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Substitution Of Fish Meal With Fermented Maggot Meal Mixture Of Microorganisms On Feed Quality And Growth Performance Of Vannamei Shrimp (Litopenaeus Vannamei)

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Abstract

Maggots are insect larvae which can be an alternative raw material to replace fish meal, they have good nutritional content but chitin is a limiting factor in their use. Fermentation using a combination of liquid pineapple extract and mixed microorganisms is an alternative to chemical fermentation in reducing chitin content which is considered expensive and pollutes the environment. This research aims to determine the best substitution of various concentrations of fermented maggot flour for feed quality and growth performance of vannamei shrimp. The test animals used were vannamei PL 25 shrimp with an initial weight of +0.4 grams kept at a density of 20 in an aquarium measuring 60 x 50 x 50 cm containing 20 L of water with a salinity of 25 ppt and equipped with a recirculation system. The research was designed in a completely randomized design with 5 treatments and 3 replications. The treatments tested were as follows: P1 (substitution of fish meal with 0% fermented maggot meal), P2 (substitution of fish meal with 25% fermented maggot meal), P3 (substitution of fish meal with 50% fermented maggot meal), P4 (substitution of fermented maggot meal). fish with 75% fermented maggot meal) and P5 (substitution of fish meal with 100% fermented maggot meal). Vannamei shrimp were reared for 30 days and were given experimental feed 4 times a day at 07.00, 11.00, 16.00 and 21.00, amounting to 10% of the body weight of the test animals. The results of the research concluded that there were significant differences in feed quality, namely solids dispersion and sinking speed of the test feed, while the parameters of breaking speed and hardness level were not significantly different. The best concentration of fish meal substitution with fermented maggot meal was treatment E which was able to produce survival of 88.33+2.89% and biomass of 16.67+0.58 grams. The growth of vannamei shrimp given test feed for 30 days had an effect on survival and biomass but no effect was found on absolute

growth, specific growth rate and feed conversion ratio.

Keywords: *Maggot, Feed Quality, Growth, Vannamei Shrimp*

1. Introduction

In vannamei shrimp cultivation activities, feed plays an important role as a source of nutrition to support growth and survival. The use of artificial feed in cultivating vannamei shrimp reaches 30-70% of total production costs (Hugues et al., 2018). One of the main ingredients in feed as a source of protein is fish meal, most of which is imported and the quantity is increasingly limited due to the decline in fishery resources due to uncontrolled exploitation (Yan et al., 2014). The challenges faced in vannamei shrimp cultivation activities are getting alternative feed raw materials that can substitute fish meal. In fact, reducing the proportion of fishmeal used in shrimp feed means saving fishmeal worldwide, as well as reducing production costs.

Maggot (Hermetia illucens) is an insect that has the potential to replace imported fish meal. Because maggots have a fairly high protein content of around 42%, various amino acids which are equivalent to fish meal and are easy to cultivate. However, the use of maggots as an alternative feed raw material has a weakness, namely the chitin content ranging from 8-24% (Soetamans et al., 2020). Chitin in maggots is found in the exoskeleton, proteins, minerals and pigments (Nasution et al., 2020) which can slow the movement of nutrients in the digestive tract, thereby reducing growth. Efforts to reduce chitin levels in maggots can be done through a fermentation process.

Fermentation changes organic compounds into simpler compounds with the help of microorganisms (bacteria, protozoa, fungi/molds, yeast) (Dawood and Koshio, 2020). The use of commercial chemicals and proteolytic enzymes to reduce chitin levels in maggots is considered expensive and polluting the environment. For this reason, an alternative proteolytic enzyme that is more environmentally friendly is needed, namely pineapple which contains bromelain to break down cysteine-peptide bonds in proteins. Sukanya et al., (2022) show that chitin extraction from shrimp shell waste using the pineapple bromelain enzyme can be done effectively and cheaply. Psarianos et al., (2022) used lactococcus lactis bacterial fermentation and bromelain deproteinization to separate chitin from crickets (Acheta domesticus). The success of fermentation is largely determined by the fermenter used. According to Aslamyah et al., (2018), mix microorganisms are probiotics in the form of a mixture of microbes consisting of bacteria, fungi, yeast and mold which are useful for improving feed quality by producing enzymes that have an impact on the digestibility of feed ingredients such as protease, amylase and lipase enzymes. Until now there has been no study regarding the effect of using fermented maggot flour which utilizes pineapple bromelain enzymes and mixed microorganisms to improve feed quality and growth performance of vannamei shrimp.

