Potential of water hyacinth (*Eichhornia crassipes* (Mart.) Solms) in Rawapening lake as raw material for fish feed

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Abstract. Feed is a major factor in determining the success of aquaculture business. The quality and quantity of feeding properly will maximize the growth of fish. Various research and application of technology has been made to obtain alternative feed source so as to reduce the level of dependence on the food production industry. The eutrophication condition of Rawapening Lake has triggered the water hyacinth (*Eichhornia crassipes* (Mart.) Solms) to grow out of control. It speeds up the loss of water weeds, cover the surface of the water into the fishing area and degrade water quality. The purpose of this study was to determine the potential of water hyacinth as an alternative fish feed ingredient. In addition, it is also an effort to control the growth of water hyacinth in Rawapening Lake. The descriptive analysis method with a quantitative approach was chosen in this study. After making flour, water hyacinth has a protein content of 12.51%. Water hyacinth fine flour mixed with other ingredients including fish meal and fish feed bisamenghasilkan rice bran protein content of 30.2477%. The results of testing the stability of feed in water (Water Stability Feed) showed that the feed was destroyed after being immersed in cold water for 17 hours. The buoyancy test shows the feed is classified as a submerged type. The feed sinks because it has a specific gravity which is greater than the specific gravity of water. The feed hardness test shows that the feed is not destroyed after being given a load of 500 grams. The heavier the load that the feed can hold, it means the feed is getting harder. Protein content of 30.2477% indicates that alternative fish feed has competitive quality because it is able to meet the protein needs of cultivated fish. Especially fish cultivated in tropical areas which have lower protein requirements (20-30%).

1. Introduction
Aquaculture fish require feed which should meet the nutritional needs of cultivated fish, such as: protein, fat, carbohydrates, vitamins and minerals. The quality of feed depends on the level of nutrients required by fish. However, the matter of nutrition in quality feed is difficult to describe because of the many interactions that occur between various nutrients during and after absorption in fish digestion. Selection of raw materials depends on: nutritional ingredients; digestibility and bioavailability of fish; does not contain anti-nutrients and toxic substances; available in large quantities and relatively cheap prices. Generally, raw materials come from plant and animal materials. In general, fish cultivators have used...
raw materials and agricultural and fishery waste as additional feed. Some of these feed ingredients have to be purchased and some are available at home or easily available in the vicinity.

One source of vegetable protein can be used as fish feed ingredients is the water hyacinth (*Eichhornia crassipes* (Mart.) Solms). The water hyacinth that has become a weed in Rawapening Lake, Semarang Regency is very abundant and damages the aquatic ecosystem. Water hyacinth has a high growth rate and its presence in water can cause a blockage of drains, accelerating silting rivers and causes water to evaporate. Research on Lake Toba shows that the growth rate of water hyacinth is 4.21% [1]. The rapid growth of water hyacinth is the result of nutrient proliferation in fresh water [2]. Rawapening, which is located in Semarang Regency, is a shallow lake and in such conditions organic material is more easily absorbed for the growth of water hyacinth. The decline in the quality of Rawapening water can be seen from the uncontrolled growth of water hyacinth, even 70% of the lake surface is covered with water hyacinth in the dry season [3].

The nutritional content of water hyacinth is quite high and has the potential as animal feed. Parts of plants such as leaves can be used as animal / fish feed. Utilization of water hyacinth as a material for making fish feed is expected to increase economic value and reduce feed costs. One of the efforts to control the growth of water hyacinth in Rawapening Lake is to use it as a fish feed ingredient [4].

Although it has potential as a source of fish feed water hyacinth has drawbacks, namely: the high water content, delicate texture, containing hemicellulose is quite high and the protein is difficult to digest. It takes special treatment to process water hyacinth either mechanically, chemically or biologically or in combination. One of the efforts to increase the digestibility of water hyacinth as fish feed is to make it as flour first.

Based on the description above, the purpose of this study was to determine the potential of water hyacinth as an alternative fish feed ingredients. In addition, it is also an effort to control the growth of water hyacinth in Rawapening Lake and other waters experiencing similar problems.

