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The Effect of Palm Kernel Cake Thickness as a Culture Medium on the Growth and Production of Maggots (*Hermetia illucens*)

Pengaruh Ketebalan Bungkil Sawit sebagai Media Kultur terhadap Pertumbuhan dan Produksi Maggot (Hermetia illucens)

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Abstract

Hermetia illucens larvae, commonly known as Black Soldier Fly (BSF) maggots, are rich in protein and fat, making them an excellent alternative feed for fish. Utilizing them as a fish feed source and as a bio-machine for waste processing requires cultivating maggots. This study was conducted for 30 days, from February 6 to March 6, 2024, at the Fish Seed Center (BBI) of the Faculty of Agriculture, Riau Islamic University, Pekanbaru. The method used was a completely randomized design (CRD) with 5 treatments and 3 replicates, namely, P1 = palm kernel meal thickness (5 cm), P2 = 7 cm, P3 = 9 cm, P4 = 11 cm, and P5 = 13 cm. The study's results showed the best results in treatment P5, with a weight gain of 0.252 g, a length gain of 1.83 cm, a daily growth rate of 0.00351%, and an average production of 967 g. The best culture medium content test results were obtained from P5, with water content of 29.74%, protein of 36.60%, fat of 4.31%, carbohydrates of 1.31%, and crude fiber of 2.13%. The environmental parameters during the study were a temperature range of 35.7 to 41.2 °C, a humidity range of 70-96%, and a pH range of 6.3-6.5.

Keywords: Maggot, Culture Media, Thickness, Growth, Production

Abstrak

Larva serangga *Hermetia illucen* atau *Black Soldier Fly* (BSF) yang sering disebut dengan istilah magot mengandung protein dan lemak sangat tinggi sehingga baik digunakan sebagai pakan alternatif untuk ikan. Pemanfaatan sebagai sumber pakan ikan sekaligus sebagai bio mesin pengolahan sampah, maka magot harus dibudidayakan. Penelitian ini dilaksanakan selama 30 hari yang dimulai pada tanggal 06 Februari hingga tanggal 06 Maret 2024 di Balai Benih Ikan (BBI) Fakultas Pertanian Universitas Islam Riau Pekanbaru. Metode yang digunakan adalah Rancangan Acak lengkap (RAL) 5 perlakuan dengan 3 ulangan yaitu, P1 = ketebalan bungkil sawit (5 cm), P2 = 7 cm, P3 = 9 cm, P4 = 11 cm, dan P5 = 13 cm. Hasil penelitian memperoleh hasil terbaik pada perlakuan P5 dengan pertumbuhan berat sebesar 0,252 gr, pertumbuhan panjang sebesar 1,83 cm, laju pertumbuhan harian sebesar 0,00351% dan mendapatkan rata-rata produksi sebesar 967 gr. Hasil uji kandungan media kultur yang terbaik yaitu P5 dengan kadar air 29,74%, protein 36,60%, lemak 4,31%, karbohidrat 1,31%, serat kasar 2,13%. Parameter lingkungan selama penelitian yaitu suhu berkisar 35,7 hingga 41,2^{o}C, kelembaban 70-96% dan pH 6,3-6,5.

Kata kunci: Maggot, Media Kultur, Ketebalan, Pertumbuhan, Produksi

1. Introduction

These BSF larvae can grow and develop in media that contain nutrients suitable for their life needs. Maggot cultivation can be carried out using media containing organic materials derived from waste or by-products of agro-industrial activities. Some materials that can be used as media for maggot cultivation include pollard flour, palm kernel meal (BIS), bran, tofu pulp, and coconut meal (Bokau et al., 2018). However, palm kernel meal has greater development potential, especially in Riau Province, which has ample land for palm oil plantations and industry. This opinion is reinforced by Harahap (2022), who states that one of the media for cultivating maggots is palm kernel meal.

In addition to the type of medium that affects maggot growth and production, the thickness of the medium can also affect maggot growth and production. According to observations from secondary data obtained from three maggot farmers in Pekanbaru (Arman, Erdison, and Hamid), thickness also plays an important role in maggot growth and production. This is because the process of maggot growth and production requires sufficient space within the culture medium and evenly distributed nutrients.

Several researchers have studied different thicknesses. Wicaksono (2020) researched maggots with a media thickness of 5 cm. Harahap (2022) conducted a study titled "The effect of a combination of palm kernel meal and tofu pulp" with a thickness of 7 cm. Purba (2002) conducted research on the effect of administering a combination of tofu pulp and discarded bread using a media thickness of 9 cm. Cahyadi (2023) researched the effect of administering a combination of pineapple waste with a maggot culture medium with a thickness of 11 cm. Based on the above description, the author is interested in researching the effect of palm kernel meal thickness on maggot production. The author hopes that this research will be useful for fish farmers, provide employment opportunities for the community, and serve as an example for further research.

2. Material and Method

2.1. Time and Place

This study was conducted at the Fish Seed Center (BBI) of the Faculty of Agriculture, Riau Islamic University, Pekanbaru. The study was conducted for 30 days, from February 6 to March 6, 2024.

2.2. Methods

The experimental design used in this study was a completely randomized design (CRD) with palm kernel meal thickness as the factor, with 5 treatments and 3 replicates. The treatment arrangement was as follows:

P1: Palm kernel meal thickness 5 cm
P2: 7 cm
P3: 9 cm
P4: 11 cm
P5: 13 cm.

2.3. Procedures

2.3.1. Preparing the Cage and Container

The cages used in this study were rectangular, measuring 200 x 50 x 150 (cm). The walls were made of tarpaulin tied to iron poles. The rectangular multi-level shelves are made of wood measuring 3 x 1 x 2 (m). The cage is cleaned, all unnecessary containers are removed, and it is sterilized by spraying disinfectant on the wooden shelves to prevent the wood from becoming dirty. The rectangular multi-level rack is made of wood measuring 3 x 1 x 2 (m). Oil is applied to each leg of the wooden rack to prevent pests such as ants from attacking the maggots. 15 plastic trays are measuring 40 x 30 x 13 (cm). Before use, the trays are washed with clean water and dried in the sun. They are then arranged on top of the cage according to the layout.

2.3.2. Media and Feed Preparation

In this study, the growing medium used for maggot cultivation was palm kernel meal taken from PT. Asian Agri Buatan 1, Bukit Agung Village, Kerinci Kanan Subdistrict, Siak Regency. The maggot feed used in this study was discarded bread obtained from a store on Jalan Kualu Panam, Binawidya District, Pekanbaru City, Riau Province. Before being used as a medium, the palm kernel meal was fermented using the method described by Purba (2022) as follows. The first step in preparing the fermentation culture medium for this study was to make a fermentation solution in a bucket: 60 ml of EM4, 5 L of water, and 600 grams of brown sugar. After that, the fermentation solution was stirred until all ingredients were homogeneous, covered with plastic waste, tied on top to prevent contamination, and left for 3 days. Then, palm kernel meal was poured from a 30 kg sack onto a tarp and stirred with water prepared with the fermentation solution. After that, the palm kernel meal was put into black plastic bags, tied, and left for 15 days.

The maggot feed used in this study was discarded bread obtained from Fajri's shop on Jalan Kualu Panam, Binawidya subdistrict, Pekanbaru City, Riau Province. The discarded bread was prepared in advance. After that, the bread was removed from its plastic packaging. Then, the unwrapped bread was placed in a 5 kg bucket. After that, 5 L of fermentation solution was added to help the maggots digest the bread.

2.3.3. Hatching Eggs and Maggot Maintenance

Prepared maggot eggs were weighed at 0.1 g and placed on a tissue arranged on the growing medium, avoiding direct contact with the medium, as this could prevent hatching. 0.1 g of BSF fly eggs is used per 1 kg of a mixture of coconut pulp and rice bran. Purba (2022) stated that egg observation was conducted for 4 days, with eggs checked each day to determine whether all had hatched. After the eggs hatched, the maggots were grown every 7 days for a total research period of 14 days.

The first step is to purchase BSF fly eggs. The BSF fly eggs used come from cultivated black flies. The BSF fly eggs are purchased from a maggot farmer on Jalan Suka Karya Panam, Binawidya District, Pekanbaru City, Riau Province. After that, the eggs are placed in a tray measuring 40 x 30 x 13 (cm). The tray containing the eggs and the medium is placed in a breeding cage and left for approximately three days until the eggs in the tray hatch and become BSF fly larvae. Unhatched eggs are yellowish in color, while hatched eggs are milky white. Nutrients must be available in the tray so that maggot larvae grow quickly and do not leave the tray containing the medium. BSF fly larvae and maggots do not like moist palm kernel meal medium, so it is important to maintain the moisture content of the medium.

2.3.4. Feeding Maggots, Water Spraying, Harvesting

Feeding is done twice a day, the first at 9:00 a.m. and the second at 4:00 p.m. Before feeding, the bread must be prepared in advance by placing 1 kg of bread (with the plastic packaging removed) in a bucket, then soaking it in water to soften and make it more easily digestible for the maggots. If the bread runs out, a new batch of feed must be prepared. Before feeding, the culture medium must be turned over to break down any remaining feed. After turning it over, the feed can be given.

Spraying water onto the medium helps maintain the moisture of the maggot-growing medium. The water used for the medium is available at the Fish Seed Center of the Faculty of Agriculture, Riau Islamic University, without fermentation or the addition of other ingredients. After that, the water is put into a 2.5-L sprayer with a spraying frequency of 250 (mL) per treatment. The maggot-harvesting process can begin after 2 weeks. Harvested maggots need to be separated and cleaned from the remaining growing medium. The growing medium with water or thin the medium, then remove the maggots using a sieve. The maggots obtained are then weighed to determine the yield from one maggot cultivation cycle (Purba, 2022).

2.3.5. Observation Procedures

The observation procedure in this study used two parameters. The main parameter discussed in this study was the growth of maggots. Another parameter discussed as supporting data was the maggot study's temperature, pH, and humidity.

2.4. Data Analysis

This study observed weight and length growth, as well as the production of maggots, in each treatment during the research period. In addition, the protein content was analyzed, and the nutritional value of maggots was observed, which may have an impact on this study. Maggots study temperature, pH, and humidity. were tabulated and converted into percentages before analysis. Statistical tests were then performed using the analysis of variance (ANOVA) method. If there were significant differences between treatments or if the calculated F value exceeded the F table value at the 0.01 level, the Least Significant Difference (LSD) test was performed.

3. Result and Discussion

3.1. Growth Rate

Absolute weight gain was one of the parameters measured in this study. The absolute weight gain of maggots was measured three times during the study: on the fourth day after hatching, on the seventh day, and on the fourteenth day or at harvest time. The average weight gain of maggots across treatments ranged from 0.23 g to 0.25 g. The average weight gain of maggots in treatment P1 was the same as the average weight gain of maggots in treatment P2, which was 0.23 g. Similarly, the average weight gain of maggots in treatment P3 was the same as the average weight gain of maggots in treatment P4, which was 0.24 g. The highest weight gain for maggots was observed in treatment P5, at 0.25 g. Maggot growth in this media thickness study reached (0.23-0.25 g), which was higher than the growth of maggots cultured in pineapple media.

Monita (2017) stated that BSF larva growth is highly dependent on the environment and the quality and quantity of the media and feed used to enhance growth, because maggots aged 3 to 7 days require the best nutrients from the feed or media provided to support maggot weight growth. Based on the ANOVA analysis, the calculated F value (3.94) > F table (0.05) at a 95% precision level, indicating that the thickness of palm kernel meal as a culture medium has a significant effect on maggot weight growth.

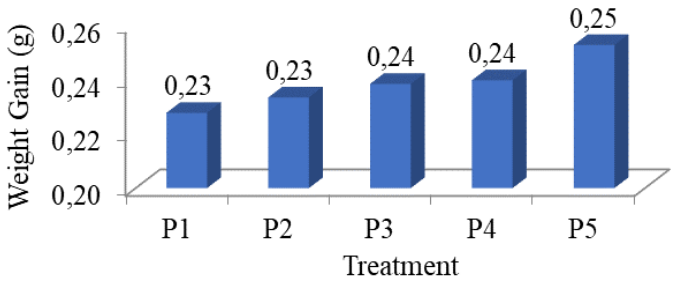

Figure 1. Average Absolute Weight Growth of Maggots

Figure 1 shows the differences in maggot weight growth in each treatment. The absolute weight growth of maggots increased with the thickness of the test medium. The absolute weight growth of maggots from P1 to P5, in sequence, was P1 = 0.23 g, P2 = 0.23, P3 = 0.24, P4 = 0.24, and P5 = 0.25.

One factor that may affect the level of maggot weight growth is the condition of the maggot culture medium. The humidity levels of P1 and P2 were too high, as were those of P3 and P4. Therefore, the overly wet culture medium made it difficult for the maggots to access the food and medium provided. However, in P5, the increase was more significant. This may indicate that the media conditions were suitable for maggot growth and conducive to optimal growth. These moist media conditions were more conducive to maggots absorbing nutrients and growing faster. The results of this study are supported by Purba (2022), who states that maggot weight growth depends on the availability of sufficient nutrients or feed in the maggot cultivation medium, but will decrease if the medium and nutrient conditions no longer support their life. In addition to nutrient content, another factor affecting maggot growth is the medium's humidity. As stated by Silmina (2011), factors that influence maggot production include the cultivation environment and the nutrient content of the material. Based on environmental conditions, maggots prefer a humid environment. The same applies to the nutrient content of the maggot growth medium.

The humidity of the culture medium in this study is related to the thickness of the medium. In treatments P1 and P2, the moisture level was too high, as was the case with P3 and P4. However, in treatment P5, the moisture level was relatively low. According to Cicilia (2018), media with high water content can inhibit maggot growth. Excessive moisture can create an environment too wet for maggots, disrupting their metabolic processes and inhibiting their growth. Purba (2022) added that media conditions that are too wet or too dry can also cause poor media conditions, such as the growth of pathogenic microorganisms, which can disrupt maggot health and growth.

In this study, initial measurements were taken on the fourth day, yielding a length of 0.38 cm. After 14 days, measurements were taken on the last day of the study, yielding the average maggot length for each treatment. The average growth length of maggots in treatment P1 was 1.71 cm, while those in treatments P2 and P3 were 1.76 cm. The average growth length of maggots in treatment P4 was slightly higher, namely 1.81 cm. The larvae growth length in all treatments in this study (1.71-1.83 cm), which used palm kernel meal and fermented soybean meal as media to obtain the highest growth length of 0.59 cm, Similarly, when compared to the growth of larvae reared on a mixture of tofu pulp and fermented stale bread, the growth length of the larvae reached 1.32-1.62 cm (Purba, 2022). Based on the ANOVA analysis, the calculated F value (3.84) > F table (0.05) at a 95% precision level, indicating that the thickness of palm kernel meal as a culture medium has a significant effect on maggot length growth. For more detailed information on the average maggot length growth, see Figure 2.

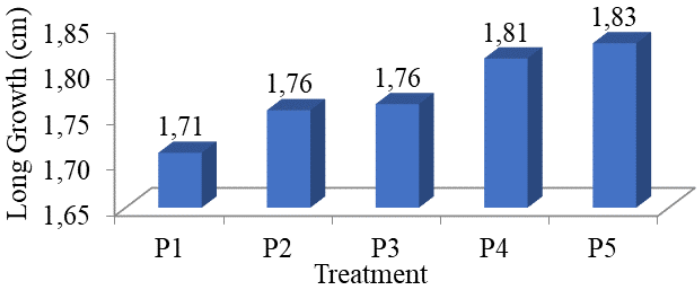

Figure 2. Average Growth of Maggot Length

Figure 2 shows that maggot length increased with increasing culture medium thickness, although the increase across treatments differed slightly. The difference in maggot length growth across treatments is thought to be due to differences in thickness, which result in different nutrient sources. The thicker the culture medium, the more organic material maggots consume.

The growth of maggots during the study was due to variations in the quality and quantity. Each treatment used a different thickness of medium, resulting in different nutrient sources. In P1, the media conditions clumped,

which was caused by the maggots' inability to decompose the palm kernel meal at low temperature, resulting in very low feed utilization. This resulted in maggot length growth in P1, which had the lowest average per maggot at 1.71 cm. In contrast, the media conditions in P5 were very effective for maggots, enabling them to decompose well. In addition, the quantity of palm kernel meal in P5 was sufficient to support maggot growth. Therefore, the quantity of palm kernel meal, which was higher than in the other treatments, resulted in the highest average maggot length in P5, with an average of 1.83 cm. Suin in Rakhmanda (2011) stated that high organic matter in the culture medium can increase the amount of decomposed organic particles, thereby affecting the population and growth of maggots. Jul in Syahrizal et al. (2014) that water content, protein, and minerals are closely related to growth rate and feed intake by maggots.

The initial weight of the test maggots in all treatments was 0.001 g. After being raised for 14 days, the maggots grew to 0.229 g – 0.254 g. The best daily growth rate occurred in P5 at 1.80%, followed by P4 at 1.71%, P3 at 1.70%, and P2 at 1.66%. The lowest growth rate in this study occurred in treatment P1, at 1.62%. The high and low daily growth rates in this study occurred due to the conditions of the media and feed provided to the maggots. The media used in this study were palm kernel meal with varying thicknesses. The fermented palm kernel meal used in this study, in addition to serving as media, could also serve as a nutrient source for the maggots. The more media provided, the higher the maggots' growth rate during the study. Based on the ANOVA analysis, the calculated F value (3.94) > F table (0.05) at a 95% precision level, indicating that the thickness of palm kernel meal as a culture medium has a significant effect on the daily growth rate of maggots. For more details on the differences in the average daily growth rate of maggots in each treatment, see Figure 3.

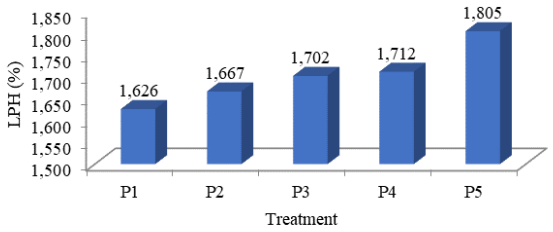

Figure 3. Daily Growth Rate

Figure 3 shows that the best daily growth rate during the study occurred in P5, at 1.80%. P5 had the best growth rate, presumably because the P5 treatment had more fermented palm kernel meal than the other treatments, which provided support for the maggots if they ran out of food or if the food they were provided could not be digested properly. In addition, during observation at P5, the media and environmental conditions were very conducive to growth, as the media at P5 contained moisture that supported maggot growth. The good moisture factor was due to the thickness of the fermented media, which could retain water that entered P5, and to the feed provided, namely discarded bread, which helped reduce excessive moisture in the media, so that the culture media conditions at P5 were not too wet. This aligns with Purba (2022), who stated that maggot growth media requires sufficient moisture and that the nutrients provided to maggots should not contain high levels of coarse fiber, as this can make it difficult for them to utilize the media and the feed. Research by Cahyadi (2023) using organic waste from pineapple peel and stale bread, as well as palm kernel meal, as the culture medium, reported the highest daily weight gain of 1.34%. This is in line with what Cicilia & Susila (2018) stated, that culture media and feed containing high water and fiber content can inhibit the daily growth rate of maggots.

3.2. Maggot Production

The high maggot production in this study indicates that fermented palm kernel meal as a culture medium is superior to a mixed culture medium of pineapple waste or a mixture of discarded bread and tofu pulp. Based on ANOVA analysis, which shows a calculated F value (0.20) < F Table (0.05) at a 95% confidence level, the thickness of palm kernel meal as a maggot culture medium has no significant effect on maggot production. For a clearer picture of the differences in the average daily growth rate of maggots in each treatment, see Figure 4.

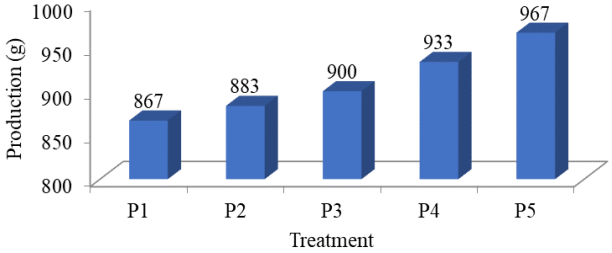

Figure 4. Maggot Production

Figure 4 shows that maggot production during the study increased significantly from P1 to P5. Starting from the lowest level in treatment P1 with a quantity of 867 (g) to the highest production in P5 with a quantity of 967 (g), there was an increase of 100 (g) during the study. The increase in production across treatments indicates that the quality and quantity of the medium can affect maggot growth. In addition, the condition of the medium and the availability of feed are also thought to affect maggot production during the study.

Treatment P5, with a culture medium thickness of 13 cm, had the highest production because the medium conditions remained moist during the study. This is suspected to be because the larger quantity of medium absorbed the provided water, thereby maintaining the moisture content of the palm kernel meal in P5 at a level suitable for maggots. In addition, if the maggots cannot digest the provided feed, the quantity and quality of the P5 culture medium can serve as a substitute feed in the P5 treatment. This is in line with what was stated by Hem et al. (2008), who noted that producing large numbers of maggots requires a high-quality substrate, as it provides sufficient nutrients for their growth and development, as measured by maggot weight production.

In contrast, treatment P1 experienced low production. At a thickness of 5 cm, the maggot culture medium was unable to absorb the provided water content, resulting in the medium becoming wet and the temperature dropping. Low temperatures made it difficult for the maggots to digest and decompose. In addition, the quantity and quality of the culture medium for maggots are not optimal as a substitute feed when the feed provided cannot be digested. This is thought to be the reason why the production quantity in P1 is the lowest at 867 g. Suin's in Rakhmanda (2011), who states that high-quality organic materials in the culture medium can increase the number of organic particles produced by decomposition, thereby affecting the population and growth of maggots.

3.3. Environmental Parameters

Temperature is one of the factors affecting the growth of the maggot ecosystem; therefore, this study also measured temperature. Measurements were taken daily using a soil instrument to determine the temperature during the study. The environmental parameter of the maggot culture medium during the study is shown in Table 1.

Table 1. Environmental Parameters

Treatment	temperature (°C)	Humidity (%)	Potential of Hydrogen pH
P1 = 5 cm	35,7	89-96	6,3
P2 = 7 cm	36	78-88	6,4
P3 = 9 cm	37,3	78-87	6,5
P4 = 11 cm	40,5	72-87	6,5
P5 = 13 cm	41,2	70-80	6,5

The temperature in each treatment ranged from 35.7°C to 41.2°C, indicating that the medium temperature during the study on differences in the thickness of palm kernel meal culture media was suitable for maggot growth and production. According to Monita et al. (2017), changes in temperature during media decomposition can be influenced by, or closely related to, the feeding activity of maggot larvae. Maggots also have a fairly high tolerance for life, allowing them to adapt to a wide range of conditions, including high media temperatures.

On the other hand, temperatures that are too low can also inhibit decomposition. When the temperature drops, microbial activity slows down or even stops. The factor causing the temperature to drop is high moisture content, which slows down maggot movement and prevents them from digesting the medium and feed provided, thereby slightly inhibiting growth. As stated by Monita (2017), excessive moisture content can affect the temperature of the maggot culture medium, and low temperatures slow down maggot metabolism.

The humidity in the maggot culture medium during the study ranged from 70 to 96%. In this study, the humidity parameter was abnormal only in P1. This was influenced by the thickness of the culture medium in treatment P1, which was unable to absorb water optimally, resulting in excessively high humidity unsuitable for the conditions required by maggots. Harlim et al. (2022) stated that the normal humidity for maggot cultivation is 60 to 80%. In addition, the humidity suitable for maggots occurred in treatment P5 with an average humidity of 70-80%. This was because the 13 cm culture medium thickness could absorb the water provided, keeping the humidity level in the P5 culture medium low and suitable for maggot growth. This is in line with what Yuwono & Mentari (2018) stated that the ideal humidity required for the development and growth of BSF maggots is around 60 to 80%.

The pH of the maggot culture medium during the study ranged from 6,3 to 6,8. The culture medium with the highest pH was in treatments P3, P4, and P5, at 6.5. Meanwhile, the lowest pH was observed in treatments P1 and P2, at 6,3. The maggot culture media conditions during the study were well-suited to maggot growth. As stated by Astriani (2021), the pH range for maggot growth is 6.5 to 7.5

3.4. Analysis of Culture Media

Table 2 shows that the maggot culture medium used in the study has a fairly high protein content of 36.30%, which is good for maggot growth and production.

Table 2. Analysis of Maggot Culture Media Content

Parameters	Contents (%)	Testing Methods
Water Content	29,74	SNI 01-2891-1992 item 5.1
Protein	36,60	SNI 01-2891-1992 item 7.1
Fat	4,31	SNI 01-2891-1992 item 8.1
Carbohydrates	1,31	SNI 01-2891-1992 item 9
Crude Fiber	2,13	SNI 01-2891-1992 item 11

Table 2 shows that the high protein content of palm kernel meal used as culture media is likely due to fermentation, which increases protein content. In addition, the crude fiber in the culture media is quite low at 2.13%, which is good for maggots because they can utilize the media well. The maggot culture medium used in this study has a content that is quite good for maggot growth and production. In this study, the protein content is 36.60%, which is thought to be due to the culture medium being fermented beforehand, thereby increasing the protein content. Purba (2022) stated that maggot growth is not solely due to nutrition but also influenced by fermented culture media. According to Subamia (2010), maggots can store nutrients from the culture media in their storage organs and convert them into good growth and protein.

4. Conclusions

Based on research conducted over 30 days, results and discussions on the effect of palm kernel meal thickness as a culture medium on maggot growth and production have been reported. This research can be concluded as follows: Differences in palm kernel meal thickness as a culture medium for growth, but no significant difference in maggot production. The highest growth in weight and length, daily growth rate, and production were found in treatment P5, which used palm kernel meal with a thickness of 13 cm, the highest weight growth was 0.25 g/maggot, 2.21 g. The highest length growth was 1.83 cm, and the highest production was with an average weight of 967 g.

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