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Chemical analysis of the effect of the effect of the use of maggots as a source of protein on the quality of fish feed

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Abstract

Objective: The research aims to analyze the chemical content of making fish food by using maggot as a substitute for fish meal as a protein source to improve the quality of fish feed.

Material and method: The research method used was an experimental method with 4 treatments and 3 replications. Treatment A is feed consisting of 45% fish meal, 35% maggot meal, 16% corn meal, and 4% tapioca flour; treatment B is feed consisting of 50% fish meal, 30% maggot meal, 16% corn flour, and 4% tapioca flour; treatment C is feed consisting of 55% fish meal, 25% maggot meal, 16% corn flour, and 4% tapioca flour; and control treatment (k) is feed consisting of 0% fish meal, 50% maggot flour, 16% corn flour, and 4% tapioca flour.

Results: The results of the research show that the overall water content of the feed produced is low. Regarding protein content, the highest protein content was in the control treatment. The use of maggot flour in feed has the lowest ash content. Regarding fat content, the higher the dose of maggot flour, the lower the fat content of the fish feed. All treatments tested had a lower carbohydrate content than the control treatment.

Conclusion: The use of maggot meal as a substitute for fish meal in this research for making fish feed can support chemical feed quality, which contains water, protein, fat, ash, and carbohydrates according to fish needs.

Keywords: Pakan; Maggot; Kimia; Protein; Kualitas pakan

1. Introduction

Fish farming activities cannot be separated from the feed component, which is one of the factors supporting the development of goldfish farming businesses. The availability of food will affect the growth and survival of fish cultivation; in fish farming, businesses require sufficient feed for growth (Djissou et al., 2016; Ngatung et al., 2017). Feed is an important element in the development of cultivation activities that support the growth and survival of fish. Feed in cultivation activities generally uses commercial feed, which consumes around 60–70% of the total production costs incurred (Arief et al., 2014).

Feed is one of the most important factors in increasing the growth and development of cultivated biota. Good feed that has high nutrition has an important role as a source of energy for body maintenance, growth, and reproduction. Feed that has good nutritional and physical quality is the key to achieving production and economic goals for fish farmers. Therefore, the nutrients contained in the feed must be truly controlled and meet the needs of the fish (Gunawan and Khalil, 2015).

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The need for feed is quite important considering its role in the productivity of cultivation businesses (Anwar et al., 2024). Bactiar (2006) stated that 60–70% of cultivation businesses use commercial feed, and the price of feed purchased by cultivators continues to increase. The high price of commercial feed means that the profits from fish production obtained by farmers are not optimal, and they even suffer losses. Feed also greatly influences the growth and survival of fish. Proper feeding must pay attention to quality and quantity so that it meets the needs of the fish to be cultivated. Feed that contains high protein and nutritional value can encourage faster fish growth (Berampu et al., 2021).

One alternative feed ingredient as a source of animal protein is maggots, which are easy to breed. Maggots have the potential to be a feed source of high protein (44.26%). The protein content of maggots is higher than the content of commercial feed, ranging from 20 to 25% (Indramarwan, 2014). Maggots also function as an alternative feed for fish, which can be given in fresh form. The use of maggots can be applied to commercial feed so that production costs can be automatically reduced without reducing fish growth (Putri et al., 2019).

Fish feed is given with the aim of ensuring the survival of the fish until harvest time. Fish food is said to be of good quality if the nutritional needs of the fish contained in the food can support the fish's survival. This means that feed plays a very important role in the growth and development of fish (Nurdiana, 2024). According to Khasani (2018) in Nurdiana (2024), feed is one of the main factors that influences the growth rate and health of fish, both in terms of nutritional content and quantity. At least the nutrients that fish must contain are protein, carbohydrates, and fat. As much as 50% of the calories needed by fish come from protein. There are several sources of protein that can meet the nutritional needs of fish, namely fish meal and maggot meal.

Maggots are organisms that originate from the eggs of black soldiers (*Hermetia illucens*), which are known as rotting organisms because of their habit of consuming organic materials (Murni, 2013). Maggot (Hermatia illucens.) is a suitable ingredient as a feed substitute because it contains nutrients that can be utilized by fish (Ranggana et al., 2023).

