



The use of maggot (*Hermetia illucens*) oil in artificial feeds on the growth performance and survival rate of saline tilapia (*Oreochromis niloticus*)

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ABSTRACT

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Tilapia is one of the commodities favored by the community and is widely cultivated in Indonesia. At this time, the development of tilapia cultivation has entered the location of marine and brackish waters, known as saline tilapia. The increase in tilapia cultivation has increased feed production, so the price of raw materials, especially fish oil, has increased. The source of crude fat that is usually used in feed formulations is fish oil, but the availability of fish oil is limited, so the price is increasing. One of the alternatives that can replace fish oil is maggot oil. Maggot contains 42-48% lipids. The purpose of this study is to find the effect of giving maggot oil on the growth and survival of saline tilapia. The method used was experimental, with a completely randomized design (CRD) consisting of 4 treatments and three replications. The treatments tested were treatment A (control), B (1.5 ml of maggot oil), C (2 ml of maggot oil), D (2.5 ml of maggot oil) on 100 grams of feed. The saline tilapia used was 1.4-1.9 grams/head. The fish were reared for 30 days in 15-liter volume containers, ten fish density, and were fed three times a day. The results showed that fish oil substitution using maggot oil (*H. illucens*) significantly affected FUE, SGR, absolute weight, FCR, and SR of saline tilapia. The best dose of maggot oil was found in treatment B with a dose of 1.5 ml/100 grams of feed capable of producing FUE (88.78±3.80%), SGR (7.98±0.23%/day), absolute weight (41.17±4.57gram), FCR (1.13±0.05), and SR (100±0.00%).

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Introduction

Tilapia is one of the commodities favored by the community and is widely cultivated in Indonesia. This type of fish is widely cultivated because it can adapt to a wide range of salinity. At this time, the development of tilapia cultivation has entered the location of marine and brackish waters, known as saline tilapia. Saline tilapia is a cross from tilapia that can tolerate brackish and marine waters with a salinity of 20 ppt (Angriani *et al.*, 2020). According to Song *et al.* (2021), tilapia has the advantage that it can tolerate various environmental conditions, has fast growth, has high disease resistance, and has the high reproductive ability.

Feed is one of the main factors in determining the success of saline tilapia cultivation. The quality and

quantity of raw materials must be considered so that the feed can increase the growth of saline tilapia. One of the essential raw materials in feed is crude fat. The fat crude source usually used in feed formulations is fish oil (Hender *et al.*, 2021). At this time, the availability of fish oil is so limited that it becomes a step, and the price increases (Fernandes *et al.*, 2018). Therefore, it is necessary to have an alternative to replace fish oil as a source of crude fat.

One of the raw materials that can replace fish oil is maggot oil. Maggot is high in lipids. Maggot-fed animal manure contains 35% lipids, and when fed food waste feed rich in oil contains 42-48% lipids (Bakar *et al.*, 2021). Maggot contains 42% protein and 35% fat nutrients and has a linoleic fatty acid profile with a concentration of 3.6% - 4.5% and linolenic

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fatty acid of 0.08%-0.74% (Li et al., 2016). Maggot oil is produced from Black soldier fly larvae extraction, which contains fatty acid levels, especially lauric acid, 21-49% (Fawole et al., 2021). Research on maggot oil has previously been carried out on several fish; in the study of Hender et al. (2021), a substitution of maggot oil was carried out on barramundi fish. The results obtained in this study are an SGR value of 6.98% and the absolute weight value of 29.76 grams. While in the study of Bakar et al. (2021), the use of maggot oil on red tilapia with a dose of 25% can increase the highest SGR of tilapia by 2.27% and affect growth, FCR of 1.18 and produce an absolute weight of 48, 10 grams. This research is important to find differences in the effect of giving maggot oil to saline tilapia that live in different water salinity.

Materials and Methods

The research was carried out in May-July 2022 at the Brackish Water Aquaculture Center (BBPBAP), Jepara. The test fish used in this study were saline tilapia with a size of 1.4-1.9 grams/head with a stocking custom of 10 fish/treatment tanks. The container used in the study was a container with a volume of 15 liters of water in a total of 12 pieces and equipped with aeration. The rearing medium used was seawater with an average salinity of 17 ppt. The source of the maintenance media comes from seawater from the Brackish Water Aquaculture Center (BBPBAP) Jepara, Central Java, which has previously been accommodated, filtered, and ensured that it is clean of pollutants.