2. Materials And Methods

Probiotic Preparations

The probiotics used were the best combination of microorganisms in the research of Aslamyah et al. (2022), namely Bacillus sp., Lactobacillus sp., Rhizophus sp., Aspergillus sp., Saccharomyces sp. and Trichoderma sp. These microorganisms are from the collection of the Fisheries Biotechnology Laboratory, Research Activity Center (PKP), Hasanuddin University. The probiotic starter before use is refreshed following the Afrizal & Purwanto (2011) method with several modifications. Refreshment begins by preparing a substrate solution which is a mixture of 2 L of old coconut water and 500 g of granulated sugar. Next, inoculate with 2 mL of starter and incubate for 24 hours at room temperature.

Fermentasi Maggot

Maggots (Hermetia illcuens) aged 16 days were obtained from maggot cultivators in Tajinan Village, Tajinan District, Malang Regency. Maggots are washed with running water until they are separated from their living medium. The maggots are blanched for 3 minutes at 950C, air-dried, then the maggots are put into a press. Maggots that have had their fat removed are then added with liquid pineapple extract in a ratio of 3:1 and 10% NaCl is added which is placed in a tightly closed container. Every day, stir 3-4 times to mix until homogeneous. Next, following Aslamyah et al., (2021), on the fifth day, inoculation of mixed microorganisms as a fermenter was carried out at a dose of 10 ml/100 g of raw feed material. Maggot fermentation was incubated for 7 days in a closed and vacuum container so that the fermentation process took place anaerobically. On the eighth day, fermentation was stopped by opening the container and the

fermentation product was dried in the sun until dry. The dried maggots are ground using a blender and sieved to obtain fermented maggot flour which can then be analyzed for chitin content and proximate analysis.

Determination of Chitin Content

The chitin content in maggot flour was observed before and after fermentation following the method of Woods et al., (2020). Hermetia illucens larvae aged 16 days were used as sample material by blanching for 3 minutes at a temperature of 95 0C and air-dried then dried at a temperature of 600C for 24 hours and stirred until homogeneous then stored in vacuum plastic at a temperature of -400C. The analytical method consists of fat removal treatment by means of fast solvent extraction (2:1 chloroform: methanol), followed by treatment with 1 M HCL (demineralization) and 1 M NaOH (deproteinization). The deproteinization results were dried at 600C for 24 hours. The chitin content of the samples was calculated using Equations 1 and 2: where A is the weight of the residue remaining after demineralization and deproteinization, B is the weight of the sample before demineralization and deproteinization, C is the value obtained from Equation 1 and D is the fat content (dry base) of original sample.

Chitin%(defatted) = (A / B) × 100 (1)

Chitin% = C (100 – D) / 100 (2)

Feed Preparation

The feed used is artificial feed with the composition of feed raw materials and the results of proximate analysis of feed referring to the AOAC method (2005) are presented in Table 1. Feed production begins with preparing, drying and grinding feed raw materials, except for fish oil, vitamins and minerals. Next, all feed raw materials are weighed according to composition and mixed starting from the smallest amount to the largest, stirring until homogeneous. Once the mixture is homogeneous, 10% warm water is added while stirring evenly and molded into pellets and then dried. The dried feed is cooled to room temperature, then placed in a labeled plastic bag and stored in a dry place.

Table 1. Composition (% bk) of Raw Materials and Proximate Analysis Results of

Raw material	**% Fish flour: % Fermented Maggot Flour**				
	A (100 :0)	**B (75: 25)**	**C (50: 50)**	**D (25: 75)**	**E (0: 100)**
Fish flour	36	27.25	18	8.75	0
Fermented maggot flour	0	8.75	18	27.25	36
Soy flour	27	27	27	27	27
Cornstarch	18	18	18	18	18
Bran flour	10	10	10	10	
Flour	3	3	3	3	3
CMC	2	2	2	2	2
Vitamin Mineral Mix	2	2	2	2	2
Fish oil	2	2	2	2	2
Amount	100	100	100	100	100
Proximate Analysis					
Dry Ingredients	98.81	94.25	93.48	93.72	93.22
Ash	23.68	23.99	20.86	14.55	12.63
Crude protein	35.54	36.96	36.06	36.78	35.71
Crude Fat	4.59	5.14	7.97	9.05	10.55
Crude Fiber	14.48	23.09	20.33	11.56	10.61

Physical properties of test feed

Determination of crushing speed

The disintegration speed of test feed measures how long it takes for the feed to disintegrate in water. The disintegration test was observed visually. Five food sticks were put into a beaker containing 1 L of sea water. Observations are made every 15 minutes to determine whether the feed is soft or not. Observations are continued until the feed is damaged/destroyed.

