Jurnal Presipitasi
Media Komunikasi dan Pengembangan Teknik Lingkungan
e-ISSN: 2550-0023

Vol 22, No 3, 2025,
Article available at homepage presipitasi

Original Research Article

Utilization of Liquid Tofu Waste as a Fish Supplement: Impact on Fish and Economic Analysis

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Abstract

Tofu liquid waste produced by the tofu industry in rural areas is often not reprocessed and has the potential to cause pollution if left untreated, so it is necessary to utilize tofu liquid waste which is the main idea in this research. The aim of this research is to analyze the potential for utilizing tofu liquid waste into fish supplements through the fermentation process with EM4 and Nitrobacter Plus and analyzing the economic and environmental benefits of utilizing tofu liquid waste into fish supplements. This research was conducted using an experimental method using a Completely Randomized Design (CRD) with 4 treatments and 3 replications. This research result showed that the provision of fish supplements from fermented tofu liquid waste has no significant effect on absolute weight growth, absolute length growth, specific growth rate, feed conversion ratio and survival rate. Based on the results of the economic analysis, the utilization of tofu liquid waste as a fish supplement was considered economically feasible with a Benefit Cost Ratio (BCR) of 1.285, Net Present Value (NPV) of Rp. 16,320,630,763 and Return on Investment (ROI) of 48.4%.

Keywords: Tofu, liquid tofu waste, fermentation, fish supplement, economic analysis

1. Introduction

Tofu is a traditional food commonly consumed by Indonesian people. Tofu is produced by the tofu industry where this industry is still a small-medium scale industry so that waste management is still not as good as modern industry. The tofu factory industry not only produces products but also by-products, namely solid tofu waste (tofu dregs) and liquid tofu waste. The utilization of tofu dregs has been widely carried out, such as being processed into basic ingredients for making cakes, animal feed and organic fertilizer. Meanwhile, the liquid waste produced from tofu production has not been widely utilized and is directly discharged into the environment so that it has the potential to cause environmental pollution in this case water pollution (Matilda et al., 2016; Putra et al., 2022).

Liquid tofu waste comes from the remaining washing, soaking, coagulating and molding processes during tofu making (Bahri et al., 2022). The tofu industry can produce around 700 kg of tofu/day with clean water usage of around 6000 liters/day and produces liquid tofu waste of ±4000 liters/day (Sungkowo et al., 2015).

The suitability of tofu liquid waste that can be discharged into the environment is determined based on the standard quality of tofu liquid waste regulated in the Regulation of the Minister of Environment No. 5 of 2014 concerning Wastewater Quality Standards for Soybean Businesses and/or Management Activities. The parameters measured include pH, BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), and TSS (Total Suspended Solid) with respective values, namely pH 6-9, BOD of 150 mg/L, COD of 300 mg/L and TSS of 200 mg/L. Based on research conducted by Pradana et al. (2018), tofu liquid waste has a pH value of 7.48, BOD 161 mg/L, COD 666.4 mg/L and TSS 1,320 mg/L. These standard quality values do not meet the established standards. Therefore, the utilization of tofu liquid waste needs to be carried out to reduce the potential for environmental pollution caused by tofu liquid waste.

Liquid tofu waste can cause the death of living things in water including microorganisms that play an important role in regulating biological balance in water. Liquid tofu waste that is directly discharged into the environment has the potential to cause various negative impacts such as water pollution, sources of disease, increasing mosquito growth, and reducing the aesthetics of the surrounding environment (Wisudawati et al., 2019).

In addition to the negative effects caused by tofu liquid waste, there are contents of tofu liquid waste that can be used as other products. Organic substances contained in tofu liquid waste include 0.1% carbohydrates, 0.42% protein, 0.13% fat, 4.55% Fe, 1.74% phosphorus, and 98.8% water. The contents of tofu liquid waste can be used as a good supplement for fish to improve fish quality and prevent fish from getting sick (Nurman et al., 2022).

The utilization of liquid tofu waste can be combined with several other ingredients such as EM4 and nitrifying bacteria. EM4 is a brown liquid and consists of a mixture of fermentative microorganisms including lactic acid (*Lactobacillus casei*) and yeast (*Saccharomyces cerevisiae*) as much as $\geq 10^6$ CFU/mL, 50 mL of molasses and water. *Lactobacillus casei* contained in the EM4 solution plays a role in accelerating the decomposition of organic matter and inhibiting the growth of disease-causing bacteria and food-rotting bacteria. Meanwhile, *Saccharomyces cerevisiae* acts as an enzyme producer to accelerate the fermentation of organic materials. These enzymes include lactase, zymase, protease and lipase (Herdiana & Soedjono, 2021).

Based on research conducted by Siringoringo et al. (2021) on the effectiveness of tofu liquid waste treatment using EM4 in a biofilter to reduce BOD5 and COD levels, it shows that the use of EM4 is effective in reducing BOD5 levels by 76.70% on average P2 treatment (EM4 15 mg/L) and COD by 75.31% on average P2 treatment (EM4 15 mg/L). The pass rate of carp reached 93.33% on P2U1. The research concluded that the processed tofu liquid waste can be used in fish farming and is safe if directly discharged into the aquatic environment (Siringoringo et al., 2021).

One of the pollutants commonly contained in waste with a high level of toxicity is ammonia. The ammonia content in waste is one of the pollutants that is dangerous to aquatic ecosystems. Ammonia is not only produced from waste, but also from fish excretion, decomposition of organic matter, and decomposition by bacteria. Utilization of tofu liquid waste can also be done through a combination of EM4 and Nitrobacter Plus. Nitrobacter Plus is a product containing *Nitrosomonas sp*. and *Nitrobacter sp*. as much as 2×10^{13} CFU, which act as nitrifying bacteria. Nitrifying bacteria are usually used in aquaculture environments as managers of ammonia compounds, biodegradation of pond waste, and additions to fish feed (Sihite et al., 2020).

The utilization of tofu liquid waste into fish supplement through the addition of EM4 and Nitrobacter Plus is expected to reduce the potential for pollution caused by liquid tofu waste and improve economic conditions through the provision of fish supplement in improving the quality and durability of fish so that it will produce good quality fish for the market and have high selling value. In addition, fish supplement from the utilization of tofu liquid waste can be sold to the market at affordable prices, thereby improving the economy.

Based on the description, research will be conducted on Utilization of Fermented Liquid Tofu Waste with EM4 and Nitrobacter Plus as Fish Supplement: Impact on Fish Growth and Economic Analysis. The purpose of this research was analyzed the effectiveness of using liquid tofu waste fermented with EM4 and Nitrobacter Plus as a fish supplement on fish growth and survival and analyzed the economic feasibility of using tofu liquid waste as a fish supplement. The hypothesis in this research is expected that providing fish supplements from fermented tofu liquid waste, EM4 and Nitrobacter Plus can give an effect on fish growth.

2. Methods

This research was conducted in July - August 2024 at the Nano Finder Laboratory U-CoE Padjadjaran University. Sampling of tofu liquid waste was carried out at the Hikmah Round Tofu Factory, Jelat Village, Baregbeg District, Ciamis Regency (7°16'55.1"S 108°22'52.8"E). Liquid tofu waste was analyzed at the West Java Province Environmental Health Chemistry Laboratory to determine the environmental parameters of liquid tofu waste.

2.1. Tools and Materials

The tools used in this research were 1 L agro bottles, beakers, droppers, digital scales, 19 L containers (12 pieces), pH meters, TDS EC meters, DO meters HI98193, heaters, aerator stones and aerator hoses. The materials used in this research were red tilapia (*O. Niloticus*), tofu liquid waste, fisheries EM4, Nitrobacter plus, and PF-500 fish feed.

2.2. Experimental Design

This research used a laboratory-scale experimental method using a Completely Randomized Design (CRD) with 4 treatments and 3 repetitions, namely treatment control P0 (1 L of tofu liquid waste + 50 mL EM4 + 0 mg Nitrobacter Plus), P1 (1 L of tofu liquid waste + 50 mL EM4 + 1 mg Nitrobacter Plus), P2 (1 L of tofu liquid waste + 50 mL EM4 + 2 mg Nitrobacter Plus) and P3 (1 L of tofu liquid waste + 50 mL EM4 + 3 mg Nitrobacter Plus).

2.3. Procedures

2.3.1 Fermentation of Tofu Liquid Waste with EM4 and Nitrobacter Plus

The first procedure in this research was the fermentation of tofu liquid waste using EM4 and Nitrobacter Plus. Tools and materials were prepared for use during the research. The fermentation process was carried out by mixing the 3 materials used (tofu liquid waste, EM4, and Nitrobacter Plus) into a beaker and then put into a 1 L agro bottle. The fermentation process was carried out for 14 days. The supplement is controlled every day by opening the bottle cap for ± 1 minute which aims to release gas during fermentation and also smell the aroma produced from the fermentation of the supplement. The fermentation process was carried out anaerobically. The temperature during the fermentation process is at room temperature (25°C) at pH 4.0.

2.3.2 Trial of Fish Supplement from Fermented Tofu Liquid Waste

The next stage was the trial of candidate supplement from the fermentation of tofu liquid waste with EM4 and Nitrobacter Plus on red tilapia (*O. Niloticus*). The trial of fish supplements made from fermented tofu liquid waste was carried out for 30 days. A total of 120 fish were used in this research. The red tilapia used in this research weighed ±5 grams with a length of 4-6 cm. The fish came from the Nano Finder U-CoE fish pond, Padjadjaran University. The number of fish stocking density was 10 fish/container. The feed was put into a thin wall cup with the amount of feed given 3% of the fish's body weight. The feed was sprayed with fermented fish supplements that had been put into a spray bottle as much as 0.4 mL per day for each treatment. Supplement were given by spraying them evenly into the feed. The frequency of feeding was 3 times a day, namely at 09.00, 13.00 and 17.00. During the maintenance process, siphoning was carried out every 4 days. Sampling of test fish was carried out every 10 days.

2.4. Observation Data

The data observed in this research include absolute weight growth, absolute length growth, daily specific growth rate (SGR), feed conversion ratio (FCR) and survival (SR). The water quality parameters as supporting parameters observed include pH, temperature, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), ammonia, nitrite and nitrate.

