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STUDY OF NUTRITIONAL CONTENTS OF SEA URCHIN GONAD FROM DRINI BEACH, GUNUNG KIDUL, YOGYAKARTA

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ABSTRACT

This paper aims to determine the types and contents of protein, fatty acids, amino acids and protein in the gonads of Arbacia lixula, Colobocentrotus atratus, Heterocentrotus trigonarius and Echinotrix diadema from the waters of Drini, Gunung Kidul, Yogyakarta. Kjedal method was used to analyze the protein content, while GC and HPLC methods were employed to analyze amino acids in this study. The results showed that the protein contents of each sample, consequently from highest to lowest, were Heterocentrotus trigonarius (13.3 %), Echinotrix diadema (10.86), Colobocentrotus atratus (10.41) and Arbacia lixula (9.90%). Amino acids analysis from all identified both saturated fatty acids, consisting of lauric acid, myristic acid, palmitic acid, stearic acid, arachidonic acid, lignoceric acid, as well as non-saturated fatty acids, consisting of palmitoleic acid, oleic acid, linoleic acid, erucic acid, EPA, and DHA. The highest contents of non-saturated fatty acids were identified in Colobocentrotus atratus (434.14 mg/100g) and the lowest content in Arbacia lixula (197.71 mg/100g). The highest percentage of essential fatty acids was found in Heterocentrotus trigonarius (0.29%), whereas the lowest was found in Echinotrix diadema (0.19 %). It is concluded that the gonad of Heterocentrotus trigonarius showed the highest protein and essential fatty acids contents. This study also found that Colobocentrotus atratus sea urchin gonads possess the highest content of non-saturated fatty acids (434.14 mg/100g).

Keywords: *amino acid, fatty acid, protein, sea urchin gonad.*

INTRODUCTION

Protein is a vital nutrition for human body functions since it is the most significant substance in many biological processes. It is the building block in the formation of new tissues during development phase, and during the process of maintaining, repairing, and replacing damaged tissues. Protein is also stored and converted in the body as an energy reserve in the event of fat and carbohydrate deficiency. Through biochemical reactions, excess protein is converted into fat and stored as fat reserve (Sumardjo, 2008).

Life in Earth thrives by the availability of many natural media, namely air, land and sea. Marine life is a complex structure with vast biological pattern, chemistry and material diversity. This puts sea not only as a source of food, but also as a repository of materials which are precious, special, and impactful for humanity. Recent studies found potency of various marine resources as biomaterials with a plethora of application in the field of medicine (Talumepa *et al.,* 2016). One of such marine lives with potential medicinal properties is sea urchin (Pringgenies *et al.,* 2012).

Sea urchin is commonly found in coastal areas and waters of Indonesia, and many other places in the world. The test or shell of this marine animal is commonly covered with venomous spines that the common people often think trivially of sea urchins. Upon bisection of a sea urchin, eggs or gonads appears to be the dominant organ, which is known to have high nutritional value. For example, gonad of Diadema setosum species has been known to possess high amount of essential nutrition which is needed by the body. As with any animals, different sea urchin species may contain different nutritional value. Therefore, this study aims to determine the contents of protein, amino acids, and fatty acids of sea urchins from the species Arbacia lixula, Colobocentrotus atratus, Heterocentrotus trigonarius and Echinotrix diadema from the waters of Drini, Gunung Kidul, Yogyakarta.

MATERIALS AND METHODS

Sea Urchin Sample Collection

Samples of live sea urchins consiting of Arbacia lixula, Colobocentrotus atratus, Heterocentrotus trigonarius and Echinotrix diademawere collected using a small scoop from waters of Drini, Gunung Kidul, Yogyakarta. Each sample was bisected from mouth to anus with a knife, followed by collection of gonad using a small spoon. The gonad of each sample was put into a glass vial using a glass funnel. The samples were then divided into ratio, with 5 grams for 10 cc vial and 50 grams for 50 cc vial. The contained samples were then stored in a freezer to avoid deterioration.

Analysis of Protein, Amino Acids and Fatty Acids Contents

Analysis of protein contents in this study employed Micro method (AOAC, 1970) and Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC) were used to analyze amino acids and fatty acids contents in the samples.

