ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 8(6), 501–509, March 2015*
DOI : 10.17485/ijst/2015/v8i6/62337

Changes in Proximate and Fatty Acids of the Eggs during Embryo Development in the Blue Swimming Crab, *Portunus pelagicus* (Linnaeus 1758) at Lasongko Bay, Southeast Sulawesi, Indonesia

Abdul Hamid[1]*, Yusli Wardiatno[2], Djamar TF Lumban Batu[2] and Etty Riani[2]

[1]Department of Fisheries, Faculty of Fisheries and Marine Sciences, Halu Oleo University, Indonesia; abdhamid_lamun@yahoo.com
[2]Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Indonesia; yusli@ipb.ac.id, msp-fpik@ipb.ac.id, msp-fpik@ipb.ac.id, etty_riani_harsono@yahoo.com

Abstract

This study was aimed to elucidate changes in the contents of proximate and fatty acid of the blue swimming crab (*Portunus pelagicus*) eggs during embryonic development based on changes in egg colors. The changes in egg color during the embryonic development are as follows: yellow, orange, brown and finally gray and black. The content of protein, fat and carbohydrate in P. pelagicus eggs decreased, but the the content of water and ash increased at different embryonic development stages. Twenty-nine types of fatty acids were detected in the crab eggs. The fatty acid content of orange-colored eggs had lower fat compared to the other three colors. The content of SFA and MUFA eggs decreased as the egg color changed, but the FUFA content increased. In general, the contents of ARA, EPA and DHA eggs increased during the color change process from yellow to dark gray but declined sharply in the orange-colored eggs. Thus the content of proximate and fatty acid was changed as the egg color changed from yellow to dark gray.

Keywords: Blue Swimming Crab, Embryo Development, Fatty Acid, Indonesia, Proximate

1. Introduction

The blue swimming crab, Portunus pelagicus (Linnaeus 1758), locally known as rajungan in Indonesia, has an important economic value. The crab is abundantly found at Lasongko Bay, Southeast Sulawesi and is one of main species target in fishery sector of the bay. The intensive catch of the crab in the bay has begun in the early 2000s[1] and high exploitation continues due to its high demand. To ensure the sustainability of crab population, it should be supported by the success of its reproductive cycle. Eggs are part of the reproductive cycle that plays an important role in life history of aquatic animals that spawn freely[2–4]. An egg contains a number of nutrients required for embryonic development and is used during embryo development by specific cells folowing an "embryonic genetic program"[5,6]. The egg condition affects the larval development of marine invertebrate animals[4], including the larvae of *P. pelagicus*. The main component of an egg is protein, but in the process of metabolism, an embryo takes more fat than protein[2,6]. Fat is an essential nutrient and serves as the major source of energy and

Author for correspondence

and as a structural component of the cell membrane in the process of embryonic development of decapods[2,3,6,8]. Proximate and fatty acid content of decapod eggs had an effect on reproduction, egg survival and embryonic development, egg hatching and survival of decapod larvae[3,5,6,9]. Their contents in decapod eggs are generally determined by the size of the egg and egg yolk material[2,4,10], habitat conditions such as temperature, salinity, food availability, and depth[2,4,7], and embryonic development[5,8,10–14]. The embryonic development of P. pelagicus from egg to zoea is divided into six stages[15] and gradually it undergoes changes in color, shape and size[15–18]. The changes in egg color during the embryonic development are as follows: yellow, orange, brown and finally gray and black[15,16,18]. The changes in colour are due to the absorption of the yellow color in yolk and the development of dark pigment in the eyes[19].

Information on proximate and fatty acid of P. pelagicus is closely related to gonadal development[10,20,21], ovary[22,23], sex[24,25], the influence of season[20,26] and food type[27]. Researches on proximate and fatty acid of *P. pelagicus* eggs are still few[8,10,11], and none of them tried to elucidate the composition and content of fatty acid in *P. pelagicus* eggs based on embryonic development or the color changes in *P. pelagicus* eggs. Therefore, it is necessary to study this particular aspect. This research aimed to describe changes in the content of proximate and fatty acid of *P. pelagicus* during the embryonic development based on the changes in egg colors.

2. Methodology

2.1 Research Site

The research was conducted in Lasongko Bay, Southeast Sulawesi, Indonesia from April 2013 to January 2014. The bay is located at latitude 05°15' to 05°27 'S and Longitude 122°27' to 122°33' E (Figure 1).

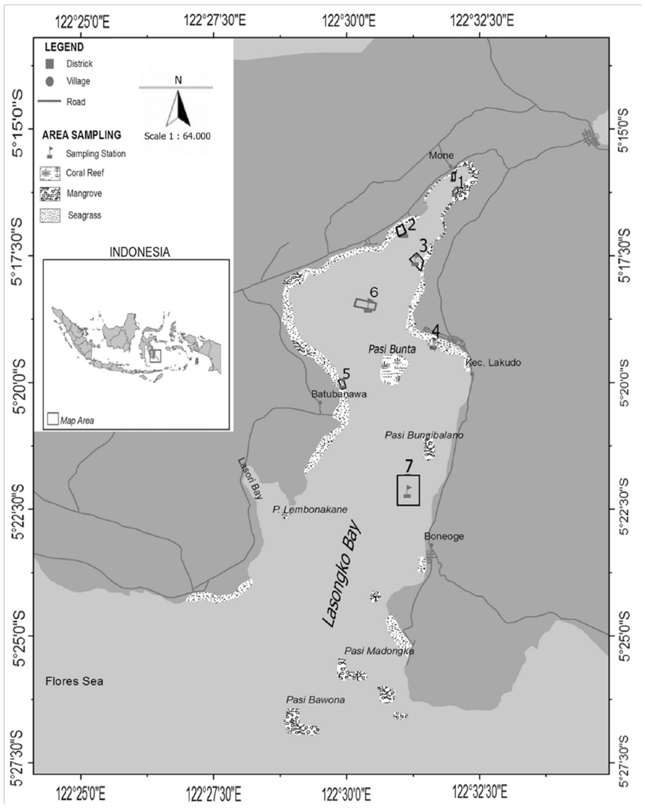

Figure 1. Map of the study site and sampling in Lasongko Bay, Southeast Sulawesi, Indonesia. Numbers are indicating sampling points.

2.2 Sampling Methods and Sample Treatment

Samples of ovigerous females P. pelagicus were collected by gillnet and trap at seven stations. Collections were carried out every month. All collected specimens were were stored in cold boxes for laboratory analyses. Ninety five ovigerous females with various embryos development were used for proximate and fatty acid analyses, i.e. 21 crabs with yellow eggs, 27 crabs with orange eggs, 26 crabs with brown eggs, and 21 crabs with dark grey eggs. The carapac width and the body weight were measured. The eggs in the abdomen were gently removed, weighed, and dried in oven at 65oC for 24 hours prior to proximate and fatty acid analyses[28].

2.3 Statistical Analysis

One way ANOVA at $p = 0.05$ was performed to reveal the difference between proximate and fatty acid content in the different stages of embryonic developments, and it was followed by the Duncan test, if necessary[29].

3. Result

The biometric data of the ovigerous females *P. pelagicus* used in this study is presented in Table 1. While Table 2 shows the proximate content of different stages eggs.

Table 2 shows that in general the highest proximate content is water and the lowest one is fat. Of four proximate characteristics, two of them (water and ash) increased in accordance to the embryonic

Table 1. Biometric data of the ovigerous females Portunus pelagicus used for analysing proximate and fatty acid by the embryonic development (characterised by the color)

Eggs color	Carapace width (cm)	Body weight (g)	Egg wet weight (g)
Yellow	10.25 – 13.96	77.24 – 249.33	1.67 – 42.10
Orange	9.95 – 14.47	79.74 – 241.53	4.61 – 35.41
Brown	9.90 – 13.51	51.47– 189.98	10.75 – 34.91
Dark grey	9.85 – 14.21	72.11– 227.17	10.21 – 46.47

development, but the other three (fat, protein and carbohydrate) showed decreasing trend due to the development. One-way ANOVA test following by Duncan test at p= 0.05 showed that there was a significant different in the content of water, ash and protein between yellow color stage to dark grey color stage. In carbohydrate, the significant content was shown already in brown color stage compared to yellow and orange color. However, fat content in all stages were not different sginificantly. and myristoleic acid was not found in dark gray-colored eggs. Nervonic acid was found only in yellow and brown eggs, and linolelaidic acid was only found in orange eggs. The average of the total fatty acid content of P. pelagicus eggs ranged from 39.87 to 60.32%, consisting of 18.83 to 28.45 %, MUFA 9.51 to 14.17 %, and PUFA 9.34 to 23.02 % (Table 3). The total fatty acid content was the highest in brown eggs and the lowest one was in orange eggs. The SFA content was the highest in brown eggs and the lowest one was in orange eggs. The highest MUFA content was in yellow eggs and the lowest in dark gray eggs,whereas the highest PUFA content was in dark gray and the lowest in orange eggs. The content of SFA and MUFA decreased, respectively 12.56 % and 32.89 %

Table 2. Proximate content of Portunus pelagicus eggs based on embryonic development (change of the egg stage is characterised by the color)