2.4.1. Absolute Weight Growth

Absolute weight gain can be calculated using the following formula 1 (Rahman et al., 2022):

$$W = W_t - W_o \quad (1)$$

W (absolute fish weight growth) refers to the change in fish weight during the observation period, which is calculated by subtracting the fish weight at the initial time (W_o) from the fish weight at the final time (W_t). W_t is the weight of the fish at the end of the observation period (grams), while W_o is the weight of the fish at the beginning of the observation period (grams).

2.4.2. Absolute Length Growth

The absolute length growth can be calculated using the following formula 2 (Lucas et al., 2015):

$$L = L_t - L_o \quad (2)$$

L (absolute fish length growth) refers to the change in fish length during the observation period, which is calculated by subtracting the length of the fish at the initial time (L_o) from the length of the fish at the final time (L_t). L_t is the length of the fish at the end of the observation period (cm), while L_o is the length of the fish at the beginning of the observation period (cm).

2.4.3. Specific Growth Rate (SGR)

The daily specific growth rate (SGR) was calculated using the following formula 3 (Kusku et al., 2019):

$$SGR = (W_t - W_o)/t \times 100\% \quad (3)$$

SGR (Specific Growth Rate) is the specific growth rate of fish calculated in percentage per day. W_t is the average weight of fish at the end of the observation period (grams), W_o is the average weight of fish at the beginning of the observation period (grams), and t is the duration of cultivation time measured in days. SGR is used to measure the efficiency of fish growth during a certain period.

2.4.4. Feed Conversion Ratio (FCR)

The feed conversion ratio (FCR) was calculated using the following formula (4) (Inawati et al., 2022):

$$FCR = F/((W_t - W_o) + D) \quad (4)$$

FCR (Feed Conversion Ratio) measures the efficiency of feed utilization in fish. F refers to the total weight of feed given during the observation period (in grams), W_t is the average weight of fish at the end of the observation period (in grams), W_o is the average weight of fish at the beginning of the observation period (in grams), and D is the weight of fish that died during the observation period (in grams). FCR is used to evaluate how efficient fish are in converting feed into body weight.

2.4.5. Fish Survival Rate (SR)

Fish survival (SR) can be calculated using the following formula (5) (Nairuti et al., 2021):

$$SR = N_t/N_o \times 100\% \quad (5)$$

N_o is the number of fish at the beginning of the cultivation period, while N_t is the number of fish at the end of the cultivation period. SR is used to measure the proportion of fish that survive during the observation or cultivation period.

2.4.6. Water Quality

The water quality parameters observed were ammonia levels. Supporting water quality data include pH with ISO 10523 standard, temperature (already included in the DO meter), DO (Dissolved Oxygen) with ASTM D888 standard, TDS (Total Dissolve Solid) and EC (Electrical Conductivity) with ASTM D1125, ammonia, nitrite and nitrate. pH measurements were carried out using a pH meter. Temperature and DO measurements were carried out using a DO meter HI98193. TDS and EC measurements were carried out using a TDS and EC meter. Measurements of ammonia, nitrite and nitrate were carried out using the API Freshwater Mastertest Kit. Ammonia in water consists of two forms, namely NH_4^+ (ammonium ion) and NH_3. These two forms are collectively called Total Ammonia Nitrogen (TAN), the proportion of which depends on pH and temperature. Therefore, the ammonia levels in the maintenance media that have been analyzed with the API Freshwater Mastertest Kit need to be calculated using an ammonia calculator via the website https://www.hamzasreef.com/Contents/Calculators/FreeAmmonia.php.

2.5. Data analysis

The data obtained from the research results were analyzed using ANOVA (Analysis of Variance) analysis using the JASP (Jeffreys's Amazing Statistics Program) application. The analysis begins with a normality test to determine whether the observed data is normally distributed or not. The normality test is mandatory in parametric analysis. Data that is not normally distributed is analyzed using non-parametric analysis. If the data meets the normality assumption, it is continued with a homogeneity test to test the homogeneity of the data. The analysis is continued with ANOVA analysis of variance. If the analysis results show a significant difference, it is continued with Tukey's further test.

2.6. Economic Analysis

Analysis from the economic aspect is needed to determine the economic value of utilization of tofu waste into fish feed and supplement. The analysis carried out is the Benefit Cost Ratio (BCR), Net Present Value (NPV) and Return of Investment (ROI) (Silvia et al., 2021).

1. Benefit Cost Ratio (BCR)

   The BCR indicator can be expressed in the following formula 6 (Chriswahyudi & Darma, 2021):

   $$BCR = Benefit/Cost \tag{6}$$

   The value of the BCR indicator can be interpreted as follows:

   BCR > 1 : indicates that a business generates greater profits than the costs incurred so that the business can be carried out.

   BCR = 1 : indicates that a business is making a profit that is just enough to cover production costs.

   BCR < 1 : indicates that a business plan will not generate profits, or will generate profits over a relatively long period of time.

2. Net Present Value (NPV)

   Mathematically, the NPV calculation is formulated as follows equation 7 (Khotimah & Sutiono, 2015):

   $$NPV = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+\mathrm{i})^t} \tag{7}$$

   NPV measures the difference between the total benefits and costs discounted in each year of an investment or project. B_t is the benefit (income) obtained in year t (in IDR). C_t is the cost or expenditure incurred in year t (in IDR). i is the interest rate used to discount the value of money in year t. t is the t-year in the observation or analysis period. The feasibility indicator is: if the

NPV is positive (NPV>o) then the business is worth running. On the other hand, if the NPV is negative (NPV<o) then the business is not worth running.

3. Return on Investment (ROI)

ROI analysis can measure how much ability it has in returning the invested capital. Thus, ROI analysis can be used to measure the efficiency of capital use in a business. To calculate the amount of ROI can be obtained through the following formula 8 (Rusmayanti et al., 2022):

$$ROI = \frac{Benefit}{Investment} \; x \; 100\% \tag{8}$$

3. Results and Discussion

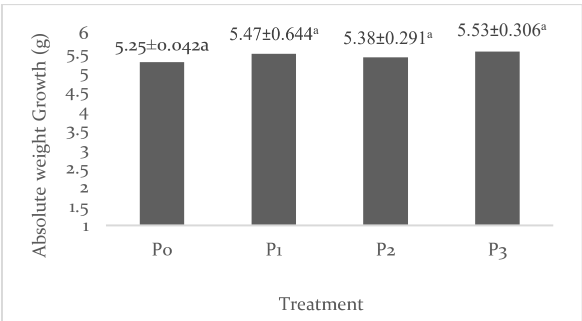
3.1 Observation Data Analysis

Table 1. Analysis of variance and non-parametric (Kruskal Wallis) analysis results

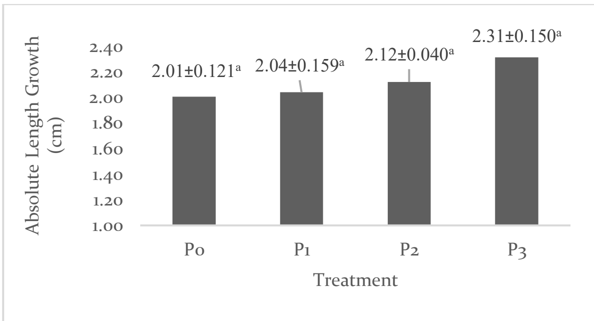
No	Variables	Significance
1	Absolute Weight Growth	0.814^{ns}
2	Absolute Length Growth	0.068^{ns}
3	Specific Growth Rate (SGR)	0.834^{ns}
4	Feed Conversion Ratio (FCR)	0.791^{ns}
5	Survival Rate (SR)	0.300^{ns}

Description:
ns : No significant effect
Source: Primary Data (2024)

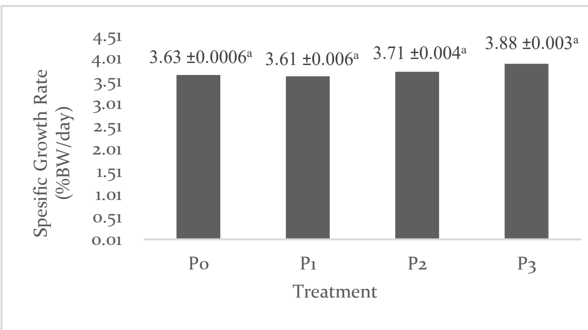
The results of the analysis of variance (ANOVA) are shown in Table 1. The results of the analysis of variance (ANOVA) showed that the use of experimental fish supplement has no significant effect on absolute weight growth, absolute length growth, specific growth rate (SGR), feed conversion ratio (FCR) and survival rate (SR) with a sig value>0.05. It can be caused by the lack of concentration of *Nitrobacter Plus* which causes insignificant differences in statistical analysis of variance.



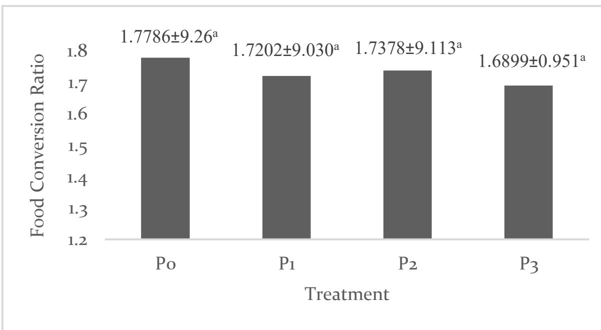
(A)



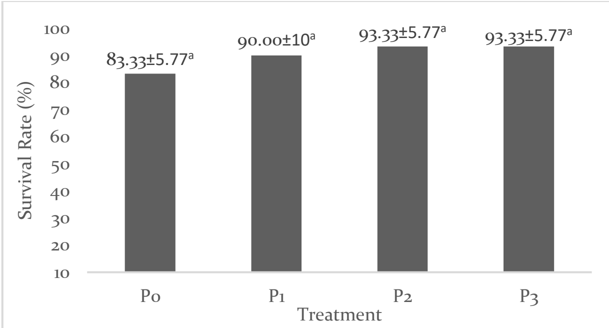
(B)



(C)



(D)



(E)

Figure 1. Histogram of absolute weight growth (a), absolute length growth (b), spesific growth rate (c), food conversion ratio (d), survival rate (e) of tilapia (*O. Niloticus*) during cultivation

3.1.1 Absolute Weight Growth

Figure 1a. shows that the P3 treatment gave a slightly better growth effect compared to other treatments. The highest absolute weight growth was shown in the P3 treatment of 5.53 grams and the lowest treatment in the P0 (control) treatment of 5.25 grams.

