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Optimization Feeding Rate Towards Saline Tilapia Production in Stagnant Waters, Pekalongan City

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Abstract

The flood disaster in the coastal area of Pekalongan City resulted in stagnant water, thus impacting the community's livelihoods previously. The adaptation that has been made to deal with these conditions is by cultivating saline tilapia. Feed is the most important factor in supporting the growth of saline tilapia production. However, research on feed quality and frequency that has been carried out for tilapia production has not been optimal in obtaining the results obtained. This study aims to determine the effect of different feeding rates on growth performance, feed utilization, and survival rate of tilapia reared in stagnant brackish water. The study consisted of feeding rates of 3%, 5%, 7%, and 9% with three replications, and parameters were observed every seven days. Based on the research results it is known that the optimal feeding rate in saline tilapia culture ranges from 6.67% - 7% based on growth parameters. Although the other parameters do not show the same feeding rate as the growth parameter, these parameters are still in a good range for saline tilapia culture.

INTRODUCTION

Natural disasters in the form of floods and land subsidence over a long period have resulted in waterlogging in several coastal areas of Pekalongan City (Miftakhudin, 2021; Hsiao *et al.*, 2022). It was reported that the rise in sea level (±4.3 mm/year) with the rate of land subsidence (±16.74 cm/year) resulted in water inundation covering an area of ±477.57 hectares to ±1877.07 hectares in 2025 in Pekalongan City (Iskandar *et al.*, 2020). If there are no significant management policies, the extent and risk of flooding are predicted to expand and increase with the estimated area of inundation in the area reaching ±5.700 ha in 2035 (Zain *et al.*, 2023). This of course has an impact on the income of local communities. Fishing, agricultural, and residential land is not utilized because it is covered by water (Khaqiqi and Syamsuddin, 2021). Tilapia cultivation is an alternative solution that can be adapted to overcome this problem (Syakirin *et al.*, 2023). Tilapia is known to be euryhaline and more resistant to disease, making it more suitable for cultivation in stagnant waters compared to other

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brackish water biota (Fahrurrozi *et al*., 2021).

The quality of the aquatic environment, seeds, and feed are important factors in successful cultivation (Karimah *et al*., 2018). In particular, feed is one of the determining factors in generating income, because 45-50% of operational costs are feed (Afewerki *et al*., 2023). Feed management in its application does not only focus on price but can be broader. The quality of feed, feed raw materials and feeding methods are determining factors for the success of aquaculture (Prasad *et al*., 2023). So, research on feed management is still a topic that is often researched. There has been a lot of research on feed for salted tilapia cultivation in Pekalongan City, but it still focuses on the quality of feed and raw materials. Some examples of this research include the addition of ginger flour to the growth of salted tilapia (Imaniar *et al*., 2018), increasing the growth and feed efficiency of salted tilapia with the use of tamarind eggplant extract (Syakirin *et al*., 2022) and giving aloe vera plant extract the effect on tilapia production (Yunus *et al*., 2023).

The growth parameter is an important aspect of determining success in aquaculture. This is because, the growth rate affects the maintenance time (Lippmann *et al*., 2023). The Feed Conversion Ratio (FCR) is the conversion of feed to fish weight, the smaller the FCR value indicates good feeding (Naz *et al*., 2023). The feed efficiency is related to the addition of biomass weight in the body that comes from the utilization of feed protein. The value is obtained from the comparison between the weight gain of the fish and the amount of feed consumed (Nayak *et al*., 2023). Meanwhile, the survival rate is a parameter to determine the impact of a given factor. survival rate shows the survival rate of a population during the study (Novák *et al*., 2023).

The method of feeding, especially the feeding rate, is an important aspect apart from price, quality, and feed raw materials. Feeding rate is a way of providing feed by paying attention to the amount of feed given every day to fish which is calculated based on biomass (Gabriel *et al*., 2023). Research on feeding rates is important because besides affecting the quantity of feed, it can also affect the quality of the digested feed to produce optimal tilapia production (Mengistu *et al*., 2020). Proper feeding can also minimize waste so that the survival of fish can be maintained (Ahmed, 2023).

