

DIETARY SUPPLEMENTATION WITH BILLYGOAT-WEED (*Ageratum conyzoides* L.) LEAF MEAL: EFFECTS ON THE GROWTH PERFORMANCE AND SURVIVAL OF SNAKEHEAD (*Channa striata*)

Nur Ikhlas Syuhada^{1,4*}, Ronal Kurniawan^{2,4}, Rodhi Firmansyah², Windarti³, Pebri Nanda Perdana², Rizal Okta Karsih²

¹Department of Biology, Faculty of Mathematics and Natural Science,
Universitas Riau, Pekanbaru, 28293 Indonesia

²Department of Aquaculture, Faculty of Fisheries and Marine,
Universitas Riau, Pekanbaru, 28293 Indonesia

³Department of Aquatic Resources Management, Faculty of Fisheries and Marine,
Universitas Riau, Pekanbaru, 28293 Indonesia

⁴Center for Peatland and Disaster Studies, LPPM Universitas Riau, Pekanbaru, Indonesia

* nur.ikhlas@lecturer.unri.ac.id

ABSTRACT

Channa striata (snakehead fish) is a fishery commodity of high economic and medicinal value, yet a relatively slow growth rate constrains its culture. This study aimed to evaluate the effect of billygoat-weed (*Ageratum conyzoides* L.) leaf meal supplementation in feed on growth, feed efficiency, and survival of snakehead fish. The study used a one-factor Completely Randomized Design with four dose treatments (0, 5, 10, and 15 g/kg feed) and three replicates (n= 20 fish per experimental unit, 12 experimental units in total). Snakehead fingerlings measuring 6.00 ± 1 cm were reared for 30 days and fed ad satiation. The results showed that the addition of billygoat-weed leaf meal significantly affected absolute weight gain, specific growth rate, feed efficiency, and feed conversion ratio ($p < 0.05$). The dose of 5 g/kg feed produced the best performance, with an absolute weight gain of 3.19 ± 0.37 g, specific growth rate of $1.61 \pm 0.21\%$ /day, feed efficiency of $161.85 \pm 14.99\%$, and FCR of 0.62 ± 0.05 , indicating that 5 g/kg feed is the optimal dose in snakehead fish feed and reflecting a hormetic response pattern (i.e., a beneficial effect at a low dose that diminishes at higher doses) at higher doses. The survival rate remained high across all treatments (93.33–98.33%), indicating the ingredient's safety up to the highest dose tested. In conclusion, billygoat-weed leaf meal has potential as a phytoadditive to enhance the growth performance of snakehead fish.

Keywords: *Ageratum conyzoides*, Phytoadditive, Snakehead, Growth, Survival rate

1. INTRODUCTION

Snakehead fish (*Channa striata*) is one of Indonesia's indigenous freshwater fishery commodities with high economic and medicinal value¹. The high content of albumin, essential amino acids, and unsaturated fatty acids in snakehead fish flesh makes it a highly sought-after commodity, not only as a source of animal protein for daily consumption but also as a raw material for health supplements². The

albumin content of snakehead fish has been reported to reach 6.22 g/dL, exceeding that of chicken egg albumin (3.70 g/dL) and cow's milk (3.40 g/dL); as a result, this fish is often used to accelerate wound healing and post-surgical recovery³. Growing public awareness of the nutritional value and benefits of snakehead fish has significantly increased market demand, thereby driving the need to develop more intensive culture

systems to meet production needs sustainably.

Despite its high economic potential, the development of intensive snakehead fish culture still faces several constraints that may limit productivity. One of the main problems is the relatively slower growth rate of snakehead fish compared to other commercially cultured fish species, such as tilapia and catfish, which requires a longer rearing period⁴ and higher production costs⁵. In addition, the carnivorous nature of snakehead fish results in a relatively low capacity to adapt to artificial feed, potentially affecting feed intake and utilization. In fish farming, feed is the largest operational cost component in aquaculture and directly affects profitability; consequently, feed utilization efficiency is one of the key factors determining the success and sustainability of aquaculture businesses⁶. Developing strategies to enhance growth and feed efficiency in snakehead fish remains an important area of study. One increasingly popular approach to improving fish growth performance is the addition of natural, plant-based feed additives, or phytoadditives.

Phytoadditives are bioactive compounds derived from plants, including essential oils, flavonoids, tannins, alkaloids, and saponins, which have been shown to increase feed palatability, stimulate the secretion of endogenous digestive enzymes, and improve intestinal epithelial permeability and morphology, thereby enhancing nutrient absorption efficiency and fish growth rate⁷. Compared with synthetic hormones or antibiotics used as growth promoters, phytoadditives offer advantages such as greater residual safety, reduced resistance risk, and greater compatibility with sustainable aquaculture principles⁸. Various studies have demonstrated the effectiveness of plant extracts, such as turmeric, curcuma, and moringa leaves, as growth promoters in cultured fish species⁹⁻¹⁰. Among the various plants with potential as phytoadditives, billygoat-weed

(*Ageratum conyzoides* L.) is one particularly interesting candidate for further study.

Billygoat-weed is an annual herbaceous plant of the Asteraceae family that grows wild and abundantly across various tropical regions, including Indonesia. Although often regarded as a weed, this plant harbors a significant wealth of phytochemicals. Billygoat-weed leaves are known to contain various bioactive compounds, including flavonoids (ageratin, quercetin, kaempferol), pyrrolizidine alkaloids, essential oils with precocene I and II and chromene as major components, tannins, saponins, and steroids¹¹⁻¹². Flavonoids in billygoat-weed leaves exhibit strong antioxidant activity, neutralizing free radicals generated by metabolic stress during intensive feed digestion, while also contributing to the enhancement of fish immune response¹³. The presence of essential oils, particularly chromene and precocene compounds, imparts a distinctive aroma that increases feed attractability, thereby stimulating fish appetite¹⁴.

Previous studies on the use of phytoadditives in cultured fish have largely focused on common food-fish species such as tilapia, catfish, and carp¹⁵⁻¹⁶, while studies on snakehead fish remain relatively limited, with reports only on the addition of cinnamon leaf meal (*Cinnamomum burmannii*)¹⁷ and moringa leaf meal (*Moringa oleifera*)¹⁸ as feed additives. In fact, billygoat-weed leaves have great potential to be developed as a local phytoadditive source, owing to their abundant availability, ease of acquisition, relatively low cost, and various bioactive compounds that may support fish growth performance. Therefore, this study was conducted to evaluate the effect and optimal dose of billygoat-weed leaf meal supplementation in feed on the growth and feed efficiency of snakehead fish.

2. RESEARCH METHOD

Time and Place

This study was conducted from June to August 2026 at the Integrated Laboratory of

the Faculty of Fisheries and Marine Science, Universitas Riau.

Method

This study used an experimental method with a one-factor Completely Randomized Design (CRD). The factor tested was the dose of billygoat-weed leaf meal added to the feed, with four treatments and three replicates, requiring 12 experimental units. The treatments applied were as follows:

- P0 : Commercial feed without the addition of billygoat-weed leaf meal (control)
- P1 : Commercial feed with the addition of billygoat-weed leaf meal at a dose of 5 g/kg feed
- P2 : 10 g/kg
- P3 : 15 g/kg

Procedures

Feed Preparation

The treatment feed was prepared according to the procedure described by Windarti et al.¹⁰. The materials used included commercial feed, billygoat-weed leaf meal, tapioca starch, and warm water. Fresh billygoat-weed leaves were first sun-dried, then ground to a fine powder and sieved. The billygoat-weed leaf meal was weighed according to the dose of each treatment, then mixed with a tapioca starch solution (20 g in 10 mL warm water) serving as a binder. The mixture was homogenized with the commercial feed until evenly distributed, forming a cohesive pellet dough. The formed pellets were then sun-dried until completely dry before being used as treatment feed.

Preparation of Rearing Containers and Rearing of Test Fish

The rearing containers used were circular tanks 60 cm in diameter, filled with 60 L of water per experimental unit. Each container was equipped with a recirculation system. Fish rearing was also conducted under a total dark photoperiod (0L:24D), i.e., complete darkness without artificial

lighting, to minimize stress, stabilize the biological rhythms of the nocturnal snakehead fish, and improve feed efficiency during the rearing period¹⁹.

The test fish used were snakehead fish fry measuring 6.00 ± 1 cm. Before being placed into the treatment containers, all fry were acclimatized for seven days to adjust to the new environmental conditions. After acclimatization, the fish were weighed to obtain initial data (day 0). Fish were then randomly distributed into each experimental unit at a density of 20 fish per container. During the 30-day rearing period, fish were fed the treatment feed ad satiation three times a day, at 08:00, 12:00, and 17:00 local time (Western Indonesia Time). The amount of feed given and the uneaten feed residue were recorded daily to calculate actual feed consumption.

Parameters Observed

The growth and feed efficiency parameters observed in this study included absolute weight gain, absolute length gain, specific growth rate (SGR), feed efficiency, feed conversion ratio (FCR), and survival rate (SR). Fish weight and length measurements were taken every 10 days until day 30 of the experiment.

Absolute Weight Gain

Absolute weight gain was calculated using the following formula²⁰:

$$GR = W_t - W_o$$

Description:

GR = Absolute weight gain (g)

Wt = Average fish weight at the end of the study (g)

Wo = Average fish weight at the start of the study (g)

Absolute Length Gain

Absolute length gain was calculated using the following formula²¹:

$$PM = L_t - L_o$$

Description:

PM = Absolute length (cm)

Lt = Average fish length at the end of the study (cm)

Lo = Average fish length at the start of the study (cm)

Specific Growth Rate (SGR)

Specific growth rate was calculated using the following formula²¹:

$$\text{SGR} = ((\text{Ln Wt} - \text{Ln Wo}) / t) \times 100$$

Description:

SGR = Specific growth rate (%/day)

Wt = Average fish weight at the end of the study (g)

Wo = Average fish weight at the start of the study (g)

t = Rearing duration (days)

Feed Efficiency (FE)

Feed efficiency was calculated using the following formula²¹:

$$\text{FE} = ((\text{Bt} + \text{Bd}) - \text{Bo}) / F \times 100$$

Description:

FE = Feed efficiency (%)

Bt = Fish biomass at the end of rearing (g)

Bd = Biomass of fish that died during the study (g)

Bo = Fish biomass at the start of rearing (g)

F = Total feed given during rearing (g)

Feed Conversion Ratio (FCR)

Feed conversion ratio was calculated using the following formula²¹:

$$\text{FCR} = \Sigma F / ((\text{Bt} + \text{Bm}) - \text{Bo})$$

Description:

FCR = Feed conversion ratio

ΣF = Total feed (g)

Bt = Fish biomass at the end of rearing (g)

Bm = Biomass of fish that died during rearing (g)

Bo = Fish biomass at the start of rearing (g)

Survival Rate (SR)

Survival rate was calculated using the following formula²¹:

$$\text{SR} = (\text{Nt} / \text{No}) \times 100\%$$

Description:

SR = Survival rate (%)

Nt = Number of fish at the end of the study (individuals)

No = Number of fish at the start of the study (individuals)

Data Analysis

Data on growth parameters, feed efficiency, and FCR were tabulated and statistically analyzed using SPSS version 26. Prior to analysis of variance, the data were tested for normality and homogeneity of variance. Data were analyzed using a one-way ANOVA at the 95% confidence level ($\alpha = 0.05$). Where the analysis showed significant differences among treatments ($p < 0.05$), a Student–Newman–Keuls (SNK) test was conducted to determine the treatment yielding the best effect.