2. Material and methods

The research was conducted on July 10, 2020 - August 20, 2020. The water hyacinth harvested for the 21-day-old study was planted in mesocosm in Rawapening Lake, Semurup Village, Semarang Regency. Fish feed was made three times with the same composition and manufacturing method to test the product quality standardization. Fish feed is made at home and the results are tested for quality. The equipment used for the process of making and testing the characteristics of fish feed is a meat grinder, steamer pan, sieve, napkin, basin, stove, mortar, pestle, scale, drying mat and cup. The materials needed for practical work are water hyacinth flour, bran, fish meal, tapioca flour, cassava leaf flour, water, and vitamins.

2.1. Water hyacinth sampling

The water hyacinth harvested for the study was 21 days old and was planted mesocosmally in Rawapening Lake, Semurup Village, Semarang Regency. The planting aims to obtain raw materials for making fish feed with uniform age and quality. At the time of collecting water hyacinth, it is also conducted observations of what types of fish are cultivated by the community to determine the appropriate feed composition. Fish feed samples commonly used by fish cultivators are taken to be compared with alternative fish feeds.
2.2. Experiments on making alternative fish feed

The raw material for fish feed is preferably in the form of flour in order to obtain a good feed, which is slippery, if the material used in coarse grains is in the form of hollow feed. Water hyacinth and cassava leaves are made into flour. Rice bran, fish meal, tapioca flour and vitamins do not need to be ground because the grains are already fine.

| No. | Ingredients               | Protein Content (%) | Material part in the 100 section |
|-----|---------------------------|---------------------|----------------------------------|
| 1   | Water hyacinth [4]        | 16                  | 45                               |
| 2   | Cassava Leaf Flour [6]    | 29                  | 21                               |
| 3   | Bran [7]                  | 14                  | 25                               |
| 4   | Tapioca flour [8]         | 0,5                 | 8                                |
| 5   | Trash Fish Flour [9]      | 44                  | 30                               |
| 6   | Vitamin                   | -                   | 4 gr                             |
| 7   | Water                     | -                   | Sufficiently                     |

The protein content of each portion is calculated as the following:
- Water hyacinth flour: 38X46% = 17.48%
- Cassava leaf flour: 21X29% = 6.09%
- Bran: 23X14% = 3.22%
- Tapioca flour: 9X3% = 0.27
- Trash fish meal: 5X60% = 3%
- Total Protein Content: = 30.025

The composition of the ingredients for 1000 grams of fish feed mixture
- Water hyacinth flour: 40/100X1000 = 400 grams
- Cassava leaf flour: 14/100X1000 = 140 grams
- Bran: 9/100X1000 = 90 grams
- Tapioca flour: 5/100X1000 = 50 grams
- Trash fish meal: 31/100X1000 = 310 grams
- Vitamin = 10 grams
- Water = Sufficiently

Mixing of raw materials is done manually, namely by hand by stirring and kneading repeatedly while adding enough water until the raw materials are evenly distributed or homogeneous. Can be seen homogeneous mixing of raw materials for each different color. The finished feed dough is then steamed using a steaming pan until cooked (sticky to the hands). Furthermore, the feed dough is removed and
cooled before the molding process. Steaming is carried out for sterilization, namely to kill insects, fungi and bacteria contained in feed ingredients, so that the feed can last longer and increase the stickiness of the feed.

![Step 1](image1)
![Step 2](image2)
![Step 3](image3)
![Step 4](image4)

**Figure 3. The process of making fish feed**

The dough of raw material that has been steamed and cooled is then printed using a meat grinder. The prints came out in the form of long sticks that were still wet and soft. The bar size can be adjusted by changing the hole size of the mill. The blade size is usually between 2-5 mm. The wet bars are then dried on the tray until they are half dry. The semi-dry feed is then cut into pieces 0.5-2 cm in size. Then the feed is returned to the sun to dry. During the drying process, the feed is reversed in order to obtain an even dry feed.

2.3. Physical and chemical testing

Testing the physical quality of fish feed do three repetitions to acquire data with a high degree of validity. The purpose of this stage is to determine the physical quality of the fish feed produced. Physical tests include buoyancy of fish feed, feed violence and stability in the feed water (Water Stability Feed), namely durability artificial feed underwater. In addition, physical tests can be carried out by looking at the fineness and hardness of feed raw materials which will greatly affect the cohesiveness of feed in water [10].