RESULTS AND DISCUSSION

Protein Contents

The analysis of protein contents of sea urchin gonad was performed in accordance to methods in Kejdahl. Analysis results found that the highest percentage of protein content was in H. trigonarius (10.41) and the lowest percentage was in A. lixula (9.90), as presented in **Image 1** below.

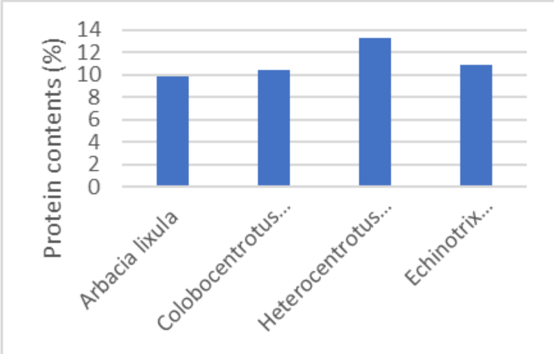

Figure 1. Protein contents of sea urchins species studied in this research.

Amino Acids Contents

Amino acids analysis by High-Performance Liquid Chromatography (HPLC) using a Shimadzu LC10A found 15 amino acids. The complete results are presented in **Table 1** and **Image 2**. Analysis result of the species A. lixula found 15 amino acids contents, in which details were 9 essential amino acids (histidine, isoleucine, lysine, valine, methionine, threonine, phenylalanine, and arginine) and 6 non-essential amino acids (glutamate, alanine, tyrosine, serine, aspartate, and glycine). The highest content of non-essential amino acids found in H. trigonarius and E. diadema was aspartic acid, 0.19%. The highest glutamate content, 1.39%, was found in E. diadema. The essential amino acids contents in all the species studied were found to be low on average. The highest content was found in E. diadema, namely arginine 0.09%. The total amino acids contents of each sea urchin species from the highest to the lowest were 0.37%, 0.35%, 0.32%, and 0.24% for E. diadema, H. trigonarius, A. lixula, and C. atratus respectively.

Table 1. Amino acid contents of sea urchin gonad.

No	Amino Acid	Amino acid content (%)			
		A. lixula	***C. atratus***	***H. trigonarius***	***E. diadema***
		Essential Amino Acids			
1.	Histidine	0.01	0.01	0.01	0.01
2.	Isoleucine	0.04	-	0.04	0.04
3.	Leucine	0.05	0.04	0.05	0.06
4.	Lysine	0.01	0.01	-	0.01
5.	Valine	0.05	-	0.05	0.06
6.	Methionine	0.01	-	-	-
7.	Threonine	0.07	0.07	0.07	0.07
8.	Phenylalanine	0.02	0.05	0.02	0.03
9.	Arginine	0.06	0.06	0.11	0.09

	Total essential am. acd	0.32	0.24	0.35	0.37
	Non-essential Amino Acids				
10.	Glutamate	0.13	0.14	0.14	1.39
11.	Alanine	0.09	0.12	0.11	0.09
12.	Tyrosine	0.03	0.03	0.03	0.04
13.	Serine	0.07	0.07	0.08	0.07
14.	Aspartate	0.17	0.17	0.19	0.19
15.	Glycine	0.15	0.14	0.12	0.11