The higher growth results in P3 were due to the influence of higher ammonia degradation compared to other treatments. Nitrosomonas sp. converts ammonia to nitrite then nitrite is converted to nitrate by Nitrobacter sp. (Fadillah et al., 2022). Ammonia degradation causes a decrease in ammonia levels in the water, thereby increase fish appetite. EM4 microorganisms consisting of Lactobacillus casei and Saccharomyces cerevisiae help in the process of degrading organic matter into simpler substances so that they can increase the activity of fish digestive enzymes. The digestion process and absorption of nutrients will be better, thereby increasing fish weight growth (Askari et al., 2024). This is in accordance with research conducted by Jannah et al (2023), where the presence of microorganism activity can increase nutrient digestibility and feed utilization, thereby increasing growth (Jannah et al., 2023).

3.1.2 Absolute Length Growth

Figure 1b. shows that the highest absolute length growth was in the P3 treatment of 2.31 cm while the lowest absolute length was in the P0 (control) treatment of 2.01 cm. Fish length growth is influenced by several factors including feed nutrition and water quality. Protein from feed and tofu liquid waste is very important for growth and tissue formation in the fish body (Subandiyono & Hastuti, 2016). In addition, fat is also a source of energy used for activities such as swimming, looking for food, avoiding enemies, growth and body resistance. Fat can dissolve vitamins A, D, E, and K which are used to meet the body's needs (Munisa et al., 2015). Providing fish supplements with different concentrations of Nitrobacter Plus makes a difference in growth rate. The P3 treatment gave a better growth rate compared to P0 (control). The amount of ammonia pollutants will cause fish to become easily stressed so that fish growth is inhibited. The presence of Nitrobacter Plus plays a role in reducing ammonia pollutants so that length growth increases.

3.1.3 Specific Growth Rate (SGR)

Figure 1c. shows that the P3 treatment gave the highest average value of the Specific Growth Rate (SGR) of 3.88% BW/day, while the lowest specific growth rate was in the P0 (control) treatment of 3.63% BW/day. This is due to the difference in adding Nitrobacter Plus which is different between treatments. In P0, the tofu liquid waste fermentation supplement does not contain Nitrobacter Plus, caused the conversion process of ammonia to nitrate is lower compared to P1, P2 and P3. The ammonia content in P0 is higher than another treatment, so that it reduces water quality and causes stress in fish which will trigger a decrease in appetite in fish.

3.1.4 Feed Conversion Ratio (FCR)

Based on Figure 1d, it can be seen that P3 treatment gave the lowest average feed conversion ratio of 1.6899, while the highest average feed conversion ratio was in treatment Po (control). In treatment P3, the presence of EM4 and Nitrobacter Plus helped degrade organic matter and increase ammonia reduction. Microorganisms from EM4 will help improve the balance of microbes in the fish intestines by reducing pathogenic bacteria and producing enzymes such as lactase, protease and lipase. While Nitrobacter Plus will help reduce ammonia in water which can cause decreased appetite in fish. Thus, feeds absorption will be faster so that the feed conversion ratio becomes lower because the total feeds converted into body weight was more less.

The high feed conversion ratio in treatment Po is because the organic matter accumulated in the fish maintenance media is not degraded properly. This is in accordance with research conducted by Taragusti et al (2019), where organic substances that are not optimally degraded in the maintenance media cause high levels of ammonia, thereby decreasing the quality of water in the maintenance media, which triggers a decrease in appetite in fish (Taragusti et al., 2019).

3.1.5 Survival Rate (SR)

Based on Figure 1e, it can be seen that P2 and P3 treatment showed the highest survival. While the lowest survival was shown by treatment Po (control). In the maintenance media, treatment Po (control) without Nitrobacter Plus had a higher concentration of ammonia (NH_3) compared to treatment with the addition of Nitrobacter Plus. High concentrations of ammonia can trigger stress in fish, reducing appetite and over time reducing the fish's immune system, resulting in fish death (Hidayati et al., 2019).

3.1.6 Water Quality

Table 2. Water quality of tilapia cultivation media

Parameters	Treatment				Standard
	Po	P1	P2	P3	
pH	6.3	6.0	6.3	5.9	5.0 – 10.0 (Sallenave, 2016)
Temperature (°C)	27.9	26.5	26.1	26.4	26 – 31°C (Shofura *et al.*, 2018)
DO (mg/L)	6.2	6.5	6.1	6.5	4 mg/L (Government Regulation No. 22 of 2021) Class II
TDS (ppm)	456	429	410	417	1000 ppm (Government Regulation No. 22 of 2021) Class II
EC (µS/cm)	911.1	836.7	786.9	786.3	100 - 2000 µS/cm (Kelany *et al.*, 2024)
Ammonia (ppm)	0.0037	0.0014	0.0019	0.0009	0.2 mg/L (Government Regulation No. 22 of 2021) Class II
Nitrite (ppm)	0.1071	0.0357	0.0119	0.0119	0.06 mg/L (Government Regulation No. 22 of 2021) Class II
Nitrate (ppm)	64.8	51.7	43.6	43.1	10 mg/L (Government Regulation No. 22 of 2021) Class II

Description:
Class II: It is used for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water for irrigating crops, and/or other uses that require the same water quality as these uses.