Stability testing of feed water (Water Stability Feed) done by soaking in cold water. The time it takes for the feed to dissolve (disintegrate) is a measure of its endurance. Buoyancy testing is carried out by dropping the feed into the water in a vessel filled with water with a depth of 20 cm. The time it takes from the time the feed hits the surface of the water until it sinks to the bottom is a measure of its buoyancy. Feed hardness testing is carried out by placing a certain load on the feed until the feed is crushed.
The chemical test aims to determine the nutritional content of artificial feed that has been prepared in accordance with the prepared feed formulation. This chemical test is carried out by sending several feed samples to be analyzed in the laboratory. The samples tested included factory-made fish feed commonly used by fish cultivators, consisting of two kinds of pellets, namely medium quality and good quality; and fish pellets as a result of experimental manufacture with a protein source in the form of water hyacinth. Analysis of the tests carried out included water content test, protein content test, fat content test, crude fiber content, and ash content.

3. Results and discussion
Proximate test results for fish feed made from water hyacinth from Rawapening Lake had a protein content of 30.2477%. The ash content was 10.2967%, 13.5559% moisture content, 28.9899% crude fiber and 6.3889% fat (Table 2). The nutritional content of water hyacinth-based feed can be said to be potential as an alternative fish feed.

| Number | Component             | Content (%) |
|--------|-----------------------|-------------|
| 1      | Crude Protein Content | 30.2477     |
| 2      | Ash Content           | 10.2967     |
| 3      | Moisture Content      | 13.5559     |
| 4      | Crude Fiber Content   | 28.9899     |
| 5      | Fat Content           | 6.3889      |

The protein content of 30.2477% fishmeal made from water hyacinth has a lower quality than factory-made feed good quality (35%), but higher than the factory-made fish feed medium quality (16%). It can be seen that the alternative fish feed made from water hyacinth (Figure 4) has competitive quality because it is able to meet the protein needs of cultivated fish. The percentage of protein in the fish's body is in the second position after water, which is between 18 - 30%. The protein content of fish feed made from water hyacinth is suitable for cultivated fish in tropical areas which have lower protein requirements (20-30%) than fish cultivated in sub-tropical areas (30-40%) [11,12]. Proteins together with other nitrogen components also form certain compounds, such as nucleic acids, enzymes, hormones, vitamins and others [13].

![Figure 4. Graph of Protein Content of Various Fish Feed.](image)
Description: Fish feed A is a factory-made fish feed with good quality, the protein content is 35%. Fish feed B is a factory-made pellet with medium quality, 16% protein content. Fish feed C is an alternative fish pellet, protein content of 30.2477%.
Protein is essential for normal tissue functioning, for maintaining and repairing body protein and for fish growth. Protein itself is essential for fish life because this substance is an active protoplasm in all living cells. Fish feed, not only the protoplasm in living cells which consists of proteins, but also the nucleus which controls the activity of cells, namely proteins. Therefore, protein is the largest part of tendons, organs, bones, and other external tissues [14].

The fat content in fish feed research results is 6.3889% has met the national standards of Indonesia (SNI). The fat content in the feed will affect the texture and taste. The ideal fish feed has a fat content ranging from 4 to 18% [15]. Fat in feed is very important for the growth of cultured fish. Fat has a role as a source of energy, maintains cell structure and membranes, is a solvent in the absorption of vitamins A, D, E and K and helps metabolic processes.

Based on the test, the result for crude fiber content of 28.9899%. The crude fiber content is still in accordance with the needs of the fish. Carbohydrates in fish feed can be in the form of crude fiber and extracts without nitrogen. Tilapia uses feed carbohydrates up to 45% for growth [16].

The ash content in fish feed was 10.2967%, which exceeded the standard nutritional requirements for fish. The ash content in the feed represents the mineral content of the feed and accordingly ranges from 3 - 7% [17]. Ash content is a collection of organic or mineral material consisting of phosphorus, zinc, magnesium, calcium and others. Minerals in feed are only needed in small amounts by fish. The presence of minerals is useful for maintaining normal body conditions and also for bone formation [18].

The water content of fish feed raw material amounted to 13.5559% water hyacinth including ideal for less than 14%. This shows the good quality of fish feed. The water content in fish feed is absolutely necessary but in small amounts. If excess moisture content will accelerate the deterioration of fish feed. Water content affects the appearance temperature, texture and taste of feed. Water content is the main parameter involved in food damage reactions such as microbial growth, hydrolysis and fat oxidation [17].