According to Lestari et al. (2018), the nutritional content of maggots ranges from protein (45.47–47.27%) to fat (21.38%–24.55%), ash (6.39–10.31%), and crude fiber (4.41–17.57%). The use of maggots in feed formulations has been widely used with various types of fish, such as Nirvana tilapia (Prajayati et al., 2020), milkfish (Herawati et al., 2020), catfish (Rachmawati and Samidjan, 2013), and balashark fish (Priyadi, 2009).

2. Material and Method

2.1 Time and Place of Research

The research was carried out from January to March 2024. The location of this research was the Laboratory of the Department of Agricultural Technology, Faculty of Engineering, Universitas Negeri Makassar. For chemical testing, namely water content and ash content, it was carried out in the laboratory of the Department of Agricultural Technology, while chemical test analysis of protein content, carbohydrate content, and fat content was carried out at the Chemistry and Water Laboratory of the Politeknik Pertanian Negeri Pangkep.

2.2 Research Treatments

The research treatments is as shown in Table 1.

Table 1 Research Treatments

Bahan	Treatments			
	Kontrol	A	B	C
Fish flour	0%	45%	50%	55%
Maggot Flour	80%	35%	30%	25%
Cornstarch	16%	16%	16%	16%
Tapioca flour	4%	4%	4%	4%
Jumlah	100	100	100	100

2.3 Research Tools and Materials

The materials used in this research were fish meal, maggot meal, corn flour, tapioca flour, bran, fish waste, and water. Meanwhile, the tools used in this research were plastic containers, digital scales, filters, drying chambers, porcelain cups, desiccators, beakers, coconut belts, basins, aluminum foil, burettes, and Erlenmeyer.

2.4 Research Procedures

The procedure in this research consists of several stages, namely :

2.4.1 Maggot Maintenance Media Preparation Stage

Following are several preparation stages in maggot maintenance, which refer to research by Fauzi and Sari (2018) :

- Prepare all materials and tools that will be used as a maggot rearing medium consisting of commercial fish pellets, coconut fiber, bran, basin and spoon.
- Crush commercial fish pellets until they are semi-coarse, then add water little by little until the pellets become moist.
- Put commercial fish pellets into the maintenance basin.
- Put coconut fiber in the rearing basin right above the commercial fish pellets.
- Sprinkle the bran on the edge of the basin right above the commercial fish pellets

2.4.2 Maggot Pisciculture Stage

The following are several stages in maggot maintenance, which refer to research by Fauzi and Sari (2018):

- Maggots are put into a basin (pisciculture medium). The maggots that are kept are 3 days after hatching, and their size is around 5 mm.
- Provide maggot food once a day in the form of fish waste
- Add water to the maggot rearing medium little by little if the rearing medium is dry.

2.4.3 Feed Formulation and Making Stage

The initial stage of feed formulation is preparing the materials and tools that will be used to determine the amount of ingredient composition in each feed treatment. The materials and tools used to determine the composition of ingredients in each feed treatment are scales, containers, spoons, and plastic bags. The stages of making feed, according to Prihanka & Nuwa (2018), are:

- First, prepare the tools and materials that will be used in making feed
- Put maggot flour, corn flour and fish meal into a container according to the specified ratio
- Mix all the ingredients until evenly mixed, pour in the water little by little until smooth
- Pour water into a container containing tapioca flour according to the specified ratio
- Heat the tapioca flour solution until the temperature reaches 100°C (boiling), then stir until cooked (forms gel).
- Add the binder gel/adhesive made from tapioca flour into the feed mixture, then stir until evenly mixed and smooth.
- Insert it into the pellet printer little by little
- If the feed that comes out of the pellet press is shaped like crumbles/pellets, then the feed is ready to be dried

2.4.4 Feed Drying Stage

The stages of feed drying according to Prihanka & Nuwa (2018) are:

- The finished pellets are spread over the gutter or winnowing covered with sacks or plastic bags.
- Cover the gutter or winch with a tool that is heavy enough to prevent the feed from being reached by insects.
- Place it in direct sunlight or in a drying room.
- Drying is done using the wet method and the dry method. In the wet drying method, the feed is dried in a drying room for 2 weeks, after which it is continued drying using a cabinet dryer (dry method drying) for 30 minutes at a temperature of 70^{o}C.

2.5 Data Collection Technique

The data collection technique used in this research is by systematically observing and recording research subjects. Data was collected through several tests, namely chemical tests, which included a water content test, a protein content test, an ash content test, a fat content test, and a carbohydrate content test. Meanwhile, physical tests include the feed color test, feed solubility test, feed attractiveness test, and feed hardness level test.

2.5.1 Water Content

The stages of water content testing (AOAC, 1995) are as follows:

- The aluminum foil cup was heated in the oven at 105°C for 20 minutes, cooled in a desiccator for 10 minutes, and then weighed.
- Next, the sample was weighed at 3 grams and placed in aluminum foil of known weight.
- Next, the sample was heated in an oven at 105°C for 3 hours
- Then the cup containing the sample was removed from the oven, cooled in a desiccator for 10 minutes, and weighed. This stage is repeated until a constant weight is achieved.
- Next, the sample was heated in an oven at 105°C for 30 minutes
- Then the cup containing the sample is removed from the oven, cooled in a desiccator for 10 minutes, and weighed. This stage is repeated until a constant weight is achieved.
- The water content is calculated as follows:

$$\text{Water Content (\%)} = \frac{B - C}{B - A} \times 100\%$$

Explanation:
A = Weight of empty cup (g)
B = Cup weight + initial sample (g)
C = Cup weight + dry sample (g)

2.5.2 Protein Content

The stages of testing protein levels (AOAC, 1995) are as follows:

- The ground material was weighed at 10 g, and after that, the sample was placed in a 50-ml beaker. Aquades are added while stirring for the homogenization process.
- Next, the ingredients are put into a 100 ml measuring flask. distilled water is added up to the tera mark
- 10 ml of sample solution is put into an Erlenmeyer, then this sample solution is added with 20 ml of distilled water, 0.4 ml of saturated K-oxalate solution (K-oxalate: water, namely 1:3), and 3 drops of PP indicator. The K-oxalate compound is a toxic compound, so you need to be careful when working and use a mask and gloves. This solution mixture was left for 2 minutes.
- The sample solution was titrated with 0.1 N NaOH solution until the color of the solution changed to pink.
- After staining, 2 ml of 40% formaldehyde solution was added, and 3 drops of PP indicator were added. Back titration was carried out with a 0.1 N NaOH solution until the color of the solution became pink again. The volume of the 0.1 N NaOH titration solution was recorded.
- A blank solution was made from 20 ml of distilled water and added to 0.4 ml of saturated K-oxalate solution, 3 drops of PP indicator, and 2 ml of 40% formaldehyde solution. This blank solution was then titrated with a 0.1 N NaOH solution until the color changed to pink.
- Formol titration is a correction titration, namely the second titration minus the blank titration. Percent nitrogen is calculated using the following formula:

$$\%\ \text{N} = \frac{\text{Formol Titration} \times \text{N (NaOH)} \times 14.008 \times \text{FP}}{\text{(Sample Weight)}} \times 100\%$$

Explanation:
Molecular weight of nitrogen = 14.008
FP = Dilution Factor
Protein is calculated using the equation: % Protein= CF × % N
Explanation:
CF = Conversion Factor

2.5.3 Ash Content

The stages of ash content testing (AOAC, 1995) are as follows:

- The cup used is preheated in the oven at 105°C for 30 minutes.
- The cup is then cooled in a desiccator to remove water vapor and the cup is weighed.
- The sample was weighed 2 g in a cup that had been dried.
- The cup containing the sample is then burned in an oven at a temperature of 550-700°C until complete combustion.
- Cool the burned sample in a desiccator and measure its weight. The ashed sample is cooled in a desiccator and weighed. Ash content is calculated using the following formula:.

