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Determination of The Best Concentration of Chitosan as a Recirculation Filter for Growth and Survival of Tilapia (*Oreochromis niloticus*)

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Abstract

Tilapia (*Oreochromis niloticus*) is a cultivated commodity that is widely developed because of its economic value and high nutritional content. However, in aquaculture activities, problems such as water pollution reduce water quality. This problem means continuous water changes to maintain water quality. A recirculation system can be a solution by reusing water. The use of filters is an important factor in a recirculation system. One alternative filter is chitosan derived from crab and shrimp shell waste. This study aims to determine the optimal concentration of chitosan as a recirculation filter. The study was conducted experimentally using a completely randomized design with four treatments and three replications. Each treatment is a variation of the concentration of chitosan as a filter. Analysis of measurements carried out was absolute weight growth, specific growth rate, survival, and water quality. Based on the ANOVA results, each treatment had a significant effect on the absolute weight growth of tilapia, $P<0.05$, with P3 being the most significantly different. At the same time, the specific growth rate and survival of tilapia did not significantly affect $P>0.05$. The water quality measurements showed that the temperature, pH, ammonia, and DO values were still by the quality standards of tilapia aquaculture, with P3 treatment, which gave better water quality results. Based on the study results, the optimal concentration of chitosan as a filter in supporting tilapia growth was in the P3 treatment, which was 50 mg.

INTRODUCTION

Tilapia (*O. niloticus*) is a freshwater fish that is widely cultivated because it has economic value and nutritional content as a protein source of 17.5% of fish protein in general, which is 18%. The increase in tilapia aquaculture production intensifies intensively with high stocking densities and high feed amounts. However, this method produces aquaculture waste problems in the waters. This condition causes a decrease in water quality, requiring an ample water supply for changing cultivation water (Sumoharjo, 2010). Water is an important element because it is a living medium, feed distribution, and oxygen for aquatic biota. However, the water medium in aquaculture is susceptible to contamination by various activities (Situmorang, 2017).

The recirculation system is the right solution with a system that reuses water by rotating the water continuously through a filter intermediary or into a filter container (Fauzzia *et al*., 2013). The working system of recirculation is that water from the maintenance media has flowed into the filter, and then the water flows back to the maintenance media. This system can maintain water quality conditions in the optimal range. The use of a recirculation system is expected to increase the carrying capacity of the culture media because the water used can be appropriately controlled, is effective in water utilization, and is more environmentally friendly for fish life and growth (Zonneveld *et al*., 1991). The key to the recirculation system is the use of filters. Filters used in recirculation systems are usually composed of biocrystal, coral, zeolite, and activated carbon (Thesiana and Pamungkas, 2015).

The selection of filters in the recirculation system is very important because it has the function of maintaining water quality. One alternative filter is chitosan. Chitosan comes from fishery waste chitin substances such as crab and shrimp shells, which are significant and underutilized. Therefore, this makes chitosan an environmentally friendly and effective filter alternative. Chitosan has advantages as an adsorption filter as well as a natural antibacterial. Chitosan is in the form of yellowish-white flakes, odorless and tasteless, so it is safe to use in aquaculture (Teguh, 2003). Chitosan is non-toxic with the characteristic of having amino functional groups as a natural protein in waters for aquaculture biota (Kartini, 1997). Chitosan has been investigated and effectively filters toxic compounds such as heavy metals Pb, Cu, Cr, and Hg in waters (Thariq *et al*., 2016).

The growth and survival of tilapia are strongly influenced by good water quality. Because water is vital in aquaculture activities, it is necessary to use the correct method in water quality management (Kelabora and Sabariah, 2010). The use of chitosan with the right concentration needs to be done to produce maximum results. This research was conducted with variations in chitosan concentration to obtain the best growth rate and survival of tilapia.

METHODOLOGY

Place and Time

This research was conducted in December 2021-March 2022 at the Mini Hatchery Laboratory and Water Quality Laboratory, Faculty of Fisheries and Marine, University of Borneo Tarakan.

Research Materials

The tools used during the research were a water pump (Yamano WP-3600), aquarium, aerator, analytical balance (Mettler Toledo AL-204), and UV-Vis spectrophotometer. The materials used in the study were tilapia (*Oreochromis niloticus*) seeds measuring 4-5 cm, crab shell chitosan with 95.22% deacetylation purchased from CV. Chi Multiguna, sponge, gravel, filter paper, charcoal, pellet feed PF999, and aquadest.

Research Design

The method used in this study was an experimental method with a completely randomized design (CRD), which consisted of four treatments and three replications. Each treatment consisted of 12 tilapia seeds measuring 4-5 cm/head. Maintenance was carried out for 30 days. Research tests with variations in the concentration of chitosan used are as follows:

P1 : Control without filter
P2 : Charcoal filter + sponge + chitosan 0 mg + sponge + gravel
P3 : Charcoal filter + sponge + chitosan 50 mg + sponge + gravel
P4 : Charcoal filter + sponge + chitosan 100 mg + sponge + gravel

Work Procedure

The maintenance container used an aquarium that is washed first with clean water. The aquarium was then filled with 12 liters of water each. A filter container

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was placed in the aquarium with an arrangement starting from the bottom, namely charcoal, sponge, chitosan, sponge, and gravel. After that, the adapted tilapia seeds were included in the aquarium as many as 12 fish per aquarium. The fish were then reared for 30 days by being fed PF 999 pellets two times a day, namely 08.00 and 16.00 ad libitum. Tilapia growth was observed by calculating absolute weight and specific growth rate (SGR) by measuring weight at the beginning and length at the end of rearing tilapia. According to Effendie (1997), the absolute weight calculation formula is as follows.

$$Wm = Wt - Wo$$

Where:
W = absolute growth (g)
Wt = final weight (g)
Wo = initial weight (g)
t = maintenance time (days)

Observation of growth in each treatment was carried out for 30 days. The growth rate is calculated using the SGR equation or the specific growth rate (Effendie, 1997).

$$SGR = \frac{\ln Wt - \ln Wo}{t} \times 100\%$$

Where:
SGR = specific growth rate (%)
Wt = final weight (g)
Wo = initial weight (g)

Survival Rate (SR) is the survival rate in a cultivation process. The survival of tilapia can be calculated using the formula according to Effendie (1997).

$$SR = \frac{Nt}{No} \times 100\%$$

Where:
SR = survival rate (%)
Nt = number of live fish
No = initial number of fish

Measurements of water quality that are carried out are temperature, pH, DO, and ammonia measured every week.

Data Analysis

Tilapia growth data were analyzed using ANOVA with an error of 5% to evaluate the effect of variations in chitosan concentration in filter arrangement. If the analysis results are significantly different, proceed with the LSD test.

RESULTS AND DISCUSSION

Absolute Weight Growth

The observations of absolute weight growth of tilapia for each treatment showed a difference. The highest absolute weight growth obtained in treatment P3 was 4.26 g, followed by treatment P4 at 4.08 g, followed by P1 at 2.95 g, and the lowest was obtained in treatment P2 at 2.91 g. The absolute weight growth of tilapia is shown in Figure 1.

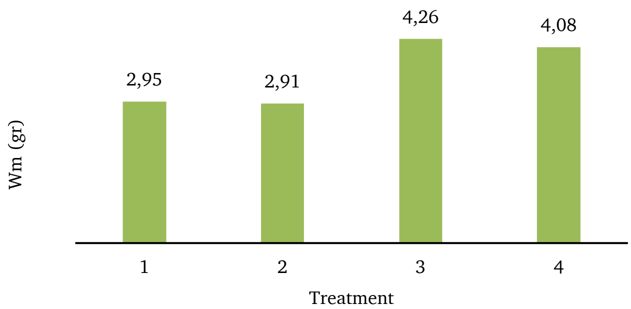

Figure 1. Growth of absolute weight of tilapia.

Based on the graph above, the absolute weight growth of tilapia in the P3 treatment with 50 mg chitosan concentration in the filter was better than in other treatments. ANOVA then tested these results, showing a p-value <0.05, which means the results of each treatment were significantly different. Duncan's Multiple Range Test (DMRT) showed that P1 and P2 were significantly different from P3 and P4, with the best result of absolute weight growth at P3, namely 50 mg chitosan concentration.

Chitosan has a reactive amine (NH) group and a hydroxyl group to act as an active component binder, absorber, stabilizer, clarifier, flocculants, and coagulants in water (Suptijah, 2006). Because of these properties, chitosan can act as a filter in maintaining water quality. Good water quality will be directly proportional to the growth of cultivated biota (Prayogo *et al.*, 2012). The recirculation system circuit consists of an array of filters. The filter serves to clean the waste from the maintenance tank so that the water from the filter tank flows back into the maintenance tank. Filters play a role in water treatment to remove pollutants so that water quality can be maintained during maintenance (Thesiana *et al.*, 2020). The addition of chitosan with the right concentration in the filter arrangement will make the filter work in reducing water pollutants more optimally. This is because chitosan has an amine group with an electron pair so it is able to bind pollutant substances in the waters. Quality water will increase fish appetite and prevent pathogenic bacteria so as to increase the growth of tilapia.

Specific Growth Rate

Measurement of the SGR of tilapia in each treatment obtained the highest percentage of SGR obtained in treatment P3, which is 0.33%, then treatment P4 is 0.30%, treatment P1 is 0.28%, and treatment P2 is 0.27 %. The graph of the SGR value is shown in Figure 2 below.

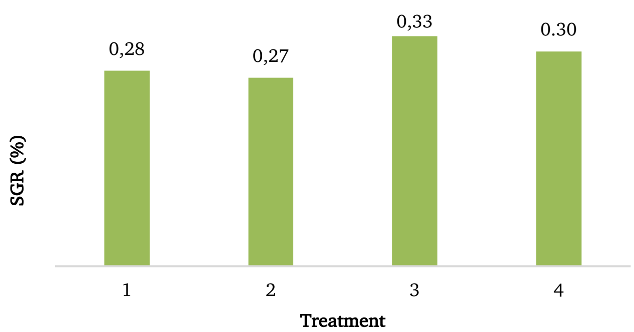

Figure 2. The specific growth rate of tilapia.

The specific growth rate of tilapia showed that, in the P2 treatment, the SGR value was lower than in the P1, P3, and P4 treatments. However, in general, the growth rate of tilapia in all treatments showed promising results. According to Hidayat *et al*. (2013), growth is influenced by several factors, namely internal factors and external factors. Internal factors include heredity, disease resistance, and the ability to utilize food, while external factors include physical, chemical, and biological characteristics. ANOVA showed that the addition of chitosan with concentration variations in the filter was not significantly different between treatments, namely $p>0,05$.

Based on the graph, the specific growth rate in P3 treatment with 50 mg chitosan concentration gave the highest results. This result follows the measurement of the absolute weight of tilapia. The use of chitosan with the right concentration can increase the ability of chitosan as a filter. If the concentration of chitosan is too much, it can pollute the waters, causing turbidity. This is because chitosan is insoluble in water (Teguh, 2003). The best concentration of chitosan will increase the role of the filter in the recirculation system. A filter that works well will maintain water quality. Good water quality prevents fish from stress thereby increasing fish consumption. This feed will increase the energy needed to support the body's metabolic processes in digesting and absorbing high protein feeds efficiently maximum to be used in the growth process so as to increase growth, this in particular can increase growth, especially the SGR value (Wong *et al*., 2006).

Survival Rate

The survival rate is the percentage of fish that live at the end of the rearing period compared to the number of fish at the beginning. The results showed that the highest survival rate of tilapia was 100% in the P2, P3, and P4 treatments. At the same time, the treatment of P1 without the filter was 94%. Mulyani *et al*. (2014) stated that the survival rate of fish at 50% is reasonable. Survival of 30-50% is moderate, and less than 30% is not good. Based on this, the survival value of tilapia in all treatments was still optimal. The following is a graph of the percentage of survival (SR) of tilapia (*O. niloticus*).

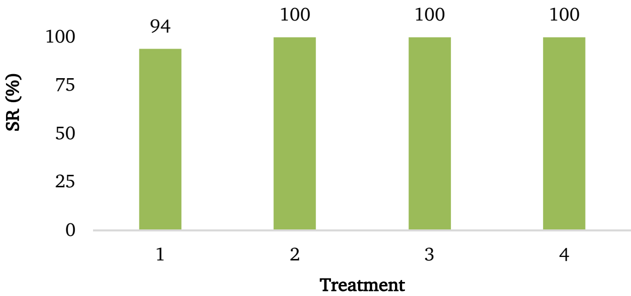

Figure 3. The survival rate of tilapia.

The survival rate of tilapia was lowest in the P1 treatment. At the same time, the treatment P2, P3, and P4 had the same value, which reached 100% or no tilapia mortality during maintenance. The high survival rate of tilapia reared is caused by the maintenance media that supports the survival of tilapia. The survival of fish is highly dependent on the adaptability of fish to food and the environment, fish health status, stocking density, and sufficient water quality to support growth (Mulyani *et al*., 2014).

The analysis of variance (ANOVA) showed that the administration of chitosan with different concentrations was not significantly different between treatments, namely p>0,05. One of the factors that affect survival is water quality. Based on the results of measurements of water quality temperature, pH, DO, and ammonia, good results were obtained for tilapia aquaculture. The results of research by Ibrahim *et al*. (2009) show chitosan is able to purify fishery wastewater including stabilizing the pH to remain neutral from 6.6 to 6.8, reducing the turbidity value by 94.33%, and absorbing ammonia by 80.84-82.56%. This is due to the reactive nature of chitosan from the amine and hydroxyl groups as electron donors. These properties cause chitosan to react with pollutant particles in the water.

Water Quality

Water quality measurements were carried out during the study to maintain the quality of cultivated water. Good water quality is an essential factor for living things in the water. Poor water quality during cultivation can inhibit growth, cause disease in fish and even cause death in fish. Good water quality is measured by the biological needs of fish or is still within the tolerance limit for fish to survive (Effendi, 2009). Water quality measurements were carried out, including temperature, pH, and ammonia. The results of water quality measurements are shown in the following table.

Table 1. Growth measurement results on floating net cages.

Treatment	Temperature (°C)	pH	Ammonia (mg/L)	DO (mg/L)
P1	26-27	6.69	0.11	4.78
P2	26-27	7.25	0.08	5.96
P3	26-27	6.72	0.05	5.96
P4	26-28	6.69	0.06	5.61
Quality standard (Effendi, 2009)	25-32	6-8	<1	4-6

Based on the water quality measurements, the temperature for each treatment was still following the quality standard during the study. The measurement of the water temperature of the maintenance media was relatively stable due to filters in the recirculation system. This follows the research of Samsundari and Wirawan (2013), which states that the temperature is relatively constant due to the filtration process. The pH measurements during the study followed the quality standards of tilapia aquaculture. According to Effendi (2009), the pH of the water suitable for tilapia ranges from 6-to 8. The pH measurements in this study were relatively stable, namely 6-7. This affects the growth and survival of tilapia. Significant changes in pH can cause fish to become stressed, which can cause disease in fish (Izzati, 2011).

Based on the results of ammonia measurements during the study, it was shown that treatment P2, P3, and P4 using a recirculating filter system produced lower ammonia values than the P1 treatment without a recirculating filter system. The P3 treatment produced the smallest ammonia value, directly proportional to the better tilapia growth results in the P3 treatment. This shows that using a chitosan concentration of 50 mg is best.

Based on the measurement of dissolved oxygen (DO) results in this study, all treatments were within the quality standards of tilapia aquaculture. The highest DO value was obtained in the treatment using a recirculation filter. The filter system will increase the oxygen in the waters because of the decrease in water pollution. This is also supported by the use of aeration during the study.

CONCLUSION

Based on the study results, it was found that the use of a recirculation filter system resulted in good growth, survival, and water quality. The addition of chitosan with concentration variations had a significant effect on the absolute weight growth of tilapia. The concentration of chitosan that resulted in good growth, survival, and water quality was P3 treatment, which was 50 mg.

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REFERENCES

Effendie, M.I., 1997. *Metode biologi perikanan*. Yayasan Pustaka Nusatama, Yogyaarta.

Effendi, I., 2009. *Budidaya perikanan*, Universitas Terbuka, Jakarta.

Fauzzia, M., Rahmawati, I. and Widiasa, I.N., 2013. Penyisihan amoniak dan kekeruhan pada sistem resirkulasi budidaya kepiting dengan teknologi membran biofilter. *Junal Teknologi Kimia dan Industri (JKTI)*, *2*(2), pp.155-161. https://ejournal3.undip.ac.id/index.php/jtki/article/view/2622

Hidayat, D., Sasanti, A.D. and Yulisman, 2013. Kelangsungan hidup, pertumbuhan dan efesiensi pakan ikan gabus (*Channa striata*) yang diberi pakan berbahan baku tepung keong mas (*Pomacea* sp). *Jurnal Akuakultur Rawa Indonesia*, *1*(2), pp.161–172. https://doi.org/10.36706/jari.v1i2.1736

Ibrahim, B., Suptijah, P. and Prantommy, 2009. The Utilization of Chitosan on Fishery Industrial Wastewater Treatment. *Jurnal Pengolahan Hasil Perikanan Indonesia, 12*(2), pp.154-166. https://doi.org/10.17844/jphpi.v12i2.879

Izzati, M., 2011. *Perubahan konsentrasi oksigen dan pH perairan tambak setelah penambahan rumput laut Sargassum plagyophyllum dan ekstraknya*. Undergraduate Thesis. Jurusan Biologi, Universitas Diponegoro, Semarang.

Kartini, 1997. *Studi tentang mutu kitin kitosan yang dihasilkan dari limbah kulit kepiting (Scylla serrata).* Fakultas Perikanan Universitas Brawijaya, Malang.

Kelabora, D.M. and Sabariah, 2010. Growth and survival of Collosoma sp. larvae at different water exchange rate in recirculating aquaculture system. *Jurnal Akuakultur Indonesia*, *9*(1), pp.56–60. https://doi.org/10.19027/jai.9.56-60

Mulyani, Y.S., Yulisman and Fitrani, M., 2014. Pertumbuhan dan efisiensi pakan ikan nila (*Oreochromis niloticus*) yang dipuasakan secara periodik. *Jurnal Akuakultur Rawa Indonesia*, *2*(1), pp.12-24. https://doi.org/10.36706/jari.v2i1.1958

Prayogo, Beodi, S.R. and Manan, A., 2012. Exploration Of Indigen Bacteria From Catfish (*Clarias sp.*) Breeding On Closed Resirculation System. *Jurnal Ilmiah Perikanan dan Kelautan, 4*(2), pp.193-197. https://doi.org/10.20473/jipk.v4i2.11571

Samsundari, S. and Wirawan, G.A., 2013. Analisis penerapan biofilter dalam sistem resirkulasi terhadap mutu kualitas air budidaya ikan sidat (*Anguilla bicolor*). *Jurnal Gamma*, *8*(2), pp.86-97. https://ejournal.umm.ac.id/index.php/gamma/article/view/2410

Situmorang, R.F., 2017. Pengolahan air menggunakan adsorben magnetik kitosan. *Zenodo*, pp.1-10. https://doi.org/10.5281/zenodo.1133838

Sumoharjo, 2010. *Penyisihan limbah nitