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Supplementation of Lysine and Methionine in Commercial Feed on the Survival and Growth of Jelawat (Leptobarbus hoevenii) Fry

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DOI: 10.14710/sat.v10.i2.30574

Abstract

This study evaluated the effect of commercial feed supplemented with the amino acids lysine and methionine on the survival and growth of jelawat (*Leptobarbus hoevenii*) fry. A completely randomized design (CRD) was used, comprising four treatments and three replicates. Lysine and methionine were added to a commercial diet at four levels based on dry feed weight: P1 (0%), P2 (1%), P3 (2%), and P4 (3%). The parameters measured were survival, total length growth, absolute weight growth, specific growth rate (SGR), feed conversion ratio (FCR), and feed utilization efficiency (FUE), with water quality recorded as supporting data. Supplementation up to 3% had no significant effect on survival, total length growth, absolute weight growth, or SGR ($P>0.05$), and survival reached 100% in all treatments. In contrast, FCR and FUE were significantly affected ($P<0.05$), with the best values obtained at 1% supplementation (P2): an FCR of 1.5 and an FUE of 65.92%. Although several growth parameters were numerically highest at 1% supplementation, the differences were not statistically significant. These results indicate that the lysine and methionine requirements of jelawat fry are likely already met by the basal commercial diet, and that supplementation mainly improves feed efficiency rather than growth under the conditions tested.

Keywords: Feed efficiency; Growth; Hoven's carp (*Leptobarbus hoevenii*); Lysine; Methionine

INTRODUCTION

Jelawat (*Leptobarbus hoevenii*) is a freshwater fish native to Sumatra, Malaysia, and Thailand (Andini, 2023). Aryani (2018) reported that jelawat is a popular local freshwater food fish whose natural habitats include several large rivers in Sumatra, such as the Musi, Batanghari, Kampar, and Indragiri. According to Bachry *et al.* (2021), jelawat can reach a body length of up to 60 cm, is omnivorous, and lives in schools. It is one of the locally important species, commanding a relatively higher market value than other food fishes. Based on information from fish farmers in Lapak Lambur Village, Tenggarong, the price of jelawat fry ranges from IDR 3,000–5,000 per individual, while traders at Ijabah Market, Samarinda, reported that consumption-size jelawat sells for IDR 60,000–70,000 per kilogram.

Jelawat aquaculture can be developed through hatchery and grow-out activities; however, a key constraint is its slow growth relative to other food-fish species (Tani *et al.*, 2025). This discourages farmers from culturing it, leading them to prefer faster-growing species that yield higher profits. Jelawat is estimated to require 9–10 months to reach harvest size, resulting in high feed consumption (Aryani *et al.*, 2018). Several efforts have been made to enhance jelawat growth, primarily by providing feed that meets the fish's nutritional requirements. Feed is one of the most important components of aquaculture because it strongly influences growth. Karimah *et al.* (2018) stated that feed plays a major role in growth, serving as the principal source of energy and material for life, growth, and reproduction. According to Ihtifazhuddin *et al*. (2026), feed provides the energy and materials needed to sustain survival and growth, and represents the largest cost component (60–80%) of production. Andriani *et al.* (2021) noted that, as the most significant input, feed costs can reach almost 60–70% of total aquaculture production costs. Therefore, applying efficient feeding strategies contributes to cost savings and improved growth (Alhijrah and Scabra, 2023). This is consistent with Kusuma *et al.* (2022), who found that supplying essential amino acids improved growth and feed utilization in baung catfish (*Hemibagrus nemurus*). Amino acids are the main building blocks of protein and comprise two groups: essential amino acids—lysine, methionine, valine, histidine, phenylalanine, arginine, isoleucine, threonine, leucine, and tryptophan—and non-essential amino acids—aspartic acid, glutamic acid, alanine, tyrosine, cystine, serine, proline, hydroxylysine, glutamine, and hydroxyproline (Muhsafat *et al.*, 2015).

Lysine plays an important role as an antioxidant in cell differentiation, growth, immunity, and the reduction of nitrogen emissions (Liebl *et al.*, 2022). It is an essential amino acid that cannot be synthesized by the fish body and must be obtained from the diet (Khalida *et al.*, 2017). According to Maulina and Widaryati (2020), lysine supplementation is expected to lower the feed conversion ratio, improve feed efficiency, and enhance the growth of jelawat fry, thereby shortening the rearing period required to reach consumption size. Methionine can also act as the limiting amino acid in the plant protein sources used in feed formulation (Wang *et al.*, 2023). Azeredo *et al.* (2017) reported that methionine is a sulfur-containing essential amino acid that plays an important role in fish physiology, including as a key precursor in the synthesis of natural antioxidants such as glutathione, which protects cells from oxidative damage.

Plant-based feed ingredients, such as soybean meal and rice bran, have incomplete amino acid profiles; this imbalance can impair protein synthesis, cause suboptimal growth, and reduce feed efficiency (Gorissen *et al.*, 2018). Supplementing commercial feed with lysine and methionine can be a cost-effective way to reduce feed and crude-protein costs without compromising growth performance, and lysine supplementation is effective in enhancing immune response (Ediwarman *et al.*, 2021). Furthermore, Obado *et al.* (2018) found that supplementing 5.1 g lysine/kg feed and 2.7 g methionine/kg feed produced a lower FCR and more economical feed utilization in the culture of Nile tilapia (*Oreochromis niloticus*). To date, the optimum lysine and methionine requirements of jelawat fry have not been quantitatively established, while available studies have generally been conducted on other species such as pangasius, tilapia, baung catfish, and common carp. Accordingly, this study was conducted to determine the effect of lysine and methionine supplementation in commercial feed on the survival and growth of jelawat (*Leptobarbus hoevenii*) fry.

MATERIALS AND METHODS

Time and Location

This study was conducted at the Experimental Pond Laboratory and the Aquaculture Environment Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Mulawarman, Samarinda, from January to February 2025.

Equipment and Materials

The equipment used included twelve aquaria (80 × 40 × 40 cm) for rearing the jelawat fry, each fitted with aeration and a biofoam filter. For feed preparation, plastic jars (1,500 mL and 250 mL), a small basin, a measuring cylinder, a digital balance (0.01 g precision), a feed pelletizer, and greaseproof paper were used. Water quality was measured using a pH meter (Starter 300; 0.01 resolution), a digital thermometer (temperature), a DO meter (Lutron DO-5510; ±0.4 mg/L accuracy) for dissolved oxygen, and a Taomsun spectrophotometer (0.001 resolution) for ammonia. Fish length and weight were measured using a scoop net, a basin, styrofoam, a ruler, a tray, plastic jars, and a digital balance (0.01 g precision). A smartphone camera (iPhone 10, 12 MP) was used for documentation, and a notebook and stationery were used to record observations.

The materials used included jelawat fry obtained from spawning at the Experimental Pond Laboratory. A total of 120 fry, approximately 30 days old, with a mean length of ±6 cm and a mean weight of 3 g, were used. Water-quality analysis required distilled water, phenate, $MnSO_4$, Clorox, and a 1 ppm (mg/L) ammonia standard. Feed preparation used water; PF-0 commercial fish feed (MS PRIMA FEED, PT Matahari Sakti), whose proximate composition per the package label was 39–41% protein, 5% lipid, 4% crude fiber, 11% ash, and 10% moisture; calcium lignosulfonate (Progol brand) as a pellet binder; L-lysine HCl (minimum 99%; PT Cheil Jedang Indonesia); and methionine (feed grade 99%; Evonik Nutrition and Care GmbH).

Experimental Design

This study used a completely randomized design (CRD) with four treatments and three replicates. Each treatment received a different supplementation level, based on dry feed weight: P1 (0% lysine and 0% methionine), P2 (1% lysine and 1% methionine), P3 (2% lysine and 2% methionine), and P4 (3% lysine and 3% methionine). The dosing followed Liaqat (2024), who supplemented 1% lysine and 1% methionine in the diet of striped catfish (*Pangasius hypophthalmus*).

Experimental Procedure

Container Preparation.

Aquaria (80 × 40 × 40 cm) were used to rear the jelawat fry. The aquaria were cleaned, and previously settled water was added to a depth of 25 cm. Each aquarium was equipped with a filtration system comprising aeration tubing and biofoam, installed and adjusted as required.

Fry Preparation.

The jelawat fry were first acclimated in aquaria fitted with aeration and biofoam. Acclimation lasted three days, during which the fry were fed a commercial diet twice daily.

Test Feed Preparation.

Test feed preparation involved preparing the dry feed stock for each treatment, preparing the lysine and methionine solutions, and producing the feed. The materials required were PF-0 fish feed, Progol, lysine, and methionine. For each batch, 600 g of PF-0 feed was weighed into a basin as the base material; 12 g of Progol powder was dissolved in 150 mL of water until homogeneous; lysine and methionine were then weighed according to the percentage of dry feed weight and mixed in until evenly distributed. The mixture was kneaded until moist adding about 50 mL of water as needed and formed into pellets using a pelletizer. The pellets were collected on a tray and oven-dried at 50 °C. Dissolving and applying the binder ensured homogeneous distribution of the amino acids and reduced losses during pelleting. After drying, the feed was stored in jars at 200 g per treatment.

Experimental run.

The study ran for 60 days, with each aquarium stocked at 10 fish. The procedure comprised length and weight measurement, feeding, water-quality maintenance, and water-quality measurement. Initial body length was measured using calipers on a styrofoam base, and weight using a balance with 0.01 g precision. The test feed was provided at satiation (until the fish stopped feeding) three times daily morning, afternoon, and night to ensure adequate nutrition throughout rearing. To maintain water quality, the tank bottom was siphoned whenever it appeared dirty or feed residue accumulated, keeping conditions optimal for growth. Dissolved oxygen, pH, and ammonia were measured every five days, and water temperature twice daily (morning and afternoon), to ensure conditions remained within the suitable range for fry growth.

Data Collection and Analysis

Survival rate (SR).

Survival is the proportion of fish alive from the start to the end of the study (Muchlisin *et al.*, 2016), calculated as:

$$SR = \frac{Nt}{No} \times 100\%$$

Where :

SR : Survival rate (%)

Nt : Number of fish alive at the end (individuals)

No : Number of fish stocked at the start (individuals)

Total length growth.

Total length growth is the difference between final and initial total length (Zonneveld *et al.*, 1991):

$$\Delta L = Lt - Lo$$

Where :

ΔL : Total length growth (cm)

Lt : Final total length (cm)

Lo : Initial total length (cm)

Absolute weight growth.

Absolute weight growth is the difference between final and initial body weight (Cahyani and Sukarti., 2026) :

$$Wm = Wt - Wo$$

Where :
Wm : Absolute weight growth (g)
Wt : Final weight (g)
W : Initial weight (g)

Specific growth rate (SGR).

SGR is the difference between the natural logarithms of final and initial weight, divided by the rearing period (Zonneveld *et al.*, 1991):

$$SGR = \frac{LnWt - LnWo}{t} \times 100\%$$

Where :
SGR : Specific growth rate (%/day)
T : Rearing period (days)
Wt : Final weight (g)
Wo : Initial weight (g)

Feed conversion ratio (FCR).

FCR was calculated following Tacon (1987):

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

Where :
FCR : Feed Conversion Ration
F : Total feed consumed during the study (g)
Wt : Final weight (g)
Wo : Initial weight (g)
D : Weight of dead fish (g)

Feed utilization efficiency (FUE).

FCR was calculated following Ihtifazhuddin *et al*. (2025) :

$$EPP = \frac{Wt - Wo}{F} \times 100\%$$

Where :
FUE : Feed Utilization Efficiency (%)
F : Total feed consumed during the study (g)
Wt : Final weight (g)
Wo : Initial weight (g)

Statistical analysis.

Data on the survival and growth of jelawat fry were analyzed by analysis of variance (ANOVA) at a 95% confidence level. Homogeneity of variance was first checked using Bartlett's test, and differences among treatments were further examined using Duncan's Multiple Range Test (DMRT) at the 5% significance level.

RESULTS AND DISCUSSION

Survival

The mean survival of jelawat fry fed commercial feed supplemented with different levels of lysine and methionine is presented in Figure 1.

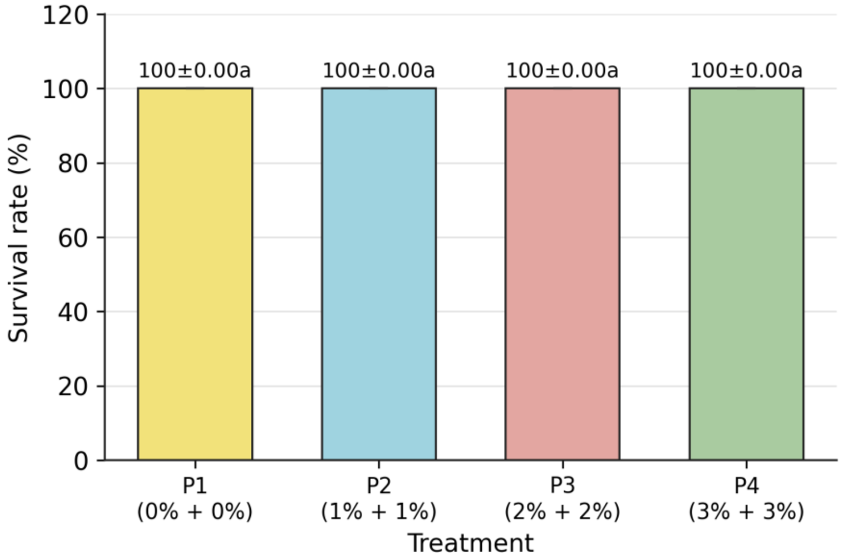

Figure 1. Survival of jelawat fry (%). Means followed by the same letter are not significantly different at α = 0.05 (P>0.05).

Mean survival was identical across all treatments P1 (0%), P2 (1%), P3 (2%), and P4 (3%) at 100%, and no mortality occurred during the study. Supplementation at different levels had no significant effect on survival. Karimah and Istyanto (2018) noted that survival is influenced by abiotic and biotic factors, including competitors, population density, age, and the organism's ability to adapt to its environment and feed. Muhsoni and Francisca (2021) defined survival rate (SR) as the percentage of test fish remaining alive at the end of a study relative to the number stocked. Iskandar and Elrifadah (2015) stated that fish survival is strongly determined by feed and the surrounding environmental conditions. Consistent with Akbar (2021), feed of adequate quantity and quality together with good environmental conditions increases survival, whereas insufficient feed and poor conditions harm fish health and reduce survival. These results are also similar to Ediwarman *et al.* (2021), who found that methionine and lysine in a locally formulated diet had no significant effect on the survival of striped catfish (*Pangasianodon hypophthalmus*).

Total Length Growth

The mean total length growth of jelawat fry across treatments is presented in Figure 2.

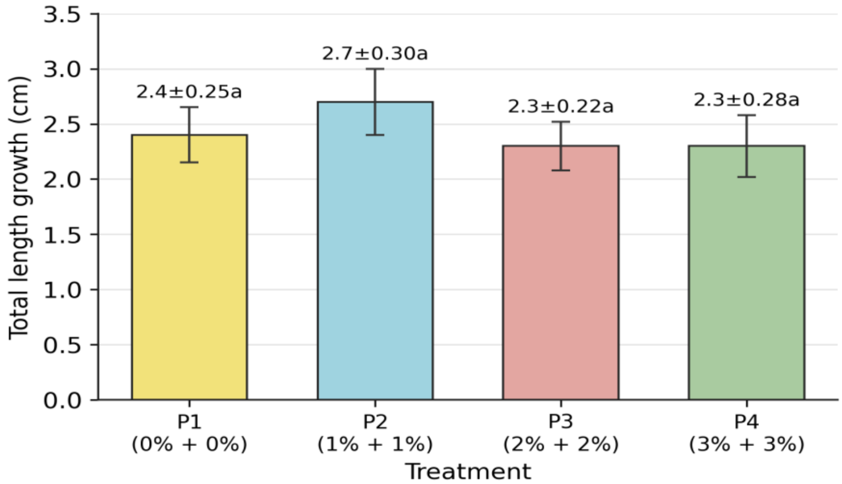

Figure 2. Total length growth of jelawat fry (cm). Means followed by the same letter are not significantly different at α = 0.05 (P>0.05).

Mean total length growth was 2.4 cm in P1 (0%), 2.7 cm in P2 (1%), 2.3 cm in P3 (2%), and 2.3 cm in P4 (3%). The highest value occurred in P2 (1%; 2.7 cm) and the lowest in P3 and P4 (2.3 cm). Supplementation at different levels had no significant effect on total length growth; nonetheless, the highest value was obtained in P2. This is consistent with Jiang *et al.* (2015), who reported that adding 2 g lysine and 0.6 g methionine to the diet improved growth and digestive capacity in grass carp (*Ctenopharyngodon idella*). Muhsoni and Francisca (2021) noted that growth results from food intake being converted into energy for activity and metabolism, and the increase in length growth observed here is attributable to the lysine and methionine provided during rearing. This aligns with Ediwarman *et al.* (2021), who found that methionine and lysine supplementation in striped catfish feed also had no significant effect on growth and feed efficiency over a seven-week observation. Referring to Radona *et al.* (2017), the effect of feed composition can depend strongly on fish species and nutritional requirements, and fry growth can be strongly influenced by total protein composition and the essential amino acids present in the feed.