No.	Eggs color	Proximate content (mean±SD % w/w)				
		Water	Ash	Fat	Protein	Carbohydrate
1.	Yellow	73.56±4.41[a]	1.78±0.45[a]	1.64±0.33[a]	15.97±2.93[b]	7.06 ±1.08[b]
2.	Orange	76.00±2.81[a]	1.94±0.24[a]	1.66±0.33[a]	14.38±1.99[ab]	6.01 ±1.03[b]
3.	Brown	81.24±4.04[ab]	1.57±0.52[a]	1.71±0.43[a]	11.37±3.10[ab]	4.23 ±1.04[a]
4.	Dark grey	82.53±4.31[b]	2.19±0.43[a]	1.31±0.57[a]	10.93±2.92[a]	3.09 ±1.09[a]
Change between yellow and dark grey (%)		12.19	23.03	-20.12	-31.56	-54.82

SD= standard deviation. Values within a column with same superscript letters are not significantly different at p= 0.05).

In term of fatty acid, there were twenty-nine kinds of fatty acids in *P. pelagicus* eggs (Table 3), consisting of twelve types of unsaturated fatty acids (SFA), eight kinds of Monounsaturated Fatty Acids (MUFA), and nine kinds of Polyunsaturated Fatty Acids (PUFA). The dominant SFA types were palmitic acid, stearic acid and myristic acid. MUFA consisted of oleic acid and palmitoleic acid, and PUFA included Arachidonic Acid (ARA), Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA). Capric acid was only found in yellow and orange; tridecanoic acid was found only in orange and brown eggs, with the change in egg stages from yellow to dark gray. The content of PUFA and the total fatty acids increased, respectively 74.23 % and 3. 40 % (Table 3). The results of ANOVA on SFA content, PUFA and the total fatty acid were significantly different ($p< 0.05$), and MUFA was not significantly different ($p> 0.05$) among the embryonic development stages. The SFA content between the colors egg were not significantly different ($p> 0.05$), while PUFA content between dark gray eggs and yellow and orange, and between orange and brown were significantly different ($p< 0.05$).

The total fatty acid content between orange egg and the other three kinds of egg colors, as well as between brown and yellow and dark gray were significantly different ($p < 0.05$).SFA type with a great content decrease (75%) due to the change in the colors of P. pelagicus eggs from yellow to dark gray was capric acid, followed by myristic acid, pentadecanoic acid, heneicosanoic acid and lignoceric acid. The contents of behenic acid, arachidic acid and stearik acid increased, but the contents of lauric acid and tridecanoic acid did not change with the change of color.
Erucic acid is a type of MUFA whose content decreased (75%) due to the change in the colors from yellow to dark gray, followed by palmitoleic and heptadecanoic acids. Miristoleic acid and nervonic acid relatively did not change with the color change of the egg, while he eicosenoic acid content increased with the color change. Generally, the content of PUFA increased as the color of *P. pelagicus* eggs changed from yellow to dark gray, except linolenic acid and eicosetrienoic acid. The types of PUFA whose contents increased sharply during the change of colors eggs were ARA, EPA and DHA acids.

4. Discussion

4.1 Proximate Content

Body size (wet weight and carapace width) and the wet weight of ovigerous female *P. pelagicus* eggs which were used in the analysis of proximate and fatty acids varied enough. This could affect the content of proximate and fatty acid[7,24,30], however proximate and fatty acid content of *P. pelagicus* eggs based on body size were not examined in this study. The water content in *P. pelagicus* eggs in this study ranged from 73.56 to 82.53 %, and it is higher than the eggs of Uca rapax and Armases cinereum[3,6], *Callinectes sapidus*[12], Macrobrachium idea[13], and Podophthalmus vigil[31]. The increasing in water content from earlier stage (yellow color) towards final stage (dark grey color) of the eggs in this study was lower than those of of U. rapax and A. cinereum[3,6] and M. idella idella[14], but higher than that of C. sapidus10. Increasing in water content of the eggs during embryonic development was also found in the eggs of M. rosenbergii32 and Chionoecetes opilio[33]. Generally, the water content of decapod eggs increased more than 50% during embryonic development[3]. Increasing in water content occurreddue to absorption of water through the egg membrane,and the water is produced by respiration and fat metabolism[3,5,6,13,14,18].