Determination of solid dispersion

Solid dispersion was determined by placing 5 grams of feed in a 10 x 10 cm gauze box, with pores of approximately 1 mm, then immersing it in the aquarium. After 6 hours, the feed that was still attached to the

gauze box was dried together with the gauze box in the oven at 105°C for 10 hours. Then cooled in a desiccator, then weighed until the weight is constant (Balazs et al., 1973). Solid dispersion is calculated using the following formula:

$$\text{Solid dispersion} = \frac{\text{final dry weight of feed}}{\text{initial dry weight of feed}} \text{ x } 100$$

Determination of sinking speed

The sinking speed is determined by paying attention to the time it takes for the pellet to reach the bottom of the water column as high as 20 cm from the water surface. The stopwatch starts exactly when the feed is dropped onto the surface of the water. Sinking speed is calculated using the formula Moond et al., (2004).

$$\text{Sinking speed (cm/sec)} = \frac{\text{water column height}}{\text{when the feed reaches the bottom}}$$

Determination Of the Level of Feed Hardness

Determining the hardness level of feed by inserting 5 grams of feed into a 1 m pipe, then the feed is dropped with a weight weighing 500 grams. The feed is sieved using a 0.5 mm sieve. The feed remaining in the filter is weighed.

$$\text{Feed hardness} = \frac{\text{weight of feed after dropping the load}}{\text{weight of feed before dropping the load}} \; x \; 100$$

Determination of the Rate of Destruction

Determination of the rate of disintegration by placing five feed sticks in a beaker containing 1 L of sea water. Observations were made every 15 minutes to determine whether the feed was soft or not. Observations were continued until the feed was destroyed.

Maintenance of Test Shrimp

Juvenile vannamei PL25 shrimp with an average weight of +0.41 grams used in this study were obtained from the PT hatchery. Summa Benur, Situbondo Regency. The experiment used a completely randomized design with 5 treatments and 3 replications. Test shrimp were given treatment feed (P1, P2, P3, P4, P5) which substituted fish meal for fermented maggot meal, namely 0%, 25%, 75%, 100%. Maintenance will be carried out for thirty days in October-November 2023 at the Hatchery Unit of the Fisheries Department, Muhammadiyah University of Malang.

Before the experiment began, the shrimp were acclimatized to adapt to the cultivation media and given control feed at satiation for 7 days. After the acclimatization period is complete, the test shrimp are fasted for 24 hours with the aim of eliminating food residue in the body. Healthy and uniformly sized test shrimp were randomly distributed into fifteen glass aquariums. Shrimp were kept in a glass aquarium with length, width and height of 60 x 50 x 50 cm each, totaling 15, which was designed with a recirculation system and each side of the aquarium was covered with black plastic. Each container is filled with 20 L of 25 ppt saline water with a stocking density of 20 shrimp.

The feeding trial lasted for thirty days. Shrimp were given test feed of 10% of the biomass and the frequency of feeding was 4 times a day, namely at 07.00, 11.00, 16.00 and 21.00. Siphoning is done every day to remove dirt that has settled at the bottom of the aquarium. Every day the water is changed by 10-20%. Shrimp are weighed every ten days to monitor growth and adjust feeding levels.

The variables observed were chitin content before and after fermentation, physical and chemical feed quality and growth material which included absolute and relative weight growth, biomass, survival and feed conversion ratio.

Growth Performance

At the end of the study, shrimp in each aquarium were fasted for 24 hours before sampling. All shrimp in each aquarium were counted and weighed to calculate survival (SR), specific growth rate (SGR), biomass, absolute weight growth, and feed conversion ratio (FCR).

Survival

Survival of test fish was analyzed using the formula according to Widyanti (2009)

$$Sintasan\ (\%) = \frac{\Sigma \text{ Final shrimp}}{\Sigma \text{ Early shrimp}} \text{ x } 100$$

Specific Growth Rate

The specific weight growth rate is the percentage increase in shrimp each day during the research (%/day), analyzed using the formula proposed by Far et al., (2009) as follows:

$$SGR = \frac{\text{Ln}Wt - \text{Ln}W0}{t} \text{ x } 100$$

Information:

SGR = Specific weight growth rate (%)
LnW_0 = Average body weight at the start of maintenance (g)
LnWt = Average body weight at the end of maintenance (g)
t = Length of maintenance time (days)

Biomass

Biomass is the total weight of live shrimp at the end of the study. Biomass in this study is the total weight of shrimp reared for 30 days in grams. Calculation of shrimp biomass can be done by weighing all the shrimp at the end of the study using a digital scale

Absolute Weight Growth

Absolute weight gain is the difference between the average weight at the end of maintenance and the beginning of maintenance, calculated using the formula (Effendi, 2003), namely:

$$Wm = Wt - W0$$

Information:

Wm = Absolute weight growth (g)
Wt = Final average weight (g)
W0 = Initial average weight (g)

Feed Conversion Ratio (FCR)

Feed conversion is calculated by comparing the amount of feed consumed with the amount of body weight gain. Feed conversion is calculated using the Djajasewaka (1985) formula, namely:

$$FCR = \frac{F}{(Wt + D) - Wo}$$

Information:

FCR = Feed conversion ratio
W_0 = Test animal weight at the start of the study (g)
W_t = Test animal weight at the end of the study (g)
D = Total weight of dead fish (g)
F = Amount of feed given/consumed during the study (g)

Monitoring Water Quality Parameters

Maintenance media water monitoring is carried out twice a day, namely in the morning and evening, including salinity, temperature, pH and dissolved oxygen (DO). During the research, the water quality of the rearing media was maintained within a suitable range for the life of vannamei shrimp. Water quality measured includes temperature 29-320C, pH 7.0-8.0, salinity 25-27 ppt, and dissolved oxygen > 3 ppm

Statistic Analysis

Data were analyzed using analysis of variance (ANOVA) and data that had a significant effect were tested followed by the W–Tuckey Advanced Test to determine differences between treatments. Tukey's mean comparison test was used to compare differences between treatments. Statistical tests were carried out using SPSS version 22 software. Physical test data of experimental feed and water quality were analyzed descriptively.

3. Results and Discussion

Proximate Analysis of Maggot Flour Before and After Fermentation

The results of the proximate analysis test on maggot flour before and after fermentation can be seen in Table 2.

Table 2. Results of proximate analysis (% bk) before and after fermentation

Treatment	Dry ingredients (%)	Ash (%)	Proteins (%)	Fat (%)	Crude Fiber (%)
Maggot flour before fermentation	93.68	13.23	45.34	9.40	10.21
Maggot flour after fermentation	84.13	16.15	47.80	30.33	16.09

The dry matter values in the two samples in this study showed differences, namely 84.13% and 93.68%, which is thought to be the maggot processing process before and after the fermentation process which influenced the water content of the treatment. In maggot flour after fermentation the dry matter value is lower, the water content is higher. Feed raw materials with high water content make it easier for spoilage microbes to damage them so that the quality of the feed ingredients becomes low (Marbun et al., 2018). The ash content values in maggot flour before and after fermentation ranged from 13.23% and 16.1%. The ash content of feed is related to the mineral content. The higher the ash content of a feed ingredient, the higher the mineral content (Sudarmadji and Bambang, 2003). The maggot flour treatment after fermentation had a crude protein content of 47.80% but the increase was not too significant when compared to maggot flour before fermentation. This is different from the research results of Wulandari et al., (2021) which used organic acid fermentation which was able to increase the protein content from 49.89% to 53.25%. It can be concluded that the use of liquid pineapple extract and mixed microorganisms has not been able to increase the protein content.

The fat and crude fiber values of maggot flour after fermentation increased. It is suspected that in the fermentation process the use of probiotic microorganisms increases the fat and crude fiber content which contains microbes such as bacteria, fungi, yeast and mold. The bacteria and fungi contained in the mix of microorganisms will produce protease, lipase and amylase enzymes. The bacteria contained in the mixed microorganisms include Bacillus sp. will produce these three enzymes. Rhizopus sp and Streptococcus sp will produce amylase and protease enzymes. The Aspergillus niger fungus found in the mix microorganisms will produce protease and amylase enzymes, while Aspergillus oryzae will produce lipase during the fermentation process. As stated by Rarumangkay (2002) who states that the fermentation process involves an oxygen reduction reaction which produces energy as an electron donor and acceptor, as well as chemical changes which then undergo a reduction reaction with an enzyme catalyst. However, organoleptically there was an improvement in the appearance, texture and odor of maggot flour after fermentation which can be seen in Table 3.

(A) (B)

Picture 1. (A) Maggot flour before fermentation
(B) Maggot flour after fermentation

Table 3. Organoleptic Test Results of Maggot Flour Before and After Fermentation

Treatment	Appearance	Smell	Texture
A Maggot flour before fermentation	Not clean, a little dirty, normal	Neutral, slightly added odor	Not lumpy, a bit dry and a little rough
B Maggot flour after fermentation	Clean, normal, bright	Lacks the specific aroma of maggot flour	Not clumpy, quite dry and smooth

Chitin Content in Maggot Flour Before and After Fermentation

The chitin content was obtained from calculation results based on the difference in initial and final mass to determine the chitin content of the defatted samples referring to the method of Woods et al., (2020). The results of research on maggot flour before and after fermentation can be seen in Table 4 below.