The fish feed made from water hyacinth which was tested for stability in cold water was destroyed after 17 hours of being submerged. The fine mixture of feed ingredients causes high hardness. This is due to the bonds between particles which are influenced by the process of pressing the material at the time of manufacture, which will be stronger so that fish feed with high hardness is obtained. The longer it takes to destroy fish feed, the better the quality will increase the chances of being eaten by fish [10].

The buoyancy test shows that the fish feed is classified as a submerged type. Fish feed sinks because it has a density greater than that of water (density of water = 1). The greater the specific gravity of the feed compared to the specific gravity of water, the faster the feed will sink [10]. Fish feed made with the use of water hyacinth as a raw material is suitable for use as nile fish feed. Because tilapia has demersal

| Physical Test                              | Treatment                                                                 | Result             | Conclusion                        |
|--------------------------------------------|---------------------------------------------------------------------------|-------------------|-----------------------------------|
| Feed stability in the water (Water Stability Feed) | Fish feed put into cold water until it dissolves (crushed)                 | 17 hours          | The stability of fish feed in the water is relatively long |
| Buoyancy                                   | Fish feed is put into the water in a vessel filled with water with a depth of 20 cm until it sinks | 1st minute : 20% 5th minute : 20% 10th minute : 17.5% 15th minute : 5% 20th minute : 37.5% | Classified as sinking fish feed |
| hardness                                   | Fish feed given a certain load (500 grams)                                 | Not destroyed     | More compact, smoother material   |
eating behavior, which is foraging for food at the bottom of the water. The hardness test shows that the fish feed is not destroyed after being given a load of 500 grams. The heavier the load that can be held, the harder the fish feed is. Fish feed with higher hardness is formulated from raw materials in the form of fine flour. The fineness of the raw material affects the cohesiveness and flatness when mixing it so that it produces fish feed grains with a high level of hardness.

4. Conclusion
Water hyacinth (Eichhornia crassipes (Mart.) Solms) is a freshwater weed which has the potential as a raw material for making alternative fish feed. The protein content contained was 30.2477, indicating that fish feed has competitive quality because it is able to meet the protein needs of cultivated fish. Especially fish in the tropics which have a lower protein requirement (20-30%) than fish cultivated in sub-tropical areas (30-40%).

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References
[1] Siahaan N, Soeprobowati T R and Purnaweni H 2016 Prosiding Seminar Nasional Hasil-Hasil Penelitian Pascasarjana, SPS UNDIP
[2] Soeprobowati T R, Hadisusanto S and Gell P 2012 Am. J. Environ. Sci. 8 3 334-344
[3] Bilah A 2017 ICIIES Conf.: IAIN Salatiga
[4] Ramlan P and Indrianti M A 2018 Prosiding Seminar Nasional Integrated Farming System, Gorontalo
[5] Sibarani D Y R 2018 Jurnal FPK Universitas Riau
[6] Amarwati H, Subandiyono, and Pinadoyo 2015 J. Aquac. Manag. Technol. 4 2
[7] Astawan M and Febrinda A E 2010 Jurnal Pangan 19 1
[8] Herawati E and Royani M 2019 J. Anim. Husbandry Sci. 4 1 6-13
[9] Yolanda S, Santos L and Harpeni E 2013 E-JRTBP 1 2
[10] Mudjiman A 2004 Makanan Ikan Edisi Revisi (Bogor: Penebar Swadaya)
[11] de Silva S S 1985 Aquac. Fish. Manag. 16 331-340
[12] Pandian T J 1989. Mineral requirements of fish and prawns cultureds in asia. Proc. Third asian Fish Nutrition Network Meeting 4 11-12
[13] Afrianto E and Evi L 2005 Pakan Ikan (Yogyakarta: Penerbit Kanisius)
[14] Murtidjo and Agus B 2001 Pedoman Meramu Pakan. (Yogyakarta: Penerbit Kanisius)
[15] Nasution H, Deliani W, Isnaniar and Wahyuningsih 2017 Jurnal Photon 7 2
[16] Merantica W 2007 Pemanfaatan Meat and Bone Meal (MBM) Sebagai Penganti Tepung Ikan pada Pakan Ikan Nila (Bogor: Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor)
[17] Winarno F G 2004 Kimia Pangan dan Gizi (Jakarta: Gramedia Pustaka Utama)
[18] Sutajaya R 2006 Pengaruh Perbedaan Kadar Protein Pakan Terhadap Kinerja Pertumbuhan Fingerlings Ikan Mas (Cyprinus carpio) (Bogor: Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor)