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POTENTIAL OF BLACK SOLDIER FLY LARVAE (*Hermetia illucens*) AS A COMMERCIAL FEED SUBSTITUTE FOR NILE TILAPIA (*Oreochromis niloticus*)

Potensi Maggot *Hermetia illucens* Sebagai Pengganti Pakan Komersial pada Budidaya Ikan Nila (*Oreochromis niloticus*)

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ABSTRACT

Maggot (*Hermetia illucens*) is a potential alternative feed source for Nile tilapia (*Oreochromis niloticus*) due to its nutritional value and potential to replace commercial feed. This study aimed to evaluate the potential of maggot *Hermetia illucens* as a substitute for commercial feed on the growth and survival of Nile tilapia (*Oreochromis niloticus*). The experiment was conducted for 28 days using three dietary treatments: P0, consisting of 100% maggot; P1, consisting of 50% maggot and 50% commercial feed; and P2, consisting of 100% commercial feed. The observed parameters included weight gain, specific growth rate (SGR), absolute length growth, and survival rate (SR). The results showed that, descriptively, P0 produced the highest weight gain and SGR, with values of 2.47 ± 1.01 g and 1.55 ± 0.78%/day, respectively, compared with P1 (1.13 ± 0.35 g and 1.03 ± 0.20%/day) and P2 (1.40 ± 0.87 g and 1.30 ± 0.84%/day). Absolute length growth in P0 and P2 was 0.73 ± 0.47 cm and 0.73 ± 0.21 cm, respectively, while P1 showed 0.43 ± 0.21 cm. The highest survival rate was observed in P1 (82.22 ± 13.33%), followed by P2 (80.00 ± 6.67%) and P0 (73.33 ± 11.55%). Analysis of variance showed that dietary treatments had no significant effect on the absolute length growth of Nile tilapia ($p>0.05$). Descriptively, maggot showed potential as an alternative feed for Nile tilapia culture.

Keywords: Alternative feed, growth, Hermetia illucens, maggot, nile tilapia, survival rate

ABSTRAK

Maggot (*Hermetia illucens*) merupakan salah satu sumber pakan alternatif yang berpotensi digunakan dalam budidaya ikan nila (*Oreochromis niloticus*) karena memiliki nilai nutrisi dan berpotensi menggantikan pakan komersial. Penelitian ini bertujuan untuk mengevaluasi potensi maggot *Hermetia illucens* sebagai pengganti pakan komersial terhadap pertumbuhan dan kelangsungan hidup ikan nila (*Oreochromis niloticus*). Penelitian dilakukan selama 28 hari menggunakan tiga perlakuan pakan, yaitu P0 berupa 100% maggot, P1 berupa kombinasi 50% maggot dan 50% pakan komersial, serta P2 berupa 100% pakan komersial. Parameter yang

diamati meliputi pertambahan bobot, laju pertumbuhan spesifik (SGR), panjang mutlak, dan kelangsungan hidup (survival rate/SR). Hasil penelitian menunjukkan bahwa secara deskriptif P0 menghasilkan pertambahan bobot dan SGR tertinggi, masing-masing sebesar 2,47 ± 1,01 g dan 1,55 ± 0,78%/hari, dibandingkan P1 sebesar 1,13 ± 0,35 g dan 1,03 ± 0,20%/hari serta P2 sebesar 1,40 ± 0,87 g dan 1,30 ± 0,84%/hari. Panjang mutlak pada P0 dan P2 masing-masing sebesar 0,73 ± 0,47 cm dan 0,73 ± 0,21 cm, sedangkan P1 sebesar 0,43 ± 0,21 cm. Nilai SR tertinggi diperoleh pada P1 sebesar 82,22 ± 13,33%, diikuti P2 sebesar 80,00 ± 6,67% dan P0 sebesar 73,33 ± 11,55%. Hasil analisis ragam menunjukkan bahwa perlakuan pakan tidak memberikan pengaruh nyata terhadap panjang mutlak ikan nila (p>0,05). Secara deskriptif, penggunaan maggot menunjukkan potensi sebagai alternatif pakan dalam pembesaran ikan nila.