The rate of water absorption by eggs may be influenced by temperature and salinity, and towards the end of embryonic development, the absorption of water is completed to support the hatching of *P. pelagicus* eggs[18].
The ash content of *P. pelagicus* eggs in this study was higher than that of female P. pelagicus meat[24,34] and of the eggs of P. vigil[31]. By comparing the early stage egg (yellow color) and the closely final stage (dark grey color), it was found that the ash content increased during embryonic development of *P. pelagicus* 23.03 %. The similar phenomenon was also showed in the eggs of *C. opilio*[33]. The ash content of *P. pelagicus* was influenced by sex[24] and food[34]. The ash content of females *P. pelagicus* meat was lower than that of males[24], but the opposite result was exhibited in the muscle of P. vigil[31].
Proximate content (fat, protein and carbohydrate) of *P. pelagicus* eggs in this study was comparable with the previous studies of P. pelagicus and other crabs species (Table 4). Proximate content of *P. pelagicus* eggs and decapod eggs are generally determined by the egg size and egg yolk material[2,4,10], temperature, salinity and food availability, and water depth[2,4,35], season[20,26,30] and embryo development stage[3,6,8,10–14]. The proximate content decreased during embryonic development which is contradictive with the water content. Other findings show that fat content of *P. pelagicus* eggs increased due to the color change of eggs from yellow to brown, whereas decreased content of protein and carbohydrates[8,11]. The decrease in carbohydrate content of *P. pelagicus* eggs in this study is higher than that of the same species collected from the Persian Gulf Coasts, Iran[8].

Decreasing in fat and protein contents during embryonic development was also found in *Uca rapax and A. Cinereum*[3,6], *Chionoecetes opilio*[33], *C. sapidus*[12], *M. idae and M idella idella*[13–14]. Other findings showed that the content of fat and carbohydrate of eggs during embryonic development decreased in several crustaceans, such as *M. Rosenbergii*[32] and *C. opilio*[33]. However, the protein content in the eggs of *M. rosenbergii* increased[32], and no protein changed was found in *C. opilio* eggs[33]. The carbohydrate content of *C. sapidus* eggs decreased[12] during embryonic development, whereas carbohydrate increased in the eggs of *M. idea* and *M. idella idella*[13,14]. A decrease in the fat content of *P. pelagicus* eggs indicated that fat serves as the main source of energy

Table 3. Fatty acid content in *P. pelagicus* eggs based on embryonic development (characterised by the color)

No.	Fatty acid	Fatty acid content/ Eggs color (X+ SD % w/w)				Increase/ Decrease (%)
		Yellow	Orange	Brown	Dark gray	
A.	SFA	26.42+0.42[c]	18.83+0.18[a]	28.45+0.11[d]	23.11+ 0.84[b]	-12.56
1.	Capric acid, C10:0	0.08+0.06	0.02+0.00	ND	ND	-75
2.	Lauric acid, C12:0	0.04+0.01	0.06+0.01	0.06+0.01	0.04+0.01	0
3.	Tridecanoic acid, C13:0	ND	0.02+0.00	0.02+0.00	ND	0
4.	Myristic acid, C14:0	1.43+0.05	1.27+0.08	1.49+0.07	0.76+0.11	-46.67
5.	Pentadecanoic acid, C15:0	0.99+0.26	0.64+0.00	0.72+0.21	0.54+0.04	-45.45
6.	Palmitic acid, C16:0	15.39+1.49	11.46+0.25	16.25+0.63	12.18+0.54	-20.86
7.	Heptadecanoic acid, C17:0	1.21+0.19	0.66+0.03	1.31+0.01	1.01+0.03	-16.60
8.	Stearic acid, C18:0	6.17+0.49	4.06+0.01	7.20+0.33	7.28+0.00	17.60
9.	Arachidic acid, C20:0	0.55+0.09	0.34+0.02	0.74+0.04	0.68+0.01	24.77
10.	Heneicosanoic acid, C21:0	0.18+0.00	0.08+0.01	0.18+0.01	0.10+0.01	-44.44
11.	Behenic acid, C22:0	0.29+0.04	0.18+0.03	0.38+0.02	0.47+0.01	63.79
12.	Lignoceric acid, C24:0	0.12+ 0.02	0.07+0.01	0.13+.0.00	0.08+0.06	-33.33
B.	MUFA	14.17+ 2.57[a]	11.70+ 0.01[a]	14.15+ 0.64[a]	9.51+0.48[a]	-32.89
1.	Myristoleic acid, C14:1	0.05 + 0.03	0.04+0.00	0.05+0.02	ND	0
2.	Palmitoleic acid, C16:1	6.15+1.88	5.34+0.19	5.56+0.74	2.65+0.11	-56.88
3.	Cis-10-Heptadecanoic acid, C17:1	0.08+0.02	0.07+0.01	0.07+0.01	0.05+0.01	-43.75
4.	Elaidic acid, C18:1n9t	0.31+0.07	0.26+0.01	0.34+0.04	0.24+0.01	-22.95
5.	Oleic acid, C18:1n9c	7.23+0.77	5.76+0.25	7.77+0.10	`6.31+0.31	-12.79
6.	Cis-11-Eicosenoic acid, C20:1	0.21+0.01	0.21+0.03	0.26+0.06	0.25+0.07	16.28
7.	Erucic acid, C22:1n9	0.10+0.00	0.03+0.01	0.05+0.00	0.02+0.01	-75
8.	Nervonic acid, C24:1	0.05+0.02	ND	0.05+0.02	ND	0
C.	PUFA	13.22+ 2.30[ab]	9.34+1.41[a]	17.72+ 0.77[bc]	23.02+ 0.39[c]	74.23
1.	Linolelaidic acid, C18:2n9t	ND	0.04+0.00	ND	ND	0
2.	Linoleic acid, C18:2n6c	0.75+0.04	0.70+0.03	0.99+0.07	0.85+0.02	14.09
3.	Linolenic acid, C18:3n3	0.34+0.02	0.19+0.03	0.39+0.03	0.21+0.01	-38.24
4.	Cis-11,14-Eicosedienoic acid, C20:2	0.70+0.15	0.31+0.03	0.85+0.24	0.78+0.17	12.23
5.	Cis-8,11,14-Eicosetrienoic acid, C20:3n6	0.20+0.02	0.16+0.01	0.25+0.02	0.16+0.00	-17.95
6.	Cis-11,14,17-Eicosetrienoic acid, C20:3n3	0.06+0.01	0.04+0.01	0.07+0.02	0.08+0.02	25.00
7.	ARA, C20:4n6	3.26+0.75	2.90+0.49	3.91+0.39	7.38+0.29	126.73
8.	EPA, C20:5n3	3.23+0.88	2.76+0.17	4.98+0.09	7.26+0.65	124.61
9.	DHA, C22:6n3	4.70+0.56	2.25+0.73	6.30+0.24	6.32+0.58	34.50
D.	Total fatty acid (%)	53.81+0.70[b]	39.87+1.56[a]	60.32+0.03[c]	55.64+0.93[b]	3.40