$$\text{Ash Content (\%)} = \frac{C - A}{B - A} \text{x } 100\%$$

Explanation:
A = Weight of empty cup
B = Weight of cup and sample before drying
C = Weight of cup and sample after drying

2.5.4 Fat Content

The Fat Test Working Procedure (Direct Extraction Method) refers to the research of Asmariani et al. (2017), namely:

- A sample of 7-10 g was weighed and placed in a paper sleeve which was sealed and lined with cotton.
- The sample is put into a soxhlet connected to a fat flask containing dried boiling stones and its weight is determined.
- The sample is extracted using hexane (for approximately 6 hours), then the hexane is distilled and extracted.
- Fat is dried in a drying oven at 105oC.
- The fat extract is cooled and weighed (drying is repeated until a constant weight is reached). Fat content is calculated using the following equation:

$$\text{Fat Content (\%)} = \frac{\text{W2} - \text{W1}}{W} \times 100\%$$

Explanation:
W = Sample weight (g)
W_1 = Fat weight before extraction (g)
W_2 = Fat weight after extraction (g)

2.5.5 Carbohydrate Content

Carbohydrate analysis was carried out using the antrone method referring to research by Gunawan and Khalil (2015), namely:

- The feed is weighed and crushed until smooth, then put into filter paper and washed using 80% alcohol with a ratio of 1: 2.
- The filter results were collected in a blender, 200 ml of water and 2 grams of CaCo3 were added and then boiled at 100oC for 30 minutes.
- After that, cool and transfer 500 ml of measuring ash, then slowly add saturated Pb acetate until the solution is clear. Pb acetate was added to as much as 5 ml, then mixed thoroughly and filtered again using Whatman paper.
- Then 1 gram of sodium acelate was added again to precipitate all the Pb, mixed until evenly distributed and filtered again, the filtered results were put into a blender.
- The filtration results above are ready to be used to determine carbohydrates. All treatments are put into a test tube, and then an antrone solution is made with the following steps: Weigh 5 mg of antrone, then put it in a measuring flask with a flask measuring 50 ml.
- Then mixed with concentrated sulfuric acid, then 0.2 ml of standard glucose solution was taken and diluted to 100 ml in a 100 ml measuring flask.
- After that, a standard glucose solution was taken and put into 5 test tubes, which had been filled with blanks of 0.2., 0.4., 0.6., 0.8, and 1 ml of 5 mg of antrone, then put in a measuring flask with a flask measuring 50 ml.

- Then 1 ml of water was added to each test tube in the blank; after that, each test tube for both treatment and blank was added with 5 ml of antrone reaction. After that, the test tube was closed using cotton wool and heated at a temperature of 100 oC for 12 minutes (soaked in boiling water).
- After that, cool it quickly using water, then observe all the solutions in the clear-colored test tubes, put them into the spectrometer cuvette, and read the absorbance at a speed of 630 nm.

2.6 Data analysis

The data analysis method used to analyze research data is descriptive analysis to describe the effect of substitution treatments for fish meal and maggot meal as a source of protein in fish feed.

3. Results

3.1 Water Content

Figure 1 shows that the highest feed water content was in treatment B, namely 3.17% ± 0.090, followed by treatment C, namely 2.8% ± 0.256, and the treatments with the lowest water content were respectively treatment A, 2.61 ± 0.756, and control treatment, namely 2.61%. ± 0.303.

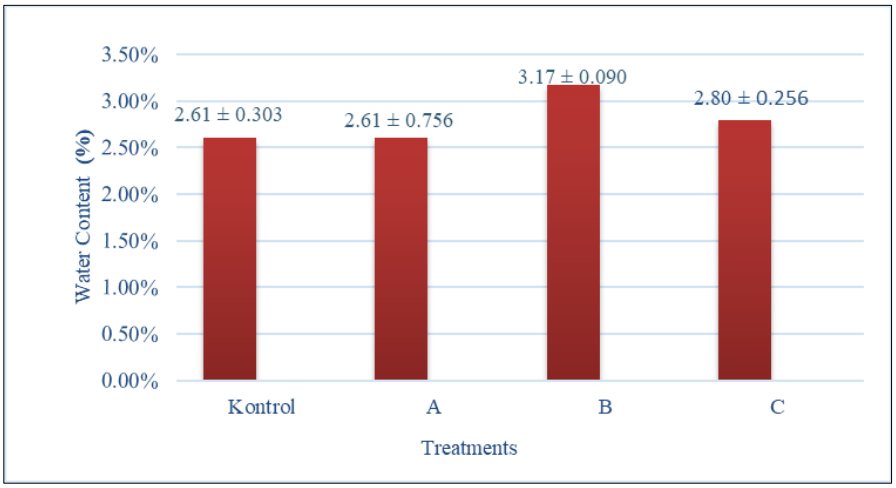

Figure 1 Feed Water Content in Various Treatments (%)

3.2 Protein Content

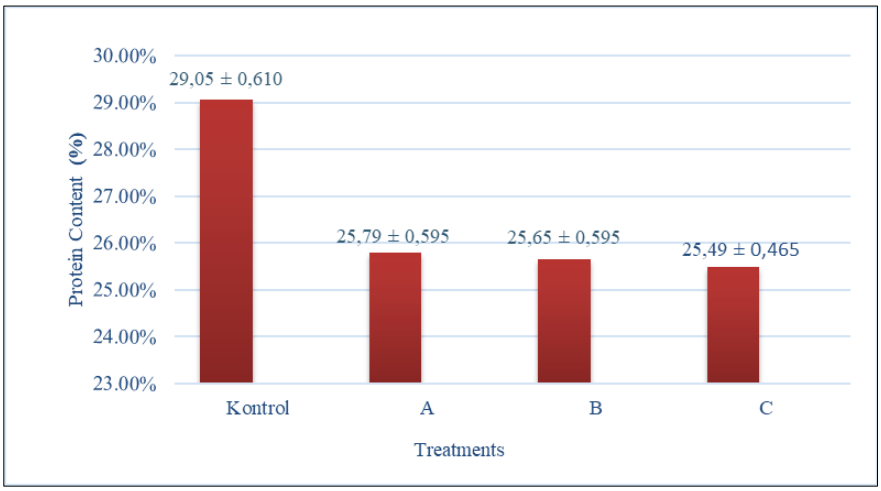

Figure 2 Feed Protein Content in Various Treatments (%)

Based on Figure 2, it shows that the highest protein content was in the control (K) treatment, namely 29.05% ± 0.610, followed by treatment A, namely 25.79% ± 0.595, treatment B, namely 25.65% ± 0.595, and the lowest was treatment C, namely 25.49% ± 0.465. Thus, it can be stated that the higher and lower the fish meal content in the treatment, the lower the protein content.

3.3 Ash Content

Figure 3 shows that the highest feed ash content was in treatment A, namely 31.17% ± 3.016, followed by treatment B, namely 29.59% ± 2.868; the control treatment was 26.96% ± 2.742; and the lowest ash content was in treatment C, namely 22. 23% ± 0.315. This means that the more maggot flour used, the lower the ash content.

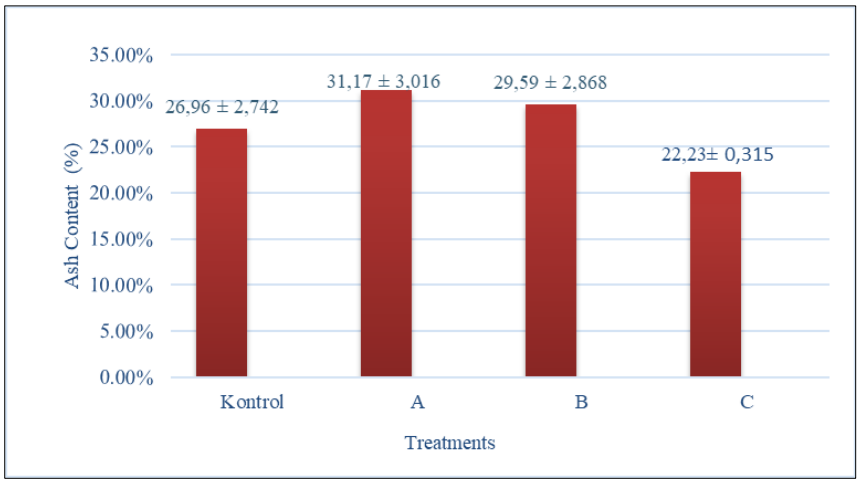

Figure 3 Feed Ash Content in Various Treatments (%)