The level of feeding in the form of a percentage of the amount to be given is of particular concern so that aquaculture production can run optimally. In the aquaculture of saline tilapia in stagnant water, not much has been done, especially to determine the optimal feeding rate. The research was conducted for 4 weeks by evaluating different feeding rates (3%, 5%, 7%, and 9%) on the production parameters of saline tilapia. The hypothesis in this study obtained the optimal feeding rate which affects growth, feed conversion ratio (FCR), feed efficiency (FE), and survival rate (SR).

METHODOLOGY

Ethical Approval

No animals were harmed or abused during this study. The test animals in this study were treated properly according to the optimal environment starting from quality, temperature, and salinity, so they did not require ethical permission. The results of water quality measurements carried out in this research still show good values. Likewise, supporting results from research by Sihombing *et al*. (2022), stated that the quality of stagnant water in Pekalongan City has a pH value of 7, temperature of 31.4 ºC, DO 20 mg/l, ammonia 0.15 mg/l, phosphate 0.03 mg/l, nitrite 0 mg/l, nitrate 2 mg/l and salinity 11 ppt. So, it can be said that the condition of the water quality parameters tends to still be good and is classified as suitable for use as a fish cultivation medium.

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Place and Time

This research was carried out in stagnant water ponds, Krapyak Lor, North Pekalongan, Pekalongan City, in June 2023.

Research Materials

The equipment used was a digital balance with an accuracy of 0.01 g (i2000, China), closed net (-, Indonesia), feed thrower (-, Indonesia), bucket (Lion Star, Indonesia), fiber pool (-, Indonesia), mercury thermometer (SP Bel-Art, China), refractometer (Atago, Japan). The material used is saline tilapia obtained from the Fish Seed Center of Pekalongan City. Commercial fish feed (HI-PRO-VITE 781, Indonesia) and crystal salt (Dolpin Salt, Indonesia).

Research Design

The method used in this research is the experimental method with Completely Randomized Design (CRD). This study used four treatments with three replications to reduce the error rate. The treatment dose used in this study refers to Liu *et al*. (2018) and Zahra *et al*. (2019), namely (FR 3%) feeding rate of 3%; (FR 5%) feeding rate 5%; (FR 7%) feeding rate 7%; (FR 9%) feeding rate 9%. Sampling was carried out four times with a distance of seven days from the first collection. The main parameters in this study are growth parameters (MBW, ADG, and biomass), survival rate, FCR, and feed efficiency. While the water quality (Temperature and Salinity) was carried out and analyzed as supporting parameters.

Mean body weight (MBW), is the average weight of the fish from the sampling results. MBW can be calculated as follows (Prabu *et al*., 2020)

$$\text{MBW} = \frac{\text{weight of fish weighed (g)}}{\text{number of fish weighed (fish)}}$$

Average daily growth (ADG) is the average daily weight gain of fish in a certain period so that it can be used to determine the speed of fish growth. According to Prabu *et al*. (2020), the formula is as follows:

$$\text{ADG} = \frac{\text{final MBW (g) - initial MBW (g)}}{\text{time span (day)}}$$

Fish biomass is the total weight of fish kept in a pond or pond at a certain time. According to Mahendra *et al*. (2023), the formula is as follows:

$$\text{Biomass} = \text{Population (fish) x MBW (g)}$$

Survival rate is a prediction of the survival of biota within a certain period. According to Prabu *et al*. (2020), the formula is as follows:

$$\text{SR} = \frac{\text{final number of dead fish (fish)}}{\text{initial number of dead fish (fish)}} \times 100\%$$

Feed conversion ratio is the ratio between the weight of fish feed that has been given in a certain cycle period, to the total weight (biomass) produced. According to Prabu *et al*. (2020), the formula is as follows:

$$\text{FCR} = \frac{F}{(Bt + D) - Bo}$$

Where:

F = amount of feed given during the study (g)

Bt = final biomass (g)

D = weight of dead fish during the study (g)

Bo = initial biomass (g)

