty acid analysis highlights the dynamic presence of saturated and unsaturated fatty acids, with notable fluctuations in specific fatty acid types across developmental stages. The results indicate that juveniles exhibit lower moisture but higher levels of ash, protein, and fat, suggesting distinct nutritional requirements during early development. Adolescents display potential adaptations in response to changing dietary and physiological needs as they transition into adulthood. Conversely, adults demonstrate higher moisture and ash content, indicating potential differences in dietary habits or metabolic processes in mature coconut crabs. The testing of fatty acid content revealed the presence of 8 types of fatty acids, consisting of 5 saturated fatty acids (C_{10}, C_{12}, C_{14}, C_{16}, and C_{18}) and 3 natural unsaturated fatty acids ($C_{18:1n}^{-9}$, $C_{18:2n}^{-6}$, and $C_{18:3n}^{-9}$). The findings suggest that the nutritional composition of coconut crabs undergoes significant changes throughout their life cycle, reflecting potential metabolic and dietary adaptations. Understanding these variations is essential for assessing the nutritional value and potential applications of coconut crabs in the food industry. Further research is warranted to explore the underlying factors influencing these compositional changes and to elucidate the health implications of consuming coconut crabs at different stages of development.

Keywords: Birgus latro, Coconut Crab, Decapoda, Fatty Acid, Nutrition, Proximate.

INTRODUCTION

The Coconut Crab or Robber Crab (*Birgus latro*, Linnaeus, 1758) is a terrestrial giant hermit crab belonging to a monospecific genus within the Coenobitidae (Anomura) (Drew et al., 2010; Krieger et al., 2012; Yorisue et al., 2020). This species is known as the "coconut crab" due to its habit of feeding on coconuts, fruits, and other organic matter (Knaden et al., 2019; Terry & Thaman, 2020). It is the largest living terrestrial arthropod with individuals recorded weighing up to 4 kg and a carapace width of 200 mm (thorax length about 78 mm) (Davie, 2021; Forth, 2019). Like its close relatives in the genus Coenobita, the early juvenile stages of *B. latro* carry

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a shell for protection; however, at a size of about 10 mm thoracic length, the thorax and pleons ossify, and the crab no longer relies on the shell for protection (Drew et al., 2010; Hamasaki et al., 2018; Ohashi et al., 2019).

B. latro is widespread on remote tropical islands in the Indian and Pacific Oceans (Manurung et al., 2017; Cumberlidge et al., 2022). Coconut crabs can be found in the tropics, including around the islands of Indonesia, one of which is Luwo Island, North Maluku (Kelly et al., 2017; Rasulu et al., 2022). Coconut crab (*B. latro* L.) or in the North Maluku language called Ketam Kelapa is one of the biological natural resources that has high economic value. People consume coconut crab dishes that have a taste similar to lobster, but have a distinctive advantage because this animal consumes coconut meat (Rasulu et al., 2022).

Although coconut crab has been the focus of previous studies, research on proximate analysis and amino acid composition of this species in the Luwo Island region is still very limited. Therefore, this study aims to determine the proximate analysis and amino acid composition of coconut crab (*B. latro*) found in Luwo Island, North Maluku, Indonesia.

Information on the nutritional composition of coconut crabs from this region can provide valuable insights into the resource potential and sustainability of this species. Proximate analysis will provide an understanding of the macronutrient content (Okunlola et al., 2018; Pratama et al., 2020) such as protein, fat, carbohydrate, fiber and water content in coconut crabs. On the other hand, the amino acid composition study will provide detailed information on the saturated and unsaturated fatty acid profiles that can provide a deeper insight into the fat quality of coconut crabs from Luwo Island. This study is expected to make a significant contribution to the scientific understanding of the nutrition of this species, as well as provide a basis for sustainable management and wise utilization of the coconut crab population in Luwo Island and its surroundings.

MATERIAL AND METHODS

Ethics statement

The present study was performed in strict accordance with the Standard Operation Procedures of the Guide for Use of Experimental Animals of Khairun University. The experimental protocol and procedures were approved by the Institutional Animal Care and Use Committee of Khairun University.

Study area

This research was conducted in November 2022. Sampling of test animals (*B. latro*) was carried out on Liwo Island, Central Halmahera Regency, North Maluku, Indonesia (Figure 1), for 3 weeks.

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Figure 1: Sampling Location in Liwo Island, Central Halmahera Regency, North Maluku, Indonesia

Sample collection

Samples of coconut crabs (*B. latro*) (Juvenile (J) with thorax length < 10 mm; Adolescent (A) with thorax length ≤ 24.5 mm; and Adult (D) with thorax length ≥ 24.5 mm) were collected from their habitat in Liwo Island, Central Halmahera Regency, each with 15 individuals for proximate tests and 5 individuals for fatty acids. Capture was assisted by local fishermen using the hand-catching method. The participation of local fishers in nature capture can provide many benefits. They have in-depth local knowledge of specific ecosystems and species, which can provide valuable insights to researchers and conservationists.