3. RESULT AND DISCUSSION

The absolute weight gain of snakehead fish over the 30-day rearing period is presented in Table 1. The highest absolute weight gain was observed in P1 (5 g/kg feed; 3.19 ± 0.37 g), followed by P2 (2.29 ± 0.09 g), P3 (2.28 ± 0.31 g), and the control (1.80 ± 0.24 g). The analysis of variance showed that the addition of billygoat-weed leaf meal in feed had a significant effect on the absolute weight gain of snakehead fish ($p < 0.05$).

The significant increase in absolute weight gain in P1 indicates that a dose of 5 g/kg feed is the optimal dose of billygoat-weed leaf meal for supporting snakehead fish growth. This is presumably attributable to the bioactive compounds contained in billygoat-weed leaves. According to Bairagi et al.²², flavonoids and saponins in billygoat-weed leaves have been shown to increase the activity of endogenous digestive enzymes, particularly protease, lipase, and amylase. This increased enzyme activity accelerates the hydrolysis of feed macromolecules into units absorbable by intestinal enterocytes, allowing more nutrients to be utilized for growth. In addition, flavonoids are known to possess antioxidant properties that protect intestinal epithelial cells from oxidative-stress damage, thereby maintaining optimal

intestinal mucosal integrity and nutrient absorption capacity²³.

Interestingly, increasing the dose of billygoat-weed leaf meal to P2 (10 g/kg) and P3 (15 g/kg) did not result in greater absolute weight gain than P1; in fact, the values were not significantly different from the control. This pattern reflects a hormetic effect, which is commonly observed with the use of phytoadditives in fish feed. At higher doses, certain secondary metabolites are presumed to exhibit antinutritional properties. Secondary metabolites in billygoat-weed

leaves, such as pyrrolizidine alkaloids and tannins, can indeed become antinutritional in excessive amounts inhibiting digestive enzyme activity, reducing feed palatability, or even interfering with the absorption of essential minerals through the formation of insoluble complexes⁷. This indicates that there is an effective phytoadditive concentration threshold, and determining the optimal dose is key to the successful application of billygoat-weed leaf meal in snakehead fish feed.

Table 1. Growth and feed efficiency parameters of snakehead fish during 30 days of rearing

Parameter	P0 (0 g/kg)	P1 (5 g/kg)	P2 (10 g/kg)	P3 (15 g/kg)
Absolute Weight (g)	1.80±0.24 ^a	3.19±0.37 ^b	2.29±0.09 ^a	2.28±0.31 ^a
Absolute Length (cm)	1.03±0.16 ^a	1.22±0.18 ^a	1.01±0.10 ^a	1.14±0.31 ^a
SGR (%/day)	0.97±0.14 ^a	1.61±0.21 ^b	1.17±0.07 ^a	1.19±0.22 ^a
Feed Efficiency (%)	83.11±6.25 ^a	161.85±14.99 ^c	123.53±5.80 ^b	121.11±14.38 ^b
FCR	1.21±0.09 ^a	0.62±0.05 ^c	0.81±0.04 ^b	0.83±0.10 ^b
SR (%)	93.33±2.89 ^a	96.67±2.89 ^a	98.33±2.89 ^a	96.67±2.89 ^a

Description: Different superscripts in the same column indicate significant differences between treatments ($P < 0.05$)

The absolute length gain of snakehead fish during the 30-day rearing period ranged from 1.01±0.10 cm (P2) to 1.22±0.18 cm (P1). The analysis of variance showed that the addition of billygoat-weed leaf meal in feed had no significant effect on the absolute length gain of snakehead fish ($p > 0.05$). This indicates that the addition of billygoat-weed leaf meal more strongly stimulated isometric growth in the form of body mass accumulation (weight gain) rather than linear growth (length gain). Fish length growth is generally strongly influenced by long-term genetic and hormonal factors, thus requiring a longer rearing period before changes become statistically observable²⁴. This is similar to a study using moringa leaf meal as a feed additive, in which 30 days of administration to snakehead fish produced a significant effect on weight gain but not on body length growth¹⁸.

