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Fish Meal Substitution Using Black Soldier Fly Larvae (*Hermetia illucens*) Meal for Feed Efficiency, Growth, and Survival of the Silver Pompano (*Trachinotus blochii*) Fingerlings

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ABSTRACT

One of the critical raw feed materials is fish meal, but the price of fish meal is increasing, and its availability is increasingly limited. Therefore, a need for an alternative for fish meal has emerged. To cover this demand, the black soldier fly larvae meal can be a viable alternative raw material. This research aimed to determine the effect of fish meal substitution using the black soldier fly larvae meal in artificial feed on the growth and survival of the silver pompano fingerlings (*T. blochii*). This research used an experimental efficiency ratio method, completely randomized design (CRD), consisting of 6 treatments with three replications. The treatments applied were treatments A, B, C, D, and E, and controls using 0, 15, 30, 45, and 60% black soldier fly larvae flour, and controls using commercial feed. The fish tested were the silver pompano fingerlings weighing 3±1.1 grams and 3-5cm long. Fingerlings were reared in containers at a stocking density of 15 fish/container for a maintenance period of 42 days. The results showed that fish meal substitution using black soldier fly larvae meal at different doses had a significant effect ($P<0.05$) on total feed consumption, feed conversion ratio, feed utilization efficiency, protein efficiency ratio (PER), protein retention (PR), and specific growth rate (SGR). However, there was no significant effect ($P\geq0.05$) on the survival rate of the silver pompano fingerlings. The best result was found in treatment C (30% BSFL meal substitution), which was able to produce total feed consumption (68.11 ± 1.17 grams), feed convention ratio (1.34 ± 0.08), protein efficiency ratio (2.95 ± 0.05), protein retention (40.61 ± 0.04%), survival growth rate (2.37 ± 0.04%/day), and survival rate (100 ± 0.00%).

INTRODUCTION

Aquaculture has recently become an industry with high market growth. It was projected that in 2030, aquaculture will contribute significantly to the global fisheries product market, producing 240 million tons of aquaculture products **(Komlatsky, 2024)**.

Despite its potential, this will also become a challenge as the need for more production resources will increase gradually. Fish meal is a well-known raw material for producing fish feed. Fish meal has been one of the main feed materials for ages, as it has a high nutritional value. However, fish meal is also known as a raw material for many industries, including terrestrial animal industries **(Parolini *et al*., 2020)**. The competition to utilize fish meals among aquatic and terrestrial animal production and its limited supply have become huge factors that have led to an increase in fish meal prices.

A viable method to reduce the reliance on fish meal is to incorporate another alternative material. Insect-based raw material has proven to be an excellent protein source for feed production. Material derived from insects typically contains high protein, similar to fish meal. **Oteri *et al*. (2022)** stated that insect meal has a high nutritional value and can serve as a fish meal substitute. The fatty acids in insect-based materials are also one of the main reasons these materials should be considered. Insect-based material is typically high in polyunsaturated fatty acids but has fewer eicosapentaenoic and docosahexaenoic fatty acids **(Alfiko *et al.*, 2022)**. Using insect-based protein sources helps mitigate the negative impacts of overfishing, easing the strain on marine ecosystems. Insect-based material is a sustainable, nutritious, and environmentally friendly alternative to traditional fishmeal. Alternative raw materials such as insect-based proteins play a key role in the future, solving ecological, economic, and ethical problems related to aquafeeds **(Fantatto *et al*., 2024)**.

The black soldier flies (*Hermetia illucens*) larvae (BSFL), as one insect-based protein source, are known to be a promising alternative raw material and a high-protein source. BSFL is rich in essential nutrients; it contains 40-50% protein, 30% lipid, and 18.82% crude fiber, as well as high in cystine, histidine, tryptophan, and tyrosine **(Herawati *et al*., 2020)**. BSFL meal has been studied widely on terrestrial and aquatic animals and has shown promising results. Previously, BSFL meal inclusion has been addressed in the rainbow trout (*Oncorhynchus mykiss*) **(Sealey *et al*., 2011)**, turbot (*Psetta maxima*) **(Kroeckel *et al*., 2012)**, Atlantic salmon (*Salmon salar*) **(Lock *et al.*, 2015)**, Jian carp (*Cyprinus carpio var. Jian*) **(Zhou *et al*., 2017)**, and the Nile tilapia (*Oreochromis niloticus*) **(Tippayadara *et al*., 2021)**. Studies in BSFL meal have been quite extensive, but there are still numerous aquaculture fish species that haven't been subjected to be studied.