Sample handling

Coconut crab (*B. latro*) samples were caught and then taken to the field laboratory of the Faculty of Fisheries and Marine Science, Khairun University in Ternate. Here the samples were killed by the ice anesthesia method (cold temperature). After limping and dying the samples were then stored in a frezzer for follow-up. Before being sent to the Fish Nutrition Laboratory of the Faculty of Fisheries and Marine Science, Bogor Agricultural University, samples were oven dried at 80ºC for 24 hours. In the Fish Nutrition Laboratory of IPB University Bogor, the samples were then subjected to proximate analysis and fatty acid profile of coconut crab (*B. latro*).

Proximate Analysis

Proximate analysis of test animals was conducted to see the chemical composition of the test animals (*B. latro*). Proximate analysis used a modified method from a published article (Uduak & Hadiza, 2020; Latimer, 2023). Each sample was properly washed and cleaned to remove all adhering extraneous materials. The meat was removed with utmost care and transferred to a petridish. The following methods were employed for estimating the proximate composition of protein, lipid, carbohydrate, moisture content, dry weight and total ash (Lyla et al., 2017).

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Fatty Acid Profile Analysis

The fatty acid profiles of coconut crab tissues were determined using published methods (Sun et al., 2019) with minor modifications. The freeze-dried samples (approximately 80 mg hepatopancreas and 120 mg muscle) were added to 12 ml volumetric glass screw cap tubes (teflon gasket); 3 ml potassium hydroxide in methanol (1 N) was added and heated at 72°C in a water bath for 20 min. After cooling, 3 ml of 2 m-HCl in methanol was added and the mixture heated at 72°C in a water bath for 20 min. Finally, 1 ml hexane was added to the mixture, shaken vigorously for 1 min and then allowed to separate into two layers. Fatty acid methyl esters were separated and identified by GC-MS (Agilent technologies 7890B-5977A) as detailed fully in published method (Balzano et al., 2017; Nguyen et al., 2020). Results were expressed as relative percentages of each fatty acid, calculated as the proportion of the area under the considered peak to the total area of all peaks.

Data Analysis

The results of the treatment of the tested parameters were analyzed by variance (ANOVA). Treatments that significantly affected the test parameters were continued with the least significant difference (LSD) test. As a statistical tool, the program package SPSS version 15.0.

RESULT AND DISCUSSION

Proximate analysis

Proximate analysis was conducted on *B. latro*, commonly known as the coconut crab, to assess the percentage composition of key nutritional components across different age groups. The analysis included parameters such as moisture content, ash, protein, fat, carbohydrate, crude fiber, and BETN (presumably nitrogen-free extract). Three distinct age groups, labeled as Juvenile (J), Adolescent (A), and Adult (D) were examined. The results revealed notable variations in the proximate composition (table 1).

In the juvenile age group (J), the coconut crabs displayed a moisture content of 3.36 ± 0.18%, ash content of 37.17 ± 0.26%, protein content of 33.71 ± 0.17%, fat content of 13.03 ± 0.21%, carbohydrate content of 12.59 ± 0.16%, crude fiber content of 0.14 ± 0.18%, and BETN of 0.14 ± 0.18%. This age group exhibited a relatively lower moisture content but higher levels of ash, protein, and fat, indicating a different nutritional profile compared to the other age groups.

In the Adolescent age group (A), the coconut crabs showed an increase in moisture content to 10.58 ± 0.16%, higher ash content at 44.85 ± 0.19%, protein content of 34.67 ± 0.22%, lower fat content at 2.83 ± 0.19%, carbohydrate content of 6.12 ± 0.24%, crude fiber content of 0.98 ± 0.25%, and BETN of 0.98 ± 0.25%. This shift in nutritional composition suggests a potential adaptation to the changing dietary and physiological needs of the crabs as they transition into adulthood. In the adult group (D), coconut crabs exhibited further changes in proximate composition, with a moisture content of 17.67 ± 0.13%, ash content of 40.86 ± 0.21%, protein content of 30.6 ± 0.21%, fat content of 3.1 ± 0.18%, carbohydrate content of 6.96 ± 0.21%, crude fiber content of 0.82 ± 0.22%, and BETN of 0.82 ± 0.22%. This age group demonstrated

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a higher moisture content and ash content, possibly indicative of distinct dietary habits or metabolic processes in mature coconut crabs. In summary, the proximate analysis of *B. latro* across different age groups provides valuable insights into the variations in their nutritional composition, shedding light on potential physiological adaptations and dietary preferences as these coconut crabs progress through different life stages.