3.4 Fat Content

Figure 4 shows that the highest feed fat content was in the control treatment, namely 8.39% ± 1.210, followed by treatment A, namely 5.02% ± 0.035, treatment B, namely 4.53% ± 0.213, and the lowest in treatment C, namely 4.36% ± 1.120. Thus, it can be stated that the higher the dose of maggot flour, the lower the fat content of the fish feed.

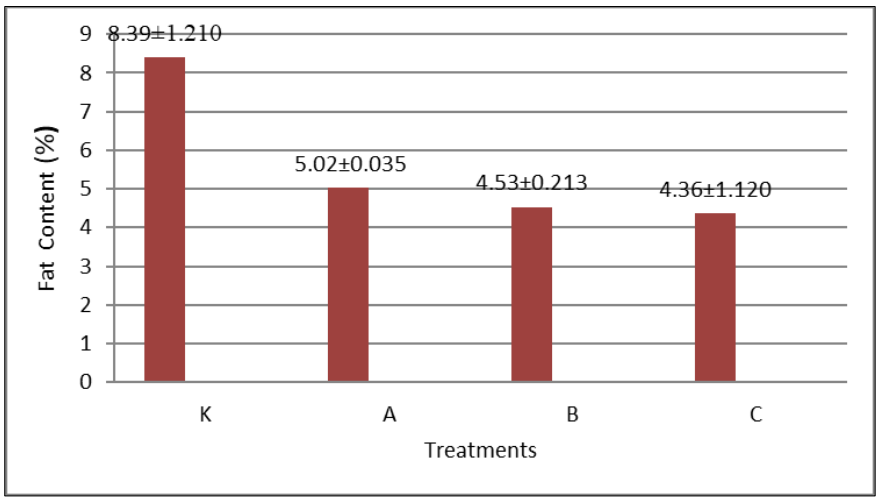

Figure 4 Fat content of feed in various treatments (%)

3.5 Carbohydrate Content

The figure shows that the highest feed carbohydrate content was obtained in the control treatment, namely 39.66% ± 15.153, followed by treatment C, namely 30.69% ± 0.185, treatment B, namely 30.01% ± 0.244, and treatment A, namely 29.03% ± 0.435. Thus, it can be stated that the treatment created has a lower carbohydrate content than the control treatment, namely feed sold commercially.

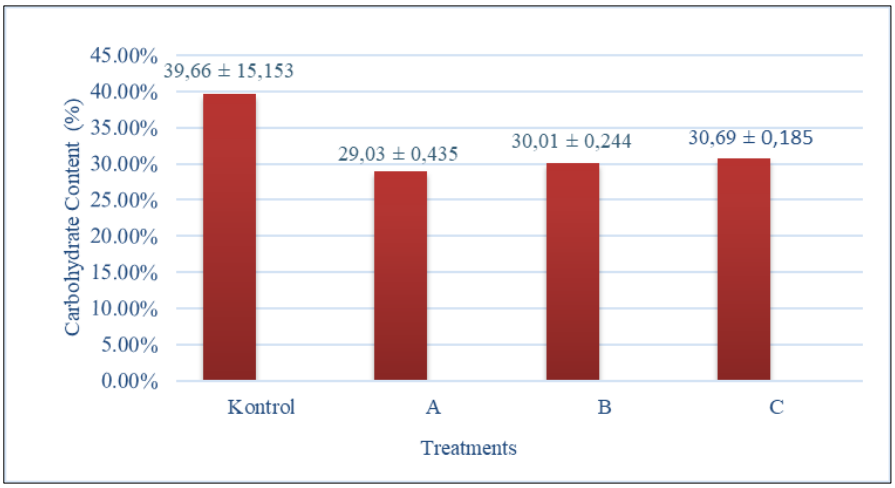

Figure 5 Carbohydrate content of feed in various treatments (%)

