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The Characteristics of Mole Crabs (Anomura: Hippidae) and Their Nutritional Composition From the Waters of Rutah Villages, Central Maluku Regency, Indonesia

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ABSTRACT

This study aimed to determine the physical characteristics and nutritional value of mole crabs (Anomura: Hippidae) from the waters of Rutah Village, Central Maluku. Sample testing performed on fresh Mole Crabs included species identification, substrate temperature, pH, salinity, morphometric, fatty acid, and amino acid profiles measurements. Meanwhile, the proximate test was carried out on fresh and processed mole crabs, namely fried, steamed and grilled. The results showed that mole crabs from the waters of the coast of Rutah identified threes species of mole crab, namely *Hippa ovalis*, *Hippa adactyla* and *Hippa marmorata* with varying color characteristics and body size. The dominant color is grayish-black. The average length of the carapace was 1.88cm; the width of the carapace was 1.08cm, while the body weight was 1.90 grams with a negative allometric growth pattern (b< 3). For the substrate, ranges of water temperature, Ph and salinity were recorded with 26.9-27.3ºC, 7.7-7.8 and 32-34ppt, respectively. Fresh sea retreats from Rutah beach contain 13 types of amino acids consisting of 5 types of essential amino acids, 2 semi-essential and 6 non-essential acids with the highest essential amino acid, namely leucine at 7.92%. It contains 11 types of fatty acids consisting of 7 types of saturated fatty acids and 4 unsaturated fatty acids with the highest unsaturated fatty acid, namely oleic acid of 7.53%. Mole crabs that are processed by frying, steaming, and grilling undergo changes in nutritional value from fresh seafood; water and carbohydrate content decreases, fat and protein levels increase, while ash levels fluctuate.

INTRODUCTION

Mole crabs have long been used as a food ingredient by the coastal communities on the southern coast of Java Island, starting from the coast of Yogyakarta, Kebumen to Cilacap. Even people living on the coast of Sodong beach and Bunton beach in Cilacap Regency have long depended on their livelihood as fishermen, processors and sellers of mole crab-based food such as mole crabs fried flour, fried crispy and rempeyek

(Wardiatno *et al.*, 2014). Likewise, the people on the coasts of Widarapayung and Wetan, Cilacap Regency. Mole crabs have been used as souvenirs typical of the region that are traded such as rempeyek snacks, fried noodles **(Kristiningsih *et al.*, 2023a)**, chips and rica-rica **(Kristiningsih *et al.*, 2023b)**. Three species of mole crabs that are commonly used include *Emerita emeritus*, *Hippa adactyla*, and *Albunea symmysta*. *Emerita emeritus* is a mole crab that is often consumed and traded because it tastes better and savory than other species. Meanwhile, mole crabs of the *Hippa adactyla* and *Albunea symmysta* are only used as bait for fishing **(Kristiningsih *et al.*, 2023b)**. On the coast of Sodong and Bunton, Cilacap Regency, mole crabs are generally from the genus *Emerita* **(Wardiatno *et al.*, 2014)**.

In Maluku, mole crabs are only used as food ingredients by a small number of coastal communities. In Seilale Village, Nusaniwe District, Ambon Island, mole crabs (called "hotong") are processed by grilling or burning using skewers or thin wood, stir-fried with kang vegetables, or fried. The regressions used are from the species of *Hippa ovalis*, *H. marmorata* and *H. celaeno* **(Silaban *et al.*, 2020)**. In Elpaputih Village, West Seram District, Central Maluku Regency, mole crabs are processed by boiling, frying and burning. The regressions that are used are from the species of *Emerita emeritus*. In Rutah Village, Amahai District, Central Maluku Regency, the use of mole crabs is still very limited to being consumed by being baked using makeshift equipment by children who play on the beach. The utilization carried out is only limited to community habits that have been going on for generations, depending on the knowledge of the community to process. The distribution of the species, nutritional composition and utilization of mole crabs in the Maluku area, especially in the waters of Rutah coast is also not widely known and researched. Research on the utilization of mole crabs is still limited to crispy fried backward **(Silaban *et al.*, 2020)**, stick snacks **(Silaban & Nanlohy, 2022)**, and sambal roa **(Riyanto *et al.*, 2023)**. On the other hand, mole crabs are known to be a source of nutritious food for the community, especially for children who are still in the growth period, especially protein, omega 3 and omega 6, vitamins and minerals **(Hanifa, 2014; Santoso *et al.*, 2015; Silaban *et al.*, 2020; Riyanto *et al.*, 2023)** but the composition varies depending on the species, origin of the waters and the processing method carried out. This study aimed to determine the physical characteristics and nutritional value of mole crabs from the Rutah waters of Central Maluku with several processing methods as the first step in the use of mole crabs.