Absolute Weight Growth

The mean absolute weight growth of jelawat fry across treatments is presented in Figure 3.

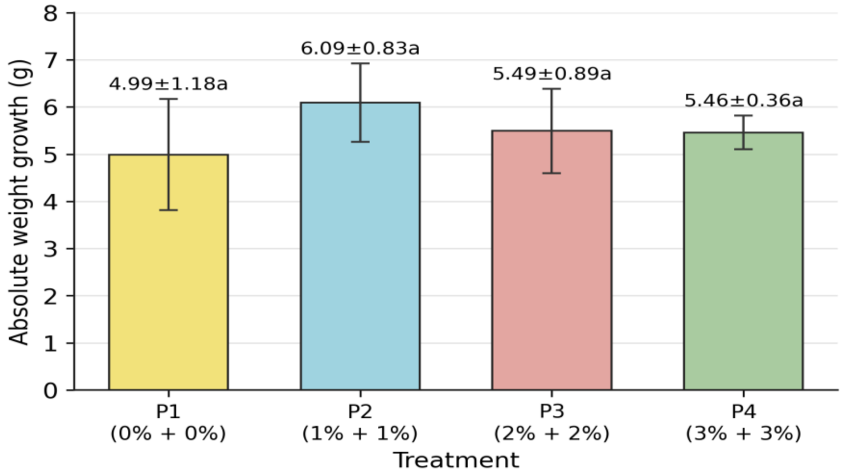

Figure 3. Absolute weight growth of jelawat fry (g). Means followed by the same letter are not significantly different at α = 0.05 (P>0.05).

Mean absolute weight growth was 4.99 g in P1 (0%), 6.09 g in P2 (1%), 5.49 g in P3 (2%), and 5.46 g in P4 (3%). The highest value occurred in P2 (1%; 6.09 g) and the lowest in P1 (0%; 4.99 g). Supplementation at different levels had no significant effect on absolute weight growth; however, supplemented treatments tended to show higher weight gain than the unsupplemented control. The highest value occurred in P2 (1% lysine and 1% methionine). This is consistent with Panigoro *et al.* (2024), who reported that adding 0.3 g lysine and 0.2 g methionine to the diet significantly increased absolute weight growth in Nile tilapia (*Oreochromis niloticus*). A balanced combination of lysine and methionine can improve metabolic efficiency and overall growth (Ahmed and Khan, 2018). Weight growth declined slightly in P3 (5.49 g) and P4 (5.46 g) relative to P2, suggesting that excessive supplementation does not further increase absolute weight growth.

Specific Growth Rate

The mean specific growth rate of jelawat fry across treatments is presented in Figure 4.

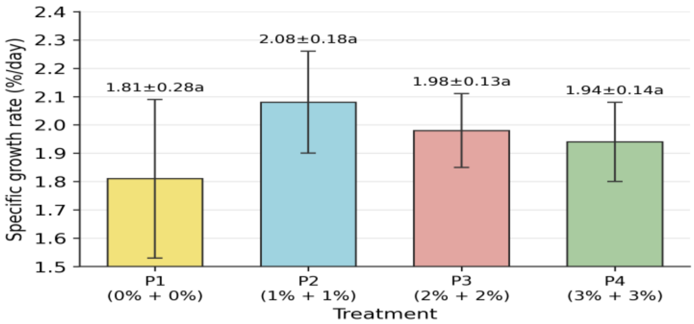

Figure 4. Specific growth rate of jelawat fry (%/day). Means followed by the same letter are not significantly different at α = 0.05 (P>0.05).

