

**EVALUATION OF THE USE OF FILTER MEDIA FROM CHICKEN EGG SHELL AND GREEN MUSSELS SHELL WASTE ON NILE TILAPIA (*Oreochromis niloticus*) CULTIVATION IN THE RAS (RECIRCULATING AQUACULTURE SYSTEM)**

Evaluasi Penggunaan Media Filter dari Limbah Cangkang Telur Ayam dan Cangkang Telur Kerang Hijau Terhadap Budidaya Ikan Nila (*Oreochromis niloticus*) dalam Sistem RAS (*Recirculating Aquaculture System*)

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**ABSTRACT**

Tilapia (*Oreochromis niloticus*) culture faces water quality challenges due to the accumulation of metabolic waste and uneaten feed. Recirculating aquaculture systems (RAS) can improve water quality, but commercial filter media are relatively expensive for small-scale farmers. Waste materials such as mussel shells, eggshells, and zeolite have potential as economical alternatives. Therefore, research is needed to evaluate the effectiveness of waste-based filter media in maintaining water quality and fish growth. This study aimed to analyze the effect of waste filter media in RAS on water quality and tilapia growth and to determine an economical alternative for small-scale farmers. A descriptive study was conducted for 28 days in Bungah Village, Gresik, using three filter media treatments. The treatments consisted of P1 (foam + mussel shell + bioball), P2 (foam + eggshell + bioball), and P3 (foam + zeolite + bioball) with a stocking density of 14 fish per aquarium. Observed parameters included pH, growth (WG, SGR), and FCR. Results showed that all treatments-maintained pH within the optimal range with minimal fluctuation. Treatments P1 and P3 produced higher growth compared to the others. FCR values in all treatments indicated good and relatively similar feed efficiency. Mussel shell and zeolite media provided more consistent biological performance. Eggshell media also maintained water quality although growth was slightly lower. Overall, waste-based filter media performed comparably to commercial filters. Waste filter media in RAS effectively maintained water quality and supported tilapia growth. Utilization of waste materials has potential as an economical alternative for small-scale farmers.

**Keywords:** Growth, Recirculating Aquaculture System, Tilapia, Waste Filter Media, Water Quality

## ABSTRAK

Budidaya ikan nila (*Oreochromis niloticus*) menghadapi tantangan kualitas air akibat akumulasi limbah metabolisme dan sisa pakan. Sistem resirkulasi akuakultur (RAS) mampu memperbaiki kualitas air, namun biaya media filter komersial relatif tinggi bagi pembudidaya skala kecil. Pemanfaatan limbah seperti cangkang kerang, cangkang telur, dan zeolit berpotensi menjadi alternatif ekonomis. Oleh karena itu, diperlukan penelitian untuk mengevaluasi efektivitas media filter limbah dalam menjaga kualitas air dan pertumbuhan ikan. Penelitian ini bertujuan menganalisis pengaruh media filter limbah pada sistem RAS terhadap kualitas air dan pertumbuhan ikan nila serta menentukan alternatif media filter ekonomis bagi pembudidaya. Penelitian deskriptif dilakukan selama 28 hari di Desa Bungah, Gresik dengan tiga perlakuan media filter. Perlakuan terdiri atas P1 (busa + cangkang kerang + bioball), P2 (busa + cangkang telur + bioball), dan P3 (busa + zeolit + bioball) dengan kepadatan 14 ekor per akuarium. Parameter yang diamati meliputi pH, pertumbuhan (WG, SGR), dan FCR. Hasil menunjukkan seluruh perlakuan mampu mempertahankan pH pada kisaran optimal dengan fluktuasi minimal. Perlakuan P1 dan P3 menghasilkan pertumbuhan lebih tinggi dibandingkan perlakuan lainnya. Nilai FCR pada semua perlakuan menunjukkan efisiensi pakan yang baik dan relatif seragam. Media cangkang kerang dan zeolit memberikan performa biologis lebih konsisten terhadap pertumbuhan ikan. Media cangkang telur juga mampu menjaga kualitas air meskipun pertumbuhan sedikit lebih rendah. Secara umum, media filter limbah memberikan hasil setara dengan filter komersial. Media filter limbah pada sistem RAS efektif menjaga kualitas air dan mendukung pertumbuhan ikan nila. Pemanfaatan bahan limbah berpotensi menjadi alternatif ekonomis bagi pembudidaya skala kecil.

**Kata Kunci:** Ikan Nila, Sistem Resirkulasi Akuakultur, Media Filter Limbah, Kualitas Air, Pertumbuhan

## INTRODUCTION

Tilapia (*Oreochromis niloticus*) cultivation is a rapidly growing freshwater fishery with promising economic prospects. Implementing a recirculating aquaculture system (RAS) in tilapia ponds can increase water efficiency while improving the quality of the cultivation environment. This system allows water to be reused after filtration, thus minimizing organic waste and maintaining stable water conditions. With better water quality, tilapia cultivation productivity can be increased and the risk of mortality due to environmental stress can be reduced. Therefore, the RAS system is becoming an increasingly popular technology alternative, especially in intensive cultivation, which requires continuous water quality control.

Tilapia (*Oreochromis niloticus*) is a leading commodity in Southeast Asia due to its various biological and economic advantages. This fish is relatively easy to cultivate, grows rapidly, and adapts to various environmental conditions. Furthermore, tilapia is known to be disease-resistant and tolerant of fluctuations in water quality such as high pH, elevated ammonia levels, and temperature changes, making it suitable for both intensive and semi-intensive cultivation systems. Its high economic value and stable market demand make tilapia a crucial commodity for supporting food security and increasing farmer incomes (Hertanto, 2013). However, the success of tilapia cultivation remains heavily influenced by the quality of the water, the primary living medium.

Water quality is a key factor in determining the success of tilapia cultivation. Water quality parameters such as temperature, pH, dissolved oxygen (DO), and ammonia concentration must be within the optimal range to support maximum fish growth. The ideal water pH for tilapia cultivation is in the range of 6–9, while sufficient dissolved oxygen levels are necessary to support fish metabolism. Furthermore, high ammonia concentrations can be toxic and inhibit fish growth. If water quality is uncontrolled, fish will experience physiological

stress, resulting in decreased appetite, slow growth, and even an increased risk of mortality (Maimunah & Kilawati, 2020). Therefore, water quality management is a crucial aspect of tilapia cultivation systems.

The main challenge in tilapia cultivation is water quality degradation due to the accumulation of organic waste. This waste originates from leftover feed, fish feces, and metabolic activities that produce harmful compounds such as ammonia and nitrite. Furthermore, environmental pollution and limited clean water resources are becoming increasingly complex problems, especially in areas with high aquaculture intensity. Anthropogenic pressures such as domestic and agricultural activities contribute to the deterioration of the water sources used in aquaculture (Bakri, 2015). This situation forces farmers to carry out regular water changes, which requires significant costs and requires the availability of water.

Previous research has shown that suboptimal water quality can significantly reduce the survival and growth rates of tilapia. Water containing high ammonia concentrations, unstable pH, and low dissolved oxygen levels will affect the physiological processes of the fish. As a result, feed efficiency decreases and growth rates are suboptimal. Furthermore, poor environmental conditions also increase the fish's susceptibility to disease (Effendi, 2003). Therefore, technology is needed that can maintain water quality sustainably without significantly increasing production costs.

One feasible solution is the use of a recirculating aquaculture system (RAS) with filter media. This system works by filtering water through several layers of filtration media that function mechanically, biologically, and chemically. Commonly used filter media include sand, activated carbon, and zeolite, which effectively filter suspended particles and absorb harmful compounds. RAS systems have been proven to maintain stable water quality and reduce the need for regular water changes. However, the use of commercial filter media is often relatively expensive, especially for small- and medium-scale farmers with limited capital.

Alternatively, waste such as chicken eggshells and mussel shells can be used as a more economical and environmentally friendly filter media. Eggshells and mussel shells contain calcium carbonate, which has the potential to help stabilize water pH and provide a surface for the growth of nitrifying bacteria. Furthermore, the use of this waste also supports the concept of sustainable cultivation through the use of readily available and low-cost materials. Therefore, the use of waste as a filter media is expected to improve water quality while reducing production costs.

The research problem formulation in this study focuses on the effect of differences in water quality produced by waste filter media on the growth of tilapia. Furthermore, this study also examines the impact of the RAS system with filter media on water pH, absolute weight, Specific Growth Rate (SGR), and Feed Conversion Ratio (FCR) parameters in tilapia cultivation. This study aims to analyze the effect of differences in water quality resulting from the use of chicken eggshell and green mussel shell filter media on tilapia growth.

Theoretically, this research is expected to contribute to the development of aquaculture science, particularly regarding the application of the RAS system with waste-based filter media. This study can also serve as a reference for further research on water quality management, waste utilization, and cost efficiency in fish cultivation. Furthermore, this research enriches the literature on the relationship between water quality, fish growth, and sustainable water recycling techniques.

