Utilization of Water Hyacinth (*Eichhornia crassipes*) as Fish Feed Ingredient

Dian Yuni Pratiwi1* and Aulia Andhikawati1

1Fisheries Department, Faculty of Fishery and Marine Science, Padjadjaran University, Indonesia.

ABSTRACT

A freshwater plant, water hyacinth (*Eichhornia crassipes*) is commonly found in public waters in Indonesia. Water hyacinth often experiences blooming which causes negative impacts such as lowering oxygen levels, reducing the number of fish, increasing evapotranspiration, disrupting transportation, becoming habitat for disease vectors, and others. However, water hyacinth can be used as an alternative raw material because it still contains nutrients such as carbohydrates, proteins, fats, vitamins, and minerals. Water hyacinth also has potential as an antibacterial agent because it contains secondary metabolites (alkaloids, saponins, steroid compounds, flavonoids, phenolic compounds, glycosides, and cardiac glycosides). The utilization of water hyacinth as fish feed ingredient has been shown to give positive effect on the growth of African catfish (*Clarias gariepinus*), grass carp (*Ctenopharyngodon idella*), goldfish (*Cyprinus carpio*), and Tilapia (*Oreochromis niloticus*) seeds. The use of water hyacinth as an alternative fish feed ingredient can be a solution to reduce production costs and reduce the impact of water hyacinth blooms.

Keywords: Water hyacinth; proximate analysis; secondary metabolites, fish feed.

1. INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is an aquatic plant that can be found in rivers, lakes, or ponds. This plant can grow in a variety of aquatic environmental conditions. However, optimal environmental conditions for the growth of water
hyacinth are shallow waters, cloudy waters, temperature ranges of 28-30°C and pH ranges of 6-8 [1]. Water hyacinth does not tolerate salinity above 1.6% [1]. In an environment rich in nutrients, especially Nitrogen (N) and Phosphorus (P), water hyacinth can grow rapidly, causing water hyacinth blooms. The relative growth rate of water hyacinth (RGR) can reach 7.26%/day [2].

Some areas in Indonesia that experience water hyacinth blooms include Rawa Pening in Banyubiru Village, Semarang Regency [3], Limboto Lake, Limboto District, Gorontalo [4] and Cirata Reservoir, West Java [5]. In 2016, 47% of the area of Rawa Pening was covered by water hyacinth [6] and currently, the area of water hyacinth in Rawa Pening is 70% [2]. Water hyacinth in Lake Limboto grows widely with a distribution reaching about 30% of the lake area [7]. Likewise, the Cirata reservoir is about 40-50% covered by water hyacinth [4]. This plant has been identified as one of the 100 most aggressive invasive species by The International Union for Conservation of Nature (IUCN) [8].

Water hyacinth bloom causes many losses, including silting of water bodies [6], lack of dissolved oxygen, decreased productivity of phytoplankton [9], reduced biodiversity, reduced number of fish, increased evapotranspiration [2], obstruction of water flow, transportation, reduced aesthetics [4], and can become a microhabitat for vectors of various diseases and pests [10].

However, this plant still has a lot of potential that can be utilized by humans. One of the potentials of water hyacinth is as fish feed because it contains various nutrients such as proteins, lipids, carbohydrates, vitamins and secondary metabolites. Feed is an important component in the success of fish farming because the growth rate of fish is influenced by the nutritional content of the feed. In addition, about 60% of production costs are dependent on feed costs [11].

Certain feed ingredients have a high enough price to add to the total cost of aquaculture. The existence of alternative feed ingredients at lower prices is needed for the success of aquaculture. Fish feed that utilizes local raw materials can save aquaculture production costs by 25-35% [11]. Therefore, the use of water hyacinth as a fish feed ingredient is expected to be a solution to water hyacinth blooms in various regions and also a solution on the need for cheap feed ingredients.

This review article aims to describe the nutritional content of water hyacinth, antibacterial potential and potential of water hyacinth as feed for several types of fish.

