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Interventions in Selection of Fish Feed Ingredients with Special Reference to Leaves and Water Plants: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Efforts in managing leafy materials and aquatic plants as fish feed are essential approaches in sustainable fish farming. The purpose of this article is to explore the potential utilization of leaves, aquatic plants, and the processing methods involved in turning them into supplementary fish feed. The writing methodology employed is a literature review, involving stages such as journal search, journal selection, journal analysis, and journal synthesis. Based on the review of several relevant journals, it is evident that various leaf species such as Taro (*Colocasia esculenta* L.), Gamal (*Gliricidia sepium*), Lamtoro (*Leucaena leucocephala*), Cassava (*Manihot utilissima*), Noni (*Morinda citrifolia*), Turi (*Sesbania grandiflora* L.), Kale (*Ipomoea aquatica*), Papaya (*Carica Papaya*), and aquatic plants like *Lemna Minor*, Water Hyacinth (*Eichornia crassipes*), *Azolla microphylla* can serve as references for supplementary feed with beneficial content for fish growth. The utilization of these plants is a judicious step as it can reduce commercial feed costs, provide stable feed

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availability throughout the year, and mitigate negative environmental impacts while enhancing water quality. Managing plants as fish feed is not only economically favorable but also a positive stride towards sustainable and environmentally friendly fish farming.

Keywords: Fish feed; cultivation; management.

1. INTRODUCTION

One of the major expenses in production through fish farming is the cost of feed, typically accounting for 60% to 70% of the total production costs [1]. A crucial aspect of aquaculture is the availability of comprehensive feed with a nutrient composition suitable for fish requirements. Generally, in fish farming practices, the primary choice often falls on artificial or commercial feeds. However, commercially available artificial feeds in the market are often expensive, with various brands and packaging [2]. Therefore, the profitability level obtained from fish farming depends on the skill of reducing feed production costs through the creation of alternative feeds, not solely relying on the use of commercial fish feeds or pellets [3].

There are various methods that can be used to reduce feed costs, and one of them is managing leaves and aquatic plants as alternative raw materials for affordable and readily available plant protein sources [4]. The primary purpose of the feed processing is to enhance profitability, alter particle size, regulate moisture content, modify feed density, increase attractiveness and acceptance (palatability/acceptability), alter nutrient content, improve nutrient availability, perform detoxification, maintain feed quality during storage, and reduce contamination risks [5]. Feeds serve as an energy supplier to stimulate growth, and proper feeding can influence the specific growth rate of fish [6].

2. METHODS

The method employed in this research is a literature review. A literature review, also known as a literature study, literature survey, theoretical review, theoretical foundation, literature analysis, or theoretical review, is a research approach conducted based on written works. Literature research refers to research that solely utilizes written sources, including both published and unpublished research findings [7].

The following stages were carried out:

1. Journal Search; Initially, a search for previous journals on the management of leaves and aquatic plants as fish feed ingredients was conducted. The search was performed on scientific journal databases such as ScienceDirect, Google Scholar, and ProQuest.
2. Journal Selection; Based on the search results, journals were selected according to specific criteria such as relevance, credibility, and accuracy of information. The chosen journals had to align with the research topic and be recognized by the scientific community.
3. Journal Analysis; After selecting the journals, an analysis of the articles within was conducted. The analysis involved identifying the management of leaves and aquatic plants as fish feed ingredients.
4. Journal Synthesis; Following the analysis, information from various relevant journals was synthesized. The gathered information serves as the foundation for compiling the currently written journal.

3. POTENTIAL USE OF LEAVES AND AQUATIC PLANTS

To alleviate the burden of expensive feed costs, certain fish farmers opt to incorporate leaves and aquatic plants into their feeding practices, supplementing commercial feeds. This strategy aims to reduce the overall expenses associated with aquaculture activities [8]. The following are the potentials of leaves and aquatic plants that can be used as fish feed:

3.1 Leaf Material

An alternative solution is essential, achieved by crafting homemade feed from readily available local raw materials. These raw materials should boast rich nutritional content, be easily accessible and manageable for processing, encompass vital nutrients for fish, and come at an affordable price. [8]. Local raw materials from leaves that have the potential as an alternative to artificial feed are as follows:

3.1.1 Taro leaves (*Colocasia esculenta* L.)

A local resource that can be utilized is taro leaves. The community has long employed taro leaves as an additional green feed for adult gourami fish. The use of taro leaves can enhance the quality of reproductive performance, with an optimal feed ratio of 75% pellet formula to 25% taro leaves [9].

A local raw material that can be used as an alternative to artificial feed is taro leaves. Taro leaves have a protein content of 27.80% and a gross energy of 3,821 kcal/g. Additionally, taro leaves are easily accessible as they can be grown in residential areas. Although taro leaves have traditionally been utilized only as supplementary green feed by the community, providing feed derived from taro leaves has a significant impact on fish growth [10].

3.1.2 Gamal leaves (*Gliricidia sepium*)

One potential raw material for use as fish feed is *Gliricidia sepium* leaf powder. Gamal foliage contains crude protein around 20-30% dry weight, crude fiber about 15%, and *in vitro* dry matter digestibility approximately 60-65%. During the dry season, gamal protein content reaches 18-24% [11].

Gamal leaves have significant potential, but their utilization as fish feed raw material is still limited, resulting in insufficient information about their usage in fish feed. Research indicates that feeding commercial pellets formulated with gamal leaves has a positive effect on the growth of tilapia. Foliage such as gamal leaves, rich in protein, is highly suitable as feedstock [12].

3.1.3 Lamtoro leaves (*Leucaena glauca*)

The lamtoro leaf, which is a plant-based protein source with a sufficiently high protein content, has great potential as fish feed. This plant is favored by livestock, grows rapidly, and is suitable for tropical regions [13].

Lamtoro leaves can be used as feed because they produce nutrient-rich green waste. Its chemical composition includes a dry weight of 97.8923%, crude protein 23.8326%, nitrogen-free extract (NFE) 31.0509%, crude fiber 23.5877%, fat 11.6858%, and ash 7.7353%. Additionally, lamtoro leaves in the form of flour can be used as a component in fish feed pellets [14]. The advantage of lamtoro leaves lies in their ability to serve as a potential local raw material for use as a fish feed source [15].

3.1.4 Cassava leaves (*Manihot utilissima*)

Cassava leaves, as an organic source with a sufficiently high protein content, have a protein content of approximately 23.28% when dry, making them an alternative option as one of the components in non-factory fish feed [16]. However, the utilization of cassava leaves requires fermentation using EM4 due to their high content of coarse fiber. This fermentation is expected to reduce the coarse fiber content and enhance the palatability of the feed [17].

3.1.5 Noni leaves (*Morinda citrifolia*)

One natural resource that can be utilized is the Noni leaf (*Morinda citrifolia*). The Noni leaf (*M. citrifolia*) is a part of the plant that falls under the category of tropical plants commonly found in various locations. The Noni plant (*M. citrifolia*) has significant potential as a medicinal plant that can be developed. All parts of the Noni plant (*M. citrifolia*), including the roots, bark, leaves, fruits, and seeds, contain secondary metabolites that are beneficial for medicinal purposes. The Noni leaf (*M. citrifolia*) as a whole contains essential nutrients for the body, including protein, especially essential and non-essential amino acids, vitamins, and minerals [18].

The results of phytochemical screening of Noni leaves indicate the presence of compounds such as flavonoids, saponins, steroids, alkaloids, vitamins, and ascorbic acid. Flavonoid compounds act as antioxidants, antibacterials, immunomodulators, and anti-inflammatory agents. Meanwhile, saponin compounds function as membrane permeabilizers and can influence the growth and enhance the feeding response of animals [19].

3.1.6 Turi leaf (*Sesbania grandiflora* L)

The Sesbania (*Sesbania grandiflora* L) plant is commonly found in the surrounding environment. Sesbania leaves are utilized as supplementary feed for tilapia, containing carotenoid content, making it a potentially viable alternative feed option for both herbivorous and omnivorous fish [20].

Sesbania leaves (*Sesbania grandiflora* L) have considerable potential as an alternative protein source for herbivorous and omnivorous fish, with a protein content of 31.7% and fat content of 1.9%. The Sesbania plant can thrive in somewhat shaded areas, whether on limestone or barren soil, allowing it to grow vigorously even during the dry season. One distinctive feature of the Sesbania plant is its rapid growth [21].

3.1.7 Kale leaves (*Ipomoea aquatica*)

Kale leaves (*Ipomoea aquatica*) are one of the types of local raw materials that are available sustainably. In terms of nutritional content, water spinach leaves have the potential to be used as fish feed raw material with a protein content of 23.99%, crude fiber 16.17%, nitrogen-free extract (BETN) 13.69%, ash 12.49%, and water 12.34% [22]. To control the cost of commercial feed and reduce expenses in fish farming, water spinach leaves can be utilized, especially since they are relatively preferred by certain fish species such as carp, tilapia, and silver barb [8].

3.1.8 Papaya leaf (*Carica papaya*)

In fish farming, there are various alternatives that can be utilized, one of which is utilizing the plant in the form of papaya leaves. Papaya leaves contain the enzyme papain, a type of protease enzyme that acts as a proteolytic agent to break down proteins in fish into peptides or amino acids, making them more easily absorbed by the fish's body [23].

The utilization of papaya leaves in cultivation (*cultivated organisms*) is often carried out through feed by mixing them into the feed, shifting the feeding pattern from natural to artificial feed. In addition to containing papain enzyme, papaya also contains antimicrobial compounds, making it an immunostimulant [24].

3.2 Water Plant Materials

In aquatic environments, the rapid proliferation of weeds is a common occurrence, leading to the extensive coverage of water bodies. One notable example is water hyacinth, a weed that proliferates swiftly, ultimately resulting in oxygen deficiency in the affected waters [25]. Some aquatic plants that can be utilized for fish feed are as follows:

3.2.1 *Lemna minor* water plant

Lemna minor, a free-floating aquatic plant with widespread distribution, holds significant potential as a high-quality animal feed forage source. Its remarkable productivity and nutritional quality position it as a promising alternative feed and feed supplement. The growth of *Lemna minor* is typically influenced by environmental factors and the nutrient adequacy in the utilized medium [26].

The plant exhibits promise as an alternative green feed, being rich in protein and minerals. With a notable crude protein content of 37.6% and relatively low fiber at 9.3%, *Lemna minor* stands out as a potential protein supplement. Additionally, it offers various benefits, serving as a biofertilizer to enhance fish growth [27].

3.2.2 Water hyacinth plant (*Eichornia crassipes*)

Water hyacinth (*Eichornia crassipes*), a prevalent weed in lakes and swamps, is currently underutilized in Indonesia, mainly employed in limited quantities for fertilizer and crafts. However, there is potential for water hyacinth biomass to serve as a local raw material for fish feed, particularly for herbivorous fish species [25]. The nutritional profile of water hyacinth is noteworthy, featuring a protein content ranging from 9.8-15.7%, ash content between 11.9-23.9%, crude fat at 1.1-3.3%, and crude fiber within the range of 16.8-24.6%. Despite these positive attributes, water hyacinth also exhibits low protein and high crude fiber content, necessitating processing before incorporation as a feed ingredient [28].

3.2.3 *Azolla microphylla* water plant

Azolla microphylla, an aquatic fern exhibiting rapid growth and development, forms a symbiotic relationship with nitrogen-fixing Cyanobacteria. This symbiosis contributes to the favorable nutritional quality of *Azolla microphylla* biomass, particularly in terms of nitrogen and its derivative compounds, including proteins [29]. Notably, the growth rate of *Azolla microphylla* is exceptionally high, with the potential to double within a span of 2-10 days, contingent upon environmental factors and nutrient availability [30].

Given its prevalence in stagnant water bodies like lakes, ponds, swamps, and rice fields, *Azolla microphylla* is utilized as a feed ingredient. The plant boasts a substantial protein content of 28.12% dry weight, further underscoring its significance in the formulation of animal feeds [31].

4. PROCESSING OF LEAVES AND WATERS PLANTS

The assessment of the nutritional content in fish feed primarily revolves around the nutrient composition, encompassing protein, fat, carbohydrates, vitamins, and minerals. While commercially available feeds typically adhere to these nutritional standards, they often come with a relatively high price tag. Consequently, there arises a need for an alternative approach, wherein individuals can craft their own feed using straightforward techniques, making use of affordable and readily available raw materials [32]. Processing of leaves and aquatic plants to be used as fish feed in a table.

Based on Table 1 and Table 2, it is known that the management of leaves and aquatic plant materials can be used as a formulation of fish feed additives that can support growth, feed efficiency, and fish survival.

Table 1. Processing of leaves

No	Name	Processing	Result	Source
1.	Taro Leaf (*Colocasia esculenta* L.)	Dry the leaves for 3 days, grind them in a blender, then mix with other ingredients.	FCR 3.09 and feed efficiency 32.36%	[33]
2.	Gamal leaves (*Gliricidia sepium*)	Dry the leaves, blend (100 g), ferment with EM4 and store for 36 hours.	Meets the standards of SNI 8227: 2015 quality of fish and shrimp feed.	[34]
3.	Lamtoro Gung leaves (*Leucaena leucocephala*)	Leaf fermentation with a mixture of flour and water (2:1.5), steamed, inoculated with *Aspergillus niger* (2%), 72 hours fermentation in perforated plastic, steamed 15 minutes, dried and blended.	Feed digestibility was 59.45%, protein retention 18.85%, feed efficiency 62.6%, absolute weight growth 17.74 g and specific growth rate 4.11%/day.	[35]
4.	Cassava Leaves (*Manihot utilissima*	Wash old cassava leaves, knit with a size of ± 2 cm, boil and dry, then in a blender, sifted, and fermented with EM4 for 5-7 days, mix with fishmeal.	Significantly affected the growth of tilapia weight.	[16]
5.	Noni Leaves (*Morinda citrifolia*)	Chopped leaves ± 2 cm in size, wind 1 day to wilt, ferment with the help of *Lactobacillus plantarum*, dry, then grind and sift until it becomes flour, formulate with other ingredients.	Significant effect on specific growth rate, FCR, protein efficiency ratio, protein retention and enzyme activity. protein, protein retention and protease enzyme activity.	[18]
6.	Turi Leaf (*Sesbania grandiflora L*)	Wash the leaves, soak for 12 hours, separate the stems, and dry with an oven (60°C), then blend and ferment with *Rhizopus oligosporus*, mix with other ingredients.	Significantly affected the daily growth rate by 3.18% and feed conversion of freshwater pomfret seeds by 1.18.	[21]
7.	Kale leaves (*Ipomoea aquatica*)	Separate the leaf stems, dry, then grind with a flouring machine, after that ferment with *Rhizopus oligosporus* mold and mix with other ingredients.	Significant effect on feed & protein digestibility, feed efficiency, protein retention, specific growth rate and fish survival.	[22]
8.	Papaya Leaf (*Carica Papaya*)	Wash the leaves, dry them in an oven at 120°C for 1 hour, then grind them in a blender until the powder is fine, and mix the leaf extract with other feed ingredients.	Significant effect on length growth, survival and feed conversion.	[36]

Table 2. Processing process of aquatic plant materials

No	Name	Processing	Result	Source
1.	*Lemna Minor*	Harvest and clean *Lemna Minor*, then feed it to carp in a wet state.	The crude protein value is high at 37.6% and low in fiber (9.3%), making it suitable as an alternative feed ingredient.	[26]
2.	Water Hyacinth (*Eichornia crassipes*)	Chop to a size of ± 3 cm, then wash in running water, dry in the sun (4-7 days). Ferment and mix with other raw materials.	Significant effect on absolute weight growth, survival rate, and FCR value.	[37]
3.	*Azolla microphylla*	Wash the leaves, separate the stems, dry in the sun, then grind with a flouring machine, fermented using *Trichoderma* sp. mold and add other feed ingredients.	Effect on feed efficiency and growth of red tilapia (O.*niloticus*).	[31]

5. CONCLUSION

The management of leafy materials and aquatic plants as an alternative fish feed has significant potential in reducing the production costs of fish farming. The article discusses various types of leaves and aquatic plants that have the potential as fish feed sources, such as taro leaves, gamal leaves, lamtoro leaves, cassava leaves, noni leaves, turi leaves, water spinach leaves, and papaya leaves. This potential is supported by the high nutritional content of these materials, including protein, fiber, and other nutrients.

Leafy materials and aquatic plants as fish feed sources have great potential to enhance profitability in fish farming by reducing reliance on expensive commercial feeds. Proper selection and processing of these materials can support fish growth, feed efficiency, and overall survival in aquaculture systems.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Putra AN, Ristiani S, Musfiroh M, Syamsunarno MB. Utilization of water hyacinth (*Eichornia crassipes*) as tilapia feed: effects on growth and feed digestibility. Leuit (Journal of Local Food Security). 2020;1(2):77-82.
2. Andriani R, Muchdar F, Ahmad K. Utilization of local raw materials as fish feed for fish farming groups in Ternate City. Indonesian Journal of Fisheries Community Empowerment. 2021;1(3):231-239.
3. Prasetiyono E, Syaputra D. Dissemination of technology for making fish feed based on local raw materials and simple applicative technology as an effort to increase profits for fish farmers in Tua Tunu Village, Pangkalpinang City. Journal of Community Service, University of Bangka Belitung. 2016;3(2).
4. Amelia F, Andriani Y, Haetami K. The utilization of plants as fish feed: A review. Journal of Ruaya: Journal of Fisheries and Marine Sciences Research and Studies. 2022;10(1).
5. Muchlis A, Sema S, Syamsu JA, Asmuddin A. Feed processing technology in tropical areas: Green feed processing techniques (Fiber). Integrated Journal of Animal Science and Technology. 2023;3(1):145-152.
6. Syahreza S, et al. Processing papaya leaves in making tilapia fish feed. Journal of Community Services Public Affairs. 2022;2(2):56-61.
7. Embun B. Dew Morning. Retrieved from Literature Research; 2012.
8. Tahir MHS, Damayanti A, Lestari PD. The effect of combination of commercial feed with water spinach leaves (*Ipomoea aquatica*) on the growth of carp fish seeds (*Cyprinus carpio*). Tropical Fisheries Journal; 2021.
9. Siegers WH, Tuhumury RA, Bariyyah S, Dogomo P. The effect of doses of taro leaf flour mixed with Hi-Pro-Vite FF-999 pellets on the growth rate of gourami fish (*Osphronemus gourami*). The Journal of Fisheries Development. 2022;5(1):47-56.

10. Batubara JP, et al. Taro leaf fermentation as artificial feed material to improve growth and survival of tilapia fish (*Oreochromis niloticus*). Journal of Aquaculture; 2023.
11. Syafaat IW, Anwar A, Haris A, Khaeriyah A, Murni M. Evaluation of the nutritional content of gamal leaf flour resulting from fermentation using local microorganisms (MOL) banana tuber as feed for carp fish (*Cyprinus carpio*). Octopus: Journal of Fisheries Science. 2021;10(2):007-014.
12. Apriani F, Prasetiyono E, Syaputra D. Growth performance of gourami fish (*Osphronemus gouramy*) seeds with the addition of commercial feed added with fermented gamal leaf flour (*Gliricidia sepium*). Samakia: Journal of Fisheries Science. 2019;10(2):57-65.
13. Amelia N, Sudirman A. Processing of cocoa fruit skin and lamtoro leaf into fish feed using Aspergillus niger fermentation (Doctoral dissertation, Faculty of Engineering); 2021.
14. Restiningtyas R. Utilization of fermented lamtoro leaf flour (*Laucaena gluca*) in artificial feed on the growth of red tilapia fish seeds (*Oreochromis niloticus*). Journal of Aquaculture Management and Technology. 2015;4(2):26-34.
15. Batubara JP, Putri MS, Fadli M. Effectiveness of lamtoro leaf fermentation as an alternative ingredient for artificial feed for Nile fish (*Oreochromis niloticus*). Journal of Pioneer. 2023;9(2):18-27.
16. Pawhestri WS, Verina OE, Wibowo GS, Sari SM. Testing the effectiveness of cassava leaf flour (*Manihot esculenta* C.) and fish flour as artificial feed in the growth of tilapia fish (*Oreochromis niloticus*). Samudra Biological Journal. 2020;2(1):26 - 34.
17. Listiowati E, & Pramono TB. Potential utilization of cassava leaves (*Manihot utillisima*) fermented as feed for tilapia fish (*Oreochromis sp*). Terubuk Fisheries Journal. 2014;42(2).
18. Cholifah D, Febriani M, Ekawati AW, Risjani Y. The effect of using fermented *Morinda citrifolia* leaf silage (*Anguilla bicolor*) in the feed formula on the growth of elver stage eels. Marine Journal: Indonesian Journal of Marine Science and Technology. 2012;5(2):93-107.
19. Herlina S. Effectiveness of Morinda citrifolia leaf extract (*Morinda citrifolia*) to increase non-specific immune response and survival of carp fish (*Cyprinus carpio*). Journal of Tropical Animal Science (Journal of Tropical Animal Science). 2017; 6(1):1-4.
20. Meilisza N, Yunita E, Murniasih S, Hirnawati R, Sholichah L, Muta'al DU. Utilization of turi leaf flour in feed for color quality and growth of Rainbow Kurumoi Fish (*Melanotaenia parva*). Journal of Fish Nutrition. 2021;1(1):30-47.
21. Utami IK, Haetami K. The effect of using fermented turi leaf flour in artificial feed on the growth of freshwater catfish seeds (*Colossoma Macropomum Cuvier*). Journal of Fisheries and Marine Sciences. 2012;3(4).
22. Samosir HN. The effect of using fermented water spinach leaves (*Ipomoea aquatica Forsk*) in feed on the growth of Tilapia Fish Seeds. [Thesis]. Aquaculture Study Program, Faculty of Fisheries and Marine Sciences, University of Riau. 2019; 62.
23. Syahreza S, et al. Processing papaya leaves in making tilapia fish feed. Journal of Community Services Public Affairs. 2022;2(2):56-61.
24. Haser TF, Febri SP, Nurdin MS. The effectiveness of papaya leaf extract in supporting the success of milkfish (*Chanos chanos Forskall*) Egg Hatching. Agroqua Journal: Agronomy and Aquaculture Information Media. 2018;16(2):92-99.
25. Akbar MF, Azhari M, Neka VA, Arif A, Simbolon CA, Hamdani H, Wijayanti M. Utilization of water hyacinth (*Eichornia crassipes*) and bagasse for making carp fish feed (*Barbonymus gonionotus*). In National Seminar on Suboptimal Land. 2021;9(2021):795-802.
26. Melinda YS, Syuhada FA. Techniques for cultivation and application of *Lemna minor* plants as probiotic broiler chicken and gourami fish feed. Agriness Journal. 2023; 1(1).
27. Nopriani U, Karti PDMH, Prihantoro I. Productivity of duckweed (*Lemna minor*) as an alternative feed for livestock at different light intensities. JITV. 2014;19(4): 272-286.
28. Kurniawan R, Suharman I, Adelina A. Utilization of water hyacinth leaf flour (*Eichhornia crassipes*) fermented using cattle rumen liquid to improve the growth of baung fish (*Hemibagrus nemurus*). Aquatic Science. 2022;10(1):31-41.
29. Suwondo D, Amin M. The effect of *Azzola microphylla* feed on the growth of tilapia

fish (*Oreochromis niloticus*) as a high school biology learning design. Biogenesis Journal. 2021;17(1):39-48.

30. Katole SB, Lende SR, Patil SS. A review on potential livestock feed: Azolla. Livestock Research International. 2017;5 (1):1-9.
31. Husnaini R, Suharman I Adelina. Utilization of fermented azolla meal (*Azolla microphylla*) in artificial feed to enhance the growth and survival of Red Nile Tilapia (*Oreochromis niloticus*) Seeds; 2021.
32. Sitanggang PL. The effect of indigofera flour concentration in making carp (*Cyprinus carpio)* pellets. Tapian Nauli: Journal of Applied Fisheries and Marine Research. 2019;1(2):53-59.
33. Haetami K, Kusumah FSW, Abun A. Effectiveness of the combination of taro leaves (*Colocasia esculenta)* and substituted powdered fish in the formulation of Nile tilapia (*Oreochromis niloticus*) feed. Jurnal Perikanan Unram. 2023;13(1):62-71.
34. Amrullah S, Octaviananda C, Ramadhani I. Analysis of mixture of waste from gamal leaves, lamtoro leaves, and banana peel as alternative feed for shrimp. Journal of Environmental Pollution Control (JPPL). 2023;5(1):91-97.
35. Raudah P, Suharman I, Alawi H. Utilization of fermented lamtoro gung (*Leucaena leucocephala*) leaf flour with *Aspergillus niger* as a substitute for soy flour in feed on the growth of siamese patin fish (*Pangasius hypophthalmus*). Journal of Fisheries and Marine Sciences. 2018;23 (2):1-8.
36. Mapparimeng M. The effect of adding papaya leaf extract (*Carica papaya*) to Nile Tilapia (*O. niloticus*) Feed. Agrominansia. 2016;1(2):148-158.
37. Batubara JP, Moris ACYDU, Marpaung G. Utilization of fermented water hyacinth (*Eichhornia crassipes*) as a raw material for feed production to improve the growth and survival of Nile Tilapia (*Oreochromis niloticus*) Fish. Tor: Journal of Aquaculture. 2023;3(3).

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