The feed efficiency (FE) is related to the addition of biomass weight in the body which comes from the utilization of protein in the feed. The value of feed efficiency is obtained from the results of a comparison between the body weight gain of the fish and the amount of feed consumed by the fish during the rearing period. According to Arisa *et al*. (2020), the formula is as follows:

$$\text{FE} = \frac{\text{final biomass (g)-initial biomass (g)}}{\text{feed given during the study (g)}} \times 100\%$$

Work Procedure

The activity begins with preparing cultivation containers in the form of installing 12 nets in fixed cages measuring 3 meters x 2 meters x 1 meter (length x width x height) on poles that have been stuck in the water. There was no treatment for stagnant pools before the research was carried out. Installation of cage nets is arranged in such a way that it does not touch the bottom of the water (± 0.2 meters

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above the bottom of the water), the top part is given a distance of ± 0.1 meters above the water surface. water level. The test fish used were tilapia which had been acclimatized to become 2-3 cm long fish in controlled tanks using crystal salt so that the test fish were able to survive at a salinity of 4 g/liter. Next, after the fish measuring 3-5 cm, they are put into each cage at a density of 185 fish/cage.

Measurements were made five times on growth parameters (MBW, ADG, and biomass), namely once before treatment and four times after treatment until the study was completed. The measurement of other parameters was carried out at the beginning and the end of the study. Measurements are made by taking as much as 10% of the fish from each cage. The amount of feed was recorded at each feeding until the end of the study, for data analysis purposes.

Data Analysis

The data obtained were analyzed using the ANOVA statistical test and the Tukey test as a follow-up test to see a significant difference. Regression analysis is to find out whether the resulting graph is linear or non-linear in determining the optimal dose, then the table and graphic data obtained are explained descriptively.

RESULTS AND DISCUSSION

Mean Body Weight (MBW)

Based on the results of the study it was known that the average weight of saline tilapia was not significantly different ($P<0.05$) at the 0th week of observation (Figure 1). This is because the observations were made before the treatment or feeding was carried out on saline tilapia. The difference in mean body weight which can be seen from the different notations at week 1 showed that the 7% feeding rate was significantly different ($P>0.05$) from the other treatments until the end of the study. This shows that the 7% feeding rate gave the best results compared to other treatments. Even though in the 2nd week of observation the mean body weight of the 7% feeding rate was the lowest, it still showed improvement and was the best until the end of the study.

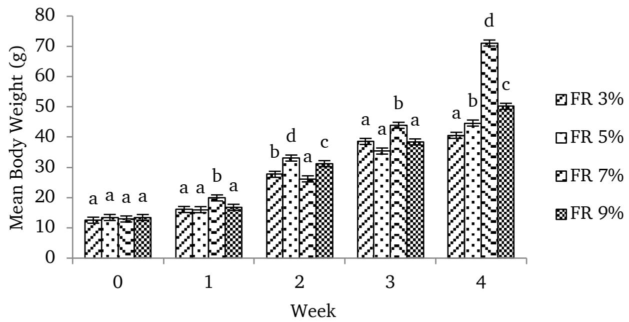

Figure 1. Increase in mean body weight of saline tilapia during the observation period.
Description: Numbers followed by the same superscript letter in the same column are not significantly different based on the Tukey test ($P>0.05$).

Inhibition of growth in the 2nd week was made possible due to feeding errors, so the feed that had been calculated and weighed previously was not utilized by the test fish. Human management practices also significantly, as well as fish feeding behavior, including the frequency, timing, and amount of feeding can affect the growth and survival rate of fish (Zhou *et al*., 2018). A treatment feeding rate of 7% of the mean body weight showed the best value among other treatments.

This result is in line with the research by Zahra *et al*. (2019), which stated that a feeding rate of 7% had the best effect on the growth of tilapia. However, this value is not yet at its optimal value, because according to Craig *et al*. (2017),

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farmed fish are usually fed 1-5 percent of their body weight per day. Feeding rate values have been widely published for most of the cultured fish species. So, it is necessary to do further analysis of the next research parameters.

Average Daily Growth (ADG)

Based on the results of the study it was found that the average daily growth of saline tilapia was significantly different (P> 0.05) which can be seen in Table 1. These conditions indicate that the treatment of differences in feeding rates affects the average daily growth produced during the study. For the treatment of feeding rate, 7% is the best treatment by producing the highest average daily growth value among other treatments, namely 1.9 ± 0.1 g/day. This difference is known after further testing is carried out and produces a notation or superscript that is different from the others.

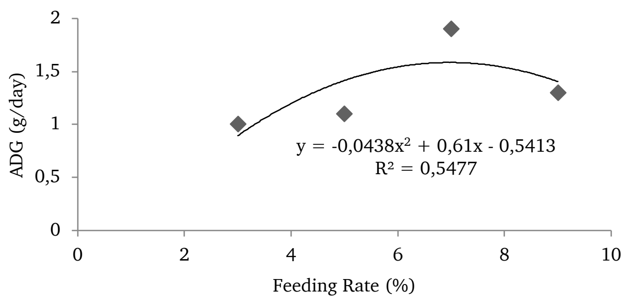

Figure 2. The regression equation for FR treatment is different from ADG.

The average daily growth value generated in all treatments is still in the good range. Because in the study of Wainaina *et al.* (2023), the average daily growth of tilapia is within the range of ±0.90 g/day. Meanwhile, the low effect of the feeding rate on the average daily growth with a value of 55% is thought to be due to the many other factors that can influence it, such as weather which can affect water quality, and other factors (Zhou *et al.*, 2018). Therefore, feeding by paying attention to the feeding rate is important because it can reduce failures during cultivation.

There is a significant linear relationship between feeding rate and average daily growth because fish growth tends to stabilize or decrease when the rate of feeding is above the optimum (Zhang *et al.* 2011). Several studies on fish have also shown that increasing feeding frequency can only promote growth to a certain limit, beyond this limit, the promotion effect is not obvious (El-Araby *et al.*, 2020; Fahrurrozi and Linayati, 2022).

Biomass

Based on the results of the study, it was found that the average biomass of saline tilapia was significantly different (P> 0.05) which can be seen in Table 2. These conditions indicate that the treatment of differences in feeding rates affected the average biomass produced during the study with an FR of 7% is the best treatment. The coefficient value terminated (R^2) in Figure 3, shows a significant effect of 60% with an optimal FR of 6.67% with the biomass produced for every 9423 grams.

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Table 2. Average biomass of saline tilapia after different feeding rates.

Treatment	Average Biomass ± SD (g)
FR 3%	6697 ± 136[a]
FR 5%	7499 ± 199[b]
FR 7%	10670 ± 470[c]
FR 9%	7727 ± 17[b]

Description: Numbers followed by the same superscript letter in the same column are not significantly different based on the Tukey test (P>0.05).

The growth of saline tilapia with the final result in the form of biomass is influenced by many factors (Zhou *et al*., 2018). Even so, in this study, the difference in the concentration of the feeding rate still had an impact with a 60% confidence level. So, the recommended feeding percentage for saline tilapia cultivation is 6.67%. In the aquaculture process, especially in fish-raising activities, the most important factor is the availability of feed in sufficient quantities, and it must contain all the necessary nutrients such as carbohydrates, fats, proteins, minerals, and vitamins (Fahrurrozi *et al*., 2023b). The existence of differences in biomass from different concentrations of feeding rates is thought to be due to the availability and adequacy of the amount of feed needed for saline tilapia during the study.

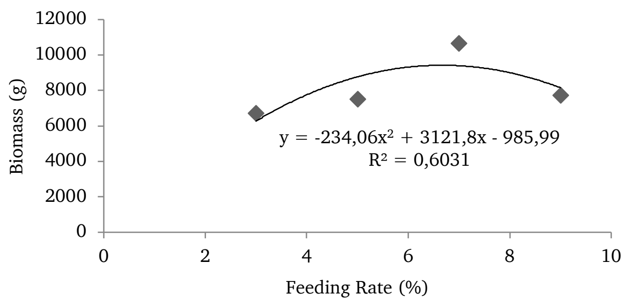

Figure 3. The regression equation for FR treatment is different from Biomass.