The method used in this study is an experimental method with a completely randomized design (CRD) consisting of 4 treatments and three replications. The treatments used include:

- Treatment A: Feed treatment without maggot oil
- Treatment B: Feed treatment with the use of 1.5 ml maggot oil/kg feed
- Treatment C: Feed treatment with the use of 2 ml maggot oil/kg feed
- Treatment D: Feed treatment with the use of 2.5 ml maggot oil/kg feed

The culture of saline tilapia was carried out for 30 days with the frequency of feeding three times a day at 07.00, 12.00, and 17.00 WIB. The method of feeding saline tilapia is given using the fixed feeding rate method (Zulkifli et al., 2019) as much as 5% of the total weight of tilapia biomass (Angriani et al., 2020). During the study, water quality observations, including temperature, DO, pH, and salinity, were

carried out every morning. Parameters measured during the study included total feed consumption (TFC), feed utilization efficiency (FUE), specific growth rate, absolute weight growth, Food conversion ratio (FCR), and survival (SR).

Total Feed Consumption (TFC)

Total feed consumption (TFC) can be calculated using the formula according to Weatherly (1972) as follows:

$$F = C - S \dots\dots\dots (1)$$

Information: F = Total feed consumed (g); C = Feed given (g); and S = Leftover feed (g)

Feed Utilization Efficiency (FUE)

Feed utilization efficiency (FUE) can be calculated using the formula according to Zonneveld et al. (1991), as follows:

$$FUE = (W_t - W_0) / F \times 100\% \dots\dots\dots (2)$$

Information: FUE = Feed Utilization Efficiency (%); W_t = Weight of Fish at the end of the Maintenance Period (g); W_0 = Fish Weight at the beginning of the Maintenance Period (g); F = Weight of Feed Given (g)

Specific Growth Rate (SGR)

The specific growth rate (SGR) can be calculated using the formula according to Takeuchi (1988) as follows:

$$SGR = (W_t - W_0) / (W_0 \times t) \times 100 \dots\dots\dots (3)$$

Information: SGR = Specific growth rate (% per day); W_t = Weight of biomass at the end of the study (g); W_0 = Weight of biomass at the beginning of the study (g); and t = Length of maintenance (days).

Absolute Weight Growth

The absolute weight growth can be calculated using the formula according to Effendi (1979) as follows:

$$W_m = W_t - W_0 \dots\dots\dots (4)$$

Information: W_m = Weight gain (g); W_t = Weight of fish at the end of the study (g); and W_0 = Fish weight at the end of the study (g)

Food conversion ratio (FCR)

The food conversion ratio is the feed given to produce 1 kg of meat. According to Effendie (1997),

the Food conversion ratio can be calculated using the formula:

$$FCR = F / ((W_t - W_0) + D) \dots \dots \dots (5)$$

Information: FCR = Food conversion ratio; W_t = Weight of fish biomass at the end of the study (g); W_0 = Weight of fish biomass at the beginning of the study (g); F = Amount of feed consumed (g); D = Weight of dead fish biomass during rearing (grams)

Survival Rate (SR)

Survival (SR) can be calculated using the formula according to Effendi (1997) as follows:

$$SR = N_t / N_0 \times 100\% \dots \dots \dots (6)$$

Description: SR = survival rate (%); N_t = Number of fish at the end of maintenance; and N_0 = Number of fish at the time of initial stocking

Water quality

Water quality data in temperature, salinity, dissolved oxygen (DO), and pH were measured using a Water Quality Checker (WQC), refractometer, and pH meter.

Results

The results of the study on the effect of using maggot oil in artificial feed on the growth and survival performance of saline tilapia (*Oreochromis niloticus*) are presented in Table 1.

Table 1. Value of Total Feed Consumption (TFC), Feed Utilization Efficiency (FUE), specific growth rate (SGR), absolute weight growth, feed conversion ratio (FCR) and survival during the study

Variable	Treatment			
	A	B	C	D
TFC (g)	44.78±7.74 ^a	46.28±3.26 ^a	46.31±5.47 ^a	50.05±7.79 ^a
EPP (%)	70.25±2.00 ^a	88.78±3.80 ^b	61.20±2.96 ^c	74.38±2.00 ^a
SGR (%/day)	6.38±0.50 ^a	7.98±0.23 ^b	5.84±0.15 ^{ac}	7.27±1.31 ^{ab}
Absolute Weight (g)	31.55±6.20 ^a	41.17±4.57 ^{ab}	28.27±2.71 ^{ac}	37.20±5.50 ^{ab}
FCR	1.39±0.08 ^a	1.13±0.05 ^b	1.33±0.03 ^a	1.31±0.04 ^a
SR (%)	93.33±5.77 ^a	100.00±0.00 ^a	83.33±5.77 ^b	96.67±5.77 ^a

