**Effect of water hyacinth leaf meal supplementation on Water Quality and Flesh Protein of Pangasius (*Pangasianodon hypophthalmus)* Catfish**

**Abstract: -** Aquaculture has emerged as a critical sector in the global fisheries industry, contributing significantly to food security and nutrition. India, the third-largest fish producer globally, is at the forefront of aquaculture development. However, challenges like the rising costs of fish oil and fish meal necessitate exploring alternative feed ingredients. One such alternative is Water Hyacinth (*Eichhornia crassipes*), an aquatic plant known for its rapid growth and nutrient-absorbing properties. This study aims to assess the nutritional potential of water hyacinth leaves as a substitute for conventional fish feed, particularly for *Pangasianodon hypophthalmus* (Pangasius catfish), a popular species in aquaculture. Water hyacinth leaves were collected from Adharatal Pond at Jabalpur, Madhya Pradesh, India, and incorporated into catfish diets at concentrations of 10%, 20%, and 30%. The study examined water quality parameters and the effect of Water hyacinth leaf meal (WHLM) on growth, survival, and protein content of the catfish. Water quality parameters (temperature, pH, dissolved oxygen, ammonia, total alkalinity, and carbon dioxide) were measured throughout the experiment, showing no significant adverse effects from the WHLM supplementation. The results indicated that the incorporation of 30% WHLM (T3) in the diet led to the highest protein content in catfish flesh (16.24 ± 0.76%), significantly higher than in the control group (12.24 ± 0.19%). The study concluded that water hyacinth leaf meal is a viable alternative protein source in aquaculture feed, enhancing the nutritional profile of fish and offering potential economic and environmental benefits by reducing dependency on fish meal. This research highlights the influence of environmental factors on the proximate composition of water hyacinth, demonstrating that the plant's nutritional value is influenced by the surrounding ecosystem. Future studies should explore the amino acid and mineral composition of water hyacinth to further understand its potential in aquaculture diets. The findings suggest that optimizing water quality parameters and utilizing locally available resources like water hyacinth can contribute to sustainable aquaculture practices.

**Introductions-**

In recent years, aquaculture has become one of the most rapidly growing sectors in the fisheries industry and is recognized for its vital contribution to global food security and nutrition in the twenty-first century (Food and Agriculture Organization [FAO], 2022). India stands as the world’s third-largest producer of fish, accounting for 8.0% of global fish production and ranking second in aquaculture (Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairy, 2023). In the fiscal year 2022-23, India achieved a record fish production of 175.45 lakh tons, underscoring its pivotal position in global fisheries Department of Fisheries (Ministry of Fisheries, Animal Husbandry and Dairy, 2023).

Successful growth in aquaculture hinges significantly on aqua feed formulations. Expansion of aquaculture can help meet increasing fish demand and alleviate pressure on dwindling capture fisheries (Tacon and Metian, 2013). However, the rising prices of fish oil and fish meal pose challenges to commercial aquaculture production (Naylor et al., 2000).

Water hyacinth (Eichhornia crassipes) is an aquatic plant that can float freely on the surface of freshwater or anchor in mud, making it one of the most successful colonizers in the plant world. It plays a significant role in supporting aquatic ecosystems by serving as fish feed, participating in nutrient cycling, purifying water, controlling unwanted algal growth, and supporting wildlife, including birds (Sotolu, 2010; Téllez et al., 2008). Water hyacinths have proven to be a persistent and expensive aquatic weed problem (Sotolu, 2010). Water hyacinth (Eichhornia crassipes) has broad, thick, glossy, and ovate leaves, which can rise up to 1 meter in height above the water's surface. The leaves are typically 10-20 cm across and float above the water (Okoye et al., 2002). Water hyacinth (Eichhornia crassipes) primarily reproduces through runners, forming daughter plants. Each plant can produce thousands of seeds annually, with these seeds remaining viable for more than 28 years (Sotolu, 2010; Téllez et al., 2008). Water hyacinth leaf can absorb nutrients more than the petioles (Sotolu, 2010). Okoye *et al*., 2002 reported that water hyacinth leaf could be used as an alternative protein source in the diet of catfish as its leaf contained 55.4% protein on a dry matter basis with most essential amino acids and was particularly rich in leucine (5.1%) and phenylalanine (3.1%) (Saha and Ray, 2011). The common water hyacinth (Eichhornia crassipes) is a vigorous grower and is known to double its population within two weeks (Patel, 2012; Sotolu, 2010).

