International Journal of Life Science Research Archive

ISSN: 0799-6640 (Online)

Journal homepage: https://sciresjournals.com/ijlsra/

(RESEARCH ARTICLE)

The use of restaurant waste and tofu dregs as maggot feed on the physical quality of fish feed

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International Journal of Life Science Research Archive, 2026, 10(02), 083-091

Publication history: Received on 03 April 2026; revised on 12 May 2026; accepted on 15 May 2026

Article DOI: https://doi.org/10.53771/ijlsra.2026.10.2.0035

Abstract

The study aimed to determine the potential impact of household waste and tofu dregs as maggot food in fish feed production on the physical quality of the fish feed. The study used a completely randomized design consisting of four treatments, each replicated three times. The treatments used in this study were Treatment A: Maggots were fed restaurant waste, Treatment B: Maggots were fed tofu dregs, Treatment C: Maggots were fed a combination of household waste and tofu dregs, and Treatment K: Commercial feed. The feed that had been made was then tested chemically and physically to determine the quality of the fish feed. After then, the data was processed and statistically examined. The findings demonstrated that treatment B, which supplied tofu dregs as maggot food without restaurant garbage, had the highest feed hardness level. In the meantime, treatment A, which supplied maggot food in the form of restaurant waste, obtained the best feed solubility and attraction. In addition, all of the feeds were brown in hue.

Keywords: Restaurant waste; Tofu dregs; Fish feed; Physical properties of feed; Maggots

1 Introduction

The main issue in fish farming for fish farmers is fish feed, which is a strategic component that significantly determines the success of a cultivation business (Word & Adipu, 2023). Feed is the component that accounts for the largest percentage of total production costs (Handayani et al., 2019), reaching 60-70% (Jahan et al., 2006). Farmers are finding it more and more challenging to lower production costs due to rising feed prices brought on by the usage of soybean and fish meal as raw materials (Word & Adipu, 2023). Thus, in order to minimize feed costs, it is essential to supply natural feed that may be cultivated (Kusuma, 2017; Muliati, 2018).

The availability of feed, both in terms of quality and quantity, is absolutely essential for successful aquaculture (Putri et al., 2024). Fish feed must not only contain nutrients that meet the needs of farmed fish, but also be physically compact and stable in the water. A common drawback is that most of the nutritional content is met, but the feed easily sinks in water and decomposes quickly before it is fully consumed by the fish (Mulia et al., 2017). One of the obstacles in producing artificial animal protein feed using fish meal as a raw material is that fish meal remains an imported commodity (Directorate General of Aquaculture, 2017). Its availability often fluctuates with high prices (Fauzi & Sari, 2018).

Alternative feed is expected to address current feed issues, namely the ever-rising price of fish feed, the problem of aquatic environmental pollution due to the accumulation of leftover feed, and the emergence of various diseases that cause fish mortality (Fahmi et al., 2009). The relatively high price of fish feed requires innovation and alternative feed

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that is relatively inexpensive, easily available, and contains good nutrition to reduce the use of pellet feed (Murni, 2013). The problem is, fish meal is still an imported ingredient in fish feed, thus having a high price.

Another potential natural feed that can be used as an alternative is maggots or fruit insect larvae or black soldier fly larvae (Hermetia illucens). As a natural feed, maggots have a soft texture and are able to secrete cellulase enzymes (Santoso, 2019), making them suitable as a feed substitute because they contain nutrients that can be utilized by fish (Ranggana et al., 2023) and are one of the insects whose characteristics and nutrient content are starting to be widely studied (Čičková et al., 2015). They also have a function as an alternative feed for fish that can be given in fresh form (Subaima et al., 2010). Maggots can be used with commercial feed to automatically lower production costs without decreasing fish development, even if they cannot be utilized as the only feed element (Rini et al., 2015; Amandanisa & Suryadarma, 2020). According to Lestari et al. (2023), maggot flour is a feed item that can be utilized in a variety of livestock and fishing sectors.

Insects are a class of animals that can be used as an alternative source of protein and fat for feed (Marono et al., 2017). Black soldier fly maggots (larvae) can be used as an alternative raw material to replace fish meal as a feed ingredient. Maggots are organisms derived from black soldier fly eggs and are one of the decomposing organisms because they consume organic materials to grow (Silmina et al., 2011). The stages in the black soldier fly life cycle are maggot (larva), prepupa, pupa, and adult (Fahmi, 2015). From a cultivation perspective, BSF is very easy to develop on a mass production scale and does not require special equipment. The final larval stage (prepupae) can migrate independently from the growth medium, making it easy to harvest. Furthermore, this fly is not a pest and is not found in densely populated areas, making it relatively safe from a human health perspective (Li et al., 2011).

Maggots serve as an alternative feed for fish, offering fresh feed (Subamia et al., 2010). Maggot feed provides a 9% higher efficiency than other feed ingredients (Jumianto et al., 2023). Overall, the use of maggots as fish feed results in good growth (Fahmi et al., 2008). Olivier (2004) stated that black soldier fly maggots can be used to convert waste such as agricultural and livestock waste, or feces. Suciati and Faruq's (2017) research showed that maggots can be bred in tofu-dreg media. To obtain the desired maggots, cultivation efforts are necessary, and in the cultivation process, appropriate food is needed for maggots to obtain the appropriate nutritional value. Various food ingredients from maggot cultivation have been studied by several experts, including the use of tofu dregs waste (Fauzi & Sari, 2018). The nutrients contained in tofu dregs include water content of 51.63%, crude protein 21.66%, crude fiber 20.26%, crude fat 2.73%, ash content 1.21%, calcium 1.09%, phosphorus 0.88%, amino acids lysine and methionine, and sufficient B complex vitamins and metabolic energy of 2,830 kcal/kg (Efendi, 2013). Another study by Harahap (2013) stated that liquid waste containing organic pollutants is broken down by nitrifying bacteria, producing ammonia. High ammonia accumulation can damage river ecosystems and kill aquatic organisms. Similarly, research by Hartoyo and Sukardi (2007) stated that adding salted fish to the media serves to attract flies to nest in the cultivation media. Therefore, this study utilized restaurant waste and tofu dregs as manggot food to further examine the quality of the resulting feed, particularly the quality of the fish feed.

2 Materials and Methods

2.1. Research Design

The research design used in this study was a completely randomized design (CRD) consisting of four treatments, each replicated three times, resulting in 12 experimental units. The treatments used in this study were as follows:

- Treatment A: Maggots fed with restaurant waste
- Treatment B: Maggots fed with tofu dregs
- Treatment C: Maggots fed with a combination of household waste and tofu dregs
- Treatment K: Commercial feed

The experimental design in this study was to cultivate maggots and make maggot flour, fish meal, corn flour, and tapioca flour and then formulate them and make them into fish feed (pellets). Observation variables included physical tests of the fish feed, including color, hardness, solubility, and attractiveness. The treatments tested are as shown in Table 1.

Table 1 Treatment Design

Material	Treatments			
	K* (%)	A (%)	B (%)	C (%)
Maggot flour from restaurant waste as maggot food	-	23	-	18
Fish meal	-	57	57	44
Tofu dregs and maggot flour waste	-	-	23	18
Cornstarch	-	16	16	16
Tapioca flour	-	4	4	4
Amount (%)	100	100	100	100

Information: K* : Commercial feed purchased from the market

2.2. Preparation of Larvae Cultivation Media

In his research, Wardhana (2016) stated that female flies do not directly lay their eggs on the food source or cultivation medium, so they need a separate place. Dried banana leaves placed on the medium serve as a place for female flies to lay their eggs and as a shield so that the female flies are not easily disturbed while laying eggs. Making maggot cultivation media begins by mixing the media ingredients (tofu dregs, livestock manure, and salted fish) with sufficient water and is done slowly so that the media is not too wet. Stirring is necessary so that the cultivation media ingredients are well mixed. Once the cultivation media are homogeneous/mixed, cover the surface of the media with dried banana leaves (Fauzi & Sari, 2018).

2.3. Maggot Cultivation Process

The first step in the cultivation process is to put the maggot culture material in a container that has already been prepared. It should be kept moist and shielded from the sun and rain. It is anticipated that the black soldier fly egg-laying process and the development of the maggots after hatching will be positively impacted by an area with less light, shadow, and humidity. The black soldier flies, which act as broodstock, are placed in a culture medium surrounded by mosquito netting. The broodstock is obtained from someone who has previously bred black soldier flies. The cultivation process lasts for two weeks (Fauzi & Sari, 2018).

2.4. Maggot Harvesting

After two weeks, the procedure of harvesting maggots can start. It is necessary to separate the maggots and remove any leftover growing media. After combining the growing medium with water, the maggots are removed with a filter. The yield per maggot cultivation is then calculated by weighing the maggots (Fauzi & Sari, 2018).

2.5. Feed Making

The maggots used are still in the form of dry maggots, so they need to be floured. The process of making maggot flour is by grinding dried maggots with a blender to obtain maggot flour (Lestari et al., 2023). The maggot flour obtained is mixed with other ingredients to be used as fish feed based on treatment (Prihanka and Nuwa, 2018).

2.6. Feed Testing

Physical testing of feed includes: feed color, attractiveness, solubility, and hardness level.

2.7. Feed Color

One of the physical metrics used to assess pellet quality is feed color testing. Feed color is tested by putting it in a petri dish and looking at it with the unaided eye (Desmiati et al., 2022).

2.8. Feed Hardness Level

The hardness level of fish feed was measured by inserting 2 g of feed into a 1 m high PVC pipe. Then, the feed was dropped with a weight weighing 500 g. The feed that had been dropped was then sieved using a sieve with a mesh size of 0.5 mm. The hardness level was calculated as the percentage of feed that was not crushed using the sieve (Aslamyah and Karim, 2012), namely:

$$\text{Feed Hardness (\%)} = \frac{(B - A)}{B} X\ 100\%$$

Where :

A: Weight of whole pellet after dropping (g)

B: Weight of whole pellet before dropping (g)

2.9. Solubility of Feed

The time it takes for pellets to soften or dissolve in water is known as the dissolution rate, or breaking speed. A measuring cup filled with water is filled with ten identically sized pellets. Press the pellets with your index finger to see if they have softened. Every five minutes, the pellets are pressed to make this observation (Aslamsyah and Karim, 2012).

2.10. Feed Attractiveness

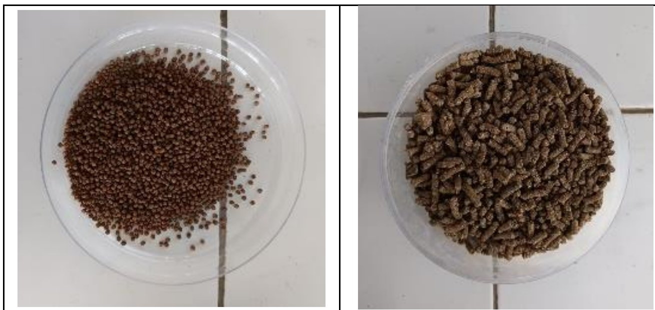
Ten grams of feed were dropped into a bowl of tilapia, with the pellets spaced thirty centimeters apart, as part of the lure test. A stopwatch was used to gauge how long it took the tilapia to eat the pellets. The lure test result, expressed in minutes, was the amount of time it took the tilapia to eat the pellets (Aslamsyah and Karim, 2012). Each bowl included five 4-cm-long tilapia (Arini et al., 2013).Statistical and descriptive analysis were the methods employed for data analysis.

3 Results and Discussion

3.1. Feed Color

The color of feed is highly dependent on the type of raw material used (Aslamyah and Karim, 2012). Cahyadi (2006) states that there are three functions of flavor: providing flavor (taste), maintaining palatability, and enhancing acceptability. According to Rusadi (2011), food is prepared based on the preferences of the fish, ensuring that fish attracted by the smell of the food are more likely to consume it, a concept commonly referred to as fish acceptance of the prepared fish food.