4. Discussion

4.1 Water content

According to research by Darsudi (2008), the water component in substances substituted for excess water is the cause of differences in water content. Apart from that, the drying time for food, storage containers, and storage techniques can also affect the water content of food (Rasyaf, 1992; Muliani et al., 2019). Alamsyah (2004) states that because raw materials have a high water content, there is a tendency for free water to be available and utilized in metabolic processes.

4.2 Protein Content

Zaenuri et al. (2013) stated that appropriate protein levels in fish feed are within the acceptable range if they are between 20 and 35%. The results of this research are in line with Ramayulis (2013), where the substitution of other ingredients with protein content can increase the total protein component of the product. Furthermore, the magnitude and quality of the protein component of the feed are influenced by the amino acids of the ingredients used (Webster and Lim, 2002). Kordi (2010) also stated that the need for food by fish is in the range of 20–60%. This is because the protein percentage component of fiber in fish feed can influence the fish growth process, such as weight and length. The protein content of fish feed is influenced by the raw materials used in making the feed. The ingredients used as a source of protein are fish meal and maggot meal. Protein can decrease systematically if the feed temperature is too high (Ariadi et al., 2023).

4.3 Ash Content

In accordance with the provisions of SNI 01-7242-2006, the ash content of fish feed is classified as not meeting the threshold, namely <12%, so that the feed that has been made in research with various ratios of raw materials is higher than the provisions of SNI 01-7242-2006, but is still suitable for use. applied. Likewise, the opinion expressed by Sutikno (2011) is that in fish feed the ash component tolerated by fish is 13%. Furthermore, the ash component in feed tends to be influenced by the mineral components in the raw materials for making fish feed so that the greater the mineral component in each ingredient, the higher the ash content value and vice versa (Murtidjo, 2001).

4.4 Fat Content

Mudjiman (2008), in his research, stated that feed has a fat content ranging from 4 to 18%. Any formulation used in research can be used. However, the amount of fat needed by fish for development also varies depending on the species. Kordi (2010) states that the fat content of fish feed should vary between 4 and 18%. Higher amounts can lead to reduced fish consumption, thereby disrupting growth. The fat content of fish feed usually reaches 6.89%. The ingredients used greatly influence the fat content of feed and the manufacturing process (Azkia, 2021).

4.5 Carbohydrate Content

Carbohydrate content is the level of reducing sugar contained in a compound. Carbohydrates are the main energy producers for humans and animals. There are two methods for determining carbohydrate levels in food, namely qualitatively and quantitatively, such as testing carbohydrates using the titration method. Several factors that influence carbohydrate levels include the type of food ingredient, processing method, and processing time (Giri & Kasa, 2019).

Carbohydrates in feed have the main function of being a source of energy for the normal life of animals. High levels of carbohydrates in fish feed can be caused by the ingredients used in making fish feed. In this case, corn flour and tapioca flour have quite high carbohydrate content, namely 77.03% and 6.99%, respectively (Kumalasari et al., 2016). Feed that contains the right carbohydrates and fats can reduce the use of protein as an energy source, which is known as the protein sparing effect. The occurrence of a protein sparing effect will reduce production and feed costs to become cheaper and reduce nitrogen waste into the environment (Nasing, 2020).

5. Conclusion

The lowest water content was in treatment A, but overall, the water content of the food produced was low. Even though the protein content was highest in the control treatment, the feed produced was still suitable for use in fish cultivation, especially freshwater fish cultivation. The more maggot flour used, the lower the ash content, although it is still higher than the provisions of SNI 01-7242-2006. Regarding fat content, it can be stated that the higher the dose of maggot flour, the lower the fat content of the fish feed. Furthermore, regarding carbohydrate content, it can be stated that all treatments have a lower carbohydrate content than the control treatment.

Compliance with ethical standards

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