2. CHEMICAL COMPOSITION OF WATER HYACINTH (Eichhornia crassipes)

Water hyacinth contains various nutrients such as proteins, carbohydrates, lipids, minerals, vitamins and secondary metabolites [12]. The value of proximate analysis of water hyacinth can be seen in Table 1. The crude protein content in water hyacinth ranges from 3.3-56.38%. Its lipid content ranges from 0.65-10.21%. The fiber content ranges from 1.02 to 21.42% and the carbohydrate content ranges from 33.49 to 58.2%. The nutrient content is different for each part of the plant. The differences in nutrient content may also influence by habitat and season. Protein content can increase in winter and decrease in summer [13]. Proteins, lipids, and carbohydrates play an important role in obtaining energy for fish activity and growth. The protein and carbohydrate content in water hyacinth is high enough that it can be used as an alternative raw material to replace commercial fish feed raw materials. This plant also contains various kinds of amino acids (Table 2), fatty acids (Table 3), vitamins and minerals (Table 4).

3. ANTIBACTERIAL POTENTIAL OF WATER HYACINTH (Eichhornia crassipes)

Water hyacinth (E. crassipes) contains many secondary metabolites. Hossain et.al [24] reported that the ethanol extract of water hyacinth leaves and stems contained alkaloids, saponins, steroidal compounds, flavonoids, phenolic compounds, glycosides, and cardiac glycosides. In addition, Kiristos et.al [25] also found tannins and terpenoids in the ethanol extract and methanol extract of water hyacinth leaves. Phenolic compounds contained in water hyacinth include Quercetin, and Gallic acid [26], catechol, pyrogallol, vanillic, salicylic acids, syringic, resorcinol, and others [27]. Flavonoids contained in water hyacinth include apigenin, tricin, chrysoeiol, azaeleatin, gossypetin, luteolin, kaempferol, orientin, isovitexin, and others. Terpenoids contained include phytol, indole compounds and giberellins, carotene [27]. Lata and Dubey [28] have identified 6 alkaloids in
Salmonella typhi growth of leaves and stems has been shown to inhibit bacteria. Ethyl acetate extract of water hyacinth pathogens in shrimp and other pathogens in aquatic animals can inhibit the growth of Bacillus subtilis, Staphylococcus aureus, and Escherichia coli [33]. While the n-butyl alcohol extract of water hyacinth leaves has antibacterial activity against Escherichia coli, Bacillus subtilis, Bacillus cereus, Lactobacillus casei and Pseudomonas aeruginosa [34].

The ethanol and methanol extracts of water hyacinth leaves are also known to have antibacterial activity against Vibrio harveyi which causes vibrosis in shrimp [26]. Water and ethanol extracts of stolon and water hyacinth lamina also inhibit the growth of Aeromonas hydrophila which causes motile Aeromonas septicemia [35]. Table 5 shows the zones of inhibition of water hyacinth against various bacteria.

### 4. THE UTILIZATION OF WATER HYACINTH (Eichhornia crassipes) AS FISH FEED INGREDIENT

Several studies have been proven that water hyacinth can be added to fish feed and has a positive effect on growth. Provision of water hyacinth plant meal and water hyacinth leaf meal was also proven to increase the growth of African catfish (Clarias gariepinus) with a weight gain value of 14.79 g for fish fed with water hyacinth plant meal, and 19.13 g for fish fed made of water hyacinth leaf meal [19].

### Table 1. Water Hyacinth Proximate Analysis (% dry weight)

| Part of Plant | Crude Lipid | Carbohydrate | Crude Protein | Crude Fiber | Ash | Reference |
|---------------|-------------|--------------|---------------|-------------|-----|-----------|
| Leaf          | 4.11        | 33.61        | 56.38         | 1.02        | 4.88| [12]      |
| Leaf          | 2.20        | 49.98        | 8.20          | 21.42       | 18.20| [14]      |
| Whole plant   | 2.5         | 58.2         | 12.52         | 4.5         | 15.37| [15]      |
| Leaf          | 10.21       | 33.49        | 49.52         | 1.15        | 5.63| [16]      |
| Root          | -           | -            | 9.60          | 19.08       | 20.95| [17]      |
| Leaf          | -           | -            | 20.13         | 18.61       | 15.60| [17]      |
| Leaf          | 1.93        | -            | 21.97         | -           | 13.10| [18]      |
| Root          | 0.65        | -            | 3.33          | -           | 50.11| [18]      |
| Stem          | 0.98        | -            | 7.70          | -           | 21.20| [18]      |
| Leaf          | 4.70        | -            | 28.20         | 14.79       | 7.03 | [19]      |
| Whole plant   | 2.37        | -            | 24.17         | 19.62       | 11.35| [19]      |
| Leaf          | 1.56        | -            | 15.27         | 15.23       | 16.79| [20]      |
| Root          | 1.24        | -            | 6.67          | 12.15       | 39.80| [20]      |
| Whole plant   | 1.31        | -            | 7.11          | 16.90       | 24.68| [20]      |
Table 2. Amino acid content in water hyacinth leaves (dry weight)