Note: Values with different superscripts indicate a significant difference (P > 0.05)

The results of ANOVA analysis of feed utilization efficiency data (FUE), specific growth rate (SGR), absolute weight growth, feed conversion ratio (FCR),

and survival shows that the use of maggot oil in artificial feed has a real effect. While the results of the ANOVA of total feed consumption (TFC) did not have a significant effect.

The results of water quality measurements in the saline tilapia shrimp rearing container are presented in Table 2.

Table 2. Water Quality Measurement

No	Variable	Unit	Results	References
1	Temperature	°C	25.6	25 - 32° C*
2	DO	mg/L	5.41	>5 mg/L**
3	pH	-	7.8	7-8***
4	Salinity	ppt	17	0-30 ppt****

Note: *: Ririhena and Palinussa (2021), **: Burhani et al., (2022), ***: Fauziah and Suseno (2020), ****: Mujalifah et al., (2018).

The results of the measurement of the water quality variable during the study showed that the value of the water quality variable during the study was still in a suitable condition to be used as a medium for saline tilapia cultivation. This is based on the literature regarding the optimal range conditions for the cultivation of saline tilapia (*O. niloticus*).

Discussion

Growth is the increase in weight, size, and length of saline tilapia fingerlings caused by optimally utilized feed. Based on the analysis of variance analysis, the use of maggot oil significantly affected the feed conversion ratio (FCR), absolute weight growth, feed utilization efficiency (FUE), specific growth rate (SGR), and survival (SR). The best results were in treatment B (1.5 ml maggot oil), in which the result of FCR, absolute weight, FUE, SGR, and SR, respectively, 1.13±0.05, 41.17±4.57gram, 88.78±3.80%, 7.98 ±0.23%/day, and 100±0.00%.

Based on the results of observations made during the study at the time of feeding, the response of cultivars in treatment B tended to be aggressive and had a reasonably good response, and the digestibility of fish to feed was also good. A good fish response to the feed will also have a good effect on fish growth. In treatment B, the specific growth rate and absolute weight values were more significant than the other treatments without maggot oil. The content of protein, fat and carbohydrates in the feed can influence increased growth in treatment B. Protein, fat, and carbohydrate feed, according to fish needs, can be a source of energy for fish and can help build muscle in the fish body. According to Nurhasanah et al. (2016), growth in fish bodies occurs when there is

excess energy after the available energy is used for normal metabolism, digestion, and activities. According to [Isnawati et al. \(2015\)](#), the high growth rate is influenced by the increase in protein content and body fat content which functions as a builder of muscles, cells, and tissues as well as an energy source.

In treatment B, the value of feed utilization efficiency was higher than in other treatments, where the difference in the efficiency value of feed utilization in treatment B and treatment C was 24.88%. According to [Royani et al. \(2022\)](#), increasing the value of nutrient digestibility allows the utilization and intake of good feed nutrients and will result in high growth performance. According to [Shofura et al. \(2017\)](#), the digestibility of the fish feed is directly proportional to the efficiency of feed utilization, so if fish digestibility is high, the efficiency value of feed utilization is also high. The high-efficiency value of feed utilization indicates that the feed given to saline tilapia fry is used efficiently by the fish to produce high weight. This follows the statement of [Wulandari et al. \(2019\)](#) that the higher the value of feeding efficiency, the better the fish use the feed provided, so the more significant the weight of the meat produced, and high feed efficiency indicates efficient use of feed. The efficiency value of feed utilization in this study was classified as good, resulting in the highest best FUE value of 88.78%. According to [Santika et al. \(2021\)](#), that feed is said to be good if the efficiency value of feed utilization is close to 100%.