Figure 1 shows that all the feed produced was brown in color, and there was no significant difference in color between all treatments. The results of this study are similar to those of Idris et al. (2024), where all feed was brown. The results of a study conducted by Handayani et al. (2019), which included the addition of molasses up to 50%, caused a change in the color of the feed to become darker. The dark color is caused by the base color of the molasses, which tends to be blackish brown. Widiastuti (2013) stated that the higher the molasses absorbed into the feed ingredients, the more it will affect the color of the feed, becoming more intense. Hermawan et al. (2015) stated that the brown color in feed is the result of a carbohydrate reaction (Maillard reaction).



(K) **(A)**

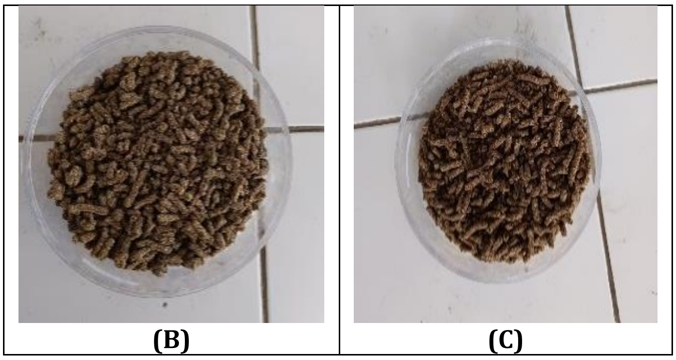


Figure 1 Feed Color

3.2. Feed Hardness Level

Figure 2 shows that the highest level of feed hardness was in treatment K, namely 74.76% ± 0.550, and the lowest was in treatment B, namely 30.83% ± 0.251. The results of the ANOVA test showed a Sig. value of 0.003, which means the treatment had an effect, and after further testing, it showed an F-hit value of 15.794. The F-Table value (0.95) was 8.745, while at the 99% level it was 27.052, which means that the treatment had a significant effect. The level of feed hardness in this study was higher than the results of the study by Idris et al. (2024), with results of 13.62-47.70%.

The hardness of feed is influenced by the water content and the feed ingredient mix used. A high water absorption index can reduce hardness because the more water absorbed, the softer the resulting product (Afrianto & Liviawaty, 2005). A fine feed mix will result in high pellet hardness. This is because the bonds between particles, influenced by the material pressing process during production, will be stronger, resulting in pellets with high hardness (Mudjiman, 2004). To obtain fish feed with good physical properties in water, it is necessary to use a binder (adhesive material) in the fish feed mixture (Saade & Aslamyah, 2009). The binder functions as a glue between all raw materials so that the feed produced is more compact and stable (Mulia et al., 2017).