Table 1: Proximate analysis of *B. latro* during the research

Age Group	Moisture	Ash	Protein	Fat	Carbohydrate	
					Crude Fiber	BETN
J	3.36 ± 0.18$_a$	37.17 ± 0.26$_a$	33.71 ± 0.17$_a$	13.03 ± 0.21$_a$	12.59 ± 0.16$_a$	0.14 ± 0.18$_a$
A	10.58 ± 0.16$_b$	44.85 ± 0.19$_b$	34.67 ± 0.22$_a$	2.83 ± 0.19$_b$	6.12 ± 0.24$_b$	0.98 ± 0.25$_b$
D	17.67 ± 0.13$_c$	40.86 ± 0.21$_b$	30.6 ± 0.21$_a$	3.1 ± 0.18$_b$	6.96 ± 0.21$_b$	0.82 ± 0.22$_b$

Note: Notations accompanied by the same letters are not significantly different in each parameter.

The juvenile age group (J) displayed a distinct nutritional profile characterized by a relatively lower moisture content but higher levels of ash, protein, and fat compared to the other age groups. This unique combination of nutritional elements suggests that juvenile coconut crabs have specific dietary and metabolic characteristics that differentiate them from their counterparts in other age categories. The lower moisture content implies a reduced water component in their composition, possibly reflecting a concentration of essential nutrients (Ahmed et al., 2022; Francesch & Brufau, 2004). In contrast, the higher levels of ash, protein, and fat suggest a more substantial presence of minerals, proteins, and lipids in the juvenile crabs (Andrée et al., 2023; Kumari et al., 2017; Wilson et al., 2017). These findings indicate potential adaptations to the specific developmental and growth requirements of this age group.

The nutritional analysis of the adolescent age group (A) in coconut crabs (*B. latro*) implies a potential adaptation to the evolving dietary and physiological requirements as the crabs undergo the transition into adulthood. The observed changes in nutritional composition during the adolescent stage suggest a dynamic response to the developmental shifts and metabolic demands associated with the maturation process (Norris et al., 2022; Shi et al., 2018). These adaptations may include adjustments in the levels of moisture, ash, protein, and fat to meet the specific needs for growth, reproductive development, and overall maturation (Anger, 1996; Li et al., 2021). The significance of these nutritional variations in the adolescent stage underscores the complexity of the physiological changes occurring during this crucial period in the coconut crab life cycle (Hidir et al., 2018). Further exploration of these adaptations can contribute to a deeper understanding of the species' biology and potentially inform conservation practices or sustainable management strategies, especially in the context of their unique ecological roles and significance. The nutritional analysis of the adult age group (D) in coconut crabs (*B. latro*) reveals distinctive characteristics, notably a higher moisture content and ash content. These findings suggest the likelihood of distinct dietary habits or metabolic processes in mature coconut crabs. The elevated moisture content may indicate specific hydration needs or dietary preferences unique to the adult stage of development (Aaqillah-Amr et al., 2021; Hidir et al., 2018; Jiang et al., 2020). Additionally, the increased ash content points towards a higher

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concentration of minerals (De Morais et al., 2016; Uduak & Hadiza, 2020; Verma & Srivastav, 2017), potentially reflecting variations in dietary sources or metabolic activities associated with maturity (Wu et al., 2019). These nutritional nuances in the adult stage shed light on the complex physiological adaptations that occur in mature coconut crabs (Anger et al., 2020; Watson-Zink, 2021). Understanding these distinct dietary and metabolic features can be crucial for both ecological research and practical applications in areas such as conservation, where tailored management strategies may be necessary to support the unique nutritional requirements of adult coconut crabs. Further investigation into the specific factors influencing these nutritional patterns can contribute to a more comprehensive understanding of the species and its role in its ecosystem.

Fatty Acid Profile Analysis

The testing of fatty acid content in coconut crabs (*B. latro*) from Liwo Island revealed the presence of 8 types of fatty acids (Table 2), consisting of 5 saturated fatty acids (C10, C12, C14, C16, and C18) and 3 natural unsaturated fatty acids (C18:1n-9, C18:2n-6, and C18:3n-9). In contrast to the findings of published research (Sato et al., 2015, 2016), a greater variety of fatty acids, specifically 25 types, were identified in male and female coconut crabs from Hatoma Island in Japan. Among these 25 fatty acids, there were 9 saturated fatty acids (C12, C14, C15, C16, C17, C18, C20, C22, and C24), 5 single-bonded saturated fatty acids (C16:1, C18:1, C20:1, C22:1, and C24:1), as well as 11 unsaturated fatty acids (C18:2n-6, C18:3n-3, C20:2n-6, C20:3n-3, C20:3n-6, C20:4n-6, C20:5n-3, C20:5n-3, C21:5n-3, C22:5n-3, C22:5n-6, C22:6n-3). This variation could be attributed to the use of different measurement methods, with Sato et al. employing gas chromatography (GC-17, Shimadzu, Kyoto, Japan), allowing for the detection of a greater number of fatty acids.

