Potential of Duckweed (*Lemna perpusilla* Torr) to improve the taste of Red Tilapia (*Oreochromis niloticus*)

N Mayasari*1, D S Said1, T Chrismadha1 and D Febrianti1

1 Research Center for Limnology, Indonesian Institute of Sciences, Cibinong, Indonesia

*Corresponding author: novi@limnologi.lipi.go.id

**Abstract.** *Lemna perpusilla* Torr is one of the freshwater plants of the duckweed group (family Lemnaceae) spread all over the world that found in inland waters such as ponds, ponds (embung), or paddy fields. This study aims to determine Lemna's potential use as a feed for tilapia to improve the taste. Three treatments are measured organoleptically. The N1 treatment is for tilapia fed by full Lemna. The N2 treatment is tilapia that fed 50% Lemna and 50% commercial feed. The last treatment, N3 is tilapia that given full commercial feed. Thirty-two semi-trained panelists among Research Center for Limnology workers conducted organoleptic tests on four tilapia preparations. The preparations are in the form of fried fish, whole fresh fish, fillets, and slices. The analysis of the organoleptic test is by the Kruskal Wallis test with a significant level of 10% proceed with the Dunn test if there are substantial differences. The result is that in fried tilapia, there is no real difference in organoleptic colors, odors, and preferences. However, fried tilapia found that the treatment of N2 was better than N1. The same thing also found in fresh whole fish preparations. Organoleptic colors and preferences give the result that N2 is better than N1. While in fillet preparations, the treatment of N2 and N3 compared with N1 gave significantly different effects on the organoleptic components of color and likeness. In sliced fish, significant differences found in organoleptic colors, where N1 and N2 treatments had better color appearance compared to N3. Treatment of 50% Lemna and 50% commercial feed gave better organoleptic results compared to the others.

1. **Introduction**

Tilapia is a fish that is favored by the community. The taste of the fish is delicious and the quality of the soft meat makes this fish popular. Intensive aquaculture is known to have a high density and also requires a sufficiently large amount of feed, so it requires special management efforts for optimal production. Efforts for the efficiency of feeding tilapia are carried out by providing a mixture of feed in its cultivation activities. *Lemna perpusilla* Torr is one of the freshwater plants of the duckweed group (family Lemnaceae) spread all over the world that is found in inland waters such as ponds, ponds (embung), or wet water paddy fields. Lemnaceae grows both in tropical and subtropical zones, found in all places except arctic zones [1]. These plants have many functions both as phytoremediators and as food for fish or livestock such as cattle, sheep, or ducks. The use of duckweeds group biomass for feed is not new. Various studies and developments have been carried out for animal feed, as well as these plant species have been reported to be effective for use as alternative fish feed [2, 3, 4, 5], even in Boyolali, Lemna has been used by the local community for food in tilapia aquaculture, and is claimed to provide up to 50% greater profits compared to cultivation using the commercial feed.
Duckweed has been widely consumed by many animals including fish, poultry, and ruminants, as well as by humans [6]. Duckweed is a staple food of various animals, including ducks and other poultry, fish, and muskrat [7]. For more than 35 years, it has been studied as a food source of protein for fish, poultry, ruminants, and pigs [8, 9, 10, 11]. These plants are promoted as cultured animal feed [7], including fish [12, 2, 3, 4]. This is based on the superior characteristics of the growth rate and productivity of the biomass, which tends to be high and the nutritional content suitable for animal feed needs [7].

Research Center for Limnology-LIPI has used the *Lemna perpusilla* as food for growth and survival in cultured fish such as tilapia, catfish, carp, and Nilem [5, 13, 14] and produce results which are quite good. Tilapia and catfish get Lemna feed supply to provide a tastier, savory, and crunchier food compared to those that only get pellet changing feed supply, as was regarding the evaluation activities of Social Laboratory, Deputy for Social Sciences and Humanities-Indonesian Institute of Sciences programme in 2015-2016. The same comments were also obtained from the audience at every opportunity to enjoy tilapia or catfish whose maintenance system uses *Lemna perpusilla* feed supply. However, scientific measurements of the taste of tilapia cultured using Lemna as feed is still very limited. Organoleptic tests on tilapia have been carried out on the quality of tilapia treated with temperature [15], galangal preservatives [16], matoa leaves [17], or others. This research is to show in a measurable way, are fish which in their cultivation system get Lemna feed will have better organoleptic values too. The aims of this study to determine how much public acceptance of the appearance and taste of tilapia cultured with Lemna as additional feed.

2. Methods
In this organoleptic test, red tilapia used came from three treatments. In the N1 treatment, tilapia fed with *Lemna perpusilla* Torr aquatic plants. In the N2 treatment, tilapia supplied with a composition of 50% of the FR and 50% of the commercial pellet. Whereas in the N3 treatment, tilapia were given only commercial pellet feed. The feed treatment was carried out for 3 months of maintenance. There are four types of tilapia fish preparations carried out organoleptic tests, namely in the form of fried, fresh whole, fillet, and in the way of fish slices. The maintenance system used in this study is a closed recirculation system in a round fiber tub and a connected cement pond. So that the three treatments have relatively the same water quality because of the rotation of the water in the system. Lemna, which is used as feed, is obtained from self-culture in the IMTA pond connected to the catfish culture pond. In this paper, only the organoleptic test will be discussed.

Tilapia organoleptic quality assessment was done directly after the fish harvesting. For fried fish samples, the organoleptic parameters used are color, odor, taste, and liking. As for the three other forms of tilapia preparation, the organoleptic parameters used are color, odor/aroma, texture, and acceptability. Before the assessment, the panelist was given an explanation about organoleptic score ranging scale from 1 (not attractive/not good) to 5 (very attractive/very good). Thirty-two semi-trained panelists among RC for Limnology workers rated the tilapia organoleptic test. This test was held by presenting the fish based on the treatment code, then panelists were asked to give their personal preferences in the provided score sheet.

Samples of the treated fish after being removed from the maintenance container, immediately cleaned, washed, and then placed in a plastic wrap container. For fried tilapia, fish is immediately fried without seasoning, with different oil and frying pans for each treatment. Fresh whole fish, fillets and cut shapes were placed in large containers filled with ice cubes as a cooler and preservative of fish (Figure 1). The respondents were then given an organoleptic questionnaire to fill out. Questionnaire data analysis was performed with a Kruskal-Wallis test with a significance level = 10%. If there are significant differences between treatments, it is continued by Dunn's test to see which treatments are significantly different [18].
Figure 1. Fish sample for organoleptic test: sample preparation & fried tilapia (A); fresh whole fish (B); fillets (C); and cutlet or sliced fish (D).

3. Result and Discussion
Four presentations were tested organoleptically in this study. The first serving is fried tilapia; the second is fresh whole fish, then tilapia fillets, and finally tilapia in the form of pieces. Kruskal-Wallis analysis of organoleptic colors obtained the results that differences in tilapia feed treatment did not have a significantly different effect on color in fried fish. While in the presentation of fresh whole fish, N2 treatment gives a brighter fish color compared to other treatments. As for the display of fillet fish, fish that fed with full Lemma, it's color is less attractive than N2 and N3. The colors in the slices of red tilapia samples in the N2 treatment were more interesting than the N1 and N3 treatments (Figure 2).
Figure 2. Organoleptic colour assessment in four preparation of red tilapia.

In organoleptic odor, found in the fourth serving of red tilapia, there was no difference in aroma due to differences in feed given to red tilapia. Fish that fed full Lemna, 50% Lemna: 50% commercial feed, and fish that were fed whole commercial pellet had a relatively similar odor according to panelists at a 10% significance level (Figure 3).