| Amino acids     | Concentration (mg/g) | Concentration (g/100g) | Concentration (% crude protein) |
|-----------------|----------------------|------------------------|---------------------------------|
| Aspartic acid   | 31.1                 | 4.96                   | 10.21                           |
| Asparagine      | 22.3                 | -                      | -                               |
| Glutamine       | 2.23                 | -                      | -                               |
| Glycine         | 2.5                  | 3.00                   | 6.51                            |
| Tyrosine        | 3.72                 | 2.20                   | 2.92                            |
| Leucine         | 11                   | 5.01                   | 9.56                            |
| Valine          | 110                  | 2.81                   | 7.46                            |
| Phenylalanine   | 5.93                 | 3.67                   | 6.01                            |
| Threonine       | 3.68                 | 2.60                   | 5.27                            |
| Proline         | 90.5                 | 2.72                   | 5.62                            |
| Glutamic acid   | 2.2                  | 6.04                   | 7.31                            |
| Cystine         | 1.63                 | 0.72                   | 0.38                            |
| Arginine        | -                    | 3.80                   | 6.58                            |
| Histidine       | -                    | 1.10                   | 2.22                            |
| Isoleucine      | -                    | 2.29                   | 5.47                            |
| Lysine          | -                    | 3.72                   | 5.06                            |
| Methionine      | -                    | 1.34                   | 1.31                            |
| Tryptophan      | -                    | -                      | 1.42                            |
| Alanine         | -                    | 3.20                   | 6.49                            |
| Serine          | -                    | 2.52                   | 10.21                           |

Reference [15] [12] [21]

Table 3. Fatty acid content in water hyacinth (dry weight)

| Fatty acid          | Concentration [17] |
|---------------------|--------------------|
| Suberic acid        | 0.30±0.02          |
| Myristic acid       | 1.34±0.23          |
| Palmititc acid      | 16.59±2.44         |
| Margaric acid       | 3.24±0.18          |
| Petroselinc acid    | 3.25 ± 0.21        |
| Linoleic acid       | 5.28±0.35          |
| Linolenic acid      | 7.34 ± 1.02        |

Table 4. Mineral content of water hyacinth (dry weight)

| Mineral | Concentration mg/100g [14] | Concentration % [22] | Concentration % [23] |
|---------|----------------------------|----------------------|----------------------|
| Ca      | 3.25                       | 3.08                 | 2.29                 |
| Mg      | 1.35                       | 0.65                 | -                    |
| Na      | 2.69                       | -                    | -                    |
| K       | 0.47                       | 4.13                 | 2.44                 |
| P       | 0.98                       | 0.28                 | 0.53                 |
| Zn      | 1.56                       | -                    | -                    |
| FE      | 0.56                       | -                    | -                    |

Provision of water hyacinth plant meal and water hyacinth leaf meal was also proven to increase the growth of grass carp (*Ctenopharyngodon idella*) fingerlings with a weight gain value of 6.871 g for fish fed water hyacinth plant meal, and 7.136 g for fish fed water hyacinth leaf meal. While the weight gain of fish that were not given water hyacinth was 5.806 g [36]. Mukti and Oktaviani (2020) [37] conducted another study by giving 25% water hyacinth to catfish. The absolute growth of catfish fed water hyacinth was 2.78 g while the control was 2.46 g. This shows that the administration of water hyacinth can increase the growth of various types of fish compared to control.
Table 5. Zone of inhibition of water hyacinth against various bacteria