Silver pompano (*Trachinotus blochii*) is a marine species brimming with potential. This fish is in great demand and has a relatively high price of around 10USD/ kg in the local and international markets **(Saputra *et al*., 2019)**. Silver pompano has rapid growth and is highly adaptive **(Pathak *et al*., 2019; Divu *et al*., 2024)**. There is no known study elucidating the effect of BSFL meal on the silver pompano growth. An experiment is needed to elaborate further on how the BSFL meal inclusion will influence silver pompano feed efficiency and growth. Thus, this study will illustrate the effect of fish meal substitution using the black soldier fly larvae (*H. illucens*) meal on the feed conversion and the growth of the silver pompano (*T. blochii*) fingerlings.

MATERIALS AND METHODS

The data collection of this study was carried out at the Balai Besar Perikanan Budi Daya Laut Lampung, Lampung. The test fish used was the silver pompano (*Trachinotus blochii*) fingerling with a weight of 3±1.1 grams. The silver pompanos (*T. blochii*) were reared in 18 container boxes with a size of 50 x 30 x 20cm³ and 15 fish/container density. The test feed was pelletized using an extruder. The test fish were fed three times daily at 07.00 WIB, 11.00 WIB, and 15.00 WIB with the satiation method. Moreover, they were reared in 30ppt salinity seawater.

Water quality data included measurements of temperature (°C), pH, salinity (ppt), and dissolved oxygen (mg/L). Water quality parameter measurement was carried out daily using a water quality checker (WQC) in the morning and evening.

The research design was completely randomized (CRD) with six treatments and three replications. The treatments carried out in this study were as follows:

K: Commercial feed

A: 0% Fish meal substitution with BSFL meal

B: 15% Fish meal substitution with BSFL meal

C: 30% Fish meal substitution with BSFL meal

D: 45% Fish meal substitution with BSFL meal

E: 60% Fish meal substitution with BSFL meal

The substitution dose of BSFL meal was based on the study of **Rawski *et al.* (2021)** with some modifications. The feed's formulation and proximate analysis used in this study are presented in Table (2).

Table 2. Silver pompano feed formulation and proximate analysis

Ingredients (%)	Treatment					
	K	A	B	C	D	E
Fish Meal	-	40.00	34.0	28.00	22.00	16.00
BSFL Meal	-	0.00	6.0	12.00	18.00	24.00
Prawn Meal	-	5.90	6.05	6.10	6.00	4.95
Soybean Meal	-	35.10	34.95	34.90	35.00	37.75
Bran Meal	-	6.00	6.00	6.00	6.00	8.3
Fish Oil	-	3.00	3.00	3.00	3.00	2.00
Corn Oil	-	3.00	3.00	3.00	3.00	2.00
Vitamin Mix	-	4.00	4.00	4.00	4.00	3.00

CMC	-	3.00	3.00	3.00	3.00	2.00
Protein*	48.00	42.00	42.24	42.53	42.84	44.00
Fat*	12.00	18.79	18.65	18.53	18.46	19.95
BETN	10.00	9.52	9.34	9.16	8.97	6.83
En. (kkal/g)	310.6	354.94	353.96	353.35	353.27	366.58

*BBPBL Jepara laboratory proximate test results.

The data observed in this study, including total feed consumption (TFC), feed utilization efficiency (FUE), feed conversion ratio (FCR), protein efficiency ratio (PER), protein retention (PR), specific growth rate (SGR), and survival rate (SR) were calculated based on following formulas:

Total feed consumption

Total feed consumption was calculated using the formula according to **Weatherly (1972)**, as follows:

$$F = C - S$$

Information:
F: Total feed consumption (g)
C: Feed given (g)
S: Leftover feed (g)

Feed utilization efficiency

Feed utilization efficiency is the feed that fish can utilize for growth. According to **Zonneveld *et al*. (1991)**, the efficiency of feed utilization was calculated using the formula:

$$FUE = \frac{W_t - W_0}{F} \times 100\%$$

Information:
FUE: Feed Utilization Efficiency
Wt: Weight of test animals at the end of the study (g)
W_0: Weight of test animal at the beginning of the study (g)
F: Total feed consumption (g)

Feed conversion ratio

Feed conversion ratio is the feed given to produce 1kg of meat. According to **Pathak *et al.* (2019)** feed conversion ratio was calculated using the formula:

$$FCR = \frac{F}{(W_t - W_0) + d}$$

Information:
FCR: Feed Conversion Ratio
Wt: Weight of test animals at the end of the study (g)

W_0: Weight of test animal at the beginning of the study (g)
d: Dead fish biomass (g)

Protein efficiency ratio
The protein efficiency ratio is the amount of protein used for growth. According to **Tacon (1987)**, protein efficiency ratios were calculated using the formula:

$$PER = \frac{W_t - W_0}{Pi} \times 100\%$$

Information:
PER: Protein Efficiency Ratio
Wt: Final weight of fish (g)
W_0: Initial weight of fish (g)
Pi: Amount of protein consumed (g)