Practically, this research is expected to provide solutions for selecting effective filter media for tilapia farmers. Utilizing waste as a filter media can support optimal fish growth, increase feed efficiency, and reduce production costs. Furthermore, the implementation of this system can also encourage more environmentally friendly cultivation through waste reduction and more efficient water use, especially for small- and medium-scale farmers.

## RESEARCH METHODS

### Research Time and Location

The research was conducted on Nongkokerep Street, Bungah Village, Bungah District, Gresik Regency. The study lasted from June 1 to June 28, 2025, for 28 days.

### Equipment and Materials

The research equipment included a 30 x 15 x 20 cm glass aquarium with a volume of approximately 7 liters as the tilapia rearing tank. The water circulation system used a GINGA GA-1200 pump with a capacity of 1,000 L/hour, fed through a ¾-inch diameter PVC pipe. An aerator was used to increase dissolved oxygen, a pH meter measured the water's acidity, and a bucket served as a water reservoir when changing the rearing media.

The research material consisted of 14 tilapia from Glagah District, Lamongan Regency, serving as the test organisms. The filtration media used included foam as a mechanical filter, zeolite as an ammonia absorber (Husaini et al., 2020), bioballs as a biological filtration medium, and green mussel shells and chicken eggshells as natural filtration media that stabilize pH and increase water alkalinity (Novianti et al., 2019; Rahmaniah et al., 2024).

### Research Design

The determination of the different treatments in this study was based on the physical and chemical characteristics of each filter media, which have the potential to affect water quality in a recirculating aquaculture system (RAS). Mussel shells were chosen because they contain calcium carbonate, which can increase alkalinity and stabilize water pH, as well as provide a surface for the growth of nitrifying bacteria. Eggshells also have a high calcium carbonate content and have the potential to function as a pH buffer and a more cost-effective biological medium. Zeolite was used as a comparison because it is known to have a high adsorption capacity for ammonia and dissolved nitrogen compounds, making it commonly used as a filter media in fish farming. Foam is used as a mechanical filter to remove suspended solid particles, while bioballs serve as a biological medium to support the growth of nitrifying bacteria. Based on these considerations, three filter media treatments were determined: P1 (foam + mussel shells + bioballs), P2 (foam + eggshells + bioballs), and P3 (foam + zeolite + bioballs). Each treatment used 14 tilapia per container, replicated three times, and randomly assigned to the experimental locations. The research layout is shown in Figure 1.

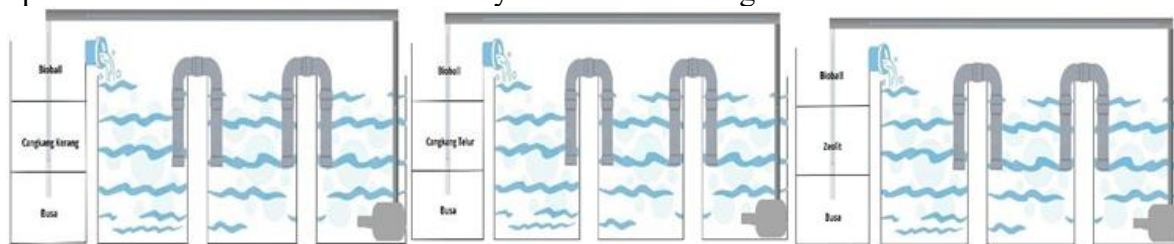


Figure 1. Design (Layout) for A Trial Using Waste Filters for Tilapia Cultivation

### Stages

The stages in this research were limited to the maintenance and preparation of the filter media for use, including washing, drying, breaking down, and designing the filter media layout.

#### Filter Media Washing

All filter media used, including foam, zeolite, bioballs, chicken eggshells, and green mussel shells, were washed thoroughly with running water to remove dirt, dust, and any remaining organic matter. This process ensures the filter media is clean before use in the next step.

### **Filter Media Drying**

The washed filter media is then dried naturally by exposing it to sunlight until the water content is significantly reduced. Drying prevents the growth of unwanted microorganisms and maintains the quality of the filter media before the crushing and sieving process.

### **Filter Media Crushing**

Zeolite media, chicken eggshells, and green mussel shells are crushed using simple tools such as hammers until a relatively uniform particle size is achieved, which are then weighed at 150g. The goal of equalizing the particle size is to increase the surface area of the media, thereby increasing its effectiveness as a filtration medium.