X = mean values SD = standart deviation.
Values within a row with same superscript letters are not significantly different (P>0.05).
ND = Not detected

Table 4. Mean proximate content in eggs of *P. pelagicus* and other crab species

No.	Crabs species	Eggs color/ Embryo stage	Mean of proximate content (%)			Sources
			Protein	Fat	Carbohydrate	
1.	*P. pelagicus*	Yellow-brown	18.50-20.68	6.20- 8.30	-	11
2	*P. pelagicus*	Ovigerous female	57.00	14.00	6.60	10
3.	*P. pelagicus*	Yellow and brown	7.80-10.73	11.00-13.00*)	1.10	21
4	*P. pelagicus*	Yellow-brown	20.50-38.68	6.21-11.30	0.50-0.88	8
5.	*P. pelagicus*	I	58.84-60.51	19.48 -20.93	-	27
6.	*C. sapidus*	I-III	13.78-16.58[a]	1.11-4.87	0.12-0.54[b]	12
7.	*P. vigil*	Ovigerous female	20.93	1.05	2.76	31
8.	*P. pelagicus*	Yellow - dark gray	10.93-15.97	1.31-1.71	3.09-7.06	This study

*) =mg ml-1 a= mean of stage I and II b= mean of stage II and III - = no data

during embryonic development. In addition, the fat is also used as a component of cell membranes and eye pigment of decapods[3,6,7,13,14,31,33]. Beside fat, protein is also important as energy source in metabolism and morphogenesis processes during embrionic development1[3,14,19].

The carbohydrate of *P. pelagicus* eggs in this study was higher than that of decapod eggs in general[4]. Some researchers reported that carbohydrate had a minor role as an energy source during embryonic development of decopods[2,3,6,8,12,14,31]. However, carbohydrate was considered as main energy source in the early embryonic development of *M. rosenbergii*[32] and played an important role at the end of embryonic development in the synthesis of specific compounds, such as chitin[7].

4.2 Fatty Acid Composition

The fatty acid composition in *P. pelagicus* eggs during embryonic development whichwas caraterized by color change from yellow to dark gray underwent a change in the number of types and its content. There were twenty-nine fatty acids found in this study, but some types of fatty acids could not be found in certain egg color. In general, the content of SFA and MUFA during embryonic development decreased, except arachidic acid, stearic acid and behenic acid for SFA, and acid eicosenoic for MUFA. Meanwhile, PUFA increased, except linolenic acid and eicosetrienoic acid (Table 5).

The color change in *P. pelagicus* eggs from yellow to dark gray during embryonic development of P. pelagicus showed a decrease trend in SFA and MUFA, whereas PUFA increased.

The similar condition of the three fatty acids was also found in *M. idea* and *M. idella idella* eggs[13,14]. In C. sapidus eggs the content of SFA and PUFA increased in line with embryonic development, but MUFA decreased[12].

The decrease in SFA and MUFA of *P. pelagicus* eggs showed that the two groups of fatty acids were probably used as an energy source during embryonic development. Cell differentiation begins after gastulasion stage and requires a certain amount of energy[19] to support the process. The decrease in SFA content was lower than MUFA content, indicating the utilization of MUFA was higher than SFA, and this pattern was found in some other kinds of decapod[5].