MATERIALS AND METHODS

The equipment used in this study includes buckets, styrofoam, a multi-tester, refractometer, analytical balance, caliper, knife, frying pan, pot, stove, strainer, grilling tools, stopwatch, tongs, porcelain crucibles, oven, desiccator, beakers, Erlenmeyer flasks, Kjeldahl flasks, nitrogen distillation apparatus, Soxhlet extraction apparatus, hotplate, burette, stand, furnace, HPLC (High-Performance Liquid Chromatography), and GC (Gas Chromatography). The materials used in this study include fresh sand crabs (*Hippa adactyla*) from the waters of Rutah beach, Amahai District, Central Maluku Regency, PE plastic, ice, water, coconut oil, skewers, coconut shell charcoal, distilled water, H_2SO_4, Na_2SO_4, H_3BO_3, HCl, $CuSO_4$, Tashiro indicator, and petroleum benzine.

The method used in this study was the experimental method. The research was conducted in July 2023. Sampling was carried out along the coast of Rutah beach, Amahai District, Central Maluku Regency. Samples were collected using a free collection method, with the assistance of local residents experienced in catching sand crabs. This process was conducted consecutively over four days. During each sampling event, water quality parameters such as temperature, pH, and salinity were measured.

On the first day, samples were collected for morphological identification and morphometric measurements. From the second to the fourth day, samples were taken for proximate analysis and processing. The collected sand crabs were cleaned, labeled in plastic bags, and frozen. They were then placed in styrofoam containing crushed ice for transport to the laboratory. Samples were sorted by species, and the most abundant species was selected for nutritional composition analysis, from the fresh state to processed products such as fried, steamed, and grilled. *Hippa adactyla* was the most abundant species compared to the other two, making it the focus of this study. Approximately, 950 grams or around 500 individuals of *Hippa adactyla* were used for both fresh and processed composition analysis.

The processing of the mole crabs was carried out using a modified version of the methods from **Silaban (2024)**, which includes the following steps:

1. **Frying:** Submersion frying for 1.5 minutes in oil at a temperature greater than 120°C.
2. **Steaming:** Steaming in a stainless-steel steamer for 16 minutes at 95°C.
3. **Grilling:** Grilling over coconut shell charcoal at 50°C for 2.5 minutes.

For the fresh samples, proximate analysis, amino acid analysis, and fatty acid analysis were performed, while only proximate analysis was carried out for the processed samples.

Morphological identification, morphometric measurements, and proximate analysis of both fresh and processed samples were conducted at the Laboratory of Fishery Products Technology, Faculty of Fisheries and Marine Science, Pattimura University, Ambon. Fatty acid and amino acid analyses of the fresh samples were carried out at the Integrated Chemistry Laboratory, Bogor Agricultural University.

The morphological identification of the mole crabs referred to **Boyko and Harvey (1999)** and **Osawa and Chan (2010)**, with confirmation using the WoRMS (World Register of Marine Species) website. Proximate measurements included moisture, ash, fat, and protein content following the method of **AOAC (2012)**; carbohydrates were calculated by difference; cooking loss was determined using the method of **Syukroni and**

Santi (2021); fatty acids were analyzed by gas chromatography (Shimadzu) following **AOAC (2012)**, and amino acids were analyzed using HPLC (Shimadzu) following **AOAC (2012)**.