### **Filter Media Arrangement and Design**

This stage involves planning the order of media placement according to their function and designing the water flow scheme through the filter media. The design focuses on filter media efficiency, ease of monitoring, and safety, without affecting the operation of the fish farming system.

### **Maintenance**

Before stocking the tilapia in the aquarium, the weight of the tilapia is measured using a scale. Tilapia were stocked at a density of 14 fish in each aquarium, followed by prior acclimatization to prevent stress and maximize growth. During the rearing period, the tilapia were fed at 9:00 AM, 1:00 PM, and 5:00 PM WIB, with a feed weight of 1.2 g.

## **Research Procedures**

### **Research Variables**

Observation variables in this study included water quality and tilapia growth. The water quality parameter observed was pH, as it plays a crucial role in supporting fish health and metabolism. The optimal pH range for tilapia is between 6.5 and 8.5, so pH measurements were conducted weekly to ensure stable water conditions and avoid stress on the fish.

Furthermore, tilapia growth was observed by measuring fish weight. Weighing was carried out individually using a digital scale with the appropriate level of accuracy and was carried out routinely throughout the study. The data obtained were used to analyze the relationship between water quality in the RAS system and tilapia growth and to evaluate the effectiveness of the filter media used.

Research data were collected through direct observation of water quality and fish growth throughout the study period. pH measurements were conducted routinely using a digital pH meter. Fish weight measurements were carried out individually using a highly accurate digital scale. The formula used to process fish growth data is as follows:

1. Absolute Average Growth (WG) (Dehaghani et al., 2015):

$$(WG) (g) = W_t - W_o$$

Where:

W : Absolute average growth (g)

W<sub>t</sub> : Average fish weight at the end of the study (g)

W<sub>o</sub> : Average fish weight at the beginning of the study (g)

2. Specific Growth Rate (SGR) (%) (Muchlisin et al., 2016):

$$SGR (\%) = (\ln W_t - \ln W_0) / t \times 100\%$$

Where:

SGR : Specific growth rate (SGR) (%)

W<sub>t</sub> : Average fish weight at the end (g)

W<sub>0</sub> : Average fish weight at the beginning (g)

t : Treatment duration (days)

3. Ratio Feed Conversion Ratio (FCR) (Safari et al., 2017):

$$FCR = F / W_t - W_o$$

Where:

FCR : Feed conversion ratio

F : Amount of feed given (g)

Wt : Final fish weight (g)

Wo : Initial fish weight (g)

Data analysis was performed using Microsoft Excel by processing the water pH and tilapia weight data obtained during the study. Data on pH and fish weight were recorded and presented in tables and graphs to facilitate observation of change trends. The pH value was analyzed descriptively by comparing it to the optimal pH range for tilapia (6.5–8.5), while fish growth was analyzed based on the difference between initial and final weights, which were averaged. The results of the analysis were used to evaluate the relationship between water quality and tilapia growth and to assess the effectiveness of the filter media in the RAS system.

## RESULT

### The Effect of Chemical Filter Media on the Water pH Quality of Tilapia Cultivation Ponds

Water pH quality was monitored weekly for four weeks during the tilapia cultivation period in three RAS (Recirculating Aquaculture Systems) using chemical filter media made from waste.