Survival Rate (SR)

Based on the results of the study it was found that the average survival rate of saline tilapia was significantly different (P> 0.05) which can be seen in Table 3. These conditions indicate that the treatment of differences in feeding rates affected the average survival rate produced during the study with FR 5% and 3% being the best treatment. The coefficient of termination (R^2) in Figure 4 shows a significant effect of 59%. The graph with a linear curve shows that the higher the concentration of the feeding rate given, the lower the survival rate.

Table 3. The average survival rate of saline tilapia after different feeding rates.

Treatment	Survival rate (%)
	Average ± SD
FR 3%	89,18 ± 1,09[b]
FR 5%	90,81 ± 0,07[b]
FR 7%	81,14 ± 0,89[a]
FR 9%	83,24 ± 3,12[a]

Description: Numbers followed by the same superscript letter in the same column are not significantly different based on the Tukey test (P>0.05).

The effect of the feeding rate on the survival rate in this study was 59%. This result can be interpreted that there is an influence between feeding rate and

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survival rate. As for the optimal feeding rate concentration, it can be said that the higher the concentration, the lower the survival rate. Even so, many other factors affect the survival rate (Zhou *et al*., 2018). The quality and quantity of feed and environmental conditions are factors that can affect the survival rate of biota in waters (Fahrurrozi and Linayati, 2022). However, in this case, the survival rate can still be said to be good for saline tilapia cultivation (Arisa *et al*., 2020).

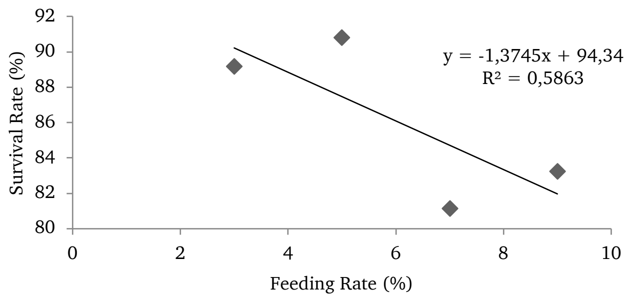

Figure 4. The regression equation for FR treatment is different from SR.

Feed Conversion Ratio (FCR)

Based on the results of the study it was found that the average survival rate of saline tilapia was significantly different (P> 0.05) which can be seen in Table 4. This condition shows that the treatment of differences in feeding rates affected the average FCR produced during the study with FR 5 % and 3% being the best treatment. The coefficient value terminated (R^2) in Figure 5, shows a significant effect of 49%. The graph in the form of a linear curve shows that the higher the concentration of the feeding rate given, the greater the FCR value.

Table 4. Average FCR of saline tilapia after different feeding rates.

Treatment	FCR Average ± SD
FR 3%	$0,23 \pm 0,01^{a}$
FR 5%	$0,22 \pm 0,01^{a}$
FR 7%	$0,73 \pm 0,03^{c}$
FR 9%	$0,50 \pm 0,02^{b}$

Description: Numbers followed by the same superscript letter in the same column are not significantly different based on the Tukey test (P>0.05).

Even though the feeding rate treatment is said to affect the FCR of the results of the ANOVA analysis, the effect is only 49% which is analyzed by regression. In addition, the regression curve shows that the higher the concentration of the feeding rate, the higher the FCR value. So, it can be said that the effect is not too significant. Because many factors can affect the FCR value (Fahrurrozi *et al*., 2023a; Zhou *et al*., 2018). However, the FCR values for all treatments in this study can be said to be good (Aliah, 2017).