The results of observations for 30 days, the pH of the tilapia maintenance media is 5.9 - 6.3. The optimal pH for tilapia growth ranges from 7 - 8 (Wijayanti et al., 2019). While the pH tolerance for tilapia ranges from 5.0 - 10.0 (Sallenave, 2016). Based on the results of the study, it shows that the pH value of the tilapia maintenance media is still included in the pH tolerance for tilapia. The results of measuring the temperature of the tilapia maintenance media showed that the temperature ranged from 26.1 - 27.9°C. The water temperature of the tilapia maintenance media is still included in the safe category for tilapia growth. Temperature is one of the factors that affects the growth of tilapia because a good temperature will have a positive effect on appetite, thereby increasing the growth of tilapia. According to Shofura et al (2018), the ideal temperature for tilapia growth ranges from 26 - 31 ° C (Shofura et al., 2018).

Based on the results of observations of the Dissolve Oxygen (DO) content of tilapia maintenance media, it shows that the DO levels range from 6.1 - 6.5. The DO levels in this study meet the quality standard requirements based on PP No. 22 of 2021 Class II, which is 4 mg/L. The dissolved oxygen (DO) level that is good for growth is 5 mg/L, while DO levels below 3 mg/L can cause a decrease in the growth rate of fish (Yusuf, 2017). The results of observations of the Total Dissolve Solid (TDS) content of tilapia maintenance media showed that the TDS levels differed for each treatment, with TDS content ranging from 410 - 456 ppm. The TDS levels in this study were still included in the standards according to PP No. 22 of 2021 Class II. The results of observations of the electrical conductivity (EC) values of tilapia maintenance media showed values ranging from 786.3 - 911.1 µS / cm. The ability of water to conduct electricity is measured through Electrical Conductivity (EC). The higher the EC value in the fish maintenance media, the higher the pollutants contained in the water. The ideal EC value for tilapia growth is between 100 - 2000 µS / cm (Kelany et al., 2024). The results of observations of ammonia levels in tilapia cultivation media showed that the P3 treatment has the lowest ammonia levels. Meanwhile, the highest ammonia levels are in the Po (control) treatment. Ammonia levels tend to decrease with increasing Nitrobacter Plus concentration. This is also in line with the increase in growth rate with increasing Nitrobacter Plus concentration. The tolerance limit for ammonia levels based on the Water Quality Standard PP No. 22 of 2021 Class II is 0.2 mg/L. The ammonia levels in this study are still included in the safe category. Ammonia is produced from the metabolic process in the form of fish feces and leftover feed that is not eaten by fish. This causes the accumulation of ammonia in the maintenance media, thereby reducing water quality. At pH 7.0 or below, ammonia in the form of NH_4^+ is non-toxic except at high concentrations. While ammonia in the form of NH_3 is toxic to water (Sallenave, 2016). The higher the pH and temperature, the higher the ammonia (NH_3) levels contained in the water (Akbar et al., 2016). The addition of Nitrobacter Plus can help reduce the levels of ammonia produced (Taragusti et al., 2019).

The results of observations of nitrite in tilapia maintenance media show that the nitrite content ranges from 0.119 - 0.1071 ppm, which indicates that the nitrite content is still safe for the growth of tilapia based on PP No. 22 of 2021 class II (0.06 mg/L). Nitrite content is important to observe because it is still classified as a substance that is harmful to fish if it is more than the normal limit. The good nitrite content for tilapia growth is below 1 ppm. According to Sallenave (2016), nitrite is harmful and toxic to fish if it reaches 5 ppm, so it must be maintained below 1 ppm (Sallenave, 2016). Based on the results of observations of nitrate in tilapia maintenance media, the nitrate content ranges from 43.1 to 46.8 ppm, indicating that the nitrate content is not within the standards based on PP No. 82 of 2001. This is due to the role of Nitrobacter Plus in converting ammonia to nitrate, resulting in excessive nitrate levels. The more conversion of ammonia to nitrate, the higher the nitrate produced. Nitrate tends to be less dangerous than ammonia and nitrite. However, in the fish maintenance process, it must be maintained so that the nitrate levels in the water are not too high. The results of research conducted by Monsees et al (2017) showed that the nitrate tolerance limit for tilapia does not exceed 500 mg/L (Monsees et al., 2017).

3.2 Economic Analysis

Based on the results of statistical analysis, the utilization of tofu liquid waste through the fermentation process with EM4 and Nitrobacter Plus has no significant effect on the growth rate of fish. However, viewed from the perspective of Food Science, the difference in growth rate can affect the growth of fish weight, so that it can indirectly affect the economic value of income. Economic analysis is carried out using theoretical calculations. The economic analysis of the utilization of tofu liquid waste as a tofu liquid waste fermentation supplement was carried out based on the results of the study with the highest value, namely P3 (1 L of tofu liquid waste + 50 mL of EM4 + 3 mg of Nitrobacter Plus). The amount of waste to be processed is 10,500 liters of tofu liquid waste per day. The preparation of the budget and determination of the amount of waste to be processed are determined based on considerations of processing capacity, number of workers, transportation costs and the area of the tofu liquid waste processing site. Production time is carried out with working hours for 26 days a month.

In the production process of utilization of liquid tofu waste into fish supplements, liquid tofu waste produced from the tofu factory will be collected using a 220 liter HDPE barrel. Liquid tofu waste will be transported to the waste processing facility using a 2.2 x 2.3 meter pickup car for 6 deliveries with a fuel gas cost of IDR 100,000 per day. Liquid tofu waste is processed as many as 53 barrels per day with 5 workers processing ± 10 barrels each. Furthermore, liquid tofu waste is processed through a fermentation process by mixing liquid tofu waste, EM4 and Nitrobacter Plus using a mixer designed by ourselves with a fermentation time of 14 days. The theoretical ratio for each ingredient in one barrel is 200 liters of liquid tofu waste, 10 liters of EM4 and 0.6 grams of Nitrobacter Plus. The fermentation results are then stored in a dark and cool place so that the stability of the microorganisms is maintained. The fish supplements that will be sold are then packaged in 25 liter jerry cans. Based on the calculation results, the dosage of fish supplement in feed is 275 mL/kg of feed. The details of investment costs and production costs for the utilization of tofu liquid waste into fish supplements are as follows :

Table 3. Investment costs of utilization of tofu liquid waste as fish supplement

No	Property List	Quantity	Unit Price (Rp)	Total (Rp)	Information
1	HDPE Barrels	742 pieces	250,000	185,500,000	Capacity 220 liters
2	Transportation	1 unit	40,000,000	40,000,000	Pickup car
3	Electric drill	5 unit	165,000	825,000	Used to stir the fermentation mixture (with some modification)
	Total			**IDR 226,325,000**	

Table 4. Operational costs of utilization of tofu liquid waste as fish supplements

No	Production Components	Volume	Unit price (Rp)	Total cost per month (Rp)	Economic Value per liter (Rp)
1	Electricity - Electric drill (kWh)	114.4	1,500/kWh	171,600	0.63
	- Desktop Computers (kWh)	62.4	1,500/kWh	93,600	0.34
2	Building Rental (20 x 40 m²)	1		15,000,000	54.95
3	Jerry can (L)	420	20,000/pcs	218,400,000	800
4	Work Wages - Factory workers (5 people)	5		13,000,000	47.62
	- Manager (1 person)	1		3,000,000	10.99
	- Factory Guard (1 person)	1		2,000,000	7,326
5	EM4 (L)	525	25,000/pcs	341,250,000	1250
6	Nitrobacter Plus (100 gr/pcs)	31.5	25,000/pcs	204,750	0.75
7	Fuel gas	1	100,000/day	2,600,000	9.52
	Total			**595,719,950**	2182.12

No	Production Components	Volume	Unit price (Rp)	Total cost per month (Rp)	Economic Value per liter (Rp)
	Selling price				3273.19

Based on the calculation results in Table 3. and Table 4, it shows that to process 10,500 liters of tofu liquid waste into fish supplements, an investment cost is required of IDR 226,325,000 and production operational costs amounting to IDR 595,719,950 per month. The selling price is determined from the total operational cost of production per liter with a profit margin of 50%. Based on the calculation results, the selling price for fish supplements from fermented tofu liquid waste with EM4 and Nitrobacter Plus is IDR 3273.19. The results of the economic calculation of the utilization of tofu liquid waste into fish supplements are as follows:

Table 5. Economic calculation of utilization of tofu liquid waste as fish supplement

Calculation	Economic value (Rp)
Initial investment costs	226,325,000
Production costs per year	7,148,639,400
Total income /year	10,722,959,100
Total profit/year	3,574,319,700

Results calculations based on Table 5 show that the sales results of fish supplement products generate total revenue of Rp.10,722,959,100 per year with a total profit of Rp. 3,574,319,700 per year.The utilization of tofu liquid waste into a fish supplement needs to be tested for its economic feasibility in order to consider the next steps for the production process to be carried out. The feasibility analysis is tested by calculating the Benefit Cost Ratio (BCR), Net Present Value (NPV) and Return on Investment (ROI). The calculation is carried out with a time span of 10 years at a discount factor of 10% which is determined based on the risk associated with the market acceptance process because the product comes from liquid waste processing. Products derived from processing and technology are still relatively unfamiliar to the public, so an explanation process is needed through counseling as well as product promotion in the marketing process simultaneously. This aims to increase public awareness in processing waste into products with economic value.