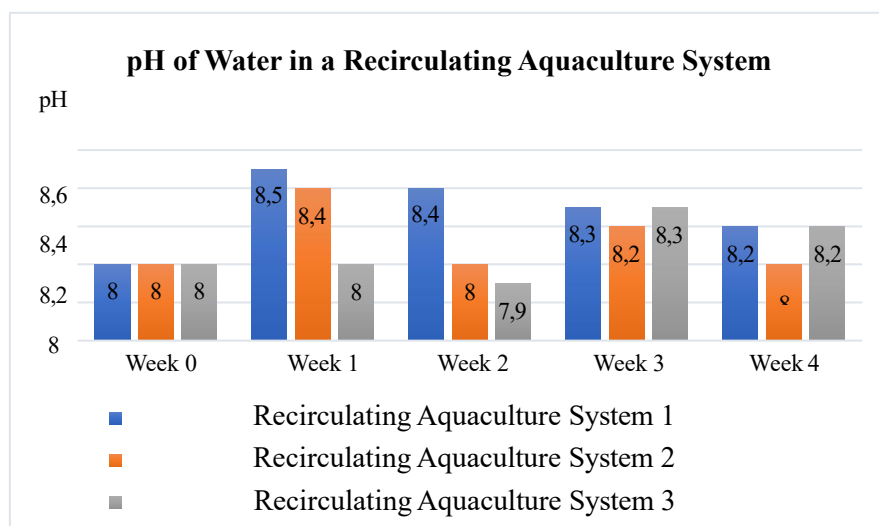


Figure 2. Water pH Quality During Testing

The waste filter media (clamshells, zeolite, eggshells) in the RAS system effectively maintained a stable water pH within the range of 7.9–8.5 for four weeks, with minimal fluctuation (Figure 2), supporting optimal tilapia metabolism according to cultivation standards (Effendi, 2016) and the nitrification process through natural adsorbents (Sari et al., 2021; Widanarni et al., 2018).

### Impact of Filter Media on Tilapia Growth and Health

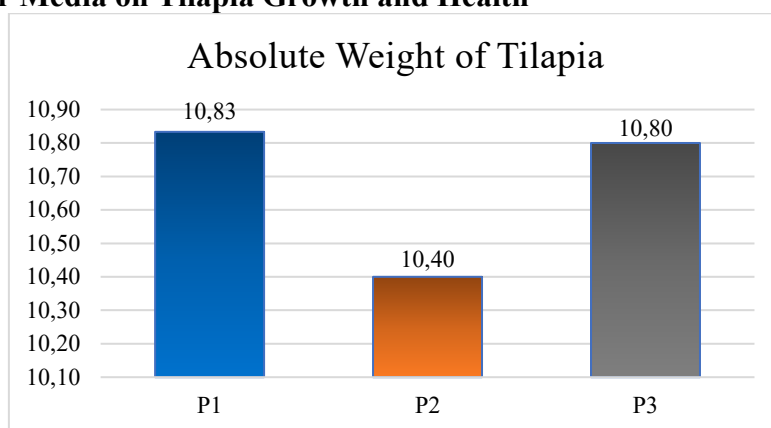


Figure 3. Average Absolute Weight (g) of Tilapia

The use of waste filter media increases tilapia weight (Figure 3), reduces physiological stress through stable pH and low ammonia, and supports the balance of nitrifying bacteria, which positively impacts health, economic efficiency, and the principles of a circular economy (Nurhasanah et al., 2022; Widanarni et al., 2018).

### Feed Utilization Efficiency and Sustainability of Waste Filter Media

Low FCR values (Figure 4) in all three treatments indicate optimal feed efficiency (Tayebi, 2020). Waste filter media made from chicken eggshells and green mussel shells helps reduce operational costs, reduce pollution, and support sustainable aquaculture through training and regular monitoring for farmers (Sari et al., 2021; Nurhasanah et al., 2022).

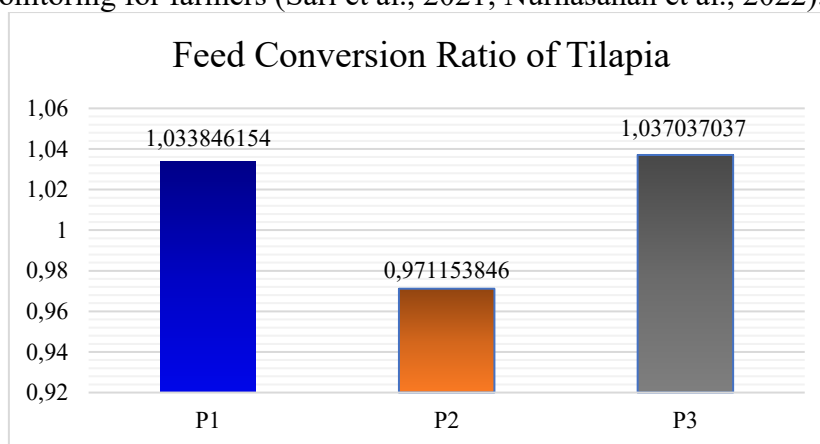


Figure 4. Feed Conversion Ratio (FCR) Results for Tilapia

### Specific Growth Rate (SGR) of Tilapia on Different Filter Media

The highest SGR value (Figure 5) confirms the effectiveness of waste filter media in increasing growth through improved water quality and nutrient absorption, in line with sustainable cultivation innovations for fisheries study programs (Diansyah et al., 2018; Ardiansyah et al., 2017).

