Global Scientific JOURNALS

GSJ: Volume 9, Issue 8, August 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

EXPLORATION OF LEMNA PLANTS (*LEMNA* SP) APPLICATION IN AQUACULTURE ACTIVITIES (A REVIEW)

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KeyWords
antioxidant, aquaculture, fish feed, Lemna, pigment

ABSTRACT

Alternative fish feed supply research has delved into a variety of potential resources, yielding a variety of outcomes and responses from diverse types of farmed fish. In Indonesia, Lemna sp. is one of the most well-known aquatic plant species. Lemna, often known as duckweed, is an aquatic plant that is found throughout Indonesian seas. Lemna has a protein content of 10–45 percent, as well as 7–14 percent fiber, 35 percent carbs, 3–7% fat, and a high vitamin and mineral content. Lemna's abundance has the potential to be developed to support aquaculture activities, such as as a feed source or to improve the quality of aquaculture water through the bioremediation process. Alternative feed should be chosen based on the requirements of feed ingredients, such as being easy to obtain, low in price, high in nutritious value, and not conflicting with human needs. Lemna has the smallest amount of crude fiber and a delicate leaf to root texture. When used as feed, Lemna has a high digestibility as a result of this. Several experiments using Lemna as a protein source in feed have had positive results.

INTRODUCTION

The immense challenge in the implementation of aquaculture is the provision of feed that meets the nutritional needs of fish that is economical, easy to obtain and competitively priced, as well as adequate water quality for aquaculture activities. Exploration of alternative fish feed supply has penetrated various potential resources and has given various results and responses to various types of cultured fish. Of course, this effort is an amplifier for fish farming actors to reduce the cost of feed in aquaculture activities, especially the lower middle scale, especially facing the challenges of performing cultivation during a pandemic like today.

Lemna sp is one of the most familiar aquatic plant materials in Indonesia. Lemna or often referred to as duckweed is an aquatic plant that is widely distributed in Indonesian waters. Several types of Lemna found in nature consist of: *Lemna perpusilla* and *Lemna minor*. Lemna mostly grows in calm waters and is protected from the wind. *Lemna minor* is a small aquatic plant that floats on water and has the potential as fresh feed or feed ingredients because it has a fairly high nutrient content. Protein content of Lemna ranges from 10–45% [1], [2], with 7–14% fiber, 35% carbohydrates, 3–7% fat, and quite high vitamin and mineral content [2].

Without proper utilization, the existence of Lemna can threaten the waters as a weed. On the other hand, the abundance of Lemna has the potential to be developed to support aquaculture activities, such as as a source of feed or to improve the quality of aquaculture water through the bioremediation process. This aquatic plant has high productivity, where under optimal conditions Lemna can double its biomass in just two days [1]. In a controlled cultivation system, Lemna can produce a harvest of 10-30 tons DM/ha/year. *Lemna minor* can grow well in water rich in nutrients [3] Nutrients can be provided by adding fertilizer to the culture medium. Several studies on *Lemna minor* culture have been carried out previously, including using organic fertilizers in the form of compost and inorganic fertilizers in the form of NPK, hoagland, and hyponex fertilizers [4]. In addition to these fertilizers, currently bioslurry also has the potential to be used as fertilizer in *Lemna minor* culture activities.

Based on its potential and abundance, *Lemna* sp has many benefits to support aquaculture activities, both as feed and as bioremediatory cultivation media. Various studies show Lemna's ability to

be further utilized in fish farming activities. This paper is a review of several uses of *Lemna* sp plants in aquaculture activities.

Figure 1. Cultivated *Lemna* sp

METHODS

This literature study was obtained from online journals such as Pubmed - NCBI, Elsevier, Research Gate, Springer, and Google Scholar. The keywords were "*lemna* sp "; "fish feed"; "pigment"; "antioxidant" and "aquaculture" used for the data search. Thus, the arranges of the theoretical framework will following the subject matter of the discussion.

RESULTS AND DISCUSSION

Lemna as Source of Protein

The protein content of Lemna sp is in the range of 10–45%, with 7–14% fiber, 35% carbohydrates, 3–7% fat, and high vitamin and mineral content. Nutrient content in dry tissue (in mg/kg): N 60,000, P 5,000-14,000, K 40,000, Ca 10,000, Mg 6,000, Na 3,250, and Fe 2,500. Several other sources indicate that Lemna sp has good nutritional content as a feed ingredient (Table 1.). The nutritional content of Lemna is influenced by the nutrients provided during the cultivation process and also the treatment used in cultivating Lemna (Table 2).

Tabel 1. The nutritional content of *Lemna* sp.

Composition	Value	Unit
Protein	30-45	%
Carbohydrate	35	%
Fiber	7-14	%
Fat	3-7	%
Ash	13	%
	30-45	%
Amino Acid Composition		
Aspartic acid	17.45	g/100 g protein
Glutamic acid	13.13	g/100 g protein
Serine	5.21	g/100 g protein
Glycine	6.09	g/100 g protein
Histidine	1.95	g/100 g protein
Arginine	5.42	g/100 g protein
Threnonine	7.72	g/100 g protein
Alanine	7.44	g/100 g protein
Proline	4.85	g/100 g protein
Tyrosine	3.55	g/100 g protein
Valine	4.36	g/100 g protein
Methionine	1.22	g/100 g protein
Cystidine	0.7	g/100 g protein
Isoleusine	2.65	g/100 g protein
Leusine	8.12	g/100 g protein
Phenylalanine	4.99	g/100 g protein

Lysine	5.15	g/100 g protein
Minerals		
P	1.136	%
S	0.707	%
K	2.650	%
Ca	1.119	%
Mg	0.357	%
Na	0.203	%
Mn	407.3	µg/g
Fe	459.1	µg/g
Zn	1732.9	µg/g
Cu	11.7	µg/g
Al	0.024	%
B	236.6	µg/g
Mo	2.4	µg/g

Source: Landesman (2005)

Tabel 2. Nutritional content of Lemna with various treatments

Composition	Fresh Lemna	Potash soaked Lemna	Sun-dried Lemna	Heated Lemna
Dry matter	97.45	97.13	97.06	97.00
Moisture content	2.55	2.87	2.94	3.00
Protein	29.28	36.25	28.62	30.04
Crude Fat	6.34	5.2	6.9	7.8
Crude Fiber	16.15	13.76	15.26	14.96
Crude Ash	15.34	17.46	20.04	16.74
NFE	30.34	24.46	28.24	27.46

Source: [4]

In several other countries, this plant from the Lemnaceae family has been widely used as additional feed for fish, chickens, and ducks, for example in several Asian countries such as Thailand, Bangladesh, and India. Even with the lack of land to produce grass, Lemna is starting to be used as forage for cattle feed. Compared to other types of aquatic plants, Lemna contains the lowest crude fiber and has a soft leaf to root texture. This further causes Lemna to have a high level of digestibility when used as feed. Several studies that have used Lemna as a source of protein in feed have shown encouraging results.

The selection of alternative feed should be considered in accordance with the provisions of feed ingredients, namely easy to acquire, low in price, has high nutritional content and not competing with human needs. In addition, as an alternative feed, the feed itself must be met in quantity, has good quality and is sustainable. However, if the use of *Lemna minor* plants is only focused on its availability in nature, this can cause its availability to decrease. In addition, *Lemna minor* intended for food production must come from waters that do not contain toxins. Toxic content in low concentrations in wastewater can be dangerous due to bioaccumulation and bioconcentration in the food chain [2]. Therefore, *Lemna minor* culture activities are needed to ensure the quantity, quality and sustainability as feed ingredients.

Research by [5] showed that the addition of 20% fresh *Lemna* sp. to grass carp fish produced a specific growth rate of 0.55% which was greater than the control which was only 0.33%. Research from [6] showed that the addition of Lemna resulted in a specific growth rate of common carp (*Cyprinus carpio* L) which was 2.00±0.09%. The combination study of 75% pellets and 25% fresh *Lemna perpusilla* in tilapia resulted in absolute weight growth of 30.95 grams which not significantly different from 100% pellet feeding [7]. In African catfish (*Clarias gariepinus*) the addition of 20% fermented Lemna flour resulted in a total feed consumption value of 170.01±9.25 g, feed utilization efficiency of 78.82±4.75%, protein efficiency ratio (PER) of 2.49±0.15% and the relative growth rate (RGR) of 4.60±0.31%/day (Sulawesty et al, 2014). While the reccomended administration method to fish it should be in dried form and mixed with other feeds. This is due to the addition of Lemna in fresh form will make the fish experience faster satiation owing to its high water content and high FCR (the value is around 11-12).

Table 3. Lemna sp. addition level to several of fresh-water fish

Sample	Level of addition	Parameters
Grass carp	20% *Lemna* sp	0.55% Specific Growth Rate
Common carp		2.00±0.09% Specific Growth Rate
Nile tilapia	75% pellet + 25% *L. perpusilla*	30.95 g weight growth
African catfish	20%	170.01±9.25 g total feed consumption

		78.82±4.75% Feed utilization efficiency 2.49±0.15% Protein efficiency ratio 4.60±0.31%/hari relative growth rate

Source: [5], [6], [7]

Lemna as a source of fish feed pigment

Color is one of the production indicators which desirable in fishery commodities, especially in ornamental fish. *Lemna* sp was recognized as having excellent pigment content to be used in ornamental fish feed. The potential sources of pigments and antioxidants in a material can be indicated by the carotenoid content contained in it. Lemna contains 3.97 mg/L chlorophyll, 0.89 mg/L carotenoids, and 5.64 mg/30g of vitamin C [8]. *Lemna minor* has a high concentration of minerals and pigments, especially beta-carotene and xanthophylls [9]. Its ability as a pigment was observed in a study that utilized Lemna as a pigment in Nilem fish eggs, where the results showed that with 40% of the Lemna application in the feed it could produce a more orange color of nilem eggs by 21.43% [10]. The effectiveness of the pigment in the feed on fish is influenced by the amino acid content in the feed ingredients. Lemna has an excellent content of amino acids, allowing carotenoids to play a role in producing color (Table 4).

Table 4. Amino acid content in Lemna feed and pellets

Amino Acids	Lemna	Pellet
Essential Amino acids		
Arginine	2.34	2.17
Methionine	0.35	0.57
Tyrosine	0.66	0.88
Histidine	0.44	0.73
Threonine	0.87	1.19
Isoleucine	1.89	1.32
Leucine	1.86	2.75
Phenylalanine	1.14	1.40
Lysine	1.20	1.69
Valine	1.36	1.77
Non Essential Amino Acids		
Aspartic	3.69	3.01
Serine	0.81	1.38
Glutamine	2.31	4.89
Proline	1.00	2.04
Glycine	1.20	2.28
Alamine	1.89	2.17

Source: Neukobin et al (2013)

Lemna for phytoremediators

Another function of Lemna is that it is used to improve water quality in biological wastewater treatment, or commonly referred to as the phytoremediation process. Lemna sp is one of the plants that can be used in the phytoremediation process because this plant has the ability to absorb organic and inorganic materials from the waters. Phytoremediation can be defined as the use of plants to remove or take up harmful contaminants from media such as soil, water and air. Plant species were selected for phytoremediation based on plant potential for metal accumulation, growth and distribution as well as root zone depth [10].

Aquatic plants are known to absorb and accumulate heavy metals [11]. *Lemna* sp. is one of the plants that can be used as a phytoremediator for heavy metal chromium. Cr^{3+} and Cr^{6+} can be absorbed by the roots of Lemna sp. and Cr^{6+} will be reduced in cells to Cr^{3+} so that Cr toxicity is reduced [12], [13], [14]. The root system of hanging plants, such as the roots of Lemna sp., usually has an absorption system of organic and inorganic substances present in the waters, so it is often used for water remediation [15]. Several studies have shown that the roots and leaves of Lemna sp are able to absorb NH_3 and NO_3, as well as pollutants such as copper, zinc, lead and chromium.

Utilization of Lemna in waste treatment can be done by culturing Lemna in liquid waste rich in organic matter/heavy metals during the deposition process during waste treatment. Several studies have stated that Lemna is able to absorb heavy metal chromium (Cr) contained in the waters up to more than 50% and this depends on the concentration of Cr which contained in the waste, the amount of Lemna used and the length of time of culture [16]. The concentration of Cr in wastewater decreased due to the transfer of Cr concentration from the waste into the Lemna network. After Cr has accumulated in Lemna, the separation of Cr from wastewater can be done easily, namely by harvesting Lemna. This method is more economical and easier to execute. By treating the waste, the

Cr which has been separated (±50%) from the liquid waste can be used and reused so that the previously missed economic value can be returned and the benefits from the environmental aspect, namely the liquid waste that is disposed of, has reduced toxicity and is not harmful to the environment.

The concept of the Lemna aquaculture industry as a source of both feed and energy has developed in the United States. In some places, there has been mass cultivation of Lemna in ponds that are able to support agro-complex activities (fishing, livestock), as well as a source of renewable energy. In Indonesia, the utilization of Lemna is still based on limited supply for individual agro-complex activities. Hopefully this article inspires us to develop aquatic plants to strengthen our freshwater fish production line, especially herbivorous fish.

Conclusion

Based on the results of the literature review, it can be concluded that the Lemna plant (*Lemna* sp) has great potential to be utilized in aquaculture activities as a source of feed protein, antioxidants and pigments in feed, as well as being used as a water bioremediation agent.