Data analysis

Morphometric measurements of the relationship between length and weight of mole crabs using the method of **Tanja *et al*. (2022)** as cited in **Silaban (2023)** with the formula $W= aL^b$, where: W is the total weight (g); a and b are constants, while L is the length of the carapace (cm). The relationship between length gain (L) and weight gain (W) was analyzed using a simple linear regression derived from the basic regression mentioned above, namely: $\text{Log } W = \log a + b \log L$. The parameter correlation of the weight length relationship can be seen from the value of the constant b, namely: Value b = 3, isometric growth pattern or length increase is balanced with the increase in weight. The value of $b \neq 3$ describes the allometric growth pattern. If $b>3$, the allometric growth pattern is positive (dominant weight growth). Whereas, if $b<3$, the allometric growth pattern is negative.

Measurement of water and ash content by the oven method, protein by the Kjeldahl method, fat by the sokhlet method **(AOAC, 2012)**, carbohydrates using calculations by difference and shrink cooking using the **Syukroni and Santi (2021)** methods. Fatty acids use gas chromatography **(AOAC, 2012)** and amino acids use HPLC **(AOAC, 2012)**. The data from the analysis of mole crabs processing were analyzed by various fingerprint analysis (ANOVA), and if it showed a real effect, it was continued with the Duncan test at the level of 1 and 5%. The data obtained were then compared with the literature and presented in the form of tables.

RESULTS AND DISCUSSION

1. Physical characteristics of mole crabs from the waters of Rutah beach

Based on the results of the identification of mole crabs found in the coastal waters of Rutah, there are 3 species, namely: *Hippa ovalis*, *Hippa adactyla* and *Hippa marmorata*. Mole crabs from the waters of Rutah have the characteristics of carapace color and varying body size. The colors of the mole crabs carapace found include: grayish-black, blackish-gray with white spots and orange with brown spots with the dominant color being grayish-black, followed by gray with white spots and orange with spots. Based on the observation results, the existence of mole crabs is almost found on all coasts with sand substances as far as ± 100 meters. The characteristics of the sand are mostly black, while only a small part is brown. Thus, the color characteristics of the sand substrate also affect the color of the carapace of mole crabs in the waters of Rutah. In addition to the characteristics of the substrate, the different colors and shapes of the carapace indicate the presence of different types or species. Different body colors indicate a form of self-adjustment to the environment or habitat of the retreat. *Hippa adactyla* is the most common species compared to the other two species, thus it is the object of this study. *Hippa adactyla* has been widely found to be influenced by the grayish-black color of the sand substat. According to **Nugraha *et al.* (2018)**, differences in the species, and number of mole crabs can be caused by differences in physical adaptations such as waves and sediments. Rutah beach has strong coastal waves so that the size of sediment grains on the beach is easily variable or fluctuating because it is easily carried away by currents. Rutah beach is a shallow and sloping coastal type and does not have a large tidal area, and thus this water is always used as a place to catch mole crabs called kolekole for children or teenagers who live around the coast.

Mole crabs are typically caught by hand using a specific method: the sand is disturbed either vertically or horizontally with the feet, creating a small mound that causes the mole crabs to emerge quickly. Once they appear, they can be caught by hand. The collected mole crabs are usually placed in paint buckets (locally referred to as "boyo") filled with seawater and sand.

Mole crabs can be consumed directly on the beach or taken home. If consumed on the beach, the testosterone in the mole crabs is released to eliminate any unpleasant taste. They are then washed and drained. The mole crabs are skewered one by one with bamboo sticks that have been sharpened at the ends, and then grilled over coconut shell coals, turning them for about 10 minutes. They are considered done when their body color turns an even red.

Mole crabs are not consumed at all times; instead, they are enjoyed during specific moments to ensure their population remains sustainable. These crabs are most commonly found from April to July in the wet zone between the highest high tide and the lowest low tide. **Sarong and Wardiatno (2013)** noted that the color of the sand is a key characteristic indicating the presence of mole crabs as nesting sites. The substrate directly affects the composition and distribution of benthic animals, serving as a habitat and food source for many species. The substrate is also a crucial ecological factor that influences the abundance and structure of various biota.

