Advances in Social Science, Education and Humanities Research, volume 298
Proceedings of the First International Conference on Applied Science and Technology (iCAST 2018)

Replacement of Fish Meal with Maggot Meal from Bioconversion Process of Palm Kernel Cake in Diets Formulation of Nile Tilapia (Oreochromis Niloticus)

Rietje J. M. Bokau*
Department of Animal Husbandry
Politeknik Negeri Lampung
Bandar Lampung, Indonesia
*rietjebokau@polinela.ac.id

Tutu Petrus Basuki
Departemen of Agriculture Technology
Politeknik Negeri Lampung
Bandar Lampung, Indonesia

***Abstract*—The objective of this research was to study the effect of replacement of fish meal with maggot meal for growth and survival rate and to determine the best percentage of substitution maggot meal in the diets of nile tilapia (*Oreochromis niloticus*) growing. Maggot used was the result of mass culture through the rearing of Black Soldier Fly (BSF) in the cage to produce eggs. Furthermore, the eggs harvested and spread on the medium of palm kernel cake for bioconversion process for 10 days and harvested, dried and milled. Replacement of fish meal with maggot meal in diets as a treatment was A (0%), B (10%), C (20%), D (30%), and E (40%) with a feed protein content 30%. The total of 350 nile as test fish with an average weigth 10-12g were cultivated in 15 units of aquarium 60 l and nurtured for 49days. The experimental method used was a completly randomized design and were analyzed by ANOVA and multiple comparisons. Among treatment means were made with Duncan's multiple comparison test using the Statistical Analysis Software Program of SPSS version 21 for Windows. all probability values were considered statistically significant at the level of P< 0.05. The result of this study show that replacement fish meal with maggot meal at various percentages of dietary treatments have a significant effect on growth, survival rate, and FCR, nevertheless the most optimal percentage is at 30%.**

Keywords—maggot meal, fish meal, bioconversion, replacement

I. Introduction

Increased aquaculture production automatically increases the need for fish feed. On the other hand fish meal as one of the important protein sources in feed formulations experienced considerable obstacles in its supply because most of it was still imported. This condition causes the price of commercial feed to be expensive, while the cost of feed is the largest component in fish farming. For fish farmers, this is one of the critical factors for successful farming. In an intensive cultivation system, feed must always be available according to the needs of fish both in quality and quantity. Tilapia fish are reared intensively, require that the form of crumb size feed pellets with protein content of not less than 30% [1]. Some of the requirements for feed ingredients are containing nutrients, relatively cheap prices, non-toxic, and not the main consumption of humans.

Various studies have been carried out to find alternative substitute feeds or feed ingredients that are more economical that can reduce production costs in fish cultivation, especially animal feed ingredients as a source of protein [2]. One type of material that has the potential to be developed as a substitute or at the same time used as a fish feed ingredient is maggot [3]. Insect larvae of Black Soldier Fly (BSF) are known as decomposers because of their habit of consuming organic materials. Its presence can be found in almost all of the world with a larval size of about 2 cm. Hilaire et al. stated that maggot has advantages, including [4]: 1) can reduce organic waste (dewatering), 2) can live in a fairly wide pH tolerance, c) do not carry disease/agent, 3) contain high enough protein (40-50%), 4) life span is quite long (around 4 weeks), and 5) Does not require high technology. The production process is known as Bioconversion, which is a process that converts forms from products/materials that are less valuable into valuable products using biological agents (living things: insect BSF). Material requirements can be used as feed ingredients, namely: harmless to fish, available at all times, containing nutrients according to the needs of fish, and the material does not compete with humans. Based on these requirements, maggot can be used as feed ingredients. This BSF larvae can grow and develop on media that contain nutrients that are suitable for their needs. Maggot cultivation can be done by using media containing organic and waste-based materials or by-products of agro-industry activities. The transformation from vegetable protein to animal protein is known as the bioconversion process. Bioconversion is the process of transforming organic waste into a source of methane energy through a fermentation process involving living microorganisms such as bacteria, fungi and insect larvae [5]. Biomonversion biomass agents in the form of maggot larvae are then used as raw material for fish feed. Insect larvae of *Hermetia illucens* (Maggot) are found in organic wastes and are not reported as agents for disease spread [5]. Palm kernel cake is one of the media that is widely used to produce maggot, especially in the area of oil palm plantations and processing industries such as Lampung. The potential of palm kernel cake can support the mass production of maggot larvae as raw material for fish feed to overcome the problem of fulfilling fish meal needs.