Specific growth rate
According to **Takeuchi (1988)**, the specific growth rate of fish was calculated using the formula:

$$SGR = \frac{Wt - W_0}{W_0 \times t} \times 100\%$$

Information:
SGR: Spesific Growth Rate
Wt: Weight of test animals at the end of the study (g)
W_0: Weight of test animal at the beginning of the study (g)
t: Maintenance time (days)

Survival rate
Survival rate is the number of fish that live until the end of rearing. According to **Pathak *et al*. (2019)**, fish survival was calculated using the formula:

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

Information:
SR: Survival rate (%)
N_t: Number of individuals at the end of the study (tails)
N_0: Number of individuals at the beginning of the study (tails)

The data obtained during the study were analyzed statistically using IBM SPSS Statistics 26. The data were tested for normality, homogeneous, and additivity, then analyzed using the analysis of variance (ANOVA) test to determine whether the treatment applied has an effect. If the analysis of variance showed a significant (P<0.05) result, then the Dunnett test was employed. Water quality data were analyzed descriptively.

RESULTS

Total feed consumption (TFC)

Statistical analysis results of the effect of fish meal substitution with the black soldier fly larvae (BSFL) meal in feed on the total feed consumption (TFC) are presented in Fig. (1).

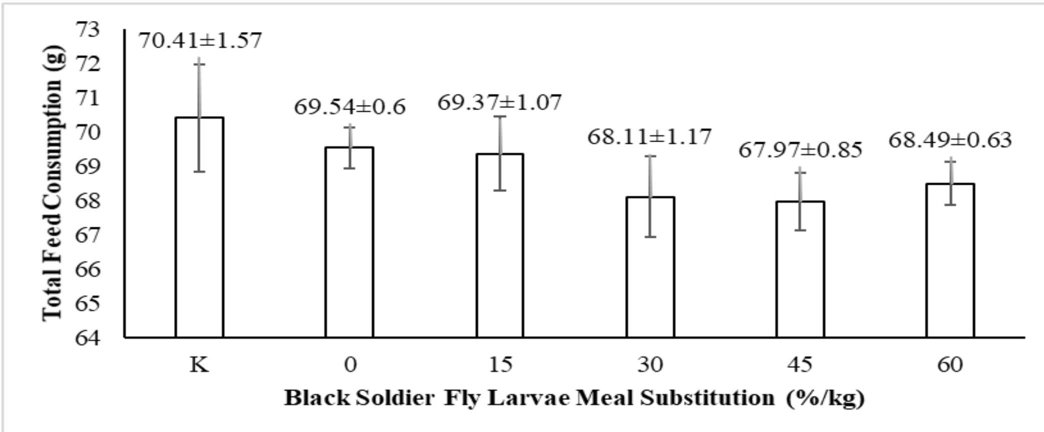

Fig. 1. Total feed consumption of the silver pompano (*Trachinotus blochii*)

Based on the variance test result analysis, there was no significant effect ($P \geq 0.05$) on the TFC. Therefore, the post hoc test could not be conducted.

Feed conversion ratio (FCR)

The results of the effect of fish meal substitution with the black soldier fly larvae (BSFL) meal in feed on the feed conversion ratio (FCR) are presented in Fig. (2).

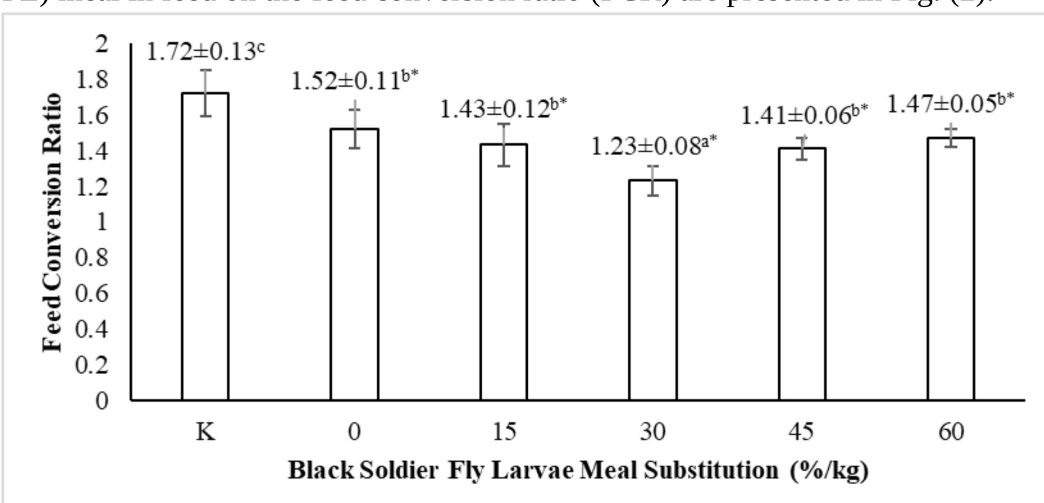

Fig. 2. Feed conversion rate of the silver pompano (*T. blochii*)