The types of dominant fatty acid in *P. pelagicus* eggs serve as the primary energy source to support the development of embryos. The fatty acids consisted of palmitic acid, stearic acid, palmitoleic acid, oleic acid, ARA, EPA and DHA.

The types of these dominant fatty acids are relatively the same as found in several species of decapods that live in the sea, such as Polybius henslowii, Macropipus tuberculatus and Plesionika narval[5], *C. sapidus*[12], *M. brachydactyla*[2], and in freshwater such as M. malcolsonii[36], M. rosenbergii[32], *M. idea* and *M .idella idella*[13,14] which consisted of such acids as palmitic, stearic, miristic, oleac, palmitoleic, vaccenic, DHA, EPA, ARA and linoleic. Fatty acid contents and the number of the types in *P. pelagicus* found in this study were higher than what were previously reported[8,10]. However, they were slightly lower than those found in the eggs of *C. sapidus*[12], *M. idea* and *M. idella idella*[13,14]. Fatty acid contents vary among and within species, which are influenced by food conditions and habitat of adult decapods[2,6]. Variations in fatty acid contents are also influenced by the size of the egg, egg yolk material[2,10] and depth[2,5] and embryonic development[2,3,5,6,13,14,36].

The total fatty acid content of orange-colored *P. pelagicus* eggs was lower than the other three egg colors, except MUFA for dark gray-colored eggs. Orange-colored *P. pelagicus* eggs showed a gastrula stage and eye placode[15] in embryonic development. The low content of fatty acids in the stage showed that fatty acid was widely used as a source of energy compared to any other stage during embryonic development. The tendency of these fatty acids identically occurred in the eggs of *M. idea* and *M. idella idella*[13,14]. MUFA, especially palmitoleic acid, is considered as a source of energy at the end of the embryonic development of *P. pelagicus*, as shown by the drastic decrease in MUFA content of dark gray-colored eggs.

Generally, the contents of ARA, EPA and DHA in this study were found to increase during embryonic development of *P. pelagicus*, respectively 126.73 %, 124.61 % and 34.50. In contrast, the content of ARA, EPA and DHA in the orange-colored eggs dropped dramatically, while the content of brown- and dark gray-colored eggs increased. This suggested that the three types of fatty acids are widely used in the gastrula stage and placode eye, and at a later stage they are not used and stored as energy reserves to be used at an early stage of *P. pelagicus* larvae (zoea). If the content of fatty acids are high, especially essential fatty acid when the eggs hatch, the larvae in the early stages do not depend on the source of food that comes from outside[2,5-6,9]. DHA content in *P. pelagicus* eggs was lower than that found in other decapods egg, which generally range from 10 to 20 % of the total fatty acids[2] ARA, EPA and DHA are fatty acid have essential roles in the development of many decapods embryo and larvae. ARA and EPA play an active role in water transport and osmoregulation[36], and EPA supports the survival of larvae9. ARA serves as a precursor of biosynthetic protaglandin[12,36], which are substances affecting reproductive, digestive, respiratory systems and control the permeability of ions through membrane and fat decomposition[12]. ARA contributes to the growth, survival and improvement of larval resilience and post-larvae marine animals to acute stress[9]. EPA and DHA have also high fucntions in hatching decapod eggs[12]. DHA plays a role in the progression of retinal eye tissue[9,36], larval growth and development of brain neural networks[9]. However, the role of ARA, EPA and DHA in the development of embryos and larvae of *P. pelagicus* has not been studied to date.

5. Conclusion

The color changes of ovigerous female eggs in the blue swimming crab, Portunus pelagicus as the indication of embryo development would be followed by changes in the contents of the proximate.

In addition, the embryo development of the crab were characterised by the increase of the water and ash content of the eggs and the decrease in protein, fat and carbohydrate. Twenty-nine types of fatty acids were detected in the four embryonic development stages of the crab. The total content of fatty acids and PUFA increased during

Table 5. Content and the number of fatty acids based on egg color or embryo development stages on several species of decapods

No.	Species	Eggs color/ Embryo stage	Content (%) and amount of eggs fatty acid			Sources
			SFA	MUFA	PUFA	
1.	*P. pelagicus*	Ovigerous females	12.78 (8)	2.97 (4)	12.66 (6)	10
2.	*P. pelagicus*	Ovigerous females	12.92 (9)	4.70 (4)	15.39 (5)	8
3.	*C. sapidus*	I-III	30.57-34.85 (5)	28.77-33.94 (8)	28.89-31.44 (13)	12
4.	*M. idea*	I-IV	35.70-41.60 (9)	28.38-36.22 (9)	9.07-11.92 (5)	13
5.	*M. idella idella*	I-IV	36.27-41.47 (9)	27.25-36.37 (9)	9.20-11.91 (5)	14
6.	*P. pelagicus*	Yellow-dark gray	18.83-28.45 (12)	9.51-14.10 (8)	9.34-23.02 (9)	This study

( ) = Number of fatty acid type

the embryonic development, but in contrast the contents of SFA and MUFA declined. The fatty acid content of orange-colored eggs had lower fat compared to the three other colors, except for MUFA. The contents of ARA, EPA and DHA in the eggs generally increased during the color change process from yellow to dark gray, but dropped dramatically in the orange-colored eggs. Composition and content of proximate and fatty acid changed during embryonic development.