Maggots can be used as feed for various stages of fish development, from seeds, to the enlargement stage and also to the brood stock. In addition, the method of use can be directly given to fish as fresh food, in dry form or pasta, and can be dried into fish meal which is one of the raw materials in the preparation of fish feed formulations so that they can be used as raw material for animal protein sources. To support the development of freshwater fish culture, among others, tilapia is needed the availability of sufficient feed with quality in accordance with fish needs. Maggot meal is an alternative source of protein derived from insects. Nowadays the research on the development of alternative animal protein sources is directed at utilizing the insects [6]. This is very important because of the increasing demand for protein which causes high prices of animal-based protein. Besides being able to be mass produced, maggot contains high enough nutrients. Protein content ranges from 40-52% [7], can even reach 63.99% [8], lipid content ranges from 23-32% [7]. The composition and amino acid content of maggot meal is not much different from menhaden fish meal [7]. Amino acids cysteine, histidine, phenylalanine, tryptophan and tyrosine are reported to be higher in maggot meal than fish meal and soy meal [9], besides that maggot meal also contains high phosphorus.

Some researchers have previously reported the results of using maggot meal as an additional raw material or as a substitute for fish meal in feed formulations for fish and livestock. Dudusola et al. concluded that 75% maggot meal in catfish feed gave the best performance [10], with a 100% substitution of fishmeal can improve the nutritional properties of meat in milking fish. Rachmawati et al. concluded that maggot meal can replace fish meal at a level of 25% for the best growth [11]. The administration of maggot in catfish feed can increase survival rates compared to giving artemia 01 [12]. The addition of fresh maggot as an additional feed of 40% results in optimal growth in catfish breeding [13]. Maggot is also used as a feed for poultry and livestock. Rambet et al concluded that maggot meal has the potential to replace fish meal to 100% level for broiler feed mixtures [14], for quail feed 50-75% [15]. This study aims to determine the mass production of maggot larvae in palm kernel cake (BIS) media as a result of bioconversion, then find out the results of the utilization of maggot meal as a substitute for fishmeal to growth and survival in tilapia rearing.

II. Material and Method

This research was conducted during 60 days at the Lampung State Polytechnic, Indonesia. This activity includes the production of maggot, drying and grinding of maggot and testing on fish was carried out at the Laboratory of aquaculture.

A. Maggot Production

Palm kernel cake was used as a BSF egg hatching medium to produce maggot larvae. The cake was mashed first and then weighed and placed in a container and mixed with water and probiotics (3%) [7], until the media becomes moist and placed indoors and left for 2-3 days. Furthermore, BSF eggs derived from the results of maintenance in separate enclosures were spread to the media. Eggs were stocked as much as 1gram/kg of media and closed using plastic net. After 7-10 days of hatching process, Maggot were able to be harvested, rinsed until bleached from the rest of the media attached and dried to dry and constant weight, then dried dry maggots, sifted and ready to be used as one of the raw materials for tilapia feed substitution.

B. Experimental Diets

Feed ingredients other than maggot meal was used locally based in Lampung, Indonesia. The major feed ingredients used were fish meal, maggot meal, soybean meal, yellow maize, fine bran, tapioca, squid liver oil, vitamins, minerals (Table 1). Substitution of maggot meal in feed formulation was a treatment consisting of 5 levels of substitution, namely: feed A (substitution of 0% maggot meal), feed B (substitution of maggot meal 10%), feed C (substitution of maggot meal 20%), D (substitution of meal maggot 30%), and E (substitution of maggot meal 40%).

TABLE I. COMPOSITION OF DIET SUBSTITUTION MAGGOT MEAL FOR NILE TILAPIA

Raw Material	Diet A	Diet B	Di et C	Di et D	Diet E
Fish meal (%)	48	39	30	21	11
Maggot meal (%)	0	10	20	30	40
Soybean meal (%)	17	18	17	17	17
Yellow maize (%)	9	9	9	9	9
Fine bran (%)	11	10	9	9	9
Tapioca (%)	10	9	10	9	9
Squid lever oil (%)	2	2	2	2	2
Vitamin (%)	2	2	2	2	2
Mineral (%)	1	1	1	1	1
Proximate analysis (% dry matter)					
Moisture	3.76	4.01	5.36	5.51	5.74
Protein	34.05	33.28	32.10	31.93	30.29
Fat	8.94	11.65	14.83	14.56	18.56
Carbohydrate	33.77	32.57	32.45	29.67	28.01
Coarse fibre	5.41	5.87	4.49	4.92	4.69
Ash	14.04	12.60	10.74	9.38	8.69

Feed A, B, C, D, and E were arranged in formulations with 30% protein content. The feeds were made into pellets using pelletizing machines. Pellets were sun dried for 5 days to reduce the moisture content and to prevent deterioration. Each treatments feed was packed separately and stored in the air tight container at room temperature.

C. Experimental Procedure

Three hundred tilapia fish seeds (Tilapia Nilotic us) which were relatively the same size around 16.21-17.58 g and the length of 8.7-9.6cm were used as test fish in this study, maintained in 15 aquarium units measuring (80x40) cm filled with water up to 30cm and aerated. The test fish were stocked as much as 20 fish per aquarium. The fish were acclimatized for ten days in preparation for the experiment. Furthermore, feeding was conducted using 3% of biomass and feeding frequency used was 3 times per day. Siphon is carried out every day before being fed to remove waste and uneaten feed, while total water replacement was done every week when measuring length and weight was conducted. During the study, periodic water quality measurements were carried out in accordance with the water parameters measured, temperature measurements were carried out in the morning and evening, pH, dissolved oxygen (DO), and ammoniac were measured every week before and after changing water.

D. Data Collection

For data collection, test fish was measured every week by harvesting in total and measuring all fish one by one for weight and length. The parameters measured were weight and length gain, specific growth rate, survival rate, feed conversion ratio (FCR). While, water quality parameters measured were Dissolved oxygen (DO), temperature, ammonia (NH3) and pH.

E. Chemical Analysis

The proximate analysis of maggot meal diet and the fish carcass were done, using the procedure outlined by AOAC (1990).

F. Statistical Analysis

The data obtained from experiment were subjected to analysis of variance (ANOVA) using completely randomized design SPSS. The Tuckey's multiple range test and Duncan's multiple range test were used to compare differences among treatment means. Treatments effect were considered significant at P<0.05.

III. Results and Discussion

A. Maggot Production

Maggot production from mass culture was done by spreading eggs on prepared media. Based on the results of the use of palm kernel cake media which was fermented by giving probiotics with different doses, the average maggot biomass varied after 7 days of maintenance. Maggot biomass produced from the media ranged from 696-859 grams. The treatment of F0 (without the addition of probiotics) obtained the lowest biomass (696gram) and the highest biomass was in F3 treatment (addition of probiotics 3%). The administration of probiotics to water used in mixing palm kernel cake as a medium influenced the production of maggot larvae biomass. The greater the dose, the greater the biomass produced, except in F4 (the addition of probiotics 4%) reduced biomass (Figure 1).

The test results show that there were significant differences in the results of maggot biomass in the medium of fermentation with probiotics and non-fermentation. Whereas in fermentation treatment, F1 was significantly different from F2 and F3. The results of research from several previous researchers who used palm kernel cake media showed that the biomass produced from this study was much higher. Silmina et al. at natural culture produced 25-50gram biomass [16]; Fahmi et al. resulted in 1kg/3kg BIS media [17]; Obtained a density of 1.21 maggot larvae/cm^3 with an average weight of 150 grams, in other media, 2kg coconut cake, Katayane et al. produced fresh weight of maggot 93.42 grams through 0.45 grams of egg stocking [18].

Proximate analysis of the resulting maggot showed a difference in the maggot protein content of each medium (Figure 1). The higher the probiotic dose, the higher the protein content, F0 (46,8081%), F3 (52,6082), F4 (51,9201%), and F5 (53,1717%), respectively. The administration of probiotics in the media was able to help the initial decomposition of organic ingredients before being further elaborated by the newly hatched maggot. Result of protein analysis is indicated by N or crude protein. According to Mangunwardoyo et.al, during the bioconversion process media, protein increases [19]. Nitrogen is the main component of cell proteins in which the nitrogen consumption has direct effect on the protein synthesis in the organism or microbe cell. Protein is a very important nutrient in the composition of artificial fish feed formulation. Protein produced by the fish. Treatment with 3% fermentation (F3) and 52.61% protein content was assumed as the optimum result used for maggot meal.

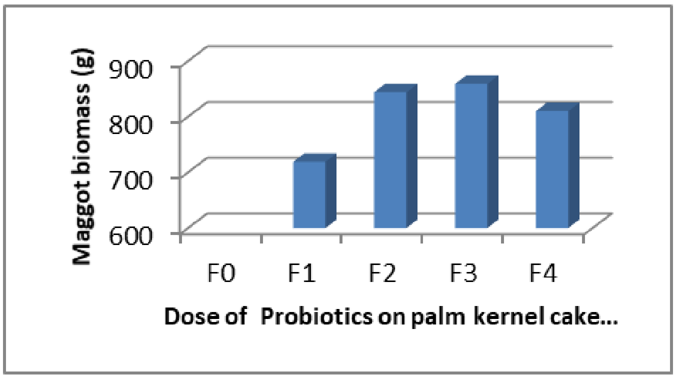

Fig. 1. The average maggot biomass produced from the process of bioconversion in palm kernel cake.

TABLE II. Proximate Analysis (%) of Maggot Fluor of Each Media

Proximate Test Parameter (%)	Treatment Media			
	F0	*F3*	*F4*	*F5*
Water	5.6425	6.6425	5.6425	7.0556
Ashes	10.7092	10.7092	10.7092	10.4828
Protein	46.8081	52.6082	51.9201	53.1717
Fat	25.6687	23.6687	20.6687	18.9407
Coarse Fiber	9.2239	9.2239	9.2239	9.6012
Carbohydrate	1.9476	1.9476	1.9476	0.7481

B. Replacement of maggot meal and Nile Tilapia Growth

The results showed that the substitution of fish meal with maggot meal in artificial feed gave a good response to the growth of tilapia where the feed given had a significant effect (P <0.05) with different results. The growth performance of Nile Tilapia fed with different levels of maggot meal (A 0%, B 10%, C 20%, D 30%, and E 40%) to replace fish meal in experiment showed different results (Table 3). Compared with treatment A (0%) as a control showed that the percentage maggot meal given significantly affected the final mean weight (FMW), mean weight gain (MWG), specific weight growth (SWG), specific length growth (SLG), Food conversion ratio, and survival rate (SR), while final mean length (FML) and mean length gain were no significant. At a replacement level of 20% and 30% (the treatment C and D) resulted in a high final mean weight of 32.12 ± 2.19 g and 32.68 ± 2.46 g. The highest mean weight gain was at D (30%), which was 15.12 ± 0.51 g and in more percentage height D (40%), MWG decreased, namely 13.09 ± 0.77 g. The highest specific weight was D (30%) which was 1.81 ± 0.83%. Food conversion ratio shows that 30% of fish meal with maggot meal replacement treatment (D treatment) was significant different (1.81 ± 0.32), while the survival rate increased significantly with an increase in percentage replacement and the highest was in treatment D (30%) which was 88.67 ± 2.87 %.

TABLE III. GROWTH, SURVIVAL RATE AND FOOD CONVERSION OF NILE TILAPIA MEAL

Parameter	Percentage of maggot meal in diets				
	A(0%)	*B(10%)*	*C(20%)*	*D(30%)*	*E(40%)*
Initial mean weight	16.34±0.85	16.89±0.65	17.23±0.98	17.56±1.21	17.48±0.11
Final mean weight	26.43±1.73	31.34±1.73	32.12±2.19	32.68±2.46	30.57±2.94
Mean weight gain	10.09±1.15	14.45±0.91	14.89±0.23	15.12±0.51	13.09±0.77
Initial mean length	8.91±0.89		9.81±0.96	9.61±1.02	9.41±0.35
Final mean length	11.71±0.38	12.18±0.38	12.62±0.26	12.92±0.39	12.08±0.39
Mean length gain	2.81±1.28		2.82±0.69	3.32±0.79	2.68±0.39
SGR (W) (%)	1.31±0.17		1.61±0.34	1.81±0.83	1.71±0.23
SGR (L) (%)	0.51±0.33		0.72±0.19	0.71±0.43	0.63±0.11
FCR	2.41±0.62	2.41±0.58	2.21±0.46	1.81±0.32	2.31±0.11
SR (%)	73.31±2.8	74.05±1.53	83.33±2.89	88.33±2.88	86.67±2.87

^{a,b,c}Letters in the same row show differences among treatments ($p < 0.05$) unit length=cm, unit weigth=gram

Growth is a change in size both weight and length in a certain period of time, where growth occurs due to the addition of tissue from mitotic cell division and the presence of excess energy and protein inputs sourced from feed and used by the body for metabolism, replacing damaged cells, reproduction and other activities. Growth is also affected by the balance of nutrients in the feed. Overall the results of the study showed that the addition of maggot meal to fish meal substitution in feed formulations gave a good response in the growth of tilapia, but long growth had no significant effect. The level of substitution of maggot flour 30% (treatment D) produced the highest growth (final weight, weight gain, specific growth. At a higher substitution (40%), it could not increase the final weight and specific growth. In previous studies using different types of fish, the level of substitution of maggot flour was different. Makinde provides an optimal limit of 25-30% for *Clarias gariepinus* and if it is increased will reduce growth performance [8]. Comparison of 4: 1 wheat bran and live maggot was used for growth performance and specific growth rate of Nile Tilapia [8]. The final mean length was not significantly different, however, the feed treatment for substitution of maggot meal B, C, D, and E was higher than control (A) which shows that the nutrients in maggot meal affected the addition of fish length. Body length growth is closely related to bone growth associated with the availability of minerals (calcium and phosphorus) and amino acids. Minerals in feed are available in small amounts and are sourced from mineral mix, maggot and fish meal [20]. Further explanation, maggot contains high phosphorus [10]. Ajani et al. mentions that the content of Phosphorus and Calcium was 0.5 and 0.6%, respectively [9].

In pangasius, the best substitution with maggot meal at a level of 25% is slightly lower than the results of this study, which is 30%. Whereas in other studies for tilapia, substitution of 0, 25, 50, 75 and 100% resulted in the best substitution rate of 50 percent of maggot meal [9]. The use of protein in artificial feed for fish varied because it is influenced by the type and size of fish, energy and nutritional balance. Increased feed protein is not always followed by increasing fish growth [11], excess protein will be excreted in the form of ammonia where to process and dispose of it requires energy and energy for reduced growth.

Food Convertion Ratio (FCR) is the ability of fish to consume feed given, and is directly proportional to the increase in body weight. Based on observations during the study, the largest FCR value obtained was 2.41 (treatment A and B), 2.21 (treatment C), 2.31 (treatment E), the smallest 1.81 (treatment D). The greater substitution of maggot meal produced a large FCR which showed the ability of fish to use decreased feed which was thought to be due to the content of chitin in maggot meal which cannot be digested by fish.

The survival rate at the end of the study showed that a higher substitution affected fish SR with the highest value of 88%.

IV. CONCLUSION

The treatment of substitution of fish meal with maggot meal (0%, 10%, 20%, 30%, and 40%) in fish-based feeds affected the growth, growth rate, FCR, and survival rate of tilapia. Substitution of fish meal with maggot meal in tilapia feed formulation, is optimal at 30% level.

ACKNOWLEDGMENT

This study was financially supported by the Competing Research Grant from Directorate General of Higher Education, Ministry of Research, Technology and Higher Education of Indonesia 2016-2017. The authors are thankful to the Laboratory of Aquaculture Politeknik Negeri Lampung, and Center of Ornamen Fish Culture Depok, West Java, Indonesia for providing facilities.

REFERENCES

[1] S.R. Suyanto, Budidaya Ikan Nila. Jakarta: Penebar Swadaya,1994.

[2] M.F. Sukadi, Strategi and Kebijakan Pengembangan Pakan Dalam Budidaya Perikanan. Prosiding Semi-Loka Aplikasi Teknologi Pakan and Peranannya Bagi Perkembangan Usaha Perikanan Budidaya, Bogor, 2003, p. 9.

[3] I.W. Subamia, B. Nur, A. Musa and R.V. Kusumah, Manfaat Maggot yang dipelihara dengan Zat Pemicu Warna Sebagai Pakan Untuk Peningkatan Kualitas Warna Ikan Rainbow (Melanotaenia boesmani) asli Papua. Balai Riset Budidaya Ikan Hias Depok. Depok, 2010.

[4] I. D'Amours and C. St-Hilaire, Levé magnétique aéroporté dans les secteurs de Villebois et Senneterre, Abitibi, Québec. Ressources naturelles et faune Québec, 2010.

[5] L.C. Newton,, D.C. Sheppard, D.W. Watson, G.J. Burtle, C.R. Dove, J.K. Tomberlin, and E.E. Thelen, The Black Soldier Fly, Hermetia illucens, as a Manure Manajement/Resource Recovery Tool. State in Science, Animal Menure and Waste Management, 2005.

[6] A.H. Wardhana, Black Soldier Fly (Hermetia illucens) as an Alternative Protein Source for Animal Feed. *Wartazoa,* vol. 26, no. 2, 2016.

[7] R.J.M. Bokau and P. Witoko, "Optimalization of Bioconversion Proses of Palm Kernel Cake for Production Maggot Hermetia illucens as A Source of Animal Protein in Fish Farming," *Jour. Of Aquacultura Indonesiana, vol.* 18, no. 1, pp. 20-25, 2017.

[8] O.J. Makinde, "Maggot Meal: A Sustainable Protein Source for Livestock Production- A Review," *Advances in Life Science and Technology,* vol. 31, pp. 35-41, 2015.

[9] E.K. Ajani, L.C. Nwanna and B.O. Musa, "Replacement of Fishmeal with Maggot Meal in the Diets of Nile tilapia, Oreochromis niloticus," *World Aquaculture*: pp. 52-54, 2004.

[10] A. Dudusola and A.S. Temenu, The Use of Maggot Meal in African Cat Fish Feeding. *Advances in Aquaculture and Fisheries Management*, vol. 1, no. 5, pp. 49-51, 2013.

[11] D. Rachmawati dan S. Istiyanto, "The Effect of Substitution of Fish Meal with Maggot in Artificial Feed for Growth and Survival Rate of Catfish (*Pangasius pangasius*)," *Jurnal Saintek Perikanan, v*ol. 9, no. 1, pp. 62-67, 2013.

[12] B.C. Atse, Y.B. Ossey, K.M. Koffi and P.L. Kouame, "Effect of Feeding by Product; Maggot Meal, Fish Meal, Bood Meal and Beef Brain on Growth, Survival and Carcass Composition of African Catfish, Heterobranchus Longifilis Valenciennes, 1840 Larvae under Recirculating Conditions," *International Journal of Agriculture Innovations and Research, v*ol 2, no. 4, pp. 530-535, 2014.

[13] R.J.M. Bokau and T.P. Basuki, "Utilization of Maggot (Larva Hermetia illucens) from The Process of Bioconversion of Palm Kernel Cake as Additional Feed for Growth of Catfish," *Proceeding of International Conference of Aquaculture Indonesia. Solo, Indonesia,* October 27-28, 2017.

[14] V. Rambet, J.F. Umboh, Y.L.R. Tulung and Y.H.S. Kowel, "Kecernaan protein dan energi ransum broiler yang menggunakan tepung maggot (Hermetia illucens) sebagai pengganti tepung ikan," J Zootek. Vol. 36, pp. 13-22, 2016.

[15] T. Widjastuti, R. Wiradimadja and D. Rusmana, "The effect of substitution of fish meal by Black Soldier Fly (Hermetia illucens) maggot meal in the diet on production performance of quail (Coturnix coturnix japonica)," Anim Sci. vol. 57, pp. 125-129, 2014.

[16] D. Silmina, G. Edriani dan M. Putri, Efektifitas Berbagai Media Budidaya Terhadap Pertumbuhan Maggot *Hermetia illucens*. IPB Bogor, 2011.

[17] M.R. Fahmi, "Manajemen pengembangan maggot menuju kawasan pakan mina mandiri. Dalam: Prosiding Forum Inovasi Teknologi Akuakultur. Jakarta (Indonesia): Pusat Penelitian dan Pengembangan Perikanan, 2011, p. 763-767.

[18] A.F. Katayane, F.R. Wolayan, dan M.R. Imbar, "Produksi dan Kandungan Protein Maggot (Hermetia illucens) dengan Menggunakan Media Tumbuh Berbeda," *Jur. Zootek, vol.* 34, pp. 27-36, 2014.

[19] W. Mangunwardoyo, A. Aulia and S. Hem, "Penggunaan bungkil inti kelapa sawit hasil biokonversi sebagai substrat pertumbuhan larva Hermetia illucens L (maggot)," Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati, vol. 16, no. 2, pp. 166-172, 2011.

[20] A. Priyadi, I.A. Zafril, I.W. Subamia dan S. Hem, "Pemanfaatan Maggot Sebagai Pengganti Tepung Ikan Dalam Pakan Buatan Untuk Benih Ikan Balashark (*Balanthiocheilus melanopterus* Bleeker)," *Jurnal Riset Akuakultur*, vol. 4, No. 3, pp. 367-375, 2009.