BSFL meal inclusion showed a significant effect ($P < 0.05$) on the FCR. The best FCR was found in treatment C, with a value of 1.23. Dunnett test of the FCR showed a significant difference ($P< 0.05$) in all of the treatment groups (A, B, C, D, and E) compared to the control group (treatment K).

Protein efficiency ratio (PER)

The results of the effect of fish meal substitution with the black soldier fly larvae (BSFL) meal in feed on the protein efficiency ratio (PER) are presented in Fig. (3).

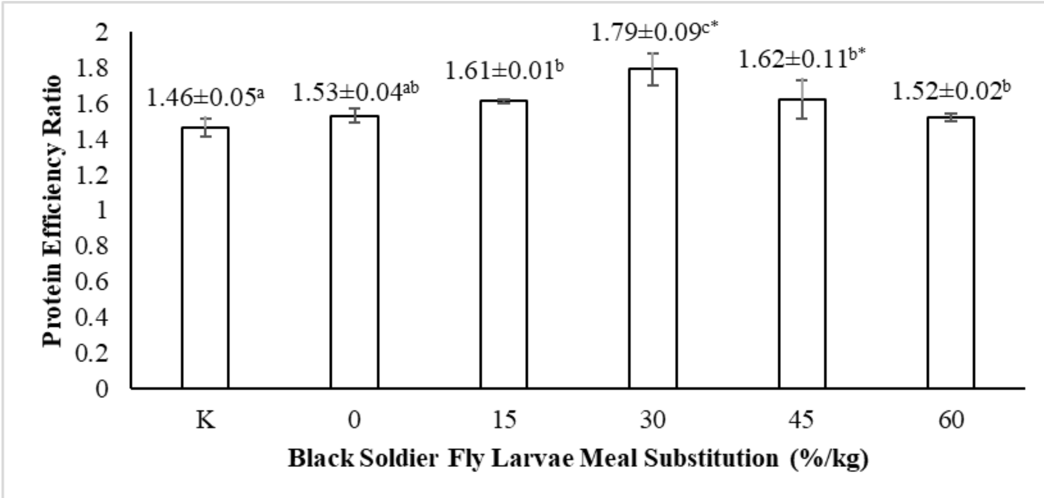

Fig. 3. Protein efficiency ratio of the silver pompano (*T. blochii*)

Based on the analysis of the variance test, BSFL meal inclusion had a significant effect ($P< 0.05$) on the PER. The best PER was found in treatment C with a value of 1.79±1.17. Dunnett test of the PER showed a significant difference ($P< 0.05$) in treatments C and D compared to the control group (treatment K).

Protein retention (PR)

The results of the study on the effect of BSFL meal addition in the feed on protein retention (PR) are presented in Fig. (4).

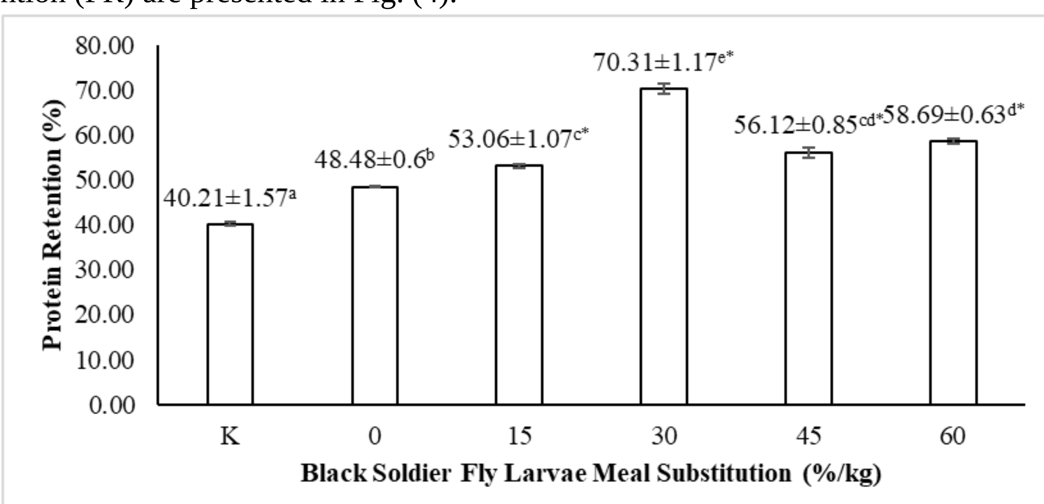

Fig. 4. Protein retention of the silver pompano (*T. blochii*)

Based on the analysis of the variance test, BSFL meal inclusion had a significant effect ($P< 0.05$) on the PR. The best PR was found in treatment C with a value of 1.79±1.17. Dunnett test of the PR showed a significant difference ($P< 0.05$) in treatments B, C, D, and E compared to the control group (treatment K).