Specific growth rate (SGR) reflects the percentage increase in fish weight per unit time, calculated logarithmically. The ANOVA results showed that billygoat-weed leaf supplementation in feed affected the

specific growth rate of snakehead fish ($p < 0.05$). This pattern is consistent with the absolute weight gain results, confirming that a dose of 5 g/kg feed is the optimal point for billygoat-weed leaf phytoadditive in supporting snakehead fish growth. The SGR value of P1, at 1.61%/day, indicates relatively good growth performance for snakehead fish. This finding is consistent with other studies reporting that snakehead fish fed phytoadditive-containing diets generally show SGR in the range of 1.2–2.0%/day. The increase in SGR in P1 is consistent with the increase in feed efficiency, indicating that more feed energy was converted into tissue growth. The active compounds in billygoat-weed leaves, at an appropriate dose, are thought to optimize the fish's metabolic energy partitioning, reducing the proportion of energy wasted as metabolic heat and increasing the proportion allocated to protein synthesis and tissue growth²³.

Feed efficiency describes the fish's ability to convert consumed feed into body weight gain, expressed as a percentage. The

higher the feed efficiency value, the better the fish's ability to utilize feed. The results showed that the addition of billygoat-weed leaf meal affected feed efficiency ($p < 0.05$). This value indicates that, at a dose of 5 g/kg feed, billygoat-weed leaf meal effectively increased feed nutrient utilization by snakehead fish. The main mechanism underlying this improvement is the stimulation of digestive enzyme secretion by flavonoids and saponins, which accelerate and complete the enzymatic digestion process in the intestine²² (Bairagi et al., 2004).

The decrease in feed efficiency in P2 and P3 compared with P1, although still higher than the control, shows a response pattern similar to that of absolute weight gain. This indicates a hormetic effect an optimal biological response at a certain dose that declines when the dose is increased further²⁵. At higher concentrations, the tannin content in billygoat-weed leaves may form complexes with feed protein and digestive protease enzymes, thereby reducing protein bioavailability and inhibiting digestive enzyme activity⁷. As a result, increasing the dose beyond the optimal level no longer improves feed utilization efficiency in a proportional manner.

Feed conversion ratio (FCR) represents the amount of feed required to produce one unit of fish weight gain. Unlike feed efficiency, a lower FCR value reflects better feed efficiency. The analysis of variance showed a highly significant effect ($p < 0.05$). The FCR value of P1, at 0.62, was the lowest and best among all treatments, indicating that snakehead fish in P1 required only 0.62 g of feed to produce 1 g of weight gain. This value is considerably lower than the control (1.21) and indicates a substantial improvement in feed conversion efficiency resulting from the addition of billygoat-weed leaf meal at a dose of 5 g/kg. From an aquaculture-economics perspective, the low FCR value directly translates into feed cost savings, given that feed is the largest component (60–80%) of fish production cost

structure²⁶. With the FCR of P1 being 48.8% lower than that of the control, the application of billygoat-weed leaf meal at 5 g/kg has the potential to provide significant feed-cost efficiency at a commercial aquaculture scale.

The FCR pattern, consistent with the feed efficiency and absolute weight gain patterns, further supports the conclusion that 5 g/kg feed is the optimal dose of billygoat-weed leaf meal. This result is consistent with the use of billygoat-weed leaf extract in tilapia, where administration at low concentrations significantly improved feed conversion efficiency, whereas higher concentrations tended to reduce performance²⁷.