Table 2: Fatty Acid Profile of coconut crab (*B. latro*) in different stage during the research

Parameter	Stage of Coconut Crab Sample		
	Juvenil	Adolescent	Adult
Average Saturated fatty acids (%)			
Caprylate (C_8)	Undetected	Undetected	Undetected
Decanoic acid (C_{10})	Undetected	2.18 ± 0.32	1.89 ± 0.11
Laurate (C_{12})	20.9 ± 0.12	4.01 ± 0.21	3.11 ± 0.3
Mirisat (C_{14})	11.56 ± 0.23	12.21 ± 0.25	11.97 ± 0.21
Palmitate (C_{16})	12.85 ± 0.21	13.32 ± 0.22	12.01 ± 0.22
Stearate (C_{18})	6.00 ± 0.16	1.24 ± 0.13	1.36 ± 0.25
Average Unsaturated fatty acids (%)			
Oleat ($C_{18:1n}^{-9}$)	36.25 ± 0.11	33.87 ± 0.12	35.13 ± 0.11
Linoleat ($C_{18:2n}^{-6}$)	2.24 ± 0.22	3.12 ± 0.24	3.75 ± 0.32
Linolenat ($C_{18:3n}^{-9}$)	0.18 ± 0.24	0.48 ± 0.24	0.51 ± 0.26

Note:

Throughout the developmental stages of coconut crabs (*B. latro*), including juvenile, adolescent, and adult phases, there are discernible variations in their fatty acid composition. The comprehensive analysis conducted on these crabs highlights the presence of a diverse array

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of both saturated and unsaturated fatty acids in their lipid profile. This intricate balance of fatty acids is indicative of the physiological changes and dietary adaptations that occur as coconut crabs progress through different life stages. Understanding these variations in fatty acid composition is crucial for gaining insights into the nutritional aspects and metabolic processes associated with the growth and maturation of *B. latro*.

Among the saturated fatty acids, Laurate (C_{12}) is notably present in relatively high percentages in juvenile coconut crabs (20.9 ± 0.12%), decreasing as the crabs progress through adolescence (4.01 ± 0.21%) and adulthood (3.11 ± 0.3%). On the other hand, Mirisat (C_{14}) remains consistently present in moderate amounts across all stages, with values of 11.56 ± 0.23%, 12.21 ± 0.25%, and 11.97 ± 0.21% for juvenile, adolescent, and adult stages, respectively. The levels of Palmitate (C_{16}) and Stearate (C_{18}) also vary among the stages.

In terms of unsaturated fatty acids, Oleat ($C_{18:1n}{}^{-9}$) constitutes a significant portion in all stages, with percentages of 36.25 ± 0.11%, 33.87 ± 0.12%, and 35.13 ± 0.11% for juvenile, adolescent, and adult stages, respectively. The presence of Linoleat ($C_{18:2n}{}^{-6}$) and Linolenat ($C_{18:3n}{}^{-9}$) is observed, albeit in smaller quantities compared to Oleat. These unsaturated fatty acids display some fluctuation across the developmental stages.

Interestingly, the analysis indicates the absence of Caprylate (C_8) and Decanoic acid (C_{10}) in all stages of coconut crab development. These findings suggest a dynamic shift in the fatty acid composition of *B. latro* throughout its life stages, reflecting potential physiological and dietary changes during growth and maturation.

CONCLUSION

In conclusion, the variation in these proximate components across different developmental stages can be indicative of the metabolic changes and dietary preferences of the coconut crabs as they mature. Additionally, the fatty acid analysis reveals a dynamic composition of both saturated and unsaturated fatty acids in coconut crabs. The specific fatty acid profiles at various stages, such as the prevalence of Laurate (C_{12}) in juvenile crabs and the consistent presence of Oleat ($C_{18:1n}{}^{-9}$) across all stages, shed light on the potential physiological and dietary factors influencing the lipid composition of *B. latro*. These findings are crucial for not only understanding the nutritional value of coconut crabs but also for informing potential applications in the food industry and dietary recommendations. The variations observed in proximate and fatty acid composition underscore the need for continued research to explore the factors influencing these changes and to further elucidate the health implications of consuming coconut crabs at different stages of development.

Author Contributions

MAM Research design, Collect data, analysis data and preparation manuscript.

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