Specific growth rate (SGR)

Fig. (5) presents the study's results on replacing fish meal with BSFL meal regarding specific growth rate (SGR) in the feed.

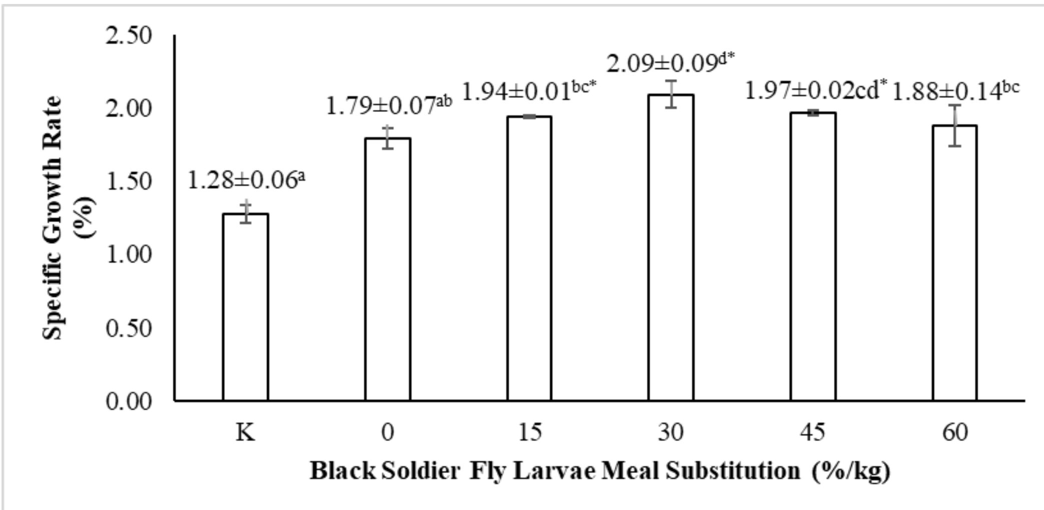

Fig. 5. Specific growth rate of the silver pompano (*T. blochii*)

Based on the analysis of the variance test, BSFL meal inclusion had a significant effect ($P< 0.05$) on the SGR. The best SGR was found in treatment C with a value of 2.09±0.09. Dunnett test of the SGR showed a significant difference ($P< 0.05$) in treatments B, C, and D compared to the control group (treatment K).

***Survival rate* (SR)**

Fig. (6) presents the study's results on the effect of adding BSFL meal feed on the survival rate of the silver pompano.

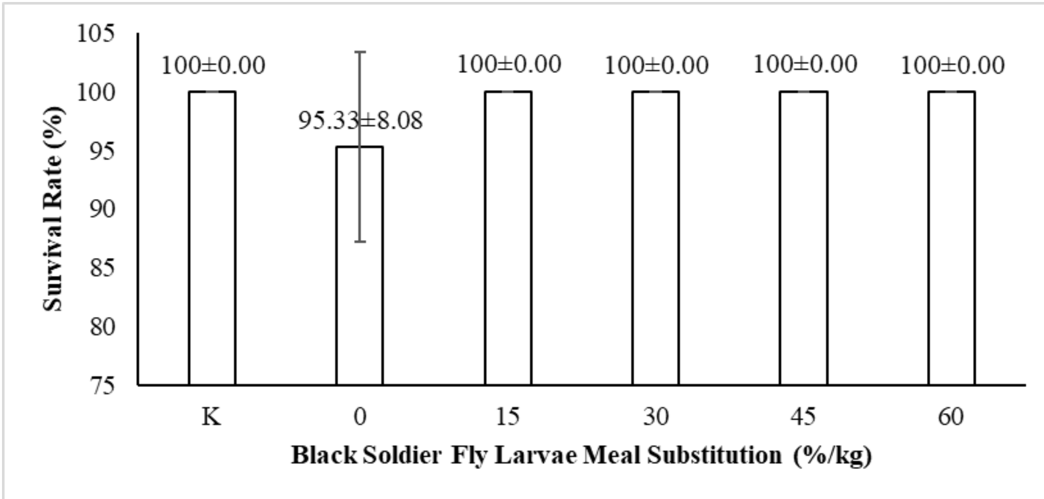

Fig. 6. Survival rate of the silver pompano (*T. blochii*)

Based on the analysis of the variance test, BSFL meal inclusion had no significant effect (P< 0.05) on the SR. The post hoc test could not be conducted because of the analysis of variance results. Amino acid content in each feed and amino acid of the silver pompano (*T. blochii*) for 42 days of maintenance are presented in Table (1).