References

[1] Landesman, L, N. C. Parker, C. B. Fedler, and M. Konikof. Modeling duckweed growth in wastewater treatment systems. Livestock Research for Rural Development, 17 (6) 2005.
[2] Iqbal, S. 1999. Duckweed aquaculture potentials: Possibilities and limitations for combined wastewater treatment and animal feed production in developing countries. EAWAG, SANDEC Report No. 6/99.
[3] Leng, R A, J. H. Stambolie and R. Bell. 1995. Duckweed - a potential high-protein feed resource for domestic animals and fish. Livestock Research for Rural Development, 7 (1).
[4] Sogbesan OA, Onoja CF, Adedeji HA, Idowu TA. 2015. Utilization of Treated Duckweed Meal (*Lemna pausicostata*) as Plant Protein Supplement in African Mud Catfish (*Clarias gariepinus*) Juvenile Diets. Fish Aquac J., 6 (4): 141.
[5] Nekoubin, H. dan M. Sudagar. 2013. Effect of Different Types of Plants (*Lemna sp., Azolla filiculoides and Alfalfa*) and Artificial Diet (With Two Protein Levels) on Growth Performance, Survival Rate, Biochemical Parameters and Body Composition of Grass Carp (*Ctenopharyngodon idella*). Journal Aquaculture Research and Development, 4 (2): 6
[6] Sulawesty, F., T. Chrismadha, dan E. Mulyana. 2014. Laju Pertumbuhan Ikan Mas (*Cyprinus carpio* L) Dengan Pemberian Pakan Lemna (*Lemna perpusilla* Torr.) Segar Pada Kolam Sistem Aliran Tertutup. Jurnal LIMNOTEK 2014 21 (2): 177 – 184.
[7] Ilyas, A. P., K. Nirmala, E. Harris, dan T. Widiyanto. 2014. Pemanfaatan Lemna perpusilla Sebagai Pakan Kombinasi Untuk Ikan Nila (*Oreochromis niloticus*) Pada Sistem Resirkulasi. Jurnal Limnotek, 21 : (2): 193–201
[8] Santo, A.P., U. Susilo., G.E. Wijayanti. 2014. Perkembangan Oosit Induk *Osteochilus hasselti* C.V. yang Diberi Hormon Estradiol-17β dan Pakan Dengan Kadar Protein Berbeda. Scripta Biologica, 1(1): 33-42
[9] Skillicorn, P., W. Spira., W. Journey. 1993. Duckweed Aquaculture: A New Aquatic Farming System for Developing Countries. United States of America: World Bank Emena Technical Department Agriculture Division.
[10] Thayaparan, M., S. S. Iqbal, dan M. C. M. Iqbal. 2015. Phytoremediation Potential of Lemna minor for Removal of Cr (VI) in Aqueous Solution at the Optimum Nutrient Strength. OUSL Journal, 9: 97–111
[11] Aisien, F. A., O. Faleye, dan E. T. Aisien. 2010. Phytoremediation of Heavy Metals in Aqueous Solution. Leonardo Journal of Sciences, issue 17: 37–46.
[12] Shanker, A. K., C. Carlos, LT. Herminia, dan S. Avudainayagam. 2005. Chromium Toxicity in Plants. Environment International, 31: 739–753.
[13] Matvieieva, N. dan V. Dupliy. 2013. The Development of Biotechnology for Water Purification from Toxic Hexavalent Chromium by Duckweed Plants (Lemna minor L.). Dalam: Sofia (Ed.), Third National Conference with International Participation and Youth Scientific Session "Ecological Engineering and Environment Protection" (EEEP'2015), 13-14 Juni 2013, p. 79–81.
[14] Matveyeva, N., V. Dupliy, V. O. Panov. 2013. Reduction of Hexavalent Chromium by Duckweed (Lemna minor) in in vitro Culture. Hydrobiological Journal, 49 (3): 58–67.
[15] Tanuwiria, U. H., dan R. F. Christi. 2017. Pengeringan Tanaman Lemna minor terhadap Fermentabilitas dan Kecernaan In Vitro. Seminar Nasional Peternakan 3, Makassar, 18 September 2017, p. 103–111.
[16] Kristianto, A. I. dan S. Hartini. 2013. Pengaruh Padat Populasi Gulma Mata Ikan Lemna perpusilla L. dalam Proses Penyerapan Total Cr dan Cd^{2+} dari Limbah Industri Tekstil. Seminar Nasional Kimia dan Pendidikan Kimia V, Surakarta, 6 April 2013, p. 294–301.