Figure 3. Organoleptic odor assessment in four preparation of red tilapia.
At the presentation of fried tilapia, the fish was tasted by the panelists and then scored the panelist’s level of preference. Fish were treated without seasoning and cooked in a separate pan on fried tilapia to know the tilapia’s real taste. In the N2 treatment, the highest-scoring results obtained were significantly different from the other treatments. Whereas the texture parameters for fresh fish, fillets, and also slices of fish, feeding treatment did not give significantly different results on the texture of the fish (p > 0.10) (Figure 4).

**Figure 4.** Organoleptic taste in fried tilapia and texture assessment in three other preparation of red tilapia.

**Figure 5.** Organoleptic overall acceptability assessment in four preparation of red tilapia.
In aquaculture, the growth and quality of fish produced are closely related to the type, quality, and quantity of feed provided [19]. The utilization of various kinds of raw materials as a source of nutrients and the ability to make feed formulations will produce good quality feed [20]. The improvement of feed quality, quantity, and nutritional quality of fish is also expected to increase fish growth. Several studies have shown that the use of various types of feed raw materials from vegetable and animal sources can improve growth performance, such as increased biomass and feed conversion ratio (FCR) [21, 22] and nutrient quality in fish produced [23].

Nutritional quality and organoleptic characteristics of fish such as color, texture, odor, taste, and appearance are thought to be affected by environmental conditions of maintenance and the quality of nutrients in feed given during the maintenance process [24]. In their experiments, [25] reported that the maintenance system (monoculture and polyculture) influenced the color produced by Cirrhinus mrigala. The results of research by [23] say different things. The co-cultivation of Wolffia arrhiza (L.) with Catla, Rohu, Mrigal, Grass carp, Puntius, and Amur carp did not show significant variations in color, odor, and appearance surface of the fish's body.

In the taste category (Figure 4) for the fried tilapia sample, fish treated with N2 showed a significantly higher score than the N1 treatment. Still, they did not show any significant difference compared to the N3 treatment. [25] reported that the maintenance system influenced the taste and level of juiciness produced in C. catla fish. This difference in taste and juiciness aspects is thought to be caused by the fat content contained in artificial feed given during the maintenance (40 g kg\(^{-1}\) of the dry weight of the feed). The research results [19] showed different results where the plant-fishmeal feed and plant-by-product-based feed did not affect the organoleptic flavor of Labeo rohita. [26] also reported a similar matter where tilapia reared using L. perpussila as a phytoremediator, and feed supplementation also did not show any significant taste differences.

Appearance is the first characteristic that influences the acceptance of a product. Based on organoleptic test results, it is known that the level of acceptance (Figure 5) for fresh whole tilapia and fillet tilapia, N2 treatment showed significantly higher scores than N1 treatment. In comparison, the level of acceptability for fried and sliced tilapia showed scores that were not different in all treatments. The high level of preference is thought to be related to the high score obtained for the organoleptic aspects of color and taste. [27] state that the addition of Lemna in a culture system could help increase the brightness of maintenance media so that the penetration of light can stimulate the intensity of the fish's body color. [5] reported that the culture-derived Lemna from Lake Maninjau water has protein and fat content of 32.90% and 9.73% dry weight, respectively. Furthermore, the Lemna in [5] research used as food in tilapia Integrated Multi Trophic Aquaculture (IMTA) aquaculture activities and partially supports the development of the IMTA scheme.

4. Conclusion
Treatment of 50% Lemna and 50% commercial feed gave better organoleptic results compared to the others. The 50% Lemna treatment and 50% commercial diet give better results in the appearance color of fresh fish, fillet, and fish cutlet. The taste of fried fish in this treatment was even better than other treatments. The results of the organoleptic test in this study showed a good response to the quality of red tilapia fed with 50% Lemna and 50% pellets. Suggestions for further research are measuring the fat content in red tilapia meat so that it can show more improvement in the quality of fish meat.

Acknowledgement
The author conveys as much gratitude to all those who have helped carry out the organoleptic test of red tilapia in this study. Special thanks go to Zaenal and Sahroni, who have helped in conducting research sampling.
References

[1] Goopy J P and Murray P J 2003 A Review on the Role of Water lentils in Nutrient Reclamation and as a Source of Animal Feed Asian-Aust. J. Anim. Sci. 16(2) p 297-305

[2] Hasan M R and Chakrabarti R 2009 Use of algae and aquatic macrophytes as feed in small scale aquaculture: A review FAO Fisheries and Aquaculture Technical Paper No. 531

[3] Chrismadha T, Sulawesty F, Awalina, Mardiai Y, Mulyana E and Widoretno M R 2012 Use of Duckweed (Lemna perpusilla Torr.) for Natural Feed and Fittoremedial Agent in Aquaculture: Profit Improvement and Sustainability Enhancement Seminar Internasional ISNPINSA 2 Semarang 3–4 Oktober 2012

[4] Chrismadha T and Mulyana E 2019 Laju Konsumsi Tumbuhan Air Mata Lele (Lemna perpusilla) oleh Ikan Nila (Oreochromis sp.) dengan Padat Tebar Berbeda Limnotek Perairan darat Tropis di Indonesia 2019 26(1) p 39–46

[5] Said D S, Chrismadha T, Mayasari N and Badjoeri M 2020 Integrated multitrophic aquaculture in Maninjau Lake: converting eutrophic water into fish meal. Proc. of Tropical Limnology Symposium, Salak Heritage Hotel, Bogor 28—29 August 2019 (in press)

[6] Rusoff L L, Blakeney Jr E W, Culley Jr D D 1980 Water lentils (Lemmaceae Family): A Potential Source of Protein and Amino Acids J. Agric. Food Chem. 28 p 848-850

[7] Leng R A, Stambolie J H and Bell R 1995 Duckweed - a potential high-protein feed resource for domestic animals and fish. Livestock Research for Rural Development 7(1): http://www.cipav.org.co/lrrd/lrrd7/1/3.htm

[8] Hassan M S and Edwards P 1992 Evaluation of water lentils (Lemna perpusilla and Spirodel a polyyrhi) as feed for Nile tilapia (Oreochromis niloticus) Aquaculture 104 p 315-326

[9] Fasakin E A, Balogun A M and Fasuru B E 1999 Use of water lentils, Spirodel a polyyrhi L. Schleiden, as a protein feedstuff in practical diets for tilapia, Oreochromis niloticus L. Aquaculture Research 30 p 313-318

[10] Bairagi A, Sarkar Gosh K, Sen S K and Ray A K 2002 Water lentils (Lemna polyyrhi) leaf meal as a source of feedstuff in formulated diets for rohu (Labeo rohita Ham.) fingerlings after fermentation with fish intestinal bacterium. Bioresource Technology 85 p 17-24

[11] El-Shafai S A, El-Gohary F A, Verreth J A J, Schrama J W and Gijzen H J 2004 Apparent digestibility coefficient of water lentils (Lemna minor), fresh and dry for Nile tilapia (Oreochromis niloticus L.) Aquaculture Research 35 p 574-586

[12] Tavares F A, Rodrigues J B R, Fracalossi D M, Esquivel J and Roubach R 2008 Dried duckweed and commercial feed promote adequate growth performance of tilapia fingerlings Biotemas 21(3) p 91–97

[13] Sulawesty F, Chrismadha T and Mulyana E 2014 Laju pertumbuhan Ikan Mas (Cyprinus carpio L) dengan pemberian pakan Lemna (Lemna perpusilla TO RR,) segar pada kolam aliran tertutup Limnotek 21(2) p 177-184

[14] Larashati S, Said D S, Mayasari N, Suririsno, Hamdani A, Tanjung L R, Lukman, Ali F and Nasution S H 2015 Pengaruh kombinasi pemberian lemna dan pakan komersil terhadap pertumbuhan ikan nilem (Osteochilus vittatus) Laporan Pelaksanaan Kegiatan DIPA Tahun 2015. TU. 012. Pengembangan Teknologi Pemanfaatan Biodiversitas Perairan Darat Pusat Penelitian Limnologi-LIPI 2015 p 51

[15] Nurjannah, Setyaningsih I, Sukarno and Muldani M 2004 Kemunduran mutu ikan nila merah (Oreochromis sp.) selama penyimpanan pada suhu ruang Buletin Teknologi Hasil Perikanan VIII(1) p 37-43

[16] Hidayah R Y 2015 Pengaruh penggunaan berbagai massa lengkuas (Alpinia galanga) terhadap sifat organoleptik dan daya simpan ikan nila (Oreochromis niloticus) segar. Skripsi. Jurusan Kimia Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Negeri Semarang. p ix+97
[17] Ladja T J, Sulistijowati R and Harmain R M 2019 Mutu ikan nila (Oreochromis niloticus) segar secara organoleptik yang diawetkan menggunakan larutan daun matoa (Pometia pinnata). Jambura Fish Processing Journal 1(2) p 46-51

[18] Hollander M and Wolfe D A 1973 Nonparametric Statistical Methods (Canada: J Wiley) p 114-132

[19] Iqbal K J, Ashraf M, Abbas F, Javid A, Hafeez-ur-Rehman M, Abbas S, Rasool F, Khan N, Khan S A and Altaf M 2014 Effect of Plant-Fishmeal and Plant By-Product Based Feed on Growth, Body Composition and Organoleptic Flesh Qualities of Labeo rohita. Pakistan J. Zool. 46(1) p 253-260

[20] Khan M A, Ahmed I and Abidi S F 2004 Effect of ration size on growth, conversion efficiency and body composition of fingerling mrigal, Cirrhinus mrigala (Hamilton) Aquacult. Nutr. 10 p 47-53

[21] Jabeen S, Salim M and Akhtar P 2004 Feed conversion ratio of major carp Cirrhinus mrigala fingerlings fed on cotton seed meal, fish meal and barley. Pak. Vet. J. 24 p 42-45

[22] Saeed M, Salim M and Noreen U 2005 Study on the growth performance and feed conversion ratio of Labeo rohita fed on soybean meal, blood meal and corn gluten 60%. Pak. Vet. J., 25 p 121-126

[23] Baidya S and Patel A B 2017 Effect of Co-cultivation of Wolffia arrhiza (L.) on flesh quality and organoleptic quality of Catla, Rohu, Mrigal, Grass carp, Puntius and Amur carp Int. J. Fish. Aquat. Stud. 5(5) p 327-333

[24] Grigorakis K, Taylor K D A and Alexis M N 2003 Organoleptic and volatile aroma compounds comparison of wild and cultured gilthead sea bream (Sparus aurata): sensory differences and possible chemical basis Aquaculture 225 p 109-119

[25] Khan N, Qureshi N A, Nasir M, Rasool F and Iqbal K J 2011 Effect of artificial diet and culture systems on sensory quality of fried fish flesh of Indian Major carps Pakistan J. Zool. 43 p 1177-82

[26] Nirmala K, Widia L, Hastuti YP, Nurussalam W and Fauzi I A 2020 Physiological response and quality of red tilapia Oreochromis sp. in the culture system using lemna (Lemna perpusilla) as Phytoremediator IOP Conf. Ser.: Earth Environ. Sci. 404 012089

[27] Said D S, Supyawati W D and Noortiningsih 2005 Pengaruh jenis pakan dan kondisi cahaya terhadap penampilan warna ikan pelangi merah Glossolepis incisus jantan J. Iktiologi Indonesia 5 p 61-67