Table 1. Amino acid contents in each feed and amino acids of the silver pompano (*T. blochii*) for 42 days of maintenance

Amino acid	Commercial	A (0%)	B (15%)	C (30%)	D (45%)	E (60%)
Arginine	1.76 ± 0,08^{a}	1.45 ± 0,03^{a}	2.15 ± 0,04^{b}	2.48 ± 0,07^{b}	2.09 ± 0,07^{a}	1.96 ± 0,08^{a}
Histidine	0.75 ± 0,04^{a}	0.90 ± 0,10^{a}	1.19 ± 0,06^{a}	1.57 ± 0,03^{b}	1.26 ± 0,06^{a}	1.28 ± 0,07^{a}
Isoleucine	0.97 ± 0,08^{a}	1.19 ± 0,04^{a}	1.96 ± 0,09^{b}	2.08 ± 0,07^{b}	1.80 ± 0,03^{a}	1.55 ± 0,02^{ab}
Leucine	1.03 ± 0,03^{a}	1.38 ± 0,03^{a}	1.39 ± 0,08^{a}	2.09 ± 0,09^{b}	1.78 ± 0,08^{a}	1.54 ± 0,04^{a}
Lysine	2.19 ± 0,05^{a}	3.79 ± 0,02^{a}	3.08 ± 0,03^{a}	3.65 ± 0,08^{b}	3.26 ± 0,07^{b}	2.16 ± 0,09^{a}
Methionine	1.08 ± 0,07^{a}	3.18 ± 0,04^{a}	3.55 ± 0,04^{a}	4.09 ± 0,09^{b}	3.89 ± 0,09^{a}	2.14 ± 0,07^{a}
Phenylalanine	1.68 ± 0,02^{a}	1.77 ± 0,05^{a}	2.07 ± 0,05^{a}	2.24 ± 0,05^{b}	2.18 ± 0,05^{b}	2.09 ± 0,06^{a}
Threonine	0.95 ± 0,01^{a}	1.16 ± 0,06^{a}	1.74 ± 0,03^{a}	2.18 ± 0,09^{b}	2.09 ± 0,06^{a}	1.68 ± 0,01^{a}
Tryptophan	1.93 ± 0,03^{a}	0.79 ± 0,09^{a}	1.08 ± 0,05^{a}	1.59 ± 0,03^{b}	1.17 ± 0,02^{a}	1.05 ± 0,03^{a}
Valine	0.99 ± 0,08^{a}	1.35 ± 0,07^{a}	1.86 ± 0,09^{a}	2.16 ± 0,09^{b}	2.09 ± 0,04^{b}	1.77 ± 0,08^{ab}

Note: different superscripts in the same row indicate significant differences (P<0.05).

The essential amino acid profile analysis showed that lysine and methionine showed high levels (3.65 and 4.09%, respectively) in the silver pompano (*T. blochii*) fed with maggot oil. Amino acid contents in the silver pompano (*T. blochii*) at 42 days of research are presented in Table (2).

Table 2. Amino acid contents in the silver pompano (*T. blochii*) at 42 days of research

Amino acid	Commercial	A (0%)	B (15%)	C (30%)	D (45%)	E (60%)
Arginine	1.79 ± 0,06^{a}	1.49 ± 0,04^{a}	2.18 ± 0,05^{b}	2.54 ± 0,05^{b}	2.13 ± 0,08^{a}	1.99 ± 0,02^{a}
Histidine	0.80 ± 0,05^{a}	0.98 ± 0,05^{a}	1.22 ± 0,08^{a}	1.63 ± 0,03^{b}	1.28 ± 0,06^{a}	1.32 ± 0,03^{a}
Isoleucine	0.99 ± 0,04^{a}	1.23 ± 0,09^{a}	1.98 ± 0,02^{b}	2.19 ± 0,06^{b}	1.83 ± 0,04^{a}	1.58 ± 0,07^{ab}
Leucine	1.15 ± 0,07^{a}	1.39 ± 0,04^{a}	1.44 ± 0,09^{a}	2.26 ± 0,03^{b}	1.80 ± 0,05^{a}	1.57 ± 0,05^{a}
Lysine	2.22 ± 0,06^{a}	3.88 ± 0,06^{a}	3.59 ± 0,02^{a}	4.20 ± 0,04^{b}	3.29 ± 0,08^{b}	2.19 ± 0,08^{a}
Methionine	1.18 ± 0,09^{a}	3.19 ± 0,08^{a}	3.18 ± 0,03^{a}	3.72 ± 0,06^{b}	3.92 ± 0,02^{a}	2.18 ± 0,04^{a}
Phenylalanine	1.69 ± 0,03^{a}	1.80 ± 0,04^{a}	2.18 ± 0,08^{a}	2.28 ± 0,06^{b}	2.21 ± 0,06^{b}	2.11 ± 0,02^{a}

