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THE EFFECT OF AUTOMATIC FISH FEEDING TECHNOLOGY ON THE QUALITY OF TILAPIA FISH CULTURE PRODUCTS

PENGARUH TEKNOLOGI PEMBERI PAKAN IKAN OTOMATIS TERHADAP KUALITAS HASIL BUDIDAYA IKAN NILA

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ABSTRACT

Fish culture has an important role in achieving food security in Indonesia. Tilapia is one of the fish that can be obtained through aquaculture activities. Several factors influence the growth of tilapia, such as water quality, feeding process, and quality of the feed provided. Too little feed can cause tilapia to experience slow growth, while too much feed can cause poor water quality because food is not eaten or eaten too late. The objective of this study is to analyze the use of an automatic feeder compared to conventional methods. The results can be a viable option for specific fish culture practices to achieve optimal yields. The results of the application of technology show that the feed conversion ratio reached 97.6%, the survival rate reached 94.4%, and the specific growth rate reached 3.58%. This is better compared to several other treatments in fish culture, so it can result in faster harvest results with efficient use of feed and maximum harvest quantity.

Keywords: automation technology, feeding, fish culture harvests, food security

ABSTRAK

Budidaya ikan air tawar memiliki peran penting untuk mencapai ketahanan pangan di Indonesia. Ikan nila merupakan salah satu ikan air tawar yang diperoleh melalui aktivitas perikanan budidaya. Terdapat beberapa faktor yang memengaruhi pertumbuhan ikan nila, seperti kualitas air, proses pemberian pakan, dan kualitas pakan yang diberikan. Jumlah pemberian pakan yang terlalu sedikit dapat menyebabkan ikan nila mengalamai pertumbuhan lambat, sedangkan pemberian pakan yang terlalu banyak dapat menyebabkan kualitas air menjadi tidak baik karena ada pakan yang tidak dimakan atau terlambat untuk dimakan. Tujuan penelitian ini adalah untuk menganalisis penggunaan *automatic feeder* dibandingkan dengan cara konvensional, sehingga hasilnya dapat digunakan sebagai pilihan yang dapat diterapkan dalam perlakuan budidaya ikan tertentu untuk menghasilkan panen maksimal. Hasil dari penerapan teknologi tersebut menunjukkan efisiensi pemberian pakan mencapai 97,6%; tingkat kelulusan hidup sebesar 94,4%; dan laju pertumbuhan spesifik mencapai 3,58%. Hal tersebut lebih baik jika dibandingkan dengan beberapa perlakuan lain dalam budidaya ikan, sehingga dapat mengakibatkan hasil panen lebih cepat dengan penggunaan pakan yang efisien, dan jumlah panen yang maksimal.

Kata kunci: hasil panen, ketahanan pangan, pemberian pakan, teknologi otomasi

INTRODUCTION

Aquaculture means the farming of aquatic animals and plants, such as fish, shrimp, shellfish, and many species of aquatic plants. Aquaculture in Indonesia plays a critical role in supporting food security by providing a large source of animal protein. The products from fish and other aquaculture contain high-quality protein important for human growth and development, one of which is tilapia. Aquaculture is further divided into different sectors based on the production method, including capture fisheries and cultured fisheries. The volume of production of cultured fisheries has increased since 2021, from 14.65 million tons in the year 2021 to 14.78 million tons in 2022 (KKP 2023).

Tilapia *Oreochromis niloticus* is a freshwater fish cultivated by aquaculture. It is a fish that has an elongated, compressed body and a rounded head, with a long dorsal fin and coloring that typically ranges from bluish tones to gray-green. In Indonesia, tilapia is listed as one of the most widely cultured fish species due to its fast growth and ability to adapt to all kinds of environmental conditions (Pattirane *et al.* 2022). Tilapia is generally farmed in small and large-scale ponds (Saputra *et al.* 2022). Tilapia meat has good consumer acceptance due to its good taste (Wibowo *et al.* 2023) and soft texture. In addition, tilapia is nutritionally valuable (Lembang and Widiawati 2022) since it has beneficial omega-3 and omega-6 fatty acids, which promote human health.

A plethora of factors influence the growth of tilapia, such as water quality (Christin *et al.* 2021), feeding habits (Alhijrah and Scabra 2023), and nutrient value of the feed provided (Pattirane *et al.* 2022). Feeding management has to be adjusted with consideration for several factors including age (Behmene *et al.* 2021), sex, season, and feeding habits. Tilapia is considered to be a herbivorous species, thus it mainly feeds on detritus, phytoplankton, and macrophytes. The type and feeding practices of feed significantly affect the economic sustainability of aquaculturists (Firdaus *et al.* 2020). An inadequate supply of pellet feed will lead to slow growth rates in tilapia, and overfeeding can affect water quality through uneaten feed that settles at the bottom or due to delayed consumption of feed. Longer periods of fish growth increase the duration from stocking the fry to harvesting and poor water quality increases the risk of fish mortality.

Technology emerges as a response to the need for problem-solving. In fish culture, technology can be used to facilitate cultivation (Setiyowati *et al.* 2022). In addition to controlled farming systems, such as recirculating aquaculture systems (RAS), there are also technologies of automation for fish feeding (Yusoff *et al.* 2018), including those using IoT-based solutions (Chaidir *et al.* 2021). Based on gathered information and previous discussions, this study explores the impact of technology on aquaculture. This work tries to determine the use of automated feeding systems compared to conventional methods, providing insights that can help best practices in fish culture to get the best harvest outcomes. Evaluation parameters of the quality of aquaculture include feed efficiency, survival rates, and specific growth rates.

METHODS

The author conducted the experiment to make the observation of the equipment operation convenient. The research began on October 8th, 2023, and continued for about 42 days. All types of tools and materials were used, from a 1 m diameter circular tank, a pump, a water filtration system, and an automatic fish feeder. The materials included 36 tilapia and commercial fish food marked as type 781-2. The study used black tilapia fry from local agricultural producers with an average weight of about 16 grams; these fry were stocked in the experimental setup at a density of 36 individuals. In the feeding regime, an automatic fish feeder was set to deliver food equal to about 3% of the fish body weight daily; the frequency of this feeding regime varied according to fish size, being done once, twice, or three times a day. The feeder was set to deliver a single feeding burst per day during the first two weeks, increased to two bursts during the following three weeks, and finished with three bursts during the last week.

Figure 1 shows the auto fish feeder that is combined with the accurate feed dispensing system and digital timing programmed. The device consists of a fish feed container, marked as component 1, whose dimensions are 40 cm long, 35 cm wide, and 50 cm tall. The feed container support frame, marked as component 2, measures 30 cm tall, 30 cm long, and 25 cm wide. The feeder also consists of a feed launcher (marked as component 3), and a precise measuring cup (marked as component 4) with a 5 cm diameter and a 5 cm length of the tube, which is attached to a servo motor having a bearing in the front. The electronic circuitry (marked as component 5) is housed inside the control box with a digital timer and a rotary selector that is used for operating the DC motor and the servo motor.

Figure 2: Block diagram of the electronic components in the control box (component 5). The processing of the received information from the rotary selector and the digital timer, and the actuation control of both the DC and the servo motors, are done by an ESP32 microcontroller board (Tania *et al*. 2023). The user can change the feeding schedule using a built-in digital timer interface and set the feed quantity using the rotary selector.

Operation of this device starts with acquiring and holding the data from the rotary selector, which has six settings corresponding to numerical values from 1 to 6, used in setting the feed dose. On the other hand, the ESP32 is continuously reading the digital signal coming from the digital timer. Upon reaching the operator-set schedule, the timer sends a “high” signal, and the feeder motor is activated to dispense the feed. After the 1-second delay, the servo motor is enabled for feed measurement; the dosage is set by the rotary selector set earlier by the operator. The dispensing operation is done, and the ESP32 resets to read the instructions once again.

The first step in data acquisition is the measurement of the initial total weight of the fish at stocking. Feeding is done by automatic fish-feeding technology, while water quality is measured daily. After 1.5 months, several parameters, such as fish weight, specific growth rate, survival rate, and feed efficiency, are measured.

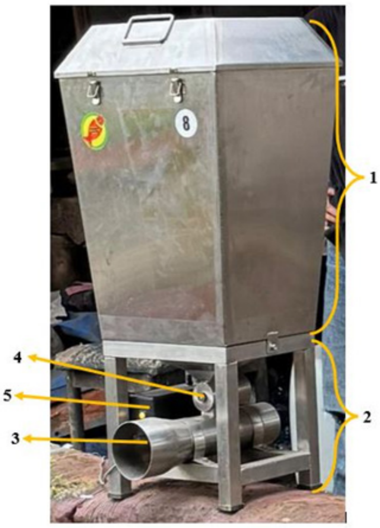

Figure 1. Automatic fish feeder that is combined with the accurate feed dispensing system and digital timing programmed.

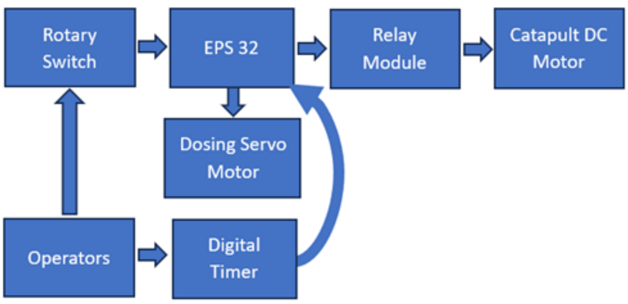

Figure 2. Electronic circuit block diagram.

Feed efficiency ratio

The feed efficiency ratio (FER) is the percent of the total amount of feed input to the total weight of the harvested fish. The FER is calculated by the following formula (Wibowo *et al.* 2023):

$$FER = ((Wt - Wo)/F) \times 100$$

Description:
FER = Feed efficiency ratio (%)
Wo = Initial biomass weight (g)
Wt = Final biomass weight (g)
F = Total consumed fish feed (g)

Survival rate

The formula used to calculate the survival rate (Kurniawan *et al.* 2023) is as follows:

$$SR = (Nt/No) \times 100$$

Here, SR represents the percent survival rate of the fish, Nt is the number of fish at the end of the testing, and No is the number of fish at the beginning of the testing.

Specific growth rate

The formula to find the specific growth rate, according to Sinaga and Mukti (2022), is:

$$LPS = ((\ln Wt - \ln Wo)/T) \times 100$$

LPS = Specific growth rate (%)
Wt = Average weight at final phase (g)
Wo = Average weight at initial phase (g)
T = Duration of fish keeping (days)

RESULTS AND DISCUSSION

Device checking was conducted to know if the device would work effectively throughout the cultivation. Checking focused on the active dispenser functionality, which was checked to have operated on schedule and the feed dosage to have corresponded to the operator-set rotary selector. The feeding times were set at 7:00 AM, 10:00 AM, 1:00 PM, 4:00 PM, and 7:00 PM.

Table 1 presents results from tests of the active dispenser versus pre-set timings. This table presents results from one week of performance of the dispenser and has results that would be consistent with previous studies using a different mechanical dispensing system (Almufaridz *et al.* 2021).

Table 2 shows the test result of feed dosage based on movements of the servo motor based on the setting made by the operator using the rotary selector. The result shows that the rotary selector works well in controlling the dosage of feed using the servo motor, where each desired dosage is measured at 27 grams. Based on this analysis, the device is deemed suitable to support the process of cultivating fish.

The use of automated fish feeding in experimental research is shown in Figure 3. The outputs obtained from the testing process are the feed efficiency ratio, survival rate, and specific growth rate. Each of the parameters was compared to alternative aquaculture practices that exclude the use of automated feeders. The comparative approaches that have been used are biofloc, protein supplementation, and the recirculating aquaculture system. The comparative results are then discussed to highlight the advantages involved in using this technology.

The FER, survival rate, and specific growth rate were calculated using equations, respectively. Parameters required for the calculation of these values were obtained during fish maintenance and entered into the equations. The following parameters were obtained over the 42-day period of maintenance:

- Total consumed fish feed = 1,950 g
- Initial biomass weight (g) = 544 g
- Final biomass weight (g) = 2,448 g
- Initial amount of fish = 36 fishes
- Final amount of fish = 34 fishes
- Average weight at final phase (g) = 72 g
- Average weight at initial phase (g) = 16 g

From these results, the following values for FER, survival rate of fish, and specific growth rate were estimated:

- EPP = 97.6%
- Survival Rate = 94.4%

For specific growth rate:

- ln Wt = 4.2
- ln Wo = 2.7
- T = 42 days

so that the specific growth rate is obtained = 3.5 %

The values were examined concerning alternative agricultural treatments, as presented in Table 3. Treatments 1 through 4 represent fish culture techniques that do not utilize automatic feeding technology.

Table 1. Scheduled testing of fish feeder dispenser.

Day	Time (Western Indonesia Time)				
	07.00	**10.00**	**13.00**	**16.00**	**19.00**
1	Success	Success	Success	Success	Success
2	Success	Success	Success	Success	Success
3	Success	Success	Success	Success	Success
4	Success	Success	Success	Success	Success
5	Success	Success	Success	Success	Success
6	Success	Success	Success	Success	Success
7	Success	Success	Success	Success	Success

Table 2. Feed dosage testing based on rotary selector settings.

Rotary Selector Positions	Amount of Feed Dosages
1	1 time
2	2 times
3	3 times
4	4 times
5	5 times
6	6 times

Figure 3. Example of application of automatic fish feeding technology.

Table 3. Comparative analysis of quality parameters in aquaculture across five distinct treatments.

Parameters	Treatment 1 (%)	Treatment 2 (%)	Treatment 3 (%)	Treatment 4 (%)	Implementation of Automatic Fish Feeding Technology
Fish feed efficiency	96.7	85.7	74.35	-	97.6
Survival rate	91.6	100	90	95	94.4
Specific growth rate	3.23	3.01	-	2.67	3.58

Treatment 1 is fish culture using biofloc technology with a twice-daily feeding frequency (Putra *et al.* 2022). This treatment has results that approach the use of automatic fish-feeding technology. The biofloc technology provides facilities for the production of natural feed in the form of floc in the cultivation medium. Floc is a natural fish feed with nutrient content, including protein (19.0%–40.6%), fat (0.46%–11.6%), and ash (7%–38.5%), which can help to improve fish growth performance.

Treatment 2 uses feed with 31% protein content added by bacterial protease enzymes (Kurniasih *et al.* 2013). The survival rate in this treatment was 100% because the water quality is always maintained by using a recirculating system with filter cleaning and TL lighting. Filter composition in the re-circulation system is beneficial to fish survival and specific growth rate. Treatments 2 and 4 have higher survival rates than the treatment with automatic feeding technology.

Vitamin C supplementation in commercial feed and stocking density are considered vital for the survival and growth of tilapia (Komalasari *et al.* 2017). Nevertheless, this particular treatment showed no better survival and growth compared to only automatic feeding technology.

From Table 3, treatment 1, which involved the application of automatic feeding technology, showed high feed efficiency and specific growth rates in comparison with other treatments. In addition, the use of this technology results in low production costs and high profitability (Verma *et al.* 2023), since treatment 1 depends on natural feed (floc) while automatic feeding technology allows for controlled feed intake. Treatments 2 and 4 indicate a better survival rate than other treatments, likely due to stable water quality maintained by recirculation systems in cultivation (Lembang and Widiawati, 2022), since filter composition affects fish survival rates (Hapsari *et al.* 2020).

CONCLUSION

The effects of automatic fish-feeding technology on feed efficiency, survival rates, and specific growth rates have been assessed. Results of the tests show feed efficiency of 97.6%, a survival rate of 94.4%, and a specific growth rate of 3.58%. These types of outcomes may lead to shortened harvests by having the most efficient use of feed and more yield compared with other treatments lacking the use of the automatic feeder. Such values can only be improved by the application of some agricultural practices, for example, maintaining stable water quality and employing automated fish-feeding technology. Using such synergy, the survival rate can conceivably be improved to 100%.

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