The survival rate of snakehead fish during the 30-day rearing period ranged from $93.33 \pm 2.89\%$ (control) to $98.33 \pm 2.89\%$ (P2). The analysis of variance showed that the addition of billygoat-weed leaf meal in feed did not affect the survival rate of snakehead fish ($p > 0.05$). Thus, all treatments produced comparable and relatively high survival rates. The high SR values ($> 93\%$) across all treatments reflect favorable rearing conditions and the absence of significant disease pressure during the study period. Moreover, the addition of billygoat-weed leaf meal at doses of 5–15 g/kg feed was not toxic to snakehead fish during the 30-day rearing period. This finding is consistent with reports that billygoat-weed leaf meal supplementation up to 2% in the feed of African catfish (*Clarias gariepinus*) did not cause toxic effects and was safe for use as a feed phytoadditive²⁸. This confirms the safety of using billygoat-weed leaf meal as a feed phytoadditive within the tested dose range and supports the broader view that plant-based feed additives are generally non-toxic, biodegradable, and biocompatible with aquatic organisms.

Nevertheless, there was a tendency toward higher SR values in treatments supplemented with billygoat-weed (P1: 96.67%; P2: 98.33%; P3: 96.67%) compared with the control (93.33%), suggesting a

potential phytogetic benefit of billygoat-weed on fish viability. Phytogetic products are generally reported to act as anti-stress agents, growth stimulants, appetite enhancers, and immunostimulants in aquaculture²⁹, thereby enhancing fish resilience to rearing conditions. However, the present study has several limitations that should be acknowledged. The number of replicates per treatment (n=3) is relatively limited for a four-treatment one-way ANOVA design, which may reduce the statistical power to detect smaller differences among treatments, particularly for parameters such as survival rate that showed no significant effect. Future studies are therefore encouraged to increase the number of replicates (n≥5) and extend the rearing period beyond 30 days to confirm this tendency and capture the full biological effects of billygoat-weed leaf meal supplementation on fish viability and long-term growth trajectory.

4. CONCLUSION

The addition of billygoat-weed leaf meal in feed had a significant effect on the growth performance of snakehead fish (*Channa striata*), but had no significant effect on absolute length or survival rate (SR) during the 30-day rearing period. A dose of 5 g/kg feed (P1) was the optimal dose, producing the best absolute weight gain, specific growth rate, feed efficiency,

and feed conversion ratio: 3.19 ± 0.37 g, $1.61 \pm 0.21\%$ /day, $161.85 \pm 14.99\%$, and 0.62 ± 0.05 , respectively, significantly superior to the control as well as the 10 and 15 g/kg feed doses. Increasing the dose above 5 g/kg feed did not improve growth performance, indicating a hormetic response pattern with the billygoat-weed leaf phytoadditive. Meanwhile, SR values across all treatments were high (93.33–98.33%) and did not differ significantly, indicating that billygoat-weed leaf meal at doses of 5–15 g/kg feed is safe and non-toxic to snakehead fish. Thus, billygoat-weed leaf meal has the potential to be developed as a natural feed phytoadditive to improve the efficiency and productivity of snakehead fish culture, with a dose of 5 g/kg feed recommended as the best option. Further research with longer rearing periods and on a larger scale is needed to confirm the consistency of this response and to elucidate further the mechanism of action of the billygoat-weed leaf phytoadditive.

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REFERENCES

1. Alba, N., Rahardjo, S., Nurhidayat, N. Pertumbuhan dan Sintasan Benih Ikan Gabus (*Channa striata*) dengan Pemberian Tubifex sp. Mengandung *Curcuma longa* L. *Media Akuakultur*, 2025; 20(1): 15-23.
2. Rasyid, R.P., Suprayitno, E., Sulistiyati, T.D. The Effect of the Addition of Arabic Gum to Amino Acid Profile and Fatty Acid Profile of Albumin Powder Cork Fisk (*Channa striata*). *International Journal of Scientific and Research Publications*, 2019; 9(5): 657-661
3. Mustafa, A., Widodo, M.A., Kristianto, Y. Albumin and Zinc Content of Snakehead Fish (*Channa striata*) Extract and its Role in Health. *IEESE International Journal of Science and Technology*, 2012; 1(2): 1–8.
4. Ashouri, G., Hoseinifar, S. H., El-Haroun, E., Imperatore, R., Paolucci, M. *Tilapia Fish for Future Sustainable Aquaculture*. Novel Approaches toward Sustainable Tilapia Aquaculture (pp. 1-47). Cham: Springer International Publishing, 2023.