Threonine	0.99 ± 0,04[a]	1.19 ± 0,02[a]	1.78 ± 0,07[a]	2.22 ± 0,05[b]	2.12 ± 0,09[a]	1.69 ± 0,01[a]
Tryptophan	1.98 ± 0,09[a]	0.83 ± 0,09[a]	1.09 ± 0,04[a]	1.66 ± 0,06[b]	1.19 ± 0,03[a]	1.15 ± 0,09[a]
Valine	1.05 ± 0,03[a]	1.39 ± 0,08[a]	1.88 ± 0,08[a]	2.19 ± 0,08[b]	2.10 ± 0,05[b]	1.79 ± 0,04[ab]

Note: different superscripts in the same row indicate significant differences (P<0.05).

Analysis of the essential amino acid profile showed that lysine showed high levels of 4.20% in the silver pompano (*T. blochii*) for 42 days of maintenance. Water quality is one of the factors that support fish growth and survival. The results of the water quality measurement in the maintenance media of the silver pompano during the study are depicted in Table (3).

Table 3. Water quality during research

Treatment	DO (ppm)	pH	Temperature(°C)	Salinity (ppt)
A (0%)	5.01-5.98	7.7-7.8	28-29	31-32
B (15%)	5.11-5.68	7.8-7.9	28-29	30-31
C (30%)	5.00-5.54	7.7-7.8	31-32	29-30
D (45%)	5.17-5.98	7.7-7.9	28-30	30-31
Control	5.02-5.21	7.7-7.9	28-29	30-31
Requirements*	>5	7.5-8.5	28-32	>28

Note: * **Kalidas *et al.* (2022)**.

The measurement of water quality variables during the study showed that the water quality variables were still in a suitable condition to be used as a medium for the cultivation of the silver pompano.

DISCUSSION

Growth performance

Fish meal substitution with the black soldier fly larvae (BSFL) meal showed no significant effect (P< 0.05) on the TFC. Several factors influence total feed consumption, including nutritional content and palatability. Based on the feed's proximate result, it can be inferred that the energy content of treatments A (0% BSFL meal inclusion), B (15% BSFL meal inclusion), C (30% BSFL meal inclusion), D (45% BSFL inclusion), and E (60% BSFL meal inclusion) was not that different but those treatments had significant differences compared to treatment K (commercial feed). According to **Olivia-Teles *et al.* (2020)**, high-energy feed can cause early satiation, thus lowering the total feed consumption. Based on that statement, fish meal substitution with BSFL meal should significantly affect the total feed consumption. However, other factors might influence the total feed consumption, and the probable factor is the feed's palatability, including its appearance, taste, and aroma. Palatability is a considerable factor in a fish's acceptance of its given feed, influenced by its flavor and odor **(Santos *et al*., 2023)**. BSFL meals have a strong odor, which might attract the silver pompano (*T. blochii*) to eat the food with BSFL meal inclusion.

BSFL meal inclusion in the feed showed a significant effect (P< 0.05) on the feed conversion ratio (FCR), showcasing its potential to improve the feed's efficiency. The best treatment was treatment C (45% BSFL meal inclusion) with an FCR value of 1.23±1.17. The feed's quality was allegedly the most significant factor for the FCR value. BSFL meal incorporation might balance the amino acid profile by combining BSFL meal and fish meal. **Kamarudin *et al*. (2021)** showed that BSFL meals have better leucine, tyrosine, and threonine values than fish meals. The treatment groups also showed a better FCR, probably due to differences in protein quality. Test feeds were alleged to have a more suitable nutritional quality than commercial feed (treatment K).