Table 4. Results of Chitin Content of Maggot Flour Before and After Fermentation

Treatment	Chitin (%)
Maggot flour before fermentation	20,51%
Maggot flour after fermentation	18,23%

The treatment did not show a significant decrease in the chitin content of maggot flour after fermentation. This is different from the research of Nafisah et al., (2019), where the reduction of chitin in maggots was carried out by biological fermentation using chitinolytic bacteria by adding Bacillus subtilis inoculum of 3.8 × 107 cfu/mL (6% dry material substrate) and incubated for 3 days. at a temperature of 40oC so that it can reduce chitin up to 7.09%. Chemical fermentation of maggots was carried out by Harefa et al., (2018). The chitin in maggot flour before fermentation was 14.39% and after fermentation it was 7.22%. Furthermore, in research by Wulandari et al., (2021), the chitin content decreased from 15.25% to 9.51% after disilage. According to Campenhout (2021), optimizing the fermentation process requires fine adjustments such as temperature, fermentation time, use of additives (type and dose), pre-treatment (blanching and grinding) and starter culture selection. If applied, this will have an impact on fermentation capability. It can be concluded that the use of liquid pineapple extract and mixed microorganisms has not been able to reduce the chitin content in maggot flour.

Physical test of feed with several concentrations of fermented maggot flour

In fish nutrition research, preliminary studies of the physical properties of the feed are important to ensure the provision of optimal nutrients in the fish feed. The physical properties of the research feed are presented in Table 5, there are significant differences ($P<0.05$) in solids dispersion and sinking speed, while the parameters of breaking speed and hardness level are not significantly different ($P>0.05$).

Table 5. Average physical test parameters for feed with several concentrations of fermented maggot Flour

Treatment	Rupture Speed (Minute)	Dispersion of Solids(%)	Level of Violence (%)	Sinking Speed (cm/sec))
P1 (0%)	$37,33\pm2,51^{a}$	$52,39\pm2,46^{b}$	$98\pm0,4^{a}$	$1,32\pm0,19^{c}$
P2 (25%)	$40,67\pm3,78^{a}$	$33,47\pm3.26^{a}$	$98,33\pm1,22^{a}$	$1,30\pm0,22^{c}$
P3 (50%)	$40\pm4,36^{a}$	$33,72\pm2.31^{a}$	$96,87\pm0,75^{a}$	$1,01\pm0,1^{b}$
P4 (75%)	45 ± 1^{a}	$34,65\pm3.18^{a}$	$96,8\pm1,25^{a}$	$0,46\pm0,07^{a}$
P5 (100%)	$42,33\pm2,51^{a}$	$33,63\pm2.00^{a}$	$96\pm1,64^{a}$	$0,26\pm0,01^{a}$

Note: different superscripts in the same column indicate significant differences ($p<0.05$)

(A) (B) (C)

(D) (E)

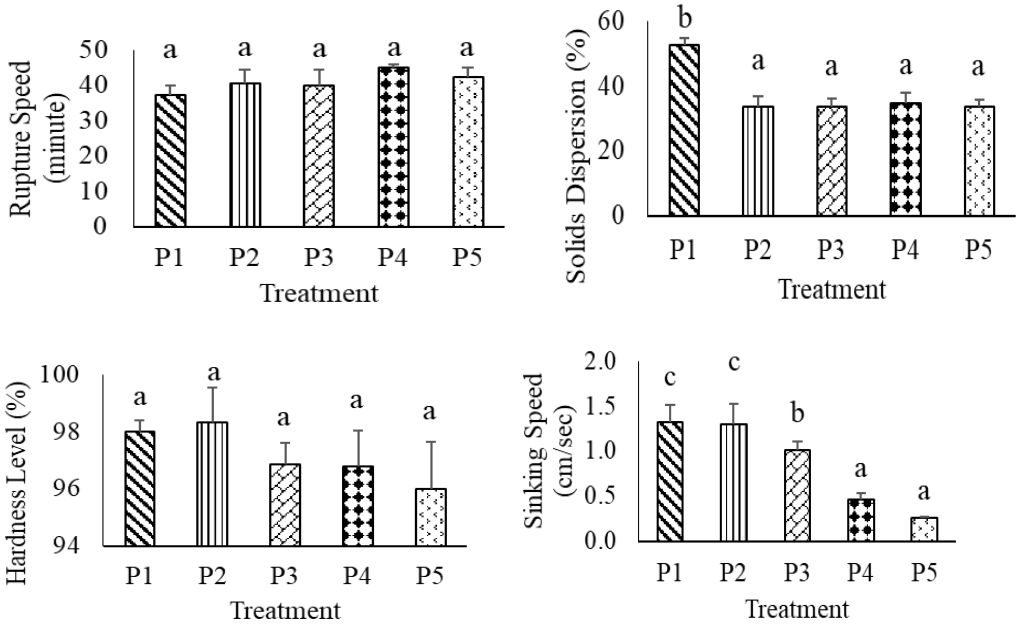
Picture 1. (A) P1= Feed with a dose of 100% fish meal: 0% fermented maggot meal /kg feed (control)
(B) P2 = Feed with a dose of 75% fish meal: 25% fermented maggot meal / kg feed
(C)P3 = Feed with a dose of 50% fish meal: 50% fermented maggot meal /kg feed
(D) P4 = Feed with a dose of 25% fish meal: 75% fermented maggot meal / kg feed
(E) P5 = Feed with a dose of 0% fish meal: 100% fermented maggot meal / kg feed (Astuti, 2023)

The significant difference in solids dispersion in the treated feed was caused by the relationship between the level of substitution of fish meal and fermented maggot meal in the feed. P1 feed has a higher solids dispersion value, namely 52.39 ± 2.46%, it is suspected that the feed is less compact, resulting in a high level of solids dispersion. Solid dispersion occurs due to the dissolution of particles during immersion in water. P2, P3, P4, and P5 feeds have solids dispersion values in the range of 33.63-34.65%. The test feed that used fermented maggot flour tended to have a lower solids dispersion value compared to the control feed. According to Aslamyah (2021), the solids dispersion rate should not be more than 10% because it affects the quality and quantity of the feed. The solid dispersion of the test feed in this study was high so the feed quality was considered to be poor.

The results of sinking speed showed a significant effect between feed treatments, namely P1 and P2 feeds were 1.32 ± 0.19 cm/sec and 1.30 ± 0.22 cm/sec sinking faster than other feeds. In this research, there was a tendency that the higher the concentration of fermented maggot flour in the test feed, the slower it sank. Saade et al., (2011), that the density of the material used to make feed affects the buoyancy of the feed, the lower the density of the feed material, the longer the buoyancy of the resulting feed will be. According to Malik (2011), good feed is feed that sinks quickly to the bottom, so that it can be consumed by vannamei shrimp before the physical and chemical quality of the test feed is reduced due to the influence of water which has properties as a solvent.

Based on the test, the breaking speed of the test feed was not significantly different (P>0.05) with a value range of 37.33-45 minutes. The best breaking speed value for feed P4 was 45 ± 1 minute, while the lowest for feed P1 was 37.33 ± 2.51 minutes. As stated by Mujiman (1985), the stability of fish feed in water must reach a minimum of ten minutes so that in this study it is considered good. This is due to the high level of fineness of the texture of the test feed ingredients so that the feed is more compact. The higher the level of fineness of the ingredients used in making feed, the longer the breakdown speed of the feed. This is in line with the level of hardness of the test feed which is generally relatively uniform with a value range of 96-98.33%.

Feed stability in water (breakdown speed and solid dispersion) is influenced by the fineness of the feed raw materials, tools and the process of mixing ingredients in the feed manufacturing process and the adhesive used in feed manufacturing. The finer the feed ingredients, the better quality feed will be produced. The process of mixing feed raw materials must be carried out as well as possible so that it can produce homogeneous feed. All test feeds in this study used conventional pellet machines which have limited capabilities in making feed. The stability of feed in water shows the persistence of the percentage of nutrients dispersed and the level of compactness of the feed. This test concluded that feed containing fermented maggot flour was not able to match the results of the general requirements for vannamei shrimp feed.



Picture 2. Graphic of physical test of feed with several concentrations of fermented maggot flour. Treatment P1 (Control without fermented maggot flour); P2 (25% fermented maggot flour); P3 (50% fermented maggot flour); P4 (75% fermented maggot flour; P5 (100% fermented maggot flour). In different subjects, different letters indicate that each treatment is significantly different

Growth

The feed used in this study had a protein content in the range of 35.54-36.96%, but produced different vannamei shrimp growth performance. The growth performance of vannamei shrimp given test feed for 30 days had an effect (P<0.05) on survival and biomass but no effect was found (P>0.05) on absolute growth, specific growth rate and feed conversion ratio. The lowest values for biomass, survival and FCR were found in vannamei shrimp fed control feed (P1). The growth performance of vannamei shrimp is presented in Table 6.

Table 6. Growth performance of vannamei shrimp fed fermented maggot flour test feed for 30 days

Treatment	Absolute Weight Growth (gram)	Specific Growth Rate (%)	Survival (%)	Feed Conversion Ratio	Biomass (grams)
P1 (0%)	0,51±0,02^{a}	2,67±0,18^{a}	66,67±5,77^{a}	1,91±0,08^{a}	12,33±0,58^{a}
P2 (25%)	0,51±0,15^{a}	2,52±0,72^{a}	70±5^{ab}	2,03±0,08^{a}	13,33±1,15^{ab}
P3 (50%)	0,57±0,12^{a}	3,08±0,84^{a}	75±5^{ab}	2,02±0,23^{a}	14,33±0,58^{b}
P4 (75%)	0,53±0,1^{a}	2,94±0,75^{a}	76,67±5,77^{b}	2,02±0,18^{a}	14±1^{b}
P5 (100%)	0,54±0,07^{a}	2,77±0,1^{a}	88,33±2,89^{c}	1,92±0,06^{a}	16,67±0,58^{c}

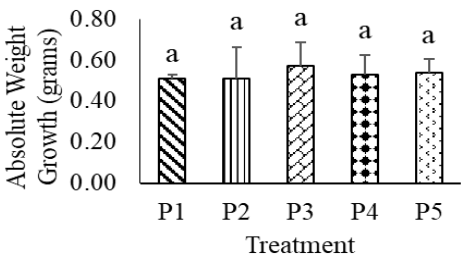
Note: different superscripts in the same column indicate significant differences (p<0.05)

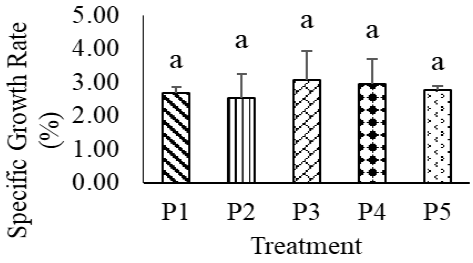
Absolute weight growth in vannamei shrimp fed various doses of fermented maggot flour showed no significant effect (P>0.05) with a range of 0.51±0.02g to 0.57±0.12g. The relatively similar absolute weight growth in each treatment is thought to be because the nutrient content in each feed can meet the nutritional needs of vannamei shrimp. Research from Chen et al., (2021), shows that there was no effect on the growth performance of shrimp fed 10% and 20% maggots, but there was a decrease in growth in shrimp fed 30% maggots. The protein content of the test feed ranged from 35.54-36.96% which was considered suitable for the needs of vannamei shrimp. In the process of digestion of food, providing feed with the right protein levels can result in the level of total digestibility and protein digestibility in the body of post larval vannamei shrimp to run optimally so that the process of breaking down protein into essential amino acids which are the basic needs for growth can be fulfilled. However, the test feed had a relatively high crude fiber content, namely 10.61-23.09%, so this is thought to have an influence on the absence of significant growth of vannamei shrimp. The recommended crude fiber content for vannamei shrimp feed is <10% (Sumeru and Anna, 1992). The high crude fiber content will affect the digestibility and nutrient absorption of vannamei shrimp feed.

The specific growth rate of vannamei shrimp between treatments showed no effect (P>0.05). The specific growth rate in this study was relatively uniform, ranging from 2.52-3.08%, it is assumed that the quality of the feed is in accordance with the needs of vannamei shrimp in carrying out their metabolic activities. Survival or survival of vannamei shrimp between treatments showed a significant effect of 66.67-88.33% for vannamei shrimp which was classified as good. The highest survival rate on P5 feed was 88.33 ± 2.89%, which means that vannamei shrimp had the lowest mortality rate compared to other treatments. This is thought to be because the combination of feed has nutritional content that is suitable for the needs of vannamei shrimp. The lowest survival value on feed P1 was 66.67 ± 5.77%, thought to be influenced by the quality of the feed which was classified as having a higher solids dispersion value and breaking speed compared to other test feeds, thus triggering cannibalism in vannamei shrimp and reducing the rearing environmental conditions, especially water quality.

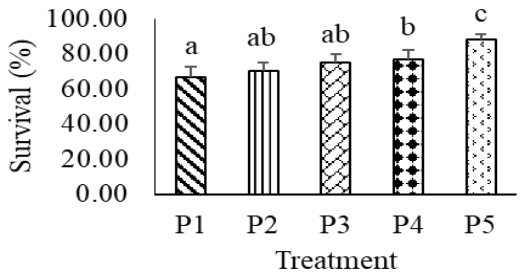
The feed conversion ratio is the ratio between the amount of feed consumed and the weight gain of the vannamei shrimp produced. The feed conversion ratio in this study statistically did not show a significant difference. The feed conversion ratio value in this study ranged from 1.91 to 2.03. The smaller the feed conversion value, the higher the quality of the feed because the amount of feed consumed is greater than the amount of feed remaining. The higher the feed conversion value, the less effective and efficient the treatment given is for growth. According to Handajani and Widodo (2010), the factors that influence the feed conversion value are the quality and quantity of feed, species, size and water quality.

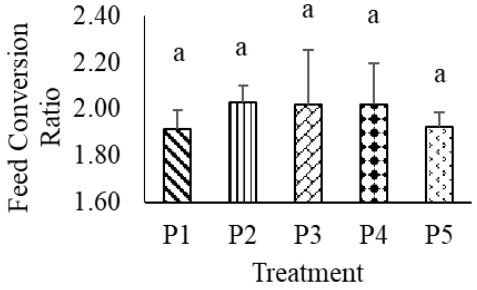
Based on the results of statistical tests, it showed that vannamei shrimp fed various doses of fermented maggot flour had a significant effect on biomass value (P<0.05). The best biomass in this study in treatment P5 was 16.67 ± 0.58g, while the lowest biomass in treatment P1 (without fermented maggot flour) was 12.33 ± 0.58g. The higher the dose of fermented maggot flour, the higher the biomass produced. This is thought to be due to the addition of a probiotic mix of microorganisms containing various superior bacteria which stimulates the growth of vannamei shrimp.



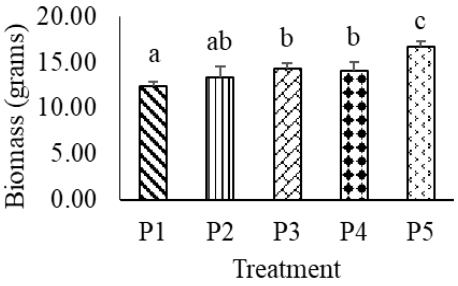


(a) Absolute Weight Growth (b) Specific Growth Rate





(c) Survival (d) Feed Conversion Ratio



(e) Biomass

Figure 3. Growth performance graph of vannamei shrimp fed with several concentrations of fermented maggot flour for 30 days

Water quality

The water quality of the rearing media is an external factor that influences the survival and growth of vannamei shrimp. Based on the results of water quality measurements presented in Table 5, it is in the optimal range which is relatively the same as for the test shrimp. From the results of water quality measurements during maintenance it is still in normal condition and good for cultivating vannamei shrimp. The temperature in each treatment was in the range 29-330C. Water temperature affects the chemical and biological processes of water, because as the temperature increases, the solubility of oxygen decreases and vice versa. The pH value obtained during maintenance in all treatments ranged from 7.0 to 8.0, this condition is still within normal conditions. If the maintenance medium is acidic (pH less than 7 or 11) it can kill vannamei shrimp in water.

The DO value range during the rearing period, namely 3.6-6.3 mg/l, is quite good in supporting the growth of vannamei shrimp. The high and low DO concentration is influenced by temperature, where if the temperature increases, the oxygen concentration decreases and conversely, if the temperature is low, the dissolved oxygen concentration increases. The availability of dissolved oxygen in water bodies is a supporting factor for the growth, development and life of shrimp (Bryand et al., 2006). Salinity plays a role in the osmoregulation and moulting processes in vannamei shrimp, so that the salinity range in the rearing media is maintained at a salinity of 25-26 ppt. If salinity conditions fluctuate, the larvae need more energy for their metabolic processes (Fujaya, 2004).

Table 7. Results Of Water Quality Measurements During the Research

Water Quality Range	Treatment					Reference Range Water quality
	P1	P2	P3	P4	P5	
Temperature (^{0}C)	29-33	28-33	29-33	29-33	29-33	15 – 33[a]
pH	7.0-7.8	7.1-8.0	7.2-8.0	7.0-8.0	7.0-8.0	6.0-8.5[b]
Salinity (ppt)	25-26	25-26	25-26	25-26	25-26	25-35[c]
DO (mg/l)	3.8-6.1	3.9-6.3	3.6-6.2	3.8-6.2	3.8-6.2	>3[c]

Description: a. Maica *et al.,* (2014), b. Adiwijaya *et al.,* (2003) c. Briggs (2004)

4. Conclusion

That can be drawn from the results of this study is that there are significant differences (P<0.05) in solid dispersion and sinking speed, while the parameters of rupture speed and hardness level are not significantly different (P>0.05). The growth performance of vannamei shrimp given the test feed for 30 days had a significant effect (P < 0.05) on survival and biomass but no effect was found (P> 0.05) on absolute growth, specific growth rate and feed conversion ratio. The best concentration of fish meal substitution with fermented maggot meal was treatment E which was able to produce survival of 88.33+2.89% and biomass of 16.67+0.58 grams.

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