5. Marques, E.A.T., de Oliveira, C.R., da Silva, G.M.N., Cardoso, A.S., do Carmo Sobral, M. Desafios para a Sustentabilidade da Piscicultura na Bacia Hidrográfica do Rio São Francisco. *Sustentare*, 2018; 2(3): 14-29.
6. Mulia, D.S., Juanita, J., Purbomartono, C. Fish Feed Production in Panembangan Village, Banyumas Regency. *Altifani Journal: International Journal of Community Engagement*, 2023; 4(1): 95-103.
7. Citarasu, T. Herbal Biomedicines: A New Opportunity for Aquaculture Industry. *Aquaculture International*, 2010; 18(3): 403–414.
8. Gruber, C., Ocelova, V., Kesselring, J.C., Wein, S. Phytogenic Feed Additives as a Sustainable Alternative to Antibiotics: Enhancing Growth and Disease Resistance in Nile Tilapia (*Oreochromis niloticus*). *Animals*, 2025; 15(3) 380.
9. Kurniawan, R., Syawal, H., Effendi, I. Efektivitas Penambahan Suplemen Herbal pada Pellet terhadap Pertumbuhan dan Kelulushidupan Ikan Patin (*Pangasius hypophthalmus*). *Jurnal Ruaya: Jurnal Penelitian dan Kajian Ilmu Perikanan dan Kelautan*, 2020; 8(1).
10. Windarti, I. Effendi., Kurniawan, R. Addition of Moringa Leaves to Feed to Improve Growth Performance and Feed Use of Striped Catfish (*Pangasianodon hypophthalmus*). *Nongye Jixie Xuebao/Transactions of the Chinese Society of Agricultural Machinery*, 2023; 54(5).
11. Okunade, A.L. *Ageratum conyzoides* L. (Asteraceae). *Fitoterapia*, 2002; 73(1): 1–16.
12. Bhatt, P., Singh, A., Kakar, S., Dhyani, D. *Ageratum conyzoides* L.: A review on its phytochemistry and pharmacological activities. *Molecules*, 2021; 26(4): 914.
13. Syuhada, N.I., Kurniawan, R., Karsih, O.R., Nur, M.I. The Potential of Billygoat-Weed Leaves (*Ageratum conyzoides* L.) as an Immunostimulant and Antibacterial Agent in Aquaculture: A Review. *Asian Journal of Aquatic Sciences*, 2025; 9(1): 1-8.
14. Mutingatun, S., Fachriyah, E., Kusriani, D. Isolation, Identification, and Antioxidant Activity of Flavonoid Compounds in the Ethanol Extract in Billygoat-Weed Leaves (*Ageratum conyzoides*). *Jurnal Kimia Sains dan Aplikasi*, 2022; 25(12): 456-466
15. Gabor, E. F., Șara, A., Bențea, M., Creța, C., Baci, A. The Effect of Phytoadditive Combinations on Growth and Consumption Indices and Resistance to *Aeromonas hydrophila* in Common Carp (*Cyprinus carpio*) Juveniles. *Scientific Papers Animal Science and Biotechnologies*, 2012; 45(2): 48-48.
16. Sandeep, R.T., Sravya, M.V.N., Simhachalam, G. Phytobiotics in Finfish and Shellfish: A Systematic Review. *Discover Animals*, 2025; 2(1), 74
17. Tamba, J.T., Komariyah, S., Faisal, T.M. Evaluasi Pertumbuhan Ikan Gabus (*Channa striata*) Diberi Pakan Mengandung Tepung Daun Kayu Manis (*Cinnamomum burmannii*). *Jurnal Perikanan Tropis*, 2020; 7(1): 35-44.
18. Yustiati, A., Koswara, B., Andriani, Y., Zidni, I. Pertumbuhan Ikan Gabus (*Channa striata*) yang Diberi Pakan dengan Penambahan Tepung Daun Kelor (*Moringa oleifera*). *Jurnal Perikanan dan Kelautan*, 2020; 11(1): 38–45.
19. Oladejo, D.S., Sotunde, O. Can Varying Photoperiod Regimes Alter the Growth Response, Behaviour and Physiology of *Clarias gariepinus*?. *Ghana Journal of Agricultural Science*, 2023; 58(1): 22-34
20. Abdelghany, M.F., El-Sawy, H.B., Abd El-hameed, S.A., Khames, M.K., Abdel-Latif, H.M., Naiel, M.A. Effects of Dietary *Nannochloropsis oculata* on Growth Performance, Serum Biochemical Parameters, Immune Responses, and Resistance against *Aeromonas veronii* Challenge in Nile Tilapia (*Oreochromis niloticus*). *Fish & Shellfish Immunology*, 2020; 107: 277-288.
21. Effendi, I., Kurniawan, R., Windarti, W., Razman, M.R., Al-Harbi, A., Nasution, N.M., Syahputra, T., Masjudi, H. The Optimal Dose of Phytoimmunostimulant for the Growth

- and Immunity of Carp (*Cyprinus carpio* L) in Brackish Water Infected with *Aeromonas hydrophila*. *The Philippine Journal of Fisheries*, 2025; 3(2).
22. Bairagi, A., Sarkar Ghosh, K., Sen, S.K., Ray, A.K. Duckweed (*Lemna polyrhiza*) Leaf Meal as a Source of Feedstuff in Formulated Diets for Rohu (*Labeo rohita* Ham.) Fingerlings after Fermentation with a Fish Intestinal Bacterium. *Bioresource Technology*, 2004; 95(2): 227–234
23. Harikrishnan, R., Balasundaram, C., Heo, M.S. Impact of Plant Products on Innate and Adaptive Immune System of Cultured Finfish and Shellfish. *Aquaculture*, 2011; 317(1–4): 1–15.
24. Effendie, M.I. *Biologi Perikanan*. Yayasan Pustaka Nusatama, Yogyakarta, 1997.
25. Jargin, S.V. Hormesis: Umbrella Mechanism only for Agents Present in the Environment. *Human & Experimental Toxicology*, 2015; 34(4): 439- 441.
26. Budiyo, D., Hendarto, T., Sutarnin, S., Ardianik, A. Reimagining Catfish (*Clarias* sp.) Cultivation: Crafting Sustainable Feed for Economic Prosperity and Eco-Friendly Practices in Simple Concrete Ponds. *Assyfa Journal of Farming and Agriculture*, 2025; 2(2): 1-10
27. Falah, S., Lisdayanti, E., Wahyudi, D. Efek Ekstrak Etanol Daun Billygoat-Weed (*Ageratum conyzoides* L.) terhadap Sistem Imun Ikan Nila (*Oreochromis niloticus*). *Jurnal Iktiologi Indonesia*, 2019; 19(2): 201–212.
28. Gbadamosi, O.K., Olanipekun, O.S. Dietary Supplementation with Goat Weed Leaf (*Ageratum conyzoides*) Improves Growth Performance, Haematological Parameters and Attenuates Pathological-Induced Stress in African Catfish (*Clarias gariepinus*) Fingerlings. *Livestock Research for Rural Development*, 2020; 32(7): 1-9.
29. Yilmaz, S., Ergün, S., Yilmaz, E., Ahmadifar, E., Yousefi, M., Abdel-Latif, H.M. Effects of a Phytogenic Diet on Growth, Haemato-Immunological Parameters, Expression of Immune-and Stress-Related Genes, and Resistance of *Oncorhynchus mykiss* to *Lactococcus garvieae* Infection. *Aquaculture*, 2024; 587: 740845.