The protein efficiency ratio value depends on various factors related to its nutritional availability, digestibility, and utility. Based on the statistical analysis, BSFL meal inclusion in the feed exhibits a significant effect (P< 0.05) on the protein efficiency ratio. The best treatment in this study was treatment C, with a PER value of 1.79±0.09. This might be due to the protein quality in the feed on treatment C being more adequate, balanced, and closer to the silver pompano's amino acid requirements than the other treatments. An acceptable level of both essential (EAA) and non-essential (NEAA) amino acids in the feeds can enhance the growth of cultivated fish **(Li *et al.,* 2020)**. The treatment groups have a higher PER value than the control group because of the higher lipid content that might cause a protein-sparing effect. The silver pompano is an omnivorous species that tends to engage in carnivorous behavior. In carnivorous species, lipids can be used as an energy source efficiently **(Colombo, 2020)**, so the protein consumed by the fish can be utilized for somatic growth when the energy requirement has been met.

Protein retention is a parameter showcasing the protein utilization for somatic growth. According to **Suprayudi *et al*. (2013)**, protein retention can be defined as the value of stored protein within the fish's body compared with protein consumed by the fish. The BSFL meal inclusion significantly (P< 0.05) improves protein retention at certain levels, with the best treatment being treatment C, with a value of 70.31±1.17%. Treatment C had the best PR value among the treatment groups, mainly influenced by the quality of the feed's balanced protein and amino acids. If the amino acid profile of the feed is not balanced, then there will be a disruption in protein synthesis in the body, resulting in nitrogen loss **(Xing *et al*., 2024)**.

Protein retention in the treatment groups can also be seen as better than in the control groups (Treatment K), as several factors affect the protein retention value between the groups. The control group is the silver pompano (*T. blochii*) fed with commercial feed, which uses entirely different raw materials from other sources. Materials are a crucial part when it comes to formulating the feeds; if the material is different, it can be assumed that there are many differences and imbalances in the amino acid profile, resulting in the lower PR value of the control feed compared to the B, C, D, and E feeds. **Nascimento *et al*. (2020)** stated that a deficiency in some essential amino acids can lead to lower protein deposition in the body. Moreover, feeds from treatment groups were high in lipids, which can be used as an energy source, causing a protein-sparing effect. The increase in body protein can be caused by the protein-sparing effect of lipids about their properties as an energy source that leads to protein accretion in the fish body **(Thirunavukkarasar *et al*., 2022)**.

The SGR value of the silver pompano fed with BSFL meal-incorporated feed was higher than those without BSFL meal inclusion. The protein and fat content can influence fish growth in the feed given. An adequate level of protein can promote growth by building new muscles, cells, and tissues **(Teles *et al*., 2020; Ahmad *et al*., 2021)**, while fat can also be stored in the body in the lipid storage tissues in the muscle, liver, and adipose tissue **(Xu *et al*., 2021)**. The high growth rate is also proportional to the high efficiency of feed utilization. According to **Isnawati *et al*. (2015)**, the growth rate can be influenced by the increase in protein and fat content, which functions as building blocks of muscles, cells, and tissues, as well as a source of energy. A high growth rate associated with low FCR indicates that the feed is utilized efficiently so that the fish can meet energy needs, and when the required energy is met, the fish can use the rest of the energy for growth. Protein can be optimized if carbohydrates and fats in the feeds are utilized efficiently as energy sources **(Pertiwi & Saputri, 2020)**.

Treatment C (30% BSFL Meal Inclusion) was the best feed on the amino acid profile, with the essential amino acid lysine at 4.09% and methionine at 3.65%. The best in silver fish pompano (*Trachinotus blochii*) at 42 days is lysine 4.09%. The amino acid lysine plays several key roles in research, as demonstrated by **Ovie and Eze (2013)**, **Valverde *et al.* (2013)** and **Herawati *et al.* (2015)**. These studies highlight its functions as a precursor for vitamin B1 synthesis, its antiviral properties, and its role in calcium absorption. Additionally, lysine contributes to appetite stimulation and supports carnitine production, which facilitates the conversion of fatty acids into energy.

The survival rate during the study showed promising results; all treatments showed a survival rate of 95.33±8.08 to 100±0.00%. Statistical analysis showed that all treatments have the same effect ($P \geq 0.05$) on the SR of the silver pompano. The minimum energy requirement of the silver pompano (*T. blochii*) must have been met to maintain its metabolism **(NRC, 2011)**. The water quality in the rearing media during the experiment was still relatively suitable for the silver pompano. Higher protein content can lead to a higher ammonia release rate due to deamination and catabolism of amino acids **(Zehra & Khan, 2012)**. However, the ammonia level of every treatment was alleged to be tolerable.

CONCLUSION

The results showed that fish meal substitution using the black soldier fly larvae meal at different doses had a significant effect ($P< 0.05$) on feed conversion ratio (FCR), feed utilization efficiency (FUE), protein efficiency ratio (PER), protein retention (PR), and specific growth rate (SGR). However, there was no significant effect ($P< 0.05$) on the total feed consumption (TFC) and the survival rate (SR) of the silver pompano fingerlings.

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