| Part of plant | Solvent         | Bacteria                          | Inhibition zone (mm) | Reference |
|---------------|-----------------|-----------------------------------|----------------------|-----------|
| Leaf          | Ethyl acetate   | *Salmonella typhi*                | 8.00                 | [24]      |
| stem          | Ethyl acetate   | *Salmonella typhi*                | 7.83                 | [24]      |
| stem          | Ethyl acetate   | *Staphylococcus aureus*           | 7.67                 | [24]      |
| Leaf          | Aqueous         | *Bacillus cereus* (mtcc 6840)     | 8                    | [32]      |
| Leaf          | Aqueous         | *Streptococcus mutans*            | 10                   | [32]      |
| Leaf          | Aqueous         | *Proteus vulgaris* (mtcc 7299)    | 20                   | [32]      |
| Leaf          | Aqueous         | *Salmonella typhi* (mtcc 3917)    | 22                   | [32]      |
| Leaf          | Aqueous         | *Bordetella bronchiseptica* (mtcc 6838) | 8 | [32]      |
| Leaf          | Ethanol         | *Bacillus subtilis*               | 11                   | [33]      |
| Leaf          | Ethanol         | *Staphylococcus epidermidis,*      | 12                   | [33]      |
| Leaf          | n-butyl alcohol | *Escherichia coli*                | 15                   | [33]      |
| Leaf          | n-butyl alcohol | *Escherichia coli*                | 22.4                 | [34]      |
| Leaf          | n-butyl alcohol | *Bacillus subtilis*               | 23.8                 | [34]      |
| Leaf          | n-butyl alcohol | *Bacillus cereus*                 | 17.7                 | [34]      |
| Leaf          | n-butyl alcohol | *Lactobacillus casei*             | 11.3                 | [34]      |
| Leaf          | n-butyl alcohol | *Pseudomonas aeruginosa*          | 15.3                 | [34]      |
| Stolon and lamina | Aqueous     | *Aeromonas hydrophila*            | 9.33                 | [35]      |
| Stolon and lamina | ethanol    | *Aeromonas hydrophila*            | 11.33                | [35]      |

However, different results were obtained on the growth performance of Nile Tilapia on supplementation with different proportions of water hyacinth. The weight gain of tilapia fed water hyacinth was lower than the control although statistically not significantly different. The final weight values of 8.52±1.96 g for fish fed 15%, 8.45±1.94 g for fish fed 30%, 8.30±1.84 g for fish fed 45% water hyacinth and 8.68±1.85 g for fish fed control diet without water hyacinth [38]. Supplementation of water hyacinth to the feed of common carp fry (Cyprinus carpio) can also increase the growth of fish, but the value is slightly lower than the control. The weight gain of fish fed control diet was 3.76 g, while 3.57 g for fish fed an additional 10% water hyacinth, 3.55 g for fish fed 20% water hyacinth, 3.31 g for fish fed 30% water hyacinth and 3.08 g for fish fed 40% water hyacinth. However, the survival rate of fish given water hyacinth was better than the control [39]. However, water hyacinth can still be used as a feed additive to reduce the cost without affecting growth rate. With the use of water hyacinth as a feed ingredient, it is hoped that it will help to reduce the cost of fish farming production [19] and can reduce water hyacinth blooms.

5. CONCLUSION

Water hyacinth (*Eichhornia crassipes*) can be used as an alternative raw material for fish feed because it has a high protein content. Fish growth and survival rate have increased. Water hyacinth also has secondary metabolites as antibacterial.

COMPETING INTERESTS

Authors have declared that no competing interests exist.
REFERENCES

1. Di Tomaso JM, Healy EA. Aquatic and riparian weeds of the West. University of California. Division of Agriculture and Natural Resources, California Weed Science Society: ANR Publications. 2003; 52-55.

2. Prasetyo S, Anggoro S, Soeprobowati TR. The Growth Rate of Water Hyacinth (Eichhornia crassipes (Mart.) Solms) in Rawapening Lake, Central Java. Journal of Ecological Engineering. 2021; 22(6):222–231 Available:https://doi.org/10.12911/22998993/13767.

3. Ningsih YW, Kurniawan T, Rahmawati A.N, Pratama RA, et.al. Persepsi Masyarakat dan Konservasi Sumber Daya Ikan. 2016. Kementerian Kelautan dan Perikanan. Ikan, Buku, Kebijakan, dan Peluang. Available: http://www.kompas.com/read/1025410/cara-kembalikan-kondisi-danau-rawapening-full&view=all.

4. Taufiqurrahman F. 2019. Eceng Gondok (Eichhornia crassipes) di Desa Banyuwangi. Kebijakan Sosok. 3: 83–90.

5. Dale YPP. Cara Kementerian PUPR Kembali Membangun Waduk Rawapening. https://bisnis.tempo.co/read/1025410/cara-kementerian-pupr-kembali-membangun-danau-rawa-pening/full?view=all.