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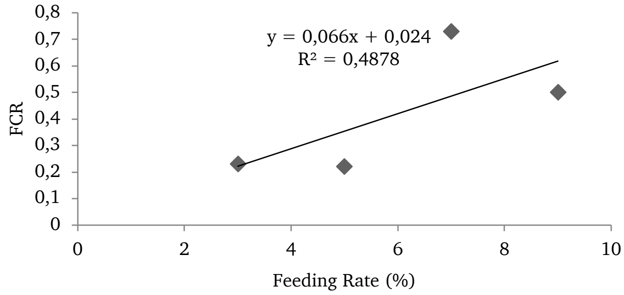

Figure 5. The regression equation for FR treatment is different from FCR.

Feed Efficiency (FE)

Based on the results of the study, it was found that the average feed efficiency of saline tilapia was significantly different (P>0.05) which can be seen in Table 5. These conditions indicate that the treatment of differences in feeding rates affects the average feed efficiency produced during research with FR 5% being the best treatment. The coefficient value terminated (R^2) in Figure 6, shows a significant effect of 50%. The graph is in the form of a linear curve, so the higher the concentration of the feeding rate given, the lower the feed efficiency value.

Table 5. Average feed efficiency of saline tilapia after different feeding rates.

Treatment	Feed Efficiency (%) Average ± SD
FR 3%	42,4 ± 0,04[c]
FR 5%	44,7 ± 0,02[d]
FR 7%	33,6 ± 0,06[a]
FR 9%	33,9 ± 0,04[b]

Description: Numbers followed by the same superscript letter in the same column are not significantly different based on the Tukey test (P>0.05).

Feed efficiency is the quantity of feed that enters the digestive system which is then broken down by metabolism in the body and used for growth (Arisa *et al*., 2020). The higher the value of feed efficiency describes the more optimal use of feed in increasing growth. The results showed that the feeding rate has an effect on the value of feed efficiency with a coefficient of determination of 50% and the highest at a concentration of 5% feeding rate. The results of the curve are in the form of a regression so that the greater the concentration of the feeding rate, the smaller the value of feed efficiency. However, the value of feed efficiency in this study is still in the optimal range. According to Nugraha *et al*. (2018), feed efficiency for saline tilapia ranged from 30.93 to 53.84%.

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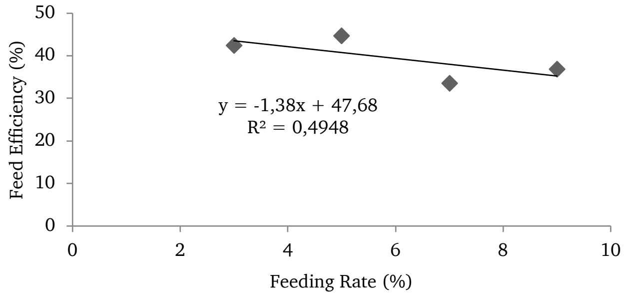

Figure 6. The regression equation for FR treatment is different from FE.

Water Quality

Water quality greatly influences the growth and survival of a biota (Fahrurrozi *et al*., 2023a). Based on the results of observations, the value of water quality is in optimal condition. The average temperature value of 30 ± 1 °C is in the good range for the survival of saline tilapia. This is because the optimal temperature value for saline tilapia culture has a range of 27-30 °C (Arisa *et al*., 2020), so the effect of temperature on research results is used as a supporting parameter. Same with temperature, the value of the salinity of the test waters during the study was in the optimal range of 4.6 ± 0.2 ppt. The optimal value of the water parameter in the form of salinity for the survival of saline tilapia ranges from 3-9 ppt (Thomas *et al*., 2021).

CONCLUSION

Based on the growth parameters in this study, the optimal feeding rate for saline tilapia culture ranged from 6.67% – 7%. Although the other parameters do not show the same feeding rate as the growth parameter, they are still in the good range for saline tilapia culture. It is recommended that the analysis of the feeding rate be accompanied by other parameters such as feed quality.

CONFLICT OF INTEREST

There is no conflict of interest in this manuscript between all authors upon writing and publishing this manuscript.

AUTHOR CONTRIBUTION

Ashari Fahrurrozi: author correspondence, principal researcher, collecting data, analysis, and manuscript writing. Benny Diah Madusari: researcher and analysis. Mohammad Bahrus Syakirin: researcher and analysis.

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