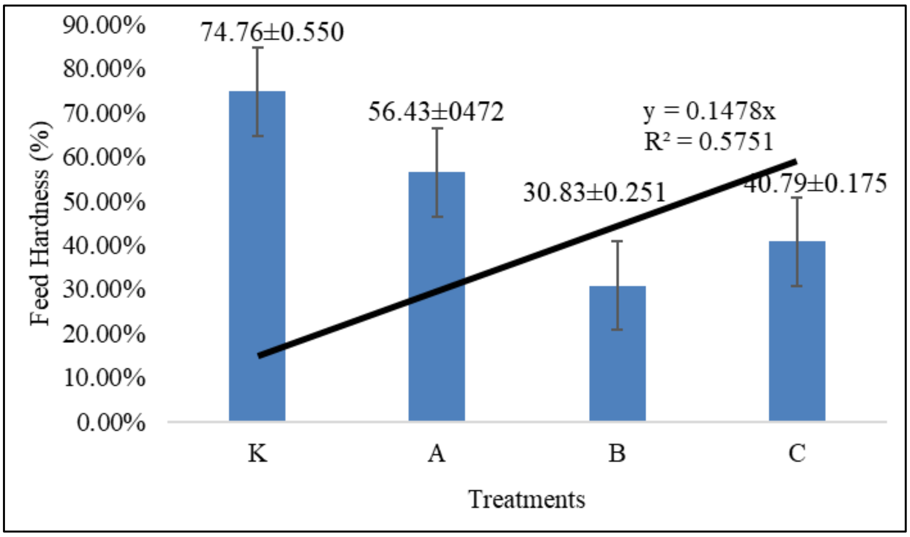


Figure 2 Feed Hardness Level (%)

Some natural ingredients that have been used include tapioca flour (Syamsu, 2007). Ingredients with high starch content can act as binding agents, for example, cassava flour, corn flour, rice flour, wheat flour, tapioca flour, molasses, cassava flour, and other ingredients (Susilawati et al., 2012). Density is the mass of particles occupying a certain volume unit (Wirakartakusumah, 1992). Density is used to determine the compactness and texture of feed. A compact feed texture will be resistant to the effects of the pressing process so that the bonds between the particles that make up the feed become very strong and the space between the particles of the feed material is not filled with air cavities (Krisnan et al., 2009). Feed density (g/cm^3) is calculated by comparing the mass (g) with the volume of feed (cm^3) as explained by the USDA (1999). Water absorption is the ability of an object to absorb water from its surroundings (Krisnan et al., 2009). Feed with high water absorption will cause the feed to become soft and disintegrate when exposed to water, so it is said to not last long in storage (Zaman, 2017).

3.3. Feed Solubility

The capacity of fish feed to float in water is one aspect influencing its quality (Mulia et al., 2017). The degree of feed resistance in water, or the amount of time it takes for the feed to soften and break down, is known as feed stability (Aslamyah and Karim, 2012). When compared to when binders are not used, the impact of binders on pellet water stability characteristics (pellet resistance in water) is comparatively considerable (Krisnan et al., 2009).

Figure 3 shows that the highest feed solubility was in treatment A, namely 149.67 minutes ± 2.516, and the lowest was in treatment B, namely 106 minutes ± 3.605. The ANOVA test results showed a Sig. value of 0.023, which means the treatment had an effect. Based on several theories, it is stated that feed solubility or feed stability in water should not be less than 2 hours or 120 minutes (Idris et al., 2024). Determination of pellet buoyancy is carried out to differentiate pellet categories, namely very good with buoyancy > 30 minutes, good in buoyancy 15-30 minutes, moderate buoyancy 5-15 minutes, and poor in buoyancy < 5 minutes (Irma, 2008).