6. Ramlan P, Indrianti MA. Analisa Potensi Eceng Gondok (Eichhornia crassipes) Danau Limboto sebagai Pakan Ternak Pomolango. Prosiding Seminar Nasional Integrated Farming System, Gorontalo 25-26 November 2018 "Pembangunan Pertanian-Peternakan-Perikanan Berkalianjuta Menuju Ketahanan Pangan Nasional". 2018.

7. Global Invasive Species Database; 2021. Available: http://www.lcngisd.org/gisd/100_worst.php.

8. Villamagna AM, Murphy BR. Ecological and socio-economic impacts of invasive water hyacinth (Eichhornia crassipes): a review. Freshwater Biology. 2010; 55 : 282–298.

9. Honlah, Segbefia AY, Appiah DO, Mensah M, Atakora PO. Effects of water hyacinth invasion on the health of the communities, and the education of children along River Tano and Abby-Tano Lagoon in Ghana. Emmanuel. Cogent Social Sciences. 2019; 5: 1619652.

10. Sivasankari B, Ravindran D. A Study on Potential Value as a Feed Ingredient in Rabbit Rations Advances in Animal and Veterinary Sciences. 2020; 3(1) : 51–59.

11. Adeyemi O. Assessment of nutritional quality of water hyacinth leaf protein concentrate. 2016. The Egyptian Journal of Aquatic Research. 2016; 42(3): 269–272.

12. Hossain ME, Sikder H, Kabir MH, and Sarma SM. Nutritive value of water hyacinth (Eichhornia Crassipes). Online J. Anim. Feed Res. 2015; 5(2): 40–44.

13. Adeyemi O. Assessment of nutritional quality of water hyacinth leaf protein concentrate. 2016. The Egyptian Journal of Aquatic Research. 2016; 42(3): 269–272.

14. Suleiman, Khadija AY, Nasiru Y, Garba AA , Alhassan M and Bello HJ. Proximate, Minerals and Anti-Nutritional Composition of Water Hyacinth (Eichhornia crassipes) Grass. Earthline Journal of Chemical Sciences. 2020; 3(1): 51–59.

15. Bahnasy SA, Kamel GA and Saaffan SE. The Nutritive Value of Aquatic Plants and their Utilization in Fish and Animal Feed. The Arab Journal of Science & Research. 2016; 18(2): 1-8.

16. Virabalin R, Kositup B, Punnapayak J. Leaf Protein Concentrate from Water Hyacinth. J. aquat. Plant Manage. 1993; 31: 2017-209.

17. Moses T, Barku VYA, Kyereme C, Odoi FNA. Composition of Water Hyacinth (Eichhornia crassipes) Plant harvested from the Volta Lake in Ghana and its Potential Value as a Feed Ingredient in Rabbit Rations Advances in Animal and Veterinary Sciences. 2021; 9(2) : 230-237.

18. Sivasankari B. Ravindran D. A Study on Chemical Analysis of Water Hyacinth (Eichhornia crassipes), Water Lettuce (Pistia stratiotes). International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization). 2016; 5 (10). DOI:10.15680/IJIRSET.2016.0510010 17566.
19. Sotolu AO, Sule O. Digestibility and Performance Of Water Hyacinth Meal In The Diets Of Catfish (Clarias gariepinus; Burchell, 1822). Tropical and Subtropical Agroecosystems. 2011;14: 245-250.

20. Okoye F, Daddy F, & Ilesanmi B. The nutritive value of water hyacinth (Eichhornia crassipes) and its utilisation in fish feed. Proceedings of the International Conference on Water Hyacinth, 27 Nov - 1 Dec 2000, New Bussa, Nigeria. 2002: 65-70.

21. Hontiveros GJS, Serrano AE. Nutritional value of water hyacinth (Eichhornia crassipes) leaf protein concentrate for aquafeeds. AACL Bioflux. 2015; 8(1). http://www.bioflux.com.ro/aa

22. Akinwande VO, Mako AA, Babayemi OJ. Biomass yield, chemical composition and the feed potential of water hyacinth (Eichhornia crassipes, Mart. Solms—Laubach) in Nigeria. Int. J. Agri Sci. 2013; 3: 659–666.