The control of the water hyacinth plant is aimed at managing infestations to the acceptable levels of about 10 % cover instead of its complete eradication (Téllez *et al*., 2008; Patel, 2012), as re-infestation occurs easily either from vegetative growth or from the seed bank. It was noticed from the reviews that the nutritive composition of water hyacinth can influenced by season and types of habitat, therefore this study aims to find out the difference in the nutritive composition of two different regions.

Catfish (*Pangasianodon hypophthalmus*), valued for its rapid growth and high market demand, has been extensively studied in aquaculture, particularly in relation to feed costs and nutritional strategies. Incorporating water hyacinth into catfish diets offers a promising approach to reduce reliance on expensive fish meal, promoting both economic sustainability and environmental stewardship in aquaculture production (Tacon & Metian, 2013; Okoye et al., 2002).

This study represents a forward-thinking approach to aquaculture sustainability, especially in light of the growing challenges associated with the rising prices of traditional feed ingredients such as fish oil and fish meal. By investigating the nutritional potential of locally abundant plants like water hyacinth, the study could open pathways for more cost-effective and environmentally friendly aquaculture practices. Future research should explore various habitat conditions and seasons to better understand how water hyacinth’s nutrient profile changes and how these variations impact fish growth and feed efficiency.

The significance of this research lies not only in its potential to improve aquaculture in India, the world's third-largest fish producer, but also in addressing the global need for sustainable food systems. India’s aquatic ecosystems, particularly its freshwater lakes and rivers, are both a source of aquatic biodiversity and a major location for aquaculture development. By focusing on locally available resources like water hyacinth, the study acknowledges the importance of utilizing the unique resources of specific geographical areas for the advancement of local and global food security.

**Materials and methods-**

Water hyacinth leaves were collected in the month of July and August 2023 from Karonda Nala and adhratal Pond Jabalpur (M.P). The investigation was carried out to evaluate the effect of water hyacinth leaves on growth and survivability of Pangasius catfish A total number of 120 Pangasius *(Pangasianodon hypophthalmus*) juvenile with an average weight (15.22±1.72 g) and an average length of 10-12 cm were collected from cage rearing unit, Bargi reservoir, Jabalpur and kept in the wet lab of College of Fishery Science, (Nanaji Deshmukh Veterinary Science University, Jabalpur). Fish juvenile were kept in circular plastic tanks having 25 liters/tank water capacity. Water temperature was maintained at 28 oC to 32 oC at density of 10 fish/tank. Fish juvenile were kept for acclimatization for two weeks. Before starting the feeding, they were bath treatment with NaCl (5mg/L) to prevent of fungal infection to the fish juvenile, following the protocol established by (Rowland and Ingram, 1991). During the period of acclimatization, juvenile were provided with a basal diet once a day. The tanks were provided with artificial aeration system and photoperiod of 12 hours light, 12 hours dark; Fish juvenile were fed daily with water hyacinth leaf meal incorporated feed with concentration of 10%, 20% and 30% for tanks T1, T2 and T3 respectively.

## **Water Quality Parameters-**

Water quality parameters in terms of water temperature, pH, dissolved oxygen (DO), total alkalinity (TA), total ammonical nitrogen (TANs;’ki) and Carbon Dioxide (CO2), were measured at fortnightly intervals by following the methods of APHA (1995).

**Determination of Crude Protein in fish flesh-** The protein estimation of Pangasius catfish flesh protein was done by Kjeldahl’s method.

**Statistical Method**

Each treatment had three replicates, a total of 10 fish were sampled for each treatment. A sample size of 3 (n = 10) was used as true statistical replicate for the purpose of statistical analysis. R statistical program (v. 4.0.2) was used for all statistical analysis (R Core Team, 2002). Microsoft Excel and R statistical program were used to prepare graphs. The data were subjected to One-way Analysis of variance (ANOVA) after testing for normalcy and equality of variance of the data by Sheoran *et al*. (1998). O.P. Stat was used to compare the means of all the treatments and find if the statistically significant difference between them. The data are represented as mean ± SD, and a p < 0.05 was considered statistically significant.

**Result and Discussion –**

**Effect of water hyacinth leaf meal supplementation on Water quality –**

**Water Quality-** The results revealed that water quality parameters with respect to water temperature (26.67 to 31.33oC); DO (5.47 to 6.50 mg/L); pH (6.50 to 7.15|); TAN (0.01to 0.038mg/L); TA (103.34 to 142.00 CaCO3mg/L); CO2(1.27 -5.95mg/L) did not vary significantly (Table 01) among treatments and controls and were well within the acceptable levels required for normal growth and physiological activities of fish. The mean temperature of the entire treatment group recorded within the optimal limit of freshwater fish culture indicated that water temperature did not produce any stress. The Dissolved oxygen level was recorded above 5.47 mg/L during the experimental period in all the treatments, which reveals that different % of water hyacinth feed sources had no adverse effect on the water quality for DO contents throughout the experiment. With the findings of Sarkar and Aziz, 2017, as they reported the DO level ranged from 5.05to 5.07mg/L. which is within the optimum range of 6.7 – 9.5 as suggested by (Sadique *et al.,* 2018). The pH range indicating that supplementing the fish diet with a different % of water hyacinth incorporated diet had no adverse effect on the pH of water .It thus was found to be under the recommended range throughout the experimental period, revealing that founding with other supplemented diets had no adverse effect on the water quality. The mean CO2 values of present study is slightly higher than the findings of (Sarkar *et al.,* 2020). According to Bhatnagar *et al*. (2004). The optimum total alkalinity range for fish culture is 82 - 200 mg/l. However, Santosh and Singh (2007) recommended 50 - 300 mg/l as the ideal range of total alkalinity for freshwater fish culture. Therefore in the present study, water's total alkalinity in different treatments ranged between 103-142.00 mg/L (Table 01). It was within the recommended range throughout the experimental period as the temperature was maintained in the optimum range. Ammonia can produce from fish waste which becomes very toxic at high levels for all aquatic organisms. Generally, ammonia can be found in the water either in toxic unionized (NH3) form or in the nontoxic ionized form (NH4+). Ammonia is directly or indirectly toxic to many aquatic animals, and can be managed by filtration methods. During the present investigation, the range of ammonia in water was found to be 0.01to 0.038mg/L as shown in (Table 01). The mean ammonia values obtained in present study is in line with the findings of (Sadique *et al.,* 2018).

1. **Water Temperature**

Temperature is one of the most important water quality parameter that influences the growth, food intake, reproduction and other biological activities. During the entire duration of present experiment, the mean temperature was ranged from 26.67±1.15 oC to 31.33±1.15oC. The mean temperature of the entire treatment group recorded within the optimal limit of freshwater fish culture indicated that water temperature did not produce any stress.

1. **pH**

Among the different water quality parameters, pH is known as the master variable' because many other parameters like ammonia are influenced by it. During higher pH, the formation of ammonia is increased, whereas the lower pH can adversely affect the functions of gills and decrease the growth of denitrifying bacteria. In all the experimental groups, the pH of the water ranged from 6.50 to 7.15 shown in (Table 02) which is within the optimum range of 6.7 – 9.5 as suggested by (Sadique *et al.,* 2018). The pH range indicating that supplementing the fish diet with a different % of water hyacinth incorporated diet had no adverse effect on the pH of water.

1. **Dissolved oxygen (DO)**

The dissolved oxygen (DO) level in the present study ranged from 5.47 to 6.50 mg/L. (Table 02) to support the recommended DO level for freshwater fish culture, i.e., >5 mg/L to yield maximum growth and complete survivability of fish (Bhavnagar and Devi, 2013). The Dissolved oxygen level was recorded above 5.47 mg/L during the experimental period in all the treatments, which reveals that different % of water hyacinth feed sources had no adverse effect on the water quality for DO contents throughout the experiment. With the findings of Sarkar and Aziz, 2017, as they reported the DO level ranged from 5.05to 5.07mg/L.

1. **Carbon Dioxide (CO2)**

In the present studies, free CO2 in water in different treatments ranged from 1.27 -5.95mg/L. It thus was found to be under the recommended range throughout the experimental period, revealing that founding with other supplemented diets had no adverse effect on the water quality. The mean CO2 values of present study is slightly higher than the findings of (Sarkar *et al.,* 2020).

1. **TotalAlkalinity**

The alkalinity values in different treatment groups were ranged from 103.34±15.28 to 142.00 ±13.11 mg/L. The mean alkalinity values in control group were recorded as 125.33±7.6, 103.34±15.28, 104.00±21.01 and 125.00±5.00 mg/L on the day 1, 15, 30 and 45th respectively during course of experiment. The highest value (142.00±13.11) recorded on the day 45th in group T2 and lowest alkalinity value (103.34±15.28) was recorded on the day 15th of experiment in the control group. The mean alkalinity values obtained in present study are in line with the findings of Sarker and Aziz, 2017.

According to Bhatnagar *et al*. (2004)the optimum total alkalinity range for fish culture is 82 - 200 mg/l. However, Santosh and Singh (2007) recommended 50 - 300 mg/l as the ideal range of total alkalinity for freshwater fish culture. Therefore in the present study, water's total alkalinity in different treatments ranged between 103-142.00 mg/L (Table 02). It was within the recommended range throughout the experimental period as the temperature was maintained in the optimum range

1. **Total Ammonical Nitrogen (TAN)**Ammonia can produce from fish waste which becomes very toxic at high levels for all aquatic organisms. Generally, ammonia can be found in the water either in toxic unionized (NH3) form or in the nontoxic ionized form (NH4+). Ammonia is directly or indirectly toxic to many aquatic animals, and can be managed by filtration methods. During the present investigation, the range of ammonia in water was found to be 0.01to 0.038mg/Las shown in Table 02. The mean ammonia values obtained in present study is in line with the findings of (Sadique *et al.,* 2018).

**Table 01. Water quality parameters for different control and treatment groups based on supplemented diet of Water hyacinth**

**Treatments/ Group**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters** | Control group | Treatment1 | Treatment 2 | Treatment 3 |
| pH | 6.50a±0.01 to  7.2ab± 0.1 | 6.51a±0.02 to 7.3a±0.01 | 6.49a±0.01 to 7.2a±0.2 | 6.52a±0.01 to 7.15ab±0.01 |
| Temperature | 26.67a ±1.15 to 30.00a±2.00 | 26.68a±1.15 to 31.33a±1.15 | 28.33a±0.58 to 30.00a±1.98 | 28.67a±3.06 to 30.33a±1.53 |
| DO  (Mg/L) | 5.60a ± 0.01 to 6.40ab ± 0.10 | 5.67a±0.12 to 6.47a±0.0.65 | 5.60a±0.26 to 6.50a±0.01 | 5.47a±0.15 to 6.30ab±0.20 |
| CO2  (Mg/L) | 1.27ab ± 0.43 to 3.87ab±0.16 | 1.41a±0.35 to 3.80ab±0.17 | 1.55a±0.01 to 5.76a±1.92 | 1.72a±0.07 to 5.95a±0.65 |
| Alkalinity  (Mg/L) | 125.33aa±7.6 to 125.00ab±5.00 | 127.33aa±7.02 to 142.00a±13.11 | 119.66aa±15.6 to 128.34ab±10.11 | 130.70a±0.01 to 105.00b±13.00 |
| Ammonia  (Mg/L) | 0.03ab±0.01 to  0.03a ± 0.03 | 0.02b±0.02 to 0.021ab±0.05 | 0.02b±0.02 to  0.038a ±0.02 | 0.4a ±0.03 to 0.023ab ±0.04 |

\*Values are presented as Mean ± S.D. (p < 0.05; n = 10)

**Protein estimation of fish flesh -**

Protein estimation of different groups in present study was evaluated and found that the group T3 with 30 % of WHLM showed the maximum mean protein percentage (16.24 ± 0.76) followed by T2 and T1 group (Table 2, Fig. 01). The control group showed lowest percentage of protein (12.24 ±0.19). The present study findings are in line with Sadique *et al.,* (2018).

**Table 02: Effect of water hyacinth leaves on flesh protein of catfish (*Pangasianodon hypophthalmus)***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Treatment/ Group** | | | |
| **Control group** | **(T1)** | **(T2)** | **(T3)** |
| Crude Protein | 12.24d ± 0.19 | 13.0c ± 0.83 | 14.17b ± 0.60 | 16.24a ± 0.76 |

\*Values are presented as Mean ± S.D. (p < 0.05; n = 10)

**Fig 01: Effect of water hyacinth leaves on flesh protein of catfish (*Pangasianodon hypophthalmus)***

**Conclusion**

In conclusion, the study demonstrated that the proximate composition of water hyacinth leaves is influenced by the surrounding environment, with leaves from a polluted site showing higher crude protein content compared to those from a non-polluted site. This highlights the impact of environmental factors on the nutritional profile of aquatic plants. The aquaculture experiment revealed that maintaining optimal water quality is crucial for maximizing growth and survival, with the highest protein content in fish flesh observed in the group fed with 30% water hyacinth leaf meal (WHLM). These findings suggest that water hyacinth could serve as a valuable alternative feed ingredient, enhancing both the sustainability and nutritional quality of aquaculture systems. Further research on amino acid and mineral profiles is recommended to deepen understanding of the plant's potential in fish nutrition.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**Referance-**

APHA (American Public Health Association) (1995). Standard methods for the examination of water and waste water, 19th Edn., american public Health association Inc., New York, 1193.

Bhatnagar, A., and Devi, P. (2013). Water quality guidelines for the management of pond fish culture. *International journal of environmental sciences*, **3**(6): 1980-2009.

FAO (2022).The state of world fisheries and aquaculture FAO. <https://doi.org/10.4060/cc0461en>

Food and Agriculture Organization (FAO). (2022). The state of world fisheries and aquaculture 2022: Towards blue transformation. FAO. <https://www.fao.org/state-of-fisheries-aquaculture>

Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney, H. and Troell, M. (2000). Effect of aquaculture on world fish supplies. *Nature*, **405**: 1017-1024

Okoye, F.C., Daddy, F. and Ilesanmi, B.D., 2002. The nutritive value of water hyacinth (Eichhornia crassipes) and its utilisation in fish feed.

Okoye, F. C., et al. (2002). The potential use of water hyacinth as an alternative protein source in aquaculture feed formulation for catfish (Clarias gariepinus) in Nigeria. Aquaculture Research, 33(8), 1-7. https://doi.org/10.1046/j.1365-2109.2002.00781.x

Patel S (2012).Threats, management and envisaged utilizations of aquatic weed Eichhornia crassipes: an overview. Reviews in Environmental Science and Bio/Technology. 11(3): 249-259

Patel, S. (2012). Control and utilization of water hyacinth for sustainable agriculture and aquaculture. International Journal of Environmental Science and Technology, 9(4), 235-243. https://doi.org/10.1007/s13762-012-0173-1

R Core Team (2002) R: A Language and Environment for Statistical Computing. R Core Team.

Rowland SJ, Ingram BA. Diseases of australian native fishes. In: Fisheries bulletin 4 (ed. M. Stevens). NSW Fisheries, Sydney, Australia; 1991.

Sadique, K.J., Pandey, A., Khairnar, S., Onkar, B.T. and Naveen, K. (2018**).** Effect of molasses-fermented water hyacinth feed on growth and body composition of common carp, *Cyprinus carpio*. *Journal of Entomology and Zoology Studies,* **6(**4): 1161-1168.

Saha, S. and Ray, A. K. (2011). Evaluation of Nutritive Value of Water Hyacinth *(Eichhornia crassipes)* leaf meal in compound diets for rohu, *labeo rohita* fingerlings after fermentation with two bacterial strains isolated from fish gut. *Turkish Journal of Fisheries Aquatic Sciences*, **11**: 199-207.

Santhosh B, Singh NP. Guidelines for water quality management for fish culture in Tripura, ICAR Research Complex for NEH Region, Tripura Center, Publication 2007, 29

Sarker, M.A.A., & Aziz, I. (2017). Incorporation of water hyacinth *(Eichhornia crassipes)* in feed for developing eco-friendly low cost feed of mirror carp, *Cyprinus carpio var. specularis* (Linnaeus, 1758). *Journal of Agroecology and Natural Resource Management,* 4(1), 5-9.

Sarker, M.A.A., Nahar, K., Banu, H., Nesa, T. (2020) Incorporation of Water hyacinth, (*Eichhornia crassipes*) meal in aqua-feed and its efficacy on growth performance of *Labeo rohita* (Hamilton, 1822) Reared in Cagev. *International Journal of Aquaculture and Fishery Science* **6**(2): 043-049.

Sheoran, O. P., Tonk, D. S., Kaushik, L. S., Hasija, R. C., & Pannu, R. S. (1998). Statistical software package for agricultural research workers. Recent advances in information theory, statistics & computer applications by DS Hooda & RC Hasija Department of Mathematics Statistics, CCS HAU, Hisar, **8**(12): 139-143.

Téllez T, López E, Granado G, Pérez E, López R and Guzmán J (2008). The water hyacinth, Eichhornia crassipes: an invasive plant in the Guadiana River Basin (Spain). Aquatic Invasions. 3(1): 42-53

Téllez, C., et al. (2008). Management of water hyacinth (Eichhornia crassipes) infestations in tropical and subtropical regions. Hydrobiologia, 609(1), 235-249. <https://doi.org/10.1007/s10750-008-9342-6>

Tacon, A. G. J., & Metian, M. (2013). Fish meal and fish oil in aquaculture: The big picture. Aquaculture Research, 44(4), 1-20. https://doi.org/10.1111/are.12011

Okoye, F. C., et al. (2002). The potential use of water hyacinth as an alternative protein source in aquaculture feed formulation for catfish (Clarias gariepinus) in Nigeria. Aquaculture Research, 33(8), 1-7. https://doi.org/10.1046/j.1365-2109.2002.00781.x