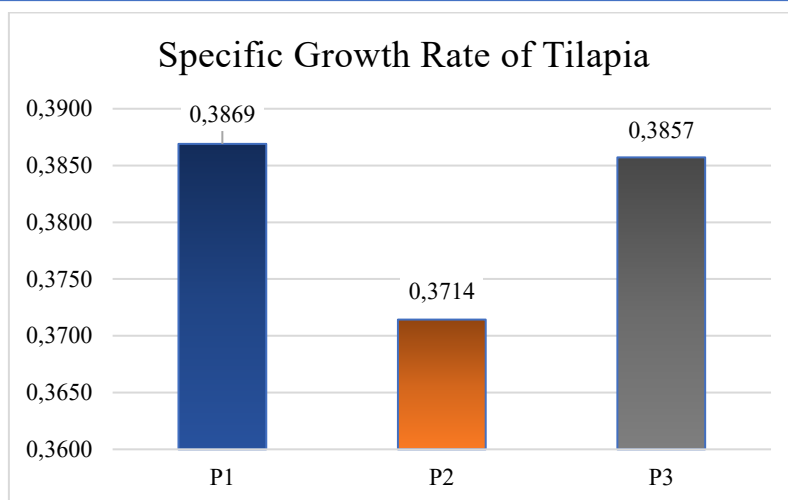


Figure 5. Specific Growth Rate Results for Tilapia

## DISCUSSION

### The Effect of Chemical Filter Media on the pH Quality of Tilapia Cultivation Pond Water

Observations of water pH over 28 days showed high stability in all three RAS systems (8.0–8.5), with fluctuations of <0.5 units. This finding confirms Effendi (2016) that the range of 6.5–8.5 is optimal for tilapia, where P1 (clamshell: 8.4–8.5) and P2 (eggshell: 8.0–8.5) function as  $\text{CaCO}_3$  buffers effectively neutralizing acid metabolites, consistent with Sari et al. (2021) who reported a similar decrease in the second week (0.2–0.4 units). Improvements to that study included maintaining stability until the fourth week, supported by bioballs that optimize nitrification ( $\text{NH}_3 \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^-$ ).

P3 (zeolite: 7.9–8.3) showed pH recovery in the third week, confirming Widanarni et al. (2018) on ammonia adsorption reduced  $\text{H}^+$  production, but rejected the absolute superiority of zeolite due to higher fluctuations (0.5 units) compared to P1/P2. Quantitatively, the average pH of P1 (8.34) > P2 (8.15) > P3 (8.10) correlated with organic  $\text{CaCO}_3$  content, answering the first problem formulation that waste media is effective in maintaining water quality.

### Impact of Using Chemical Filter Media on Tilapia Growth and Health

A significant increase in weight (initial 5.9–6.7 g → final 16.3–17.5 g; WG 10.4–10.8 g) indicates an optimal environment, with P1/P3 superior. The use of waste filter media increases tilapia weight (Figure 3), reduces physiological stress through stable pH and low ammonia, and supports the balance of nitrifying bacteria, which positively impacts health, economic efficiency, and the principles of a circular economy (Nurhasanah et al., 2022; Widanarni et al., 2018).

### Feed Utilization Efficiency and Sustainability of Waste Filter Media Use in Tilapia Cultivation

A low FCR (P3>P1>P2; range <2.0) indicates efficient conversion, confirming Tayebi (2020) (0.8–1.6 is ideal) and Safari et al. (2017). Az Zahra et al. (2019) rejects the argument that a high FCR is due to feed inefficiency, as it is optimal even with standard feed, thanks to toxin adsorption.

### Specific Growth Rate (SGR) of Tilapia on Different Filter Media

High SGR (P1: 0.3869; P3: 0.3857; P2: 0.371%/day) outperformed Diansyah et al. (2018) (0.31) and Hadi et al. (2019) (0.29–0.33). Ardiansyah et al. (2017) confirmed that wastewater filtration increases nutrient absorption, with P1/P3 > P2 due to strong buffering.

Quantitative improvement: 17–24% higher SGR due to 3-stage filtration compared to a single study (Putri, 2020).

### CONCLUSION

The waste filter media, consisting of shellfish, eggshells, and zeolite, in the RAS system effectively maintains water pH stability within the optimal range for tilapia cultivation with minimal fluctuations. This stable water quality condition supports optimal tilapia growth and produces an efficient feed conversion ratio (FCR) comparable to that of commercial filters. Furthermore, the use of waste-based filter media has lower operational costs, making it an economical alternative for small- and medium-scale farmers in Indonesia while simultaneously fulfilling the research objective of analyzing the effect of water quality on tilapia growth.

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