6. Acknowledgement

The research is funded by doctoral dissertation grant from Directorat General of Higher Education, Ministry of Education and Culture and from the University of Halu Oleo. The first author would like to thank to Kaharudin, Umi Kalsum and La Mpiri who helped him at field survey and laboratory works. The first author is indebted to Bogor Agricultural University, c.q. Department of Aquatic Resources Management for the excellent facilities during his study.

7. References

1. Hamid A. Blue swimming crab condition in Lasongko Bay Buton District, Southeast Sulawesi. Jurnal Mitra Bahari. 2011; 5(2):75–86 (in Indonesian language).
2. Figueiredo J, Narciso L. Egg volume, energy content and fatty acid profile of Maja brachydactyla (Crustacea: Brachyura: Majidae) during embryogenesis. Journal of the Marine Biological Association of the United Kingdom. 2008; 88(7):1401–5.
3. Figueiredo J, Penha-Lopes G, Anto J, Narciso L, Lin J. Potential fertility and egg development (volume, water, lipid, and fatty acid content) through embryogenesis of Uca rapax (Decapoda: Brachyura: Ocypodidae). Journal of Crustacean Biology. 2008; 28(3):528–33.
4. Moran AL, Mcalister JS. Egg size as a life history character of marine invertebrate: is it all it's cracked up to be? Biol Bull. 2009; 216:226–42.
5. Rosa R, Calado R, Narciso L, Nunes ML. Embryogenesis of decapod crustaceans with different life history traits, feeding ecologies and habitats: a fatty acid approach. Mar Biol. 2007; 151:935–47.
6. Figueiredo J, Penha-Lopes G, Anto J, Narciso L, Lin J. Fecundity, brood loss and egg development through embryogenesis of Armases cinereum (Decapoda: Grapsidae). Mar Biol. 2008; 154:287–94.
7. Garcıa-Guerrero MU. Effect of temperature on consumption rate of main yolk components during embryo development of the prawn Macrobrachium americanum (Crustacea: Decapoda: Palaemonidae). J World Aquaculture Soc. 2010; 41(S1):84–92.
8. Khoei JK, Bastami AA, Esmailian M. The biochemical composition of the eggs blue swimming crab, Portunus pelagicus (Linnaeus, 1758) in the Persian Gulf Coasts, Iran. Middle East J Sci Res. 2012; 12(7):915–20.
9. Figueiredo J, Anto J, Lin J, Narcico L. The consumption of DHA during embryogenesis as an indicative of the need to supply DHA during early larval development: a review. J Aquaculture Res Dev. 2012; 3(5):140–8.
10. Soundarapandian P, Singh RK. Biochemical composition of the eggs of commercially important crab Portunus pelagicus (Linnaeus). Int J Zool Res. 2008; 4:53–8.
11. Radhakrishnan CK. The eggs of marine crabs an unexploited resource. Naga, The ICLARM Quarterly. 2000; 23(3):4–5.
12. Li S, Cheng Y, Zhou B, Hines AH. Changes in biochemical composition of newly spawned eggs, prehatching embryos and newly hatched larvae of the blue crab (Callinectes sapidus). Journal of Shellfish Research. 2012; 31(4):941–6.
13. Soundarapandian P, Sudhakar S, Varadharajan D, Dinakaran GK. Biochemical composition during the embryonic development and freshly hatched zoea of Macrobrachium idae (Heller, 1862). J Earth Sci Climatic Change. 2013; 5:171–6.
14. Soundarapandian P, Dinakaran GK, Varadharajan D. Biochemical composition during the embryonic development and freshly hatched zoea of Macrobrachium idella idella (Hilgendorf, 1898). Advanced Techniques in Biology & Medicine. 2013; 1:111–5.
15. Soundarapandian P, Tamizhazhagan T. Embryonic development of commercially important swimming crab Portunus pelagicus (Linnaeus). Curr Res J Biol Sci. 2009; 1(3):106–8.
16. Arshad A, Efrizal, Kamarudin MS, Saad CR. Study on fecundity, embryology and larval development of blue swimming crab Portunus Pelagicus (Linnaeus, 1758) under laboratory conditions. Research Journal of Fisheries and Hydrobiology. 2006; 1(1):35–44.
17. Ikhwanuddin M, Azra MN, Aimuni HS, Abol-Munafi AB. Fecundity, embryonic and ovarian development of blue swimming crab, Portunus pelagicus (Linnaeus, 1758) in coastal water of Johor, Malaysia. Pakistan J Biol Sci. 2012; 15:720–8.
18. Ravi R, Manisseri MK. Alterations in size, weight and morphology of the eggs of blue swimmer crab, Portunus pelagicus Linnaeus, 1758 (Decapoda, Brachyura, Portunidae) during incubation. Turk J Fish Aquat Sci. 2013; 13:509–15.
19. Samuel NJ, Soundarapandian P. Embryonic development of commercially important portunid crab Portunus sanguinolentus (Herbst). Int J Anim Vet Adv. 2009; 1(2):32–8.
20. Pillay K, Nair NB. Observations on the biochemical changes in gonads and other organs of Uca annulipes, Portunus pelagicus and Metapenaeus affinis (Decapoda: Crustacea) during the reproductive cycle. Mar Biol. 1973; 18:167–98.

21. Bhat BA, Ravichandran S, Allayie SA. Influence of the eyestalk hormone on the metabolism and ionic regulation of the crab Portunus pelagicus (Linneaus, 1857). J Biol Sci. 2011; 11(2):1–7.
22. Rameshkumar G, Ravichandran S, Chandan K, Ajithkumar TT. Comparison of fatty acid profile in the edible crabs Scylla serrata and Portunus pelagicus. Global Journal of Enviromental Research. 2009; 3(1):42–5.
23. Priya ER, Jeyalakshmi-Kala KL, S Ravichandran S, Chandran M. Variation of lipid concentration in some edible crabs. World J Fish Mar Sci. 2013; 5(1):110–2.
24. Hamsa KMSA. Chemical composition of the swimming crab Portunus pelagicus Linnaeus. Indian J Fish. 1978; 25(1):271–3.
25. Ayas D, ÖzoulY. The chemical composition of sexually mature blue swimmer crab (Portunus pelagicus, Linnaeus 1758) in the Mersin Bay. Journal of Fisheries Sciences. 2011; 5(4):308–16.
26. Akbar Z, Qasim R, Siddiqui PJA. Seasonal variations in biochemical composition of edible crab (Portunus pelagicus Linneaus). Journal of Islamic Academy of Sciences. 1998; 1(2):127–33.
27. Oniam V, Chuchit L, Arkronrat W. Reproductive performance and larval quality of blue swimming crab (Portunus pelagicus) broodstock, fed with different feeds. Songklanakarin Journal of Sciences Technology. 2012; 34(4):381–6.
28. AOAC. Official methods of analysis of the association of official analysis chemists. Association of Official Analytical Chemists. 14th Ed. Washington: 1984. p. 1102.
29. Steel RGD, Torie JH. Principles and procedures of statistics. Second Edition, New York: McGraw-Hill; 1980.
30. Baklouti S, Derbali A, Dhieb K, Kammoun W, Jarboui O. Proximate composition and its seasonality of the Mediterranean green crab: Carcinus aestuarii Nardo, 1847 (Brachyura, Portunidae), in southern Tunisian waters (Central Mediterranean). Journal of Marine Biology. 2013; 6 pages.
31. Soundarapandian P, Ravichandran S, Varadharajan D. Biochemical composition of edible crab, Podophthalmus vigil (Fabricius). J Mar Sci Res Dev. 2013; 3(2):119–22.
32. Yao J, Zhao Y, Wang Q, Zhou Z, Hu X, Duan X, An C. Biochemical compositions and digestive enzyme activities during the embryonic development of prawn, Macrobrachium rosenbergii. Aquaculture. 2006; 253:573–82.
33. Reppond K, Rugolo L, de Oliveira ACM. Change in biochemical composition during development of snow crab, Chionoecetes opilio embryos. Journal of Crustacean Biology. 2008; 28(3):519–27.
34. Chaiyawat M, Eungrasamee I, Raksakulthai N. Quality characteristics of blue swimming crab (Portunus pelagicus, Linnaeus 1758) meat fed Gracilaria edulis (Gmelin) Silva. Kasetsart Journal Natural Science. 2008; 42:522–30.
35. Torres G, Gime´nez L, Anger K. Effects of reduced salinity on the biochemical composition (lipid, protein) of zoea 1 decapod crustacean larvae. J Exp Mar Biol Ecol. 2002; 277:43–60.
36. Samuel MJ, Kannupandi T, Soundarapandian P. Fatty acid profile during embryonic development of the cultivable freshwater prawn Macrobrachium malcolmsonii (H. Milne Edwards). Indian J Fish. 1998; 45(2):141–8.