Mean SGR was 1.81%/day in P1 (0%), 2.08%/day in P2 (1%), 1.98%/day in P3 (2%), and 1.94%/day in P4 (3%). The highest value occurred in P2 (1%; 2.08%/day) and the lowest in P1 (0%; 1.81%/day). Lysine and methionine play a key role in carnitine synthesis; carnitine transports fatty acids into the mitochondria, where β-oxidation occurs (Li *et al.*, 2009). Outside the mitochondria, fatty acids react with CoA to form acyl-CoA, which crosses the outer mitochondrial membrane. Acyl-CoA is the main substrate for oxidation but cannot cross the inner mitochondrial membrane except as acylcarnitine, via carnitine palmitoyltransferase 1A (CPT1A); acylcarnitine is then reconverted to acyl-CoA for β-oxidation to generate energy (Li *et al.*, 2009). Supplementation at different levels had no significant effect on SGR; nonetheless, supplemented treatments tended to show higher SGR than the control, with the highest value in P2 (1%; 2.08%/day). SGR declined slightly in P3 (1.98%/day) and P4 (1.94%/day) relative to P2, indicating that excessive supplementation does not further increase SGR.

Feed Conversion Ratio

The mean feed conversion ratio of jelawat fry across treatments is presented in Figure 5.

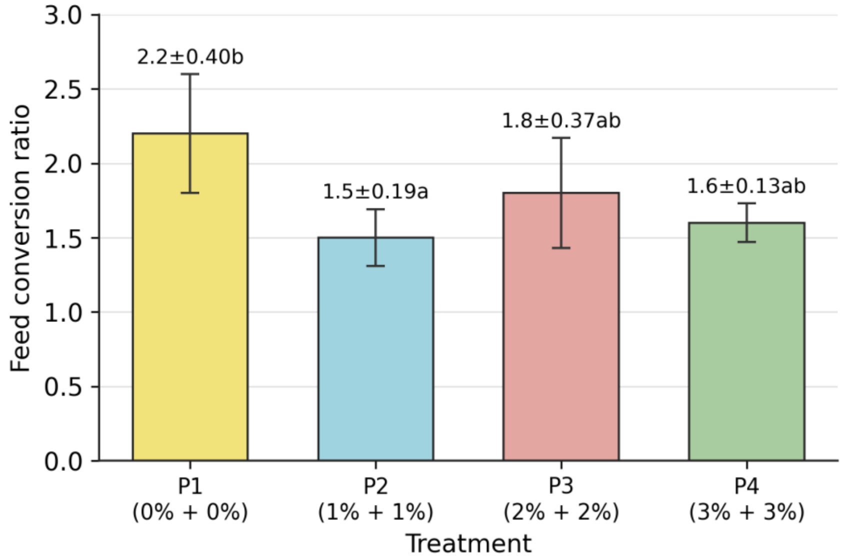

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Figure 5. Feed conversion ratio of jelawat fry. Means followed by different letters are significantly different at α = 0.05 (P<0.05).

Analysis of variance showed that lysine and methionine supplementation significantly affected the feed conversion ratio (FCR) of jelawat fry (P<0.05). The lowest (best) FCR was obtained in P2 (1%; 1.5), and the highest in P1 (unsupplemented; 2.2). According to DMRT, P1 differed significantly from the supplemented treatments P2, P3, and P4. The supplemented treatments thus showed lower FCR than the unsupplemented control, with the lowest value in P2. Niu *et al.* (2015) reported that adding 2.4 g lysine and 1.5 g methionine to a formulated diet lowered the FCR and improved growth and nutrient utilization in golden pompano (*Trachinotus ovatus*), indicating that such supplementation can reduce the FCR of jelawat fry. A low FCR is generally also supported by good feed quality, allowing the fish to utilize the feed effectively and efficiently (Islama *et al.*, 2024).

Feed Utilization Efficiency

The mean feed utilization efficiency of jelawat fry across treatments is presented in Figure 6.

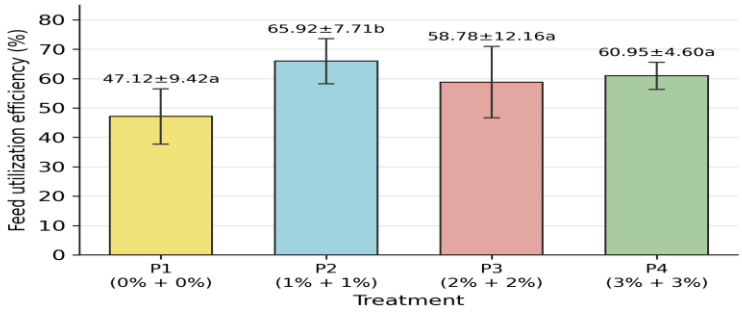

Figure 6. Feed utilization efficiency of jelawat fry (%). Means followed by different letters are significantly different at α = 0.05 (P<0.05).