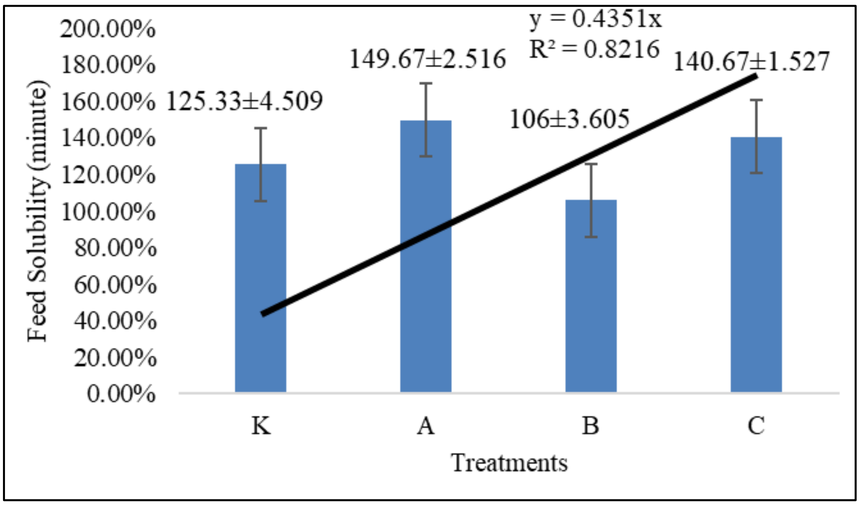


Figure 3 Feed Solubility

If the feed is too hard, the fish will have difficulty swallowing it, and if it is in the form of a paste, the pellets will easily disintegrate, causing wasted feed and water spoilage. Efficient binding materials, if very expensive, will make the final cost of feed production uneconomical (Zaman, 2017). The buoyancy of a feed determines how long the fish pellets remain above the water surface so that they can be maximally utilized by the fish when the feed is put into the water (Mulia and Maryanto, 2014). The buoyancy and integrity of the food in the water are important because food that floats and does not easily disintegrate makes it easier to observe the fish when they are full and feeding should be stopped, minimizing waste and pond water pollution due to the remaining food that is destroyed and cannot be eaten (Jauncey et al., 2007). The results of the study by Mulia et al. (2017) showed that the provision of cassava flour binder with various concentrations had a significant effect ($P < 0.05$) on the buoyancy of fish feed.

3.4. Feed Attractiveness

Feed attractiveness is closely related to the level of attractiveness or aroma of the feed. Saade et al. (2013) stated that the spicier a test food, the faster the test fish respond by approaching it for consumption. The time it takes for test animals to first eat a test pellet is expressed as the pellet's attractiveness in minutes (Saade et al., 2010). The higher the attractiveness of a feed, the faster it is consumed before it decomposes in the water.

Figure 4 shows that the lure of fish feed that has been tested on tilapia seeds shows the highest lure, namely, treatment K, at 16.67 seconds ± 1.527, and the lowest in treatment A, at 10.33 seconds ± 1.527. The results of the ANOVA test show a Sig value of 0.962 ($p > 0.05$), which means that the treatment has no effect. The results of this study are higher than the results of the study by Idris et al. (2024) with results of 7.07–17.06 seconds.

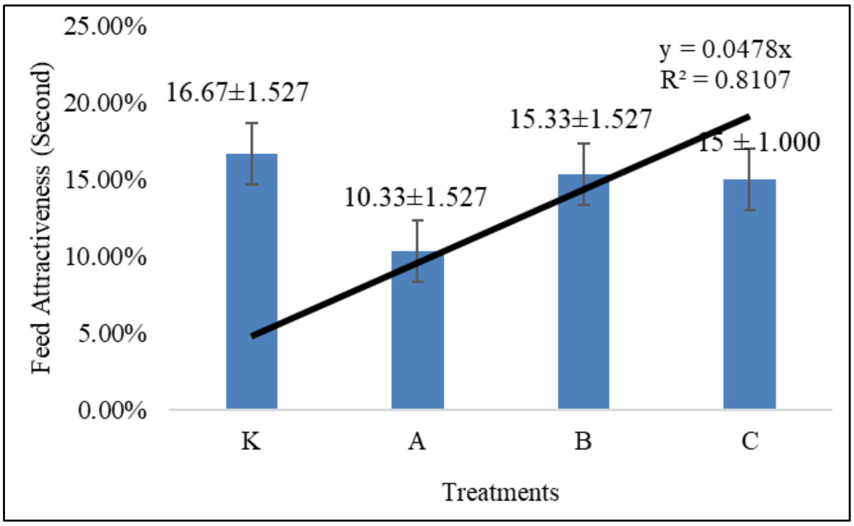


Figure 4 Feed Attraction

4 Conclusion

Based on the results of the feed test and the results of the physical test, it can be stated that the best feed hardness level is treatment B, which is providing tofu dregs as maggot food without restaurant waste, while the best solubility and attractiveness of the feed is treatment A, which is providing maggot food in the form of restaurant waste. Furthermore, regarding the color of the feed, all feeds are brown. Thus, in making fish feed, it can be recommended that household waste and tofu dregs be used as maggot food to be used as fish feed.

Compliance with ethical standards

Disclosure of conflict of interest

In this study there is no conflict of interest between the authors or researchers or other related institutions.

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