23. Poddar K, Mandal L, Banerjee GC. Studies on water hyacinth (Eichhornia crassipes)—Chemical composition of the plant and water from different habitats. Indian Vet. J. 1991;68:833–837

24. Hossain J, Khan A, Uddin MA. Antimicrobial Efficacy and Phytochemical Analysis of Three Aquatic Plant Species in Bangladesh. Bangladesh J Microbiol. 2018;35 (1):07-11

25. Kiristos TG, Kebede A, Chaithanya KK, Teka MZ. Evaluation of in vitro antibacterial potential of Eichhornia crassipes leaf extracts. Drug Invention Today. 2018;10 (5).

26. Verma VK, Prakash O, Kumar OSR, Rani KV, and Sehgal N. Water hyacinth (Eichhornia crassipes) leaves enhances disease resistance in Channa punctata from Vibrio harveyi infection. The Journal of Basic and Applied Zoology. 2021;82:6

27. Lalitha P, Sripathi SK, Jayanthi P. Secondary Metabolites of Eichhornia crassipes (Water hyacinth): A Review (1949 to 2011). Natural Product Communications. 2021;7 (9).

28. Lata N, Debay A. Quantification and identification of alkaloids of Eichhornia crassipes: the world’s worst aquatic plant. Journal of Pharmacy Research. 2010; 3(6):1229-1231.

29. Othman L, Sleiman A, Abdel-Massih RM. Antimicrobial Activity of Polyphenols and Alkaloids in Middle Eastern Plants. Front Microbiol. 2019;10:911. DOI: 10.3389/fmicb.2019.00911

30. Scalbert A. Antimicrobial properties of tannins. Phytochemistry. 1991;30(12): 3875-3883. https://doi.org/10.1016/0031-1875(91)83426-L.

31. Sumayya SS, Lubaina AS, Murugan K. Bactericidal Potentiality of Purified Terpenoid Extracts from the Selected Sea Weeds and its Mode of Action. Journal of tropical life science. 2020;10 (3):197 – 205

32. Kumar S, Kumar R, Dwivedi A, Pandey AK. In Vitro Antioxidant, Antibacterial, and Cytotoxic Activity and In Vivo Effect of Syngonium podophyllum and Eichhornia crassipes Leaf Extracts on Isoniazid Induced Oxidative Stress and Hepatic Markers. Hindawi Publishing Corporation BioMed Research International; 2014,

33. Joshi M, Kaur S. In Vitro Evaluation Of Antimicrobial Activity And Phytochemical Analysis Of Calotropis procera, Eichhornia crassipes and Datura innoxia Leaves. Asian J Pharm Clin Res. 2013; 6(5)

34. Haggag MW, Abou el Ella SM, Abouziena HF. Phytochemical analysis, antifungal, antimicrobial activities and application of Eichhornia crassipes against some plant pathogens. Planta daninha. 2017; v35:e017159560

35. Saturo JO, Maxion MT and Bartolome RM. Antibacterial activity of water hyacinth (Eichhornia crassipes) extracts against Aeromonas hydrophila in-vitro and in-vivo. Ijbps. 2019; 8(1): 65-72

36. Mahmood S, Khan N, Iqbal KJ, Ashraf M, Khalique A. Evaluation of water hyacinth (Eichhornia crassipes) supplemented diets on the growth, digestibility and histology of grass carp (Ctenopharyngodon idella) fingerlings. Journal of Applied Animal Research. 2016;46(1):24–28

37. Mukti RC, Octaviani R. Effect of plants meal from Eichhornia crassipes and Salvinia molesta on growth of Pangasius sp. e-Jurnal Rekayasa dan Teknologi Budidaya Perairan. 2020;9(1):2597-5315

38. Hailu D, Negassa A, Kebede B. Evaluation of water hyacinth (Eichhornia crassipes) as a phytogenic diet for Nile tilapia (Oreochromis niloticus). International
Journal of Fisheries and Aquatic Studies. 2020;8(1):210-218.

39. Mohapatra SB. Utilization of water hyacinth (Eichhornia crassipes) meal as partial fish protein replacement in the diet of Cyprinus carpio fry. European Journal of Experimental Biology. 2015; 5(5):31-36

© 2021 Pratiwi and Andhikawati; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/71033