In treatment B, the FCR value obtained was lower than in the other treatments. This is because using maggot oil in artificial feed with different doses will produce different FCR values. The high and low feed conversion values will be related to the efficiency value of fish feed utilization. According to [Setiawati et al. \(2013\)](#), the lower the feed conversion value, the higher the feed efficiency value, so the fish are more efficient in utilizing the feed consumed for growth. The value of the feed conversion ratio in this study can be said to be good because it has a small value. According to [Simamora et al., \(2021\)](#), which states that the smaller the value of the feed conversion ratio, the better the quality of the feed given, but if the value of the feed conversion ratio is high, the feed provided is of less quality. According to [Mubaraq et al. \(2021\)](#), the value of FCR in fish is still considered efficient if it has a value of less than 3.

The lowest growth of saline tilapia was found in treatment C with a dose of 2 ml (26.1%)/100 g of feed. Treatment C resulted in the lowest specific growth rate of $5.84 \pm 0.15\%/day$ and absolute weight value of 28.27 ± 2.71 grams with a total feed consumption value (TFC) of 46.31 ± 5.47 grams, the

value of the feed conversion ratio was 1.33 ± 0.03 , and the feed utilization efficiency (FUE) was $61.20 \pm 2.96\%$. The cause of the low growth value in treatment C is thought to come from several factors, such as factors originating from fish and the feed is given. The feed-in treatment C had a texture and odor that did not attract the fish's attention. The texture of the feed in treatment C was slightly moister than the other treatments, so the feed was easily crushed and broken, and the aroma was less pungent. According to [Yuliyanto et al. \(2021\)](#), In addition to good buoyancy, fish feed must be homogeneous, soft, and easily broken so that it can be utilized optimally by fish and produce optimal growth. According to [Sulatika et al. \(2019\)](#), a fish's appetite can be influenced by the feed's aroma. The low specific growth rate of fish can be caused by the high crude fiber contained in the feed ([Karyanto et al., 2020](#)). This is reinforced by [Iskandar et al. \(2021\)](#); if the crude fiber content is too high in the feed, it will accelerate the feed through the intestines so that the absorbed nutrients are reduced and will eventually lead to low protein absorbed by tilapia. Based on the proximate analysis results, the crude fiber content in treatment C was 9.98 greater than in treatments B and D.

Using maggot oil with different doses has a different effect on each treatment. In this study, a dose of 1.5 ml of maggot oil/100 g of feed was better than the control treatment without using maggot oil. Based on the study's results with a dose of 1.5 ml or 19.6% (treatment B), the FCR value and SGR were 1.13 ± 0.05 and $7.98 \pm 0.23\%/day$. This result is higher than the study. [Li et al. \(2016\)](#) that using maggot oil as a substitute for soybean oil for carp Jian carp in feed formulations obtained FCR values of 1.40-1.58 and SGR values of 3.30-3.36%/day. The results of this study are also higher than those of [Bakar et al. \(2021\)](#) that the replacement of fish oil with maggot oil in feed formulations for tilapia showed FCR values ranging from 1.18 to 1.87 and SGR values ranging from 2.20. -2.27.

Using maggot oil (*H. illucens*) in artificial feed for saline tilapia fry (*O. niloticus*) can optimize the growth of saline tilapia fry, which can be seen from the variables that have been measured. Maggot oil contains high potential sources of fat such as lauric acid 21.4% – 49.3%, linoleic fatty acid (18:2n-6) with a concentration of 3.6% - 4.5%, and linolenic fatty acid (18:3n. -3) by 0.08% - 0.74% ([Li et al., 2016](#)). The crude lipid content is $35.69 \pm 0.24g/100g$ ([Ebenezar et al., 2021](#)). Based on the results of proximate analysis, it was found that the nutritional content of artificial feed using maggot oil 1.5 ml/100

g feed (B) was 44.74% protein, 25.53% fat, 9.16% crude fiber, and 39% ash. Protein in feed (B) was classified as higher than protein in other treatments. Feed treatment using 0 g/100 g maggot oil (A) had a protein content of 40.19%, artificial feed treatment using 2 ml/100 g maggot oil (C) had a protein content of 42.04%, and for the treatment of feed using maggot oil 2.5 ml /100 g of feed (D) has a protein content of 43.21%. According to [Suryanto and Suprianto \(2021\)](#), the protein content in tilapia feed ranges from 30%-55% depending on the species, stadia, and cultivation method ([Suryanto and Suprianto 2021](#)). According to [Todolo et al. \(2022\)](#), The protein requirement of tilapia larvae is 20% - 60%, and the fat requirement is 8%-10%. The carbohydrate requirements of tilapia are unknown, but according to [FAO \(2016\)](#), the maximum is around 40%, and the minimum fat is 10-15%. Maggot (*H. illucens*) oil contains 40.1% lauric acid, 13.1% palmitic acid, and 9.88% myristic acid. This was also confirmed by [Li et al. \(2016\)](#), which stated that maggot oil contains 3.6% -4.5% linoleic fatty acid and 0.08% - 0.74% linolenic fatty acid. Lauric acid functions as an anti-oxidant and anti-microbial, combats various types of pathogens and increases HDL (high-density lipoprotein), which functions to minimize the narrowing of blood vessels due to fat so that metabolism can run smoothly ([Hender et al., 2021](#)).

Survival is the percentage of cultivars that survive from the total cultivar during a certain maintenance period in a cultivation container. With the high survival rate (SR) that can be obtained, it can be said that the cultivation business is thriving. Survival is closely related to the aquatic environment and the availability of food. Water quality is an essential factor in supporting fish farming. Optimal water quality can affect a suitable SR parameter.

The analysis of ANOVA showed that the use of maggot oil into artificial feed for saline tilapia fingerlings significantly affected the survival of saline tilapia. From these results, it can be seen that the use of maggot oil in the artificial feed of saline tilapia with different doses has a significant effect on the survival rate of saline tilapia fry, which produces the best SR tilapia in treatment B of $100.00 \pm 0.00\%$ and the lowest SR value. In treatment C, that is equal to $83.33 \pm 5.77\%$. When viewed from the overall average value of SR, the SR obtained during maintenance for 30 days is still quite good, with the smallest average value still above 80%. According to [Tomasoa and Azhari \(2019\)](#), the percentage of reasonable fish survival rates is >50% and not good if it only reaches 30%. This is also confirmed by [Suprianto et al. \(2019\)](#);

the survival value of good tilapia ranges from 73.5 - 86.0%. The survival rate of saline tilapia can be influenced by several factors, the nutritional content of the feed, the quality of the feed, and the water quality of the fish-rearing media.

Based on the results of water quality measurements during maintenance, the average values of the water quality parameters measured, namely temperature, pH, salinity, and DO, are still considered optimal. The average water temperature value during the maintenance period is 25.6 °C. The higher the temperature value of water quality, of course, can have an unfavorable effect on the growth of cultivated cultivars and vice versa; if the water temperature gets lower, it will have a bad impact on the cultivated cultivars. According to [Yanuar \(2016\)](#), the impact that will arise if a significant temperature change can reduce appetite and can affect endurance. Therefore, it is necessary to carry out sustainable water quality management so that the value of water quality parameters remains optimal for the growth of saline tilapia. According to [Ririhena and Palinussa \(2021\)](#), the optimum temperature for fish growth is 25 - 32° C. In addition to temperature, many water quality parameters still need to be observed, one of which is salinity. Tilapia is one of the cultivars that can live in saline media because it is euryhaline. Salinity, following the needs of fish, can increase growth, while higher salinity can affect growth ([Rahim et al., 2015](#)). The salinity value obtained during the maintenance period was 17 ppt. According to [Mujalifah et al. \(2018\)](#), the ideal salinity for the growth of saline tilapia ranges from 0-30 ppt.

Dissolved oxygen or dissolved oxygen was obtained during the study, DO 5.41 mg/L, and this value is classified as an optimal condition. This is reinforced by [Burhani et al. \(2022\)](#), which state that dissolved oxygen content should be >5 mg/L to increase fish productivity. Furthermore, the water quality parameters measured during maintenance are pH or acidity. The pH value obtained during the rearing period was 7,8. The pH value was considered optimal for the growth of saline tilapia. According to [Fauziah and Suseno \(2020\)](#), a suitable pH value for fish breeding and growth is 7-8. If the pH value is too low or too high can interfere with fish life.

Conclusion

The use of maggot oil in artificial feed for saline tilapia has a significant effect on feed utilization efficiency (FUE), specific growth rate (SGR), absolute weight growth, feed conversion ratio (FCR), and survival rate.

The best dose of using maggot oil was found in treatment B with a dose of 1.5 ml/100 grams of feed. The results obtained are FUE of $88.78 \pm 3.80\%$, SGR of $7.98 \pm 0.23\%/day$, an absolute weight of 41.17 ± 4.57 gram, FCR of 1.13 ± 0.05 , and SR of $100 \pm 0.00\%$.

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