Based on the results of measuring the quality of the substrate, it was observed that the water temperature of the substrate during the study ranged from 26.9-27.3ºC, pH 7.7-7.8 and salinity 32-34ppt (Table 1). This range is said to still be feasible for the life of macrozoobentos such as mole crabs. **Amin *et al*. (2023)** stated that the temperature range from 25-35^{0}C, pH 7-9 and salinity 15-35ppt is a normal range that can support macrozoobentos life. According to **Nugroho *et al.* (2018)**, mole crabs can live at temperatures ranging from 29-30^{0}C, pH 8 and salinity between 32-35ppt. From the results of the mophometric measurement (Table 2), it was found that the range of length and width of the carapace and the body weight of the mole crabs found ranged from 0.9-7.8cm, with an average value of 1.88cm; the width of the carapace ranged from 0.5-2.3cm, with an average value of 1.08cm, while the body weight ranged from 0.28-10.27g, with an average value of 1.90g. The results of the regression analysis between carapace length and body weight (Table 3) show that mole crabs from Rutah waters are negative allometric (b < 3) where the increase in carapace length is faster than the weight gain, meaning that the growth rate of mole crabs living in Rutah waters is not balanced.

Table 1. Measurement of environmental parameters in the waters of Rutah, Amahai District, Central Maluku Regency

Temperature (^{0}C)	pH	Salinity (‰)
27.05± 0.17	7.8 ± 0.03	32.5± 0.78

Table 2. Morphometric measurements of mole crabs (*Hippa adactyla)*

Parameters	Body size (n = 48)
Whole weight (g)	1.90 ± 1.89
Wide of carapace(cm)	1.08 ± 0.43
Length of carapace(cm)	1.88 ± 1.03

Table 3. The results of the regression analysis of the carapace (L) and body weight (W)

Types of mole crabs	Regression equation $W = a L^{b}$
Hippa adactyla	$0.4279^{2.064}$

The mole crabs found in the waters of Rutah beach during the study comprised three species: *Hippa ovalis*, *Hippa adactyla*, and *Hippa marmorata*. Among these, *Hippa adactyla* was the most abundant species, and thus it was selected for further study to analyze its chemical composition in both fresh and processed forms, focusing on changes that occur during processing. According to **Fitriyani *et al.* (2020)**, the chemical composition of marine products, such as proximate components, fatty acids, and amino acids, can vary significantly due to external and internal factors. External factors include habitat, season, food availability, and water quality, while internal factors involve species, age, gender, and reproductive phase. **Silaban (2023)** further noted that the chemical composition of different species can vary even when they inhabit the same environment. **Hanifa (2014)** also explained that processing methods can influence the nutritional value of aquatic products.

2. Amino acids and fatty acids composition of fresh mole crabs (*Hippa adactyla)*

The results of amino acid analysis in fresh mole crabs from the waters of Rutah beach identified as many as 13 types of amino acids. The diversity of amino acids consists of 5 types of essential amino acids, namely valine, phenylalanine, isoleucine, leucine and lysine; 2 semi-essentials, namely histidine, arginine and 6 non-essentials, namely aspartic acid, glutamic acid, serine, glycine, alanine, and tyrosine (Table 4). The highest essential amino acid is found in the amino acid leucine at 7.92%, the lowest is in the amino acid lysine at 2.32%. The highest non-essential amino acid content was found in glutamic acid at 18.60%, andthe lowest in the amino acid tyrosine at 3.41%. The amino acid lysine is a limiting amino acid found in fresh mole crabs. The average amino acid value of this study is higher than that of **Hanifa (2014**). According to **Abdullah *et al.* (2013)**, the high and low composition of fatty acids is influenced by several factors such as species, feed availability, age, habitat, and body size.

Leucine works alongside the amino acids isoleucine and valine to repair muscles, regulate blood sugar, provide energy reserves, increase growth hormone production, and help burn visceral fat located in the deepest layers of the body. In contrast, lysine serves as a fundamental component of blood antibodies, strengthens the circulatory system, and supports normal cell growth. Along with proline and vitamin C, lysine contributes to the formation of collagen tissue and helps lower excess blood triglyceride levels. According to **FAO (1985)**, the body's need for leucine is 0.93% while lysine is 0.66% **(Abdullah *et al.*, 2013)**. The presence of glutamate acid can provide savory taste characteristics to food and is beneficial in improving mental health, reducing depression and accelerating wound healing as well as restraining excessive alcohol consumption **(Fitriyani *et al.*, 2020)**. Glutamic acid is generally found in protein-containing foods such as fish, meat, milk and vegetables **(Putra *et al.*, 2020)**.

The analysis of fatty acids in fresh mole crabs from Rutah beach identified 11 different types of fatty acids. This diversity includes seven types of saturated fatty acids: laurate, myristate, palmitate, margarate, stearate, arachidate, and behenate. The four unsaturated fatty acids identified are palmitoleic, linoleic, oleic, and arachidonic (Table 5).

Among the saturated fatty acids, palmitic acid was found to be the highest at 13.48%, while arachidic and behenic acids were the lowest, each at 0.77%. For the unsaturated fatty acids, oleic acid was the highest at 7.53%, with arachidonic acid being the lowest at 1.07%. The levels of palmitic and oleic acids in this study are lower than those reported by **Hanifa (2014)**. According to **Abdullah *et al.* (2013)**, differences in fatty acid composition can be influenced by factors such as diet, size, gender, season, temperature, and habitat.

Table 4. Amino acid composition of fresh mole crabs (*Hippa adactyla*)

Asam amino (%)	Fresh mole crabs	
	(a)	**(b)**
Essential Amino Acids		
Valine	7.36	1.28
Phenylalanine	2.98	1.22
Isoleusin	3.76	1.06
Leucines	7.92	1.85
Lysine	2.32	1.58
Semi-Essential amino acids		
Histidine	0.77	0.52
Arginine	4.98	1.98
Non-Essential amino acids		
Acham Asparta	14.28	2.62
Glutamic acid	18.60	3.83
Cool	6.74	1.73
Glycine	5.42	1.25
Alanine	11.96	1.76
Tyrosine	3.41	1.06

Source: a) This Study, b) **Hanifa (2014)**

Palmitic acid is the most abundant saturated fatty acid found in foodstuffs. The presence of palmitic acid that is too high in meat products is undesirable because it is hyperlipidemic and can increase cholesterol in the body **(Fitriyani *et al.*, 2020)**. Palmitic acid with certain levels is used as a raw material for making soft soaps, shampoos and creams **(Putra *et al.*, 2020)**. Oleic acid (Omega 9) can play a role in inhibiting the production of ecosanaoid compounds in stimulating tumor growth. The presence of oleic acid in foodstuffs can be a source of energy and antioxidants in the body to inhibit cancer cells. In addition, oleic acid can function in lowering cholesterol levels and as a vitamin solvent. Lack of olets in the body can cause disorders in the brain cells of babies and fetuses, impaired eye vision and decreased memory **(Fitriyani *et al.*, 2020)**.

Table 5. Fatty acid composition of fresh mole crabs (*Hippa adactyla)*

Fatty acids (%)	**Fresh mole crabs**	
	(a)	**(b)**
Saturated fatty acids		
Laurat	0.86	0.28
Miristat	2.42	9.22
Palmitate	13.48	21.65
Margarat	1.09	-
Stearate	7.34	4.40
Arakhidat	0.77	0.26
Behenat	0.77	0.12
Unsaturated fatty acids		
Palmitoleat	3.57	18.31
Linoleat	2.30	0.54
Oleate	7.53	8.24
Arakhidonat	1.07	0.54

Source: a) This Study, b). **Hanifa (2014)**

3. Chemical composition of mole crabs (*Hippa adactyla)* fresh and processed

The results of the diversity analysis (ANOVA) showed that the content of water, ash, fat and protein in all treatments showed a significantly different effect at the level of 0.05. This difference is influenced by the processing process. The results of Duncan's further test (P<0.05) showed a clear difference between the treatments (Table 6). The water and carbohydrate content of fresh mole crabs is decreasing; the fat and protein levels are increasing, while the ash content fluctuates. Table (6) shows that the moisture content of fresh mole crabs is 79.17%. After steaming, it decreases to 75.12%, while baking reduces it further to 65.51%, and frying results in a moisture content of 27.69%. The ash content starts at 6.46% and increases after frying and baking to 9.74 and 9.90%, respectively, while it decreases to 6.25% after steaming.

The fat content begins at 2.2% and increases to 2.96% after steaming, 3.51% after baking, and significantly rises to 38.88% after frying. The protein content starts at 10.45% and increases to 14.04% after steaming, 22.31% after frying, and 23.53% after baking.

Based on the calculations, the carbohydrate content is initially 1.71% but decreases to 1.62% after frying, 1.36% after steaming, and 1.65% after baking. **Nurjanah *et al.* (2020)** noted that the processing methods can significantly affect the nutritional value of food, with factors such as temperature, time, surface area, and type of material playing crucial roles.

Table 6. Mole crabs proximate value

Parameters (%)	Mole crabs			
	Fresh	Fried	Boiled	Baked
Moisture	79.17± 0.42 a	27.69± 3.26 d	75.12± 0.23 b	61.51± 0.66 c
Ash	6.46 ± 0.42 b	9.74± 0.04 a	6.25± 0.26 b	9.9± 0.54 a
Fat	2.2± 0.05 d	38.88± 0.43 a	2.96± 0.18 c	3.51± 0.02 b
Protein	10.45± 0.05 d	22.31± 3,53 b	14.04± 0.04 c	23.53± 0.09 a
Carbohidrate	1.71± 8.20 a	1.62± 0.36 b	1.36± 0.20 c	1.65± 0.36 b

The number followed by the same letter did not differ in the confidence level ($P< 0.05$) for each treatment

4. Moisture content

The moisture content for all treatments decreased from the fresh ingredients. There was a decrease in the moisture content of boiled, steamed and grilled mole crabs influenced by the cooking method **(Santoso *et al.*, 2015)**. The decrease in moisture content can also be caused by the heat from the cooking process using high temperatures and different times **(Silaban, 2024)**. Steaming temperature ranges from 90-100^{o}C, baking temperature ranges from 45- 60^{o}C, and frying ranges from 120-170^{0}C. Upon steaming and roasting, the ability of heat to remove water from the ingredients is very small, whereas when frying, the ability of heat to remove water in ingredients is very large due to the hot temperature of the oil that fills the spaces. According to **Sundari *et al.* (2015)**, the higher the temperature, the lower the moisture content.

5. Ash content

The ash content in mole crabs increases when frying and baking, while it decreases slightly during steaming, though not significantly. **Silaban (2024)** noted that the processing methods can lead to an increase in ash content, whereas **Santoso *et al.* (2015)** stated that the cooking process does not significantly alter the ash content. **Sundari *et al.* (2015)** explained that processing can affect the availability of minerals in food. This impact depends on the processing method, temperature, and surface area of the product.

Minerals generally remain intact during processing; however, boiled foods typically show a decrease in ash content, while fried foods tend to experience an increase. The reduction in ash content during boiling is attributed to the shrinkage of mineral salts. The average ash content found in this study is still lower than the results reported by **Santoso *et al.* (2015)**, who measured ash content in fresh, steamed, and grilled seafood at 35.63, 32.5, and 31.59%, respectively.

6. Fat content

All cooking process treatments can increase the fat content. In general, processing can reduce fat levels, but in the steaming and steaming phases of this study, the water that comes out of the processed products is still less, so the fat content is still high from fresh mole crabs. On the other hand, the frying process can reduce the moisture content of mole crabs. The increased fat content in fried products is caused by the absorption of oil into the ingredients during frying. The lower the moisture content in the material, the higher the oil absorption. The high fat content is also affected by the measured water content. The higher the water content that comes out of the material, the greater the amount of fat content. **Silaban (2024)** elucidated that the process can increase fat content depending on the processing method, temperature and time used. **Jacoeb *et al.* (2015)** stated that the increase in fat in the frying process is due to the seepage of cooking oil into the ingredients causing an increase in fat content

7. Protein content

All processing treatments can increase the protein content. Changes in protein content are related to the shrinkage of moisture content during the processing process. According to **Jacoeb *et al.* (2015)**, the greater the shrinkage of water content after the processing process, the greater the change in protein content. According to **Sundari *et al.* (2015)**, the processing process (cooking) can be detrimental and profitable. It is beneficial if there is an increase in the content of nutrients such as protein, increased digestibility and a decrease in various antinutrient compounds. **Yuarni *et al*. (2015)** noted that the high protein content observed during heat processing is due to the heat absorbed by the meat, which denatures the colloidal protein solution and causes coagulation. This process releases water from the meat, leading to a higher concentration of compounds such as proteins, carbohydrates, fats, and minerals. **Maharani *et al.* (2022)** explained that the increase in protein levels during processing is attributed to the hydrolysis of proteins, breaking down large molecules into smaller peptides or amino acids.

The average protein content found in this study was lower than the results reported by **Santoso *et al.* (2015)**, which indicated protein levels of 38.52% in fresh seafood, 37.2% in steamed seafood, and 35.13% in grilled seafood.

8. Carbohydrate content

The carbohydrate content of a product is influenced by its overall nutritional composition. Specifically, when the levels of chemical components such as water, ash, protein, and fat are lower, the carbohydrate content tend to be higher. Conversely, higher levels of these components lead to a lower carbohydrate content **(Silaban, 2023)**.

In this study, the average carbohydrate content is lower than the results reported by **Santoso *et al.* (2015)**, who measured carbohydrate levels of 17.08% in fresh seafood, 25.98% in steamed seafood, and 27.62% in grilled seafood.

9. Ripening shrinkage

The cooking shrinkage analysis revealed that fresh mole crabs experienced a shrinkage of 3.51% after steaming, 22.11% after grilling, and 36.16% after frying. This aligns with the finding of **Silaban (2024)**, who found that products processed through frying, steaming, and drying undergo weight shrinkage compared to their fresh counterparts.

Weight shrinkage during processing is closely related to the reduction of moisture content in the material. **Sundari *et al.* (2015)** noted that the decrease in weight is primarily due to the loss of moisture caused by heating. Higher temperatures and longer cooking times result in greater moisture loss from the food. Additionally, **Syukroni and Santi (2021)** indicated that the reduction in water content is due to the denaturation of myofibril and collagen proteins. During heating, muscle tissue also experiences shrinkage and hardening, further contributing to the release of water from the meat.

CONCLUSION

The study on mole crabs from Rutah beach identified three species: *Hippa ovalis*, *Hippa adactyla*, and *Hippa marmorata*, with *Hippa adactyla* being the most abundant. The crabs exhibited varying carapace colors, predominantly grayish-black, and their sizes ranged from 0.9-7.8cm in length and 0.5-2.3cm in width, with body weights between 0.28-10.27 grams, showing negative allometric growth. The environmental conditions during sampling included substrate temperatures of 26.9-27.3°C, pH of 7.7-7.8, and salinity of 32-34ppt. Fresh mole crabs contained 13 amino acids, including five essentials (valine, phenylalanine, isoleucine, leucine, lysine), two semi-essential (histidine, arginine), and six non-essential amino acids. They also had 11 fatty acids, including seven saturated (laurate, myristate, palmitate, margarate, stearate, arachidate, behenate) and four unsaturated (palmitoleic, linoleic, oleic, arachidonic) acids. Processing methods (frying, steaming, grilling) significantly affected the nutritional composition of the crabs. Water and carbohydrate content decreased, while fat and protein levels increased. For fresh mole crabs, moisture was 79.17%; fat was 2.2%, protein was 10.45%; ash was 6.46%, and carbohydrate was 1.71%. After frying, moisture dropped to 27.69%; fat and protein increased to 38.88 and 22.31%, respectively. Steaming and grilling showed similar trends, with varying changes in ash and nutrient content.

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