Kata Kunci: Hermetia illucens ikan nila, maggot, pakan alternatif , pertumbuhan, , survival rate

INTRODUCTION

Nile tilapia (Oreochromis niloticus) is one of the main global and national freshwater aquaculture commodities, characterized by a rapid growth rate, high fecundity, and a wide tolerance to water quality dynamics (Nairuti et al., 2021). The primary constraint in the intensification of O. niloticus culture lies in the high operational cost allocation for commercial feed, which generally accounts for 60% to 70% of total production costs (Marlida et al., 2023). These elevated costs result from the feed industry's reliance on fish meal as its main protein ingredient, despite increasingly constrained availability and unstable market prices (Fahmi et al., 2021). This situation highlights the need to explore sustainable alternative feed ingredients that offer equivalent nutritional value while remaining technically cost-effective.

Black Soldier Fly (BSF) (Hermetia illucens) larvae, or maggots, emerge as a highly potential protein substitute in fish feed formulations. Biochemically, maggots contain 40–50% crude protein and 15–35% fat, and are rich in essential amino acids such as leucine, lysine, and valine, which closely resemble the amino acid profile of fish meal (Wardhana et al., 2022). Furthermore, maggots contain lauric acid and natural antimicrobial peptides, which have been proven to enhance non-specific immune systems and pathogen resistance in fish (Hidayat et al., 2023). Nevertheless, the use of whole maggots is often constrained by high chitin content in the larval exoskeleton and a high fat profile, both of which can potentially limit protein digestibility and affect nutrient retention in the fish gut (Sofyan et al., 2025).

Several studies have reported variations in the physiological and growth responses of aquaculture fish to maggot substitution, depending on the inclusion level, seed stage, and presentation form of the maggots (fresh, dried, or meal) (Rakhmawati et al., 2023). Although several studies demonstrate that partial substitution (50%) provides optimal nutrient retention, the effect of full substitution (100%) on the Specific Growth Rate (SGR), absolute weight gain, and Survival Rate (SR) of Nile tilapia still shows mixed results and requires further empirical verification.

Accordingly, this study aimed to evaluate the potential of Hermetia illucens maggots as a complete or partial replacement for commercial feed by assessing their effects on the growth performance (absolute weight gain, specific growth rate (SGR), and absolute length growth) and survival rate (SR) of Nile tilapia (Oreochromis niloticus). The results are expected to provide scientific evidence on the effectiveness of maggot-based diets and their potential application as an efficient and sustainable alternative to commercial feed in Nile tilapia aquaculture.

RESEARCH METHOD

Time and Location

This research was conducted for 3 months, starting from March 2 to May 2, 2020, at the campus hatchery of the Pangandaran Marine and Fisheries Polytechnic.

Tools and Materials

The tools and materials used in this research include container boxes, a digital scale, a ruler, a scoop net, a siphon hose, hoses, buckets, an aeration system, an aerator, air stones, aeration tubing, a thermometer, a pH meter, and stationery. The materials used in this research were tilapia measuring 7 cm, BSF (Black Soldier Fly) maggots, commercial pellets, and water.

Data Analysis Method

Nile tilapia (Oreochromis niloticus) fingerlings measuring approximately 7 cm in length, with an initial body weight of approximately 15 g per fish, were stocked at a density of 15 fish per 45-L rearing container, resulting in an initial biomass of approximately 225 g per experimental unit. The fish were reared for 28 days using a completely randomized design (CRD) comprising three treatments and three replications, resulting in nine experimental units.

The dietary treatments consisted of P0 (100% Hermetia illucens maggot), P1 (50% H. illucens maggot and 50% commercial feed), and P2 (100% commercial feed). The treatments were established to compare the effects of maggot-based feed, a combination of maggot and commercial feed, and commercial feed alone on the growth and survival of Nile tilapia. Feed was provided at 22.5 g per feeding, twice daily at 08:00 and 16:00 Western Indonesia Time (WIB), resulting in a total daily feed allocation of 45 g per experimental unit. In P0, each feeding consisted of 22.5 g of maggot; in P1, each feeding consisted of 11.25 g of maggot and 11.25 g of commercial feed; and in P2, each feeding consisted of 22.5 g of commercial feed. Fish growth was monitored through weekly sampling throughout the rearing period.

Weight Growth

Weight growth was calculated based on the difference between the final weight and the initial weight proposed by Effenide (1997);

$$W = W_t - W_0$$

Note:
W = Weight growth (g)
W_t = Fish weight at the end of the rearing period (g)
W_0 = Fish weight at the beginning of the rearing period (g)

Specific Growth Rate (SGR)

Measurement of the Specific Growth Rate (SGR) was conducted to determine the weight gain of the fish during the rearing period. SGR was calculated using the formula proposed by Jaya (2013), as follows:

$$SGR = \frac{ln\, W_t - ln\, W_0}{t} \times 100\%$$

Note:
SGR = Specific Growth Rate (SGR) (%)
W_t = Average weight at the end of the rearing period (g/fish)
W_0 = Average weight at the beginning of the rearing period (g/fish)
t = Rearing period duration (days)

Absolute Length Growth

Measurement of absolute length growth was conducted by calculating the difference between the final length and initial length of the fish during the rearing period. Absolute length growth was calculated using the following formula proposed by Effendie (1997) :

$$L = L_t - L_0$$

Note:
L = Absolute length growth (cm)
L_t = Average length of fish at the end of the rearing period (cm)

L_0 -= Average length of fish at the beginning of the rearing period (cm)

Survival Rate

The survival rate (SR) was measured by comparing the number of live fish at the end of the rearing period with the number of fish at the start, calculated using the following formula proposed by Effendie (1997):

$$SR = \frac{N_t}{N_0} x\ 100\%$$

Note:
SR = Survival rate (%)
N_t = Number of live fish at the end of the rearing period (fish)
N_0 = Number of fish at the start of the rearing period (fish)

Data Analysis

Observational data were analyzed quantitatively by calculating weight gain, length gain, specific growth rate (SGR), and survival rate (SR). Subsequently, data for each parameter were analyzed using analysis of variance (ANOVA) at a 95% confidence (α = 0,05) to determine the effect of treatments on the observed parameters. If the ANOVA results showed significant differences ($p<0.05$), a post-hoc test was performed to identify differences between treatments. Observational results are presented as mean ± standard deviation

RESULT

Weight Growth

Based on the results of the study, the absolute weight growth showed differences in the average value of absolute weight gain for tilapia (*Oreochromis niloticus*) across each feed treatment. Descriptively, the highest absolute weight gain was obtained in treatment P0 (100% maggot), which was 2.47 ± 1,01 g. This was followed by treatment P2 (100% commercial feed) at 1.40 ± 0.87 g, while the lowest value was recorded in treatment P1 (50% maggot + 50% commercial feed), at 1.13 ± 0.35 g.

Table 1. Weight Growth (g)

Treatments	Weight Growth (g)
P0	2.47 ± 1.01
P1	1.13 ± 0.35
P2	1.40 ± 0.87

Note: Data are presented as mean ± standard deviation(SD), n = 3. P0 = 100% maggot; P1 = 50% maggot + 50% commercial feed; P2 = 100% commercial feedAnalysisi of variance (ANOVA) showed that the feed treatments had no significant effect on absolute lenght ($p>0.05$).

Specific Growth Rate (SGR)

The specific growth rate (SGR) of tilapia showed a pattern consistent with weight growth. Descriptively, the highest SGR value was obtained in treatment P0 (100% maggot), which was 1.55 ± 0.78%/hari. Futhermore, the SGR value for treatment P2 (100% commercial feed) was 1.30 ± 0.84%/day, while the lowest value was recorded in treatment P1 (50% maggot + 50% commercial feed), at 1.03 ± 0.20%/day.

Table 2. Specific Growth Rate (SGR) (%/day)

Treatments	Specific Growth Rate (%/day)
P0	1.55 ± 0.78
P1	1.03 ± 0.20
P2	1.30 ± 0.84

Note: Data are presented as mean ± standard deviation(SD), n = 3. P0 = 100% maggot; P1 = 50% maggot + 50% commercial feed; P2 = 100% commercial feedAnalysisi of variance (ANOVA) showed that the feed treatments had no significant effect on absolute lenght (p>0.05).

Absolute Length Growth

The absolute length growth of tilapia showed average values of 0.73 ± 0.47 cm for P0, 0.43 ± 0.21 cm for P1, and 0.73 ± 0.21 cm for P2. Based on these mean values, the highest absolute length growth was observed on treatments P0 and P2 with identical values of 0.73 cm, while the lowest value was recorded in treatment P1 at 0.43 cm.

Table.3 Absolute Length Growth (cm)

Treatments	Absolute Length Growth (cm)
P0	0.73 ± 0.47
P1	0.43 ± 0.21
P2	0.73 ± 0.21

Note: Data are presented as mean ± standard deviation(SD), n = 3. P0 = 100% maggot; P1 = 50% maggot + 50% commercial feed; P2 = 100% commercial feedAnalysisi of variance (ANOVA) showed that the feed treatments had no significant effect on absolute lenght (p>0.05).

Survival Rate (SR)

The survival rate of tilapia showed different average values across treatments. The highest SR value was obtained in treatment P1 (50% maggot + 50% commercial feed), at 82.22 ± 13.33%. This was followed by treatments P2 (100% commercial feed) at 80.00 ± 6.67%, while the lowest value was recorded in treatments P0 (100% maggot), at 73.33 ± 11.55%.

Table.4 Survival Rate (%)

Treatments	Survival Rate (%)
P0	73.33 ± 11.55
P1	82.22 ± 13.33
P2	80.00 ± 6.67

Note: Data are presented as mean ± standard deviation(SD), n = 3. P0 = 100% maggot; P1 = 50% maggot + 50% commercial feed; P2 = 100% commercial feedAnalysisi of variance (ANOVA) showed that the feed treatments had no significant effect on absolute length (p>0.05).

DISCUSSION

Absolute weight gain serves as a key parameter for assessing fish growth responses to different dietary treatments. The present study showed that treatment P0 (100% maggot) resulted in the highest absolute weight gain descriptively, at 2.47 ± 1.01 g, followed by P2 (100% commercial feed) at 1.40 ± 0.87 g and P1 (50% maggot + 50% commercial feed) at 1.13 ± 0.35 g. This pattern indicates that Nile tilapia fed exclusively with maggot showed a tendency toward greater weight gain during the 28-day rearing period.

Black soldier fly larvae (BSFL), scientifically known as Hermetia illucens, represent a potential nutritional resource for aquaculture because they contain substantial amounts of protein, lipids, essential amino acids, minerals, and bioactive compounds. However, their nutritional quality varies based on rearing substrate, larval stage, and processing methods (Wang & Shelomi, 2017; Gasco et al., 2019; Montevecchi et al., 2022). This variation must be considered, as it directly affects nutrient availability for fish growth.

The higher weight gain in P0 suggests that Nile tilapia efficiently utilized the nutrients in fresh maggots. Dietary protein supplies building blocks for muscle tissue, while lipids provide energy, creating a "protein-sparing" effect that allows protein to be used primarily for growth. Previous research has demonstrated that black soldier fly larvae (BSFL) can serve as an

alternative to conventional protein sources in Nile tilapia diets without adversely affecting fish growth (Devic et al., 2018).

Recent research further supports BSFL as a functional feed ingredient. Limbu et al. (2024) observed improved growth in Nile tilapia fed BSFL diets, while studies on red hybrid tilapia demonstrated good nutrient digestibility and improved specific growth rates (SGR). Additionally, Maulu et al. (2025) reported that increasing BSFL meal in juvenile tilapia diets enhanced final weight, SGR, and intestinal health, indicating that BSFL benefits both growth and gut physiology.

However, fish growth response to BSFL is not always linear. Meta-analyses show that while low-to-moderate BSFL inclusion levels maintain growth, high inclusion levels can yield variable results or even reduce growth depending on the fish species and formulation (Hua, 2021; Gougbedji et al., 2022).

These discrepancies are largely due to variations in BSFL composition (protein, lipid, and chitin content) and processing methods. Dry BSFL meal has a very different nutritional density and moisture level compared to fresh maggots. Therefore, results from this study using fresh maggots should not be directly compared to studies using dried BSFL meal.

The lower weight gain in P1 compared to P0 and P2 indicates that mixing 50% fresh maggot with 50% commercial feed provided no additive benefits. Because fresh maggots contain high moisture, feeding based on wet weight reduces actual dry matter, protein, and energy intake compared to dry commercial feed. Future comparisons should thus be normalized on a dry-matter basis rather than total wet weight.

Research on Nile tilapia has also indicated that fishmeal can be replaced entirely with black soldier fly larvae (BSFL) without significantly compromising growth or survival, while certain partial replacement levels have resulted in the highest average weight gain in pond-based trials. Overall, the results for P0 indicate that fresh maggots may serve as a viable feed source for Nile tilapia. Nevertheless, a diet consisting entirely of maggots cannot be conclusively recommended without further assessment of statistical significance, feed conversion efficiency, dry matter intake, and economic feasibility

Specific growth rate (SGR) represents the relative increase in fish body weight per unit of time. In the present study, the highest SGR was descriptively observed in P0 (100% maggot), at 1.55 ± 0.78% day^{-1}, followed by P2 at 1.30 ± 0.84% day^{-1} and P1 at 1.03 ± 0.20% day^{-1}. This pattern was consistent with the absolute weight gain results, where P0 also showed the highest mean weight gain. The consistency between these two parameters indicates that fish in P0 tended to exhibit a greater relative daily increase in body weight during the rearing period.

Specific growth rate (SGR) depends on the ability of fish to utilize dietary nutrients for metabolism and tissue synthesis. Dietary protein provides amino acids for growth, while lipids and carbohydrates serve as primary energy sources. Adequate energy intake produces a "protein-sparing" effect, allowing protein to be directed toward tissue accretion. The substantial protein and lipid levels in black soldier fly larvae (BSFL) help support these metabolic functions (Gasco et al., 2019; Wang & Shelomi, 2017).

These results align with Limbu et al. (2024), who observed favorable growth, SGR, and high nutrient digestibility (dry matter, crude protein, and energy) in red hybrid tilapia fed BSFL diets. Similarly, Maulu et al. (2025) A previous study found that higher levels of black soldier fly larvae (BSFL) meal in juvenile Nile tilapia diets enhanced weight gain, specific growth rate (SGR), and intestinal health parameters, indicating a possible association between improved intestinal morphology and more efficient nutrient utilization.

However, growth responses to BSFL vary across studies. A meta-analysis of 107 studies by Tran et al. (2022) revealed that growth performance depends on insect species, fish species, and dietary inclusion level. Specifically, BSFL inclusion often exhibits a quadratic relationship with growth, indicating that higher replacement levels do not continuously increase SGR.

Likewise, Hua (2021) noted that while moderate insect meal inclusion maintains growth comparable to fishmeal, high BSFL levels can impair growth. These variations are driven by ingredient quality, amino acid balance, lipid composition, chitin content, and overall diet formulation.

Chitin from the larval exoskeleton is a critical factor influencing BSFL nutritional value. Although chitin offers potential bioactive benefits, excessive levels can reduce nutrient digestibility. Because chitin content varies significantly across larval developmental stages and processing methods, the nutritional quality of BSFL cannot be evaluated by crude protein alone.The lowest SGR observed in treatment P1 suggests that combining 50% maggot with 50% commercial feed yielded no synergistic effect. This outcome may stem from differences in moisture content, nutrient density, palatability, or nutrient availability between fresh maggot and commercial pellets. However, because proximate analyses of the maggot and mixed diets were not conducted, these mechanisms remain speculative.

Absolute length growth of Nile tilapia during the 28-day rearing period was 0.73 ± 0.47 cm in P0, 0.43 ± 0.21 cm in P1, and 0.73 ± 0.21 cm in P2. Descriptively, P0 and P2 produced the same mean absolute length growth, whereas P1 showed the lowest value. However, analysis of variance indicated that dietary treatment did not significantly affect absolute length growth of Nile tilapia ($p > 0.05$).

The absence of a statistically significant effect indicates that mean length growth did not differ substantially among dietary treatments. Notably, although treatment P0 yielded the highest absolute weight gain and SGR, it did not produce significantly greater length growth, highlighting a divergence between somatic weight gain and linear growth responses. Fish growth represents a complex interaction between genetic potential, initial size, age, environmental conditions, rearing duration, and nutritional intake. Absorbed nutrients are not solely allocated to skeletal lengthening, but are also partitioned toward basal metabolism, physiological maintenance, and soft tissue deposition. Consequently, substantial weight gain does not necessarily translate to a proportional increase in body length.

Variable morphometric responses to BSFL-based diets are well-documented in Nile tilapia. Field and laboratory trials evaluating BSFL as a fishmeal substitute frequently report maintenance of overall performance without significant differences in specific growth parameters compared to control diets. Meta-analyses by Gougbedji et al. (2022) and Tran et al. (2022) further confirm this heterogeneity across literature, demonstrating that morphometric outcomes are strongly influenced by fish species, insect species, and dietary inclusion levels.

Additionally, the 28-day experimental duration may have been insufficient to detect significant differences in body length. Linear frame expansion typically occurs at a slower rate than weight gain, as nutrients are simultaneously allocated to somatic maintenance and tissue accumulation. A longer feeding trial may be required to fully assess the impact of fresh maggot diets on linear growth parameters.In summary, 100% fresh maggot and 100% commercial feed supported equivalent mean absolute length growth. These findings demonstrate that while maggot inclusion enhances weight gain in Nile tilapia, this response does not automatically yield a corresponding increase in total body length.

The survival rate of Nile tilapia during the 28-day rearing period was highest in P1 (50% maggot + 50% commercial feed), at 82.22 ± 13.33%, followed by P2 at 80.00 ± 6.67%, whereas P0 had the lowest survival rate at 73.33 ± 11.55%. This pattern differed from the growth parameters because P0 produced the highest absolute weight gain and SGR but the lowest survival rate. This finding indicates that growth and survival may respond differently to dietary treatments.

Fish survival is governed not only by dietary nutrition but also by water quality, stocking density, physiological health, handling procedures, and environmental adaptation.

Consequently, survival variations observed in this study should be interpreted cautiously and not attributed solely to dietary treatments.

Nevertheless, *Hermetia illucens* larvae possess specific properties that may influence fish health. BSFL contain chitin and bioactive compounds known to exert immunomodulatory effects. Bruni et al. (2021) observed that replacing fishmeal with high levels of BSFL meal did not impair Nile tilapia survival, while simultaneously enhancing certain skin mucus immune parameters. Similarly, Maulu et al. (2025) reported that BSFL meal improved growth performance and intestinal structure without altering survival rates. Furthermore, dietary incorporation of H. illucens frass in hybrid tilapia diets maintained survival while boosting immune responses and resistance to bacterial pathogens. These findings suggest that insect-derived components offer physiological benefits beyond basic protein provision.

Nevertheless, diets containing black soldier fly larvae (BSFL) do not always produce better results than conventional commercial feeds. A recent study published in 2026 on raw BSFL meal in Nile tilapia found that fish receiving commercial diets achieved greater final body weight and weight gain, although survival rates remained high and comparable among treatments. These findings indicate that growth performance and survival may respond differently to the inclusion of BSFL in fish diets.

In the present study, the higher survival rate observed in treatment P1 (50% maggot + 50% commercial feed) indicates that mixed feeding adequately supported overall viability during the experimental period. However, this survival advantage did not translate into higher weight gain or SGR, suggesting that nutritional requirements for basic survival differ from those optimizing biomass production.

Conversely, while P0 (100% maggot) produced the highest weight gain and SGR, it exhibited the lowest survival rate. This lower survival cannot be definitively attributed to maggot toxicity, as specific mortality causes, immune indices, and detailed water quality parameters were not monitored. Because mortality is multifactorial, the precise relationship between an exclusive maggot diet and reduced survival warrants further investigation.

Overall, dietary maggot inclusion produced divergent responses in Nile tilapia growth and survival; P0 yielded the highest descriptive weight gain and SGR, whereas P1 achieved superior survival. These results underscore the necessity of evaluating alternative feed ingredients across comprehensive performance criteria, including biomass accumulation, linear growth, survival, feed efficiency, water quality, and physiological health indicators.

CONCLUSION

Black soldier fly (Hermetia illucens) larvae demonstrated potential as an alternative feed ingredient for supporting the growth performance of Nile tilapia (*Oreochromis niloticus*). The 100% maggot treatment (P0) resulted in the highest descriptive values of absolute weight gain (2.47 ± 1.01 g) and specific growth rate (1.55 ± 0.78% day^{-1}), whereas the 50% maggot + 50% commercial feed treatment (P1) produced the highest survival rate (82.22 ± 13.33%). Absolute length growth was highest in P0 and P2 (0.73 cm), although dietary treatment did not significantly affect absolute length growth ($p > 0.05$). Overall, maggot has potential as an alternative feed source for Nile tilapia; however, further studies with longer rearing periods, proximate analysis of the feed, feed efficiency evaluation, and optimized inclusion levels are needed to determine the most appropriate use of maggot in Nile tilapia culture.

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