Mean FUE was 47.12% in P1 (0%), 65.92% in P2 (1%), 58.78% in P3 (2%), and 60.95% in P4 (3%). Analysis of variance showed that lysine and methionine supplementation significantly affected FUE ($P<0.05$). The highest value was obtained in P2 (1%; 65.92%) and the lowest in P1 (unsupplemented; 47.12%). DMRT indicated that the unsupplemented treatment (P1) differed significantly from the supplemented treatments. The higher FUE in supplemented treatments indicates that a complete essential-amino-acid profile improves nutrient utilization for growth. This is consistent with Takagi *et al.* (2001), who reported that adding 1.03% lysine and 0.76% methionine increased efficiency in red sea bream (*Pagrus major*). Sardar *et al.* (2009) found that supplementing 4 g lysine and 7 g methionine improved feed utilization efficiency in rohu (*Labeo rohita*). Lysine and methionine contribute to body protein synthesis and to carnitine formation, which supports energy metabolism, so that more dietary energy is allocated to growth (Lin *et al.*, 2024).

Water Quality

Water-quality measurements recorded during the study are presented in Table 1.

Table 1. Water-quality measurements during the 60-day study.

Treatment	Temperature (°C)	pH	DO (mg/L)	Ammonia (mg/L)
P1	23,9 – 29,6	6,76 – 8,65	6,3 — 8,8	0,01 – 0,22
P2	24 — 29,6	6,78 – 8,58	6,3 — 8,7	0,01 – 0,29
P3	24 — 29,5	6,77 – 8,42	6,6 — 8,2	0,01 – 0,56
P4	24 — 29,5	6,62 – 8,83	6,5 — 8,3	0,02 – 0,67

Several water-quality parameters—temperature, pH, dissolved oxygen (DO), and ammonia—were monitored during rearing because they influence the survival and growth of jelawat fry.

Water temperature, measured twice daily (morning and afternoon), ranged from 23.9 to 29.6 °C. Temperature directly affects growth through biotic and abiotic factors such as activity, ambient temperature, body weight, and feed (Hernawati and Suantika, 2006). Mohamad *et al.* (2024) reported that 28–32 °C is optimal for the growth and health of jelawat. The temperatures recorded here were within the suitable range for jelawat fry.

pH ranged from 6.62 to 8.83. Kamarudin *et al.* (2013) reported that jelawat is highly sensitive to changes in pH and water quality, which can affect growth and survival. Mohamad *et al.* (2024) found that a neutral pH (7) gives the best results for jelawat growth metabolism. The pH values recorded here were within the suitable range.

Dissolved oxygen ranged from 6.3 to 8.8 mg/L. DO is an important factor affecting fish health and productivity, including in jelawat fry culture (Syafarani *et al.*, 2020). Putri and Kurniawan (2023) recommended DO above 5 mg/L to increase productivity, noting that DO below 3 mg/L can reduce growth rate. The DO recorded here was within the suitable range.

Ammonia, measured every seven days, ranged from 0.01 to 0.67 mg/L. Increases in ammonia are often influenced by pH, temperature, and stocking density (Timmons and Ebeling, 2013). Monalisa and Infa (2010) reported that the best ammonia level for fish is below 1 mg/L. Wahyuningsih and Gitarama (2020) noted that ammonia can be toxic to commercially cultured fish at concentrations above 1.5 mg/L, and that under extreme conditions the acceptable concentration may be as low as 0.025 mg/L. The ammonia levels recorded here were within the suitable range for jelawat fry.

CONCLUSION

Based on this study of lysine and methionine supplementation in commercial feed on the survival and growth of jelawat (*Leptobarbus hoevenii*) fry, the following conclusions are drawn. Supplementation up to 3% had no significant effect ($P>0.05$) on survival, total length growth, absolute weight growth, or specific growth rate, but it significantly affected ($P<0.05$) the feed conversion ratio (FCR) and feed utilization efficiency (FUE), with the best values obtained at 1% supplementation. Survival was 100% in all treatments, with or without supplementation. These results indicate that the lysine and methionine requirements of jelawat fry are likely already met by the basal commercial diet; under the present conditions, supplementation with 1% lysine and 1% methionine achieved the highest values for total length growth, absolute weight growth, SGR, and FUE

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ACKNOWLEDGMENTS

This research was fully supported by a research grant from the Experimental Pond Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Mulawarman. The authors gratefully acknowledge the support and facilities provided.

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