Table 6. Economic analysis of benefit cost ratio (BCR) utilization of tofu liquid waste as fish supplement

Year	Ct	Bt	(1+i)t	$\frac{Bt}{(1+i)^t}$	$\frac{Ct}{(1+i)^t}$
0	7,374,964,400	0	1.00	0	7,374,964,400
1	7,148,639,400	10,722,959,100	1.10	9,748,144,636	6,498,763,091
2	7,148,639,400	10,722,959,100	1.21	8,861,949,669	5,907,966,446
3	7,148,639,400	10,722,959,100	1.33	8,056,317,881	5,370,878,588
4	7,148,639,400	10,722,959,100	1.46	7,323,925,347	4,882,616,898
5	7,148,639,400	10,722,959,100	1.61	6,658,113,951	4,438,742,634
6	7,148,639,400	10,722,959,100	1.77	6,052,830,865	4,035,220,577
7	7,148,639,400	10,722,959,100	1.95	5,502,573,514	3,668,382,342
8	7,148,639,400	10,722,959,100	2.14	5,002,339,558	3,334,893,039
9	7,148,639,400	10,722,959,100	2.36	4,547,581,416	3,031,720,944
10	7,148,639,400	10,722,959,100	2.59	4.134.164.924	2,756,109,949
			Total	65,887,941,762	51.300.258.908
				BCR	**1,284**

Information:

Bt = Benefit or benefit (income) in year t; Ct = Cost or expense in year t; i = interest rate used (discount factor); and t = year t.

Benefit-Cost Ratio (BCR) is the comparison value between the total benefit value and the total value of the cost flow incurred. Based on the calculation results of the Benefit Cost Ratio (BCR) in **Table 6**, it shows that the utilization of tofu liquid waste as a fish supplement has a BCR value of 1.284 at a discount factor of 10%. The BCR value has a value of more than 1 (one), so it is economically feasible because it can generate greater profits than the costs incurred.

Table 7. Economic analysis of net present value (NPV) utilization of tofu liquid waste as fish supplement

Year	Investment (Rp)	Ct	Bt	$(1+i)^t$	$\frac{Bt - Ct}{(1+i)^t}$
0	226,325,000	7,374,964,400	0	1.00	-7,374,964,400
1		7,148,639,400	10,722,959,100	1.10	3,249,381,545
2		7,148,639,400	10,722,959,100	1.21	2,953,983,223
3		7,148,639,400	10,722,959,100	1.33	2,685,439,294
4		7,148,639,400	10,722,959,100	1.46	2,441,308,449
5		7,148,639,400	10,722,959,100	1.61	2,219,371,317
6		7,148,639,400	10,722,959,100	1.77	2,017,610,288
7		7,148,639,400	10,722,959,100	1.95	1,834,191,171
8		7,148,639,400	10,722,959,100	2.14	1,667,446,519
9		7,148,639,400	10,722,959,100	2.36	1,515,860,472
10		7,148,639,400	10,722,959,100	2.59	1,378,054,975
NPV					**14,587,682,854**

Information:
Bt = Benefit or benefit (income) in year t; Ct = Cost or expense in year t; i = interest rate used (discount factor); and t = year t.

Net Present Value (NPV) is the value of profit obtained during the business period by calculating the time value of money. To find out the value of money in the future calculated at this time, both costs and income in the future must be multiplied by a discount factor whose amount depends on the prevailing bank interest rate in the market. Based on the results of the Net Present Value (NPV) calculation in Table 7, it shows that the utilization of tofu liquid waste as a fish supplement at a discount factor of 10% has a positive value after 10 years, with IDR 14,587,682,854. The positive NPV value indicates that the utilization of tofu liquid waste as a fish supplement has economic prospects and is declared feasible.

Table 8. Economic analysis of return on investment (ROI) utilization of tofu liquid waste as fish supplement

Net Profit	Investment (Investment Cost + Production Cost)	ROI
3,574,319,700	7,374,964,400	48.4%

Return on Investment (ROI) is the value of profit obtained by entrepreneurs from each amount of money invested in a certain period of time. ROI analysis can measure the extent to which a business is able to return the invested capital so that the efficiency of capital use can be measured. Based on the calculation results in Table 8, the ROI value in 1 year of the project which is 48.4%. Based on the results of the ROI calculation, it can be concluded that the investment made in the utilization of tofu liquid waste into fish supplements provides benefits because the return on capital is greater than the investment cost.

4. Conclusions

Based on the results of the research, it can be concluded that the provision of fish supplements from fermented tofu liquid waste has no significant effect on absolute weight growth, absolute length growth, specific growth rate, feed conversion ratio and survival rate. Based on the economic aspect, the utilization of tofu liquid waste into fish supplement is considered feasible and can provide economic benefits based on the results of the economic analysis with a Net Present Value (NPV) of IDR 14,587,682,854, Benefit Cost Ratio (BCR) of 1.284, and Return on Investment (ROI) of 48.4%. This research has several limitations, including research time and financial. Recommendation that can be given for further research related to this research are needed regarding the utilization of tofu liquid waste as a fish supplement with more detailed laboratory analysis such as proximate analysis and bacterial content to strengthen the research results and providing higher concentrations of nitrifying bacteria or Nitrobacter Plus.

Acknowledgement

The researcher would like to thank the Nano Finder U-CoE Laboratory, Padjadjaran University for providing a research location for the author to collect data and data analysis during the research process.

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