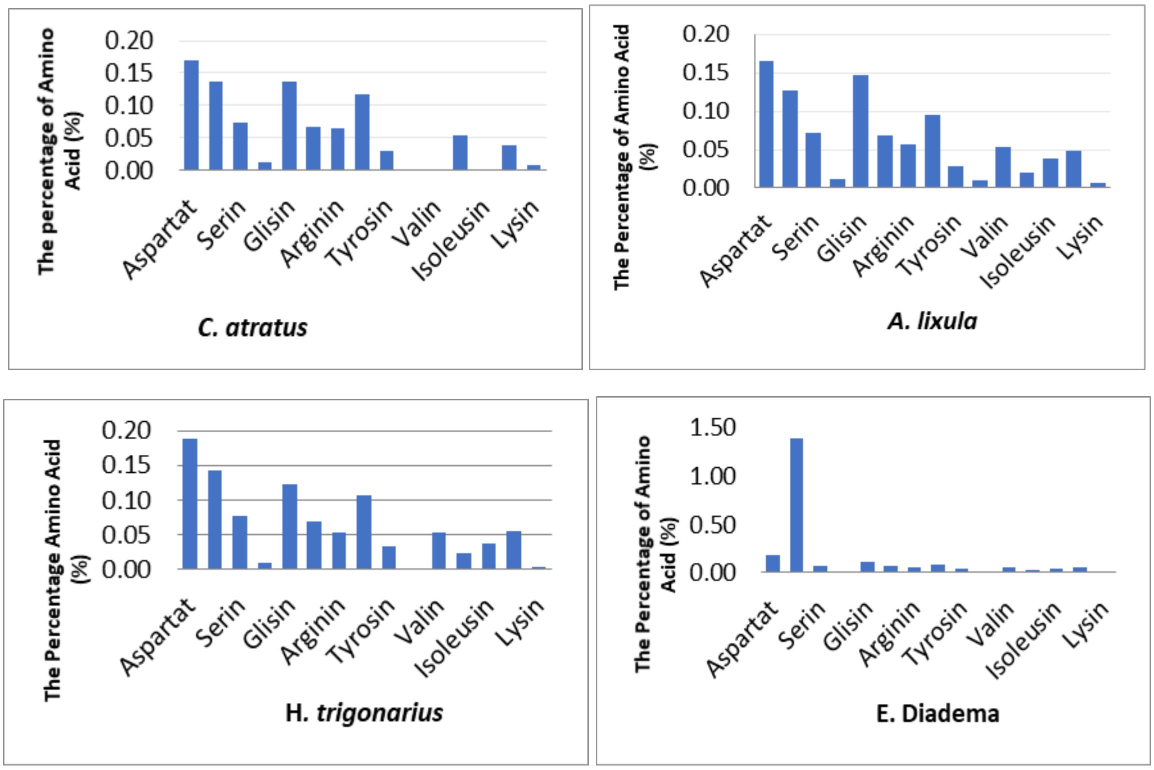

Figure 2. Composition of fatty acids in C. Atratus (a), A. Lixula (b), H. trigonarius, and E. diadema.

Fatty Acids Acids Contents

The fatty acids contents analysis in sea urchin gonads were performed using Gas Chromatography. The complete analysis results are presented in **Table 2** below.

Table 2. Fatty acids contents of A. Lixula and C. Atratus

No	Fatty Acids		Contents (mg/100g)			
			A. lixula	***C. atratus***	***H. trigonarius***	***E. diadema***
	Saturated					
1.	Lauric Acid	C12:0	1.00	0.60	-	-
2.	Myristic Acid	C14:0	72.86	35.76	162.57	186.67
3.	Palmitic Acid	C16:0	161.18	230.48	253.73	505.51
4.	Stearic Acid	C18:0	29.57	43.71	65	112
5.	Archidonic Acid (ω6)	C20:0	5.68	2.78	82.92	113.5
6.	Lignoceric Acid	C24:0	2.15	2.78	-	-
	Total Saturated Fatty Acids		272.44	316.11	564.22	917.68

	Monounsaturated					
7.	Oleic Acid (ω9)	C18:1	24.52	23.25	60.7	132.16
8.	Palmitoleic Acid (ω9)	C16:1	2.15	41.92	40.13	58.05
9.	Erucic Acid (ω9)	C22:1	37.02	52.45	-	40.69
	Total Monounsaturated Fatty Acids		63.69	117.62	100.83	230.90
	Polyunsaturated					
10.	Linoleic Acid (ω6)	C18:2	44.26	21.06	15.92	24.83
11.	Linolenic Acid (ω3)	C18:3	7.25	28.41	56.38	26.69
12.	EPA	C20:5	58.43	122.76	146.59	151.72
13	DHA	C22:6	21.93	1.95	-	-
	Total Polyunsaturated Fatty Acids		131.87	174.18	218.89	203.24

The analysis of fatty acids on all species gonads found 13 amino acids, which can be broken down into 6 saturated fatty acids and 7 unsaturated fatty acids. The 6 saturated fatty acids found were lauric acid, myristic acid, palmitic acid, stearic acid, arachidonic acid (ω6), and lignoceric acid. The 7 unsaturated fatty acids found were oleic acid (ω9), palmitoleic acid (ω9), erucic acid (ω9), linoleic acid(ω6), and linolenic acid (ω3, EPA and DHA). The highest fatty acid content was found in the species E. diadema, which was 917.68 mg/100g of palmitic acid. The lowest fatty acid content was found in C. Atratus, which was 272.44 mg/100g of lauric acid. The the highest Omega 9 or Monounsaturated Fatty Acid (MUFA) content was found in E. diadema with 230.90 mg/100g and the lowest was found in A. lixula with 63.69 mg/100g. The analysis results found the highest polyunsaturated fatty acid (PUFA) in H. trigonarius with 218.89 mg/100g and the lowest in A. lixula with 131.87 mg/100g.

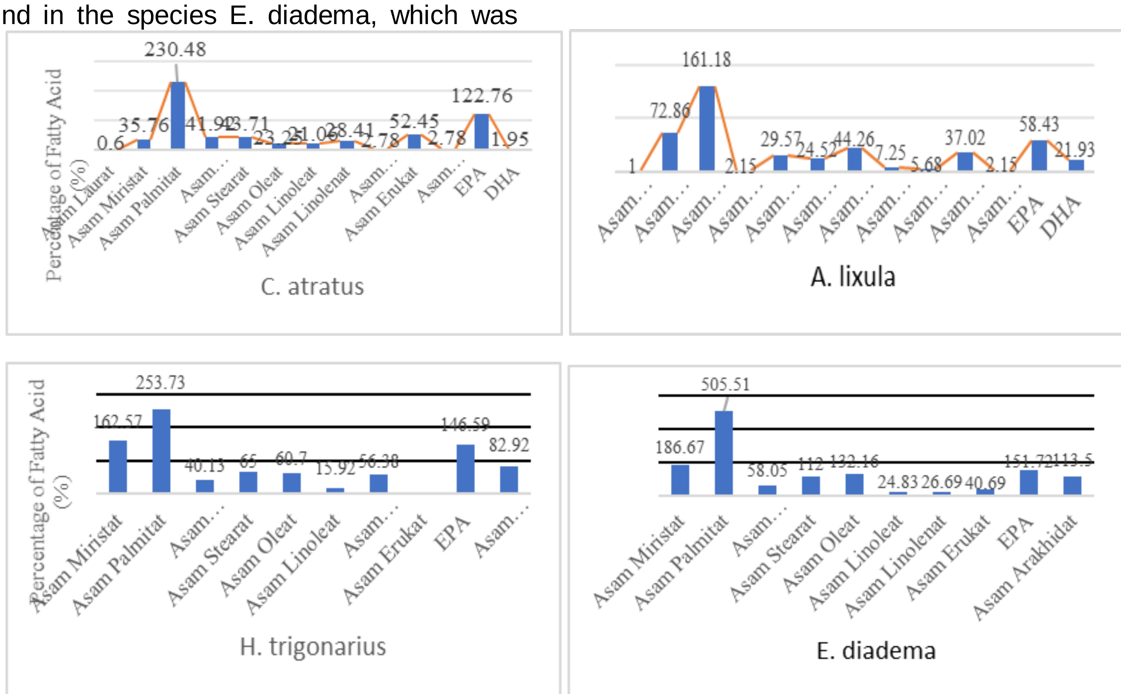

Figure 3. Fatty acids composition in C. atratus (a) and A. lixula (b) H. Trigonarius and E. diadema.

The analysis found that the highest overall protein content belonged to the species H. Trigonarius, with 13.3%, and the lowest belonged to the species A. Lixula, with 9.90%. The variation in the protein contents is highly related to the availability of food in the natural habitat of the sea urchins. H. Trigonarius is commonly found in areas with more algae population and which is far away from human activities. On the contrary, A. Lixula is commonly lives in sites often used as snorkeling, in which algae population is often diminshed do to use of snorkeling fins. According to Suryanti and Ruswahyuni (2014), among the environmental condition affecting the protein contents of sea urchins is the growth of algae, since algae is the main diet of the this herbivorous species.

The protein contents of H. trigonarius (13.3 %) was found to be higher than that of D. setosum from the waters of Martafons (12.80%), yet the protein contents of D. setosum from Sopapei waters was still the highest (17.69%) of all the sea urchin species above (Upan and Silaban, 2017). However, the lowest protein content was also found in the waters of Waai, which was 5.40%. These findings confirms the theory that the same species may have different protein contents in different environment. The varying nutrition contents is significantly related to habitat, as pointed out by Arifudin *et al*., (2014) which stated that species, age, size and habitat conditions can affect the nutrition content of an animal produce.

Based on the analysis results in this study, the protein contents in gonads of Arbacia lixula (9.90%), C. atratus (10.40%), H. trigonarius (13.3 %) and E. diadema (10.86%) were significantly higher to the protein contents found in poultry eggs. A study by Bakhtra et al (2016) on the protein contents of broiler chicken, local chicken, duck egg and quail egg found all to be no higher than 7%.

The protein contents of both sea urchin species analyzed in this study are still within the normal macro distribution of nurtrition intake, which is between 9.90-13.3%. These levels are adequate protein requirements for growth and devlopment of infants. According to Hardinsyah et al. (2016), the macro nutrition distribution range from the diet pattern of Indonesian people based on the analysis of Basic Medical Research (Riskedas) 2010 is 9-14% of protein energy. Macro Nutrition Enegy Range Recommendation (AMDR) for Indonesians in the estimation of ideal nutrition intake is 5-15% protein energy, depending on age or developmental stages. The percentage of protein enegy for 0-5 years of age is 9.4%.

The analysis of amino acids contents of all the species in this research found that they were below that of D. Setosum gonad, which was studied by Pringgenies *et al.,* (2016). The complete data showed Aspartate 11.6%; Glutamate 15.2%; Serine 5.9%; Histidine 2.4%; Glycine 3.3%; Threonine 5.5%; Arginine 8.5%; Alanine 8.3%; Tyrosine 4.9%; Methionine 3.3%; Valine 5.9%; Phenylalanine 5.6%; Isoleucine 5.0%; Leucine 9.1%; Lysine 4.3% Tryptophan 0.8%. The tryptophan content in D. setosum was not found in all species in this study. Methionine and valine contents were only found on A. lixula but not in the gonad of the other three species in this study. Isoleucin was not found un the gonad of C. atratus and lysine was not found in the gonad of H. trigonarius. This meant that the amino acid contents of sea urchins are also affected by the habitat in which they live.

The analysis of gonad of A. lixula showed 15 amino acids which consist of 9 essential and 6 non-essential amino acids. The essential amino acids found un the gonad of this species include arginine, histidine, isoleucine, leucine, lysine, valine, methionine, threonine and phenylalanine. The non-essential amino acids found in A. lixula gonad were Glutamate, alanine, tyrosine, serine, aspartate, dan glycine. Of the four species gonad studied, A. lixula gonad had the most amino acids variety. The amino acids content in A. lixula gonad is sufficient for the nutritional requirements of adults and children. However, this study also found that the amino acids content of C. atratus does not completely meet the required variety for ideal nutrition. According to Purwaningsih *et al.,* (2013), essential amino acids for adults include lysine, isoleucine, threonine, methionine, valine, phenylalanine, and tryptophan, whereas children needs the addition of arginine and histidine. Non-essential amino acids consist of aspartate, glutamate, alanine, asparigine, cysteine, glycine, proline, tyrosine, serine and glutamine.

Of all the non-essential amino acids, aspartic acid was found to be the highest content with 0.17% - 0.19%, resulting in more better taste organoleptic stimulation. This reinforces the findings in Rahayu *et al.,* (2014) which states that aspartic acid is the most vital component in construction of taste perception, which stimulates the gustatoric organs. The lowest lysine contents was found in A. lixula, C. atratus and E. diadema, and was not detected in H. trigonarius. This means the gonads of all four sea urchin species are not the most effective materials to strengthen antiboy. However, two species with the most lysine contents can still be used in nutrition source for growth. Lysine plays an imporant role as the basic building block of blood antibody, improving circulatory system, and maintaining the growth of normal cells. Together with proline and vitamin C, lysine forms colagen and helps in lowering excessive blood triglycerides. Lysine deficiency may lead to lower endurance, difficulty in concentrating, hairfall, anemia, arrested growth, and reproduction system disruption (Purwaningsih *et al.,* 2013). Methionine was only found in A. lixula in this study. Methionine possesses sulfur bond which is sensitive of oxidation and breaks down during acid hydrolisis. According to Ginting *et al.,* (2017), amino acids with sulfur bond, such as methionine and cysteine, breaks down during acid hydrolisis, requiring prior oxidation of samples using performic acid to oxidize methionine bond into methionine solfon bond, before being hydrolized with H2SO4 6N.

Analysis of fatty acid contents in the gonads of all species in this study revealed that they were higher than that found in D. setosum in a study by Pringgenies et al. (2016). However, the fatty acid contents of D. setosum in the same study is higher than that of A. lixula dan C. Atratus in this research. This difference in nutritional contents is due to difference in species, environmental conditions, size of species and gonad maturity, which coonfirms the finding of similar study bu Azka *et al.,* (2015). Fat is an excess reserved by animals, which means that the fat content in a species is highly determined by the energy balance of the said species. Purwaningsih (2012) found that the fat content of a species can be influenced by gonad maturity and the age of a species. The more mature the gonad of a species, the more fat contents it will have.

Fatty acid analysis of gonads from the species A. lixula, C. atratus, H. trigonarius and E. Diadema found omega-3, omega-6, and omega-9 with omega-3 to omega-6 ratio of 3:1. This means the gonads of all species studied in this research is safe for consumption. Silaban and Srimarina (2013) stated that acceptable fatty acid ratio of omega-3 to omega-6 is below 1:5. If omega-6 upsets omega-3 in the ratio, it will give negative impacts towards cognition, mood, and behavior. The recommended omega-6 to omega-3 consumption ratio is 4:1, which is ideal to maintain health, particularly in preventing cardiovascular disease. Those affected by cardiovascular disease are recommended to have in intake of omega-6 and omega-3 with 1:1 ratio. The highest unsaturated fatty acids in this study was found in the gonad of C.atratus (434.14 mg/100g) and the lowest in the gonad of A. lixula (197.71 mg/100g).

In addtion, analysis of Eicosapentaenoic acid (EPA) contents found the highest in the gonad of E. diadema, followed subsequently by H. trigonarius, C. atratus and A. lixula. Analysis of Docosahexaenoic acid (DHA) contents only found the fatty acids in the gonads of A. Lixula and C. Atratus. EPA and DHA are vital in the brain development as well as in body immune system. Omega 3-PUFA, EPA, and DHA have potency in preventing cardiovascular disease, improving brain capacity and strenthening the immune system (Jacoeb et al., 2014). Diana (2012) also stated similar findings that unsaturated fatty acid is dominant in the brain nervous cell system. It is also known that 60% of human brain consists of various fats, including unsaturated fatty acids namely omega 3, EPA, DHA, omega 6, AA, and omega 9. Essential fatty acids is also an important intake during the brain and physical growth and development period of foetus, infants and children (Pringgenies et al, 2016).

CONCLUSIONS AND SUGGESTIONS

The gonad of Heterocentrotus trigonarius showed the highest protein contents (10.41%) whereas the gonad of Arbacia lixula showed the lowest content (9.90%). The highest fatty acid contents was found in the gonad of Echinotrix diadema, with 917.68 mg/100g palmitic acid, whereas the lowest was found in Colobocentrus atratus with 272.44 mg/100g lauric acid. The highest omega 9 (MUFA) was found in the gonad of Echinotrix diadema (230.90 mg/100g) and the lowest was found in the gonad of Arbacia lixula (63.69 mg/100g). The highest PUFA content was found in the gonad of Heterocentrotus trigonarius (218.89 mg/100g) and the lowest was found in the gonad of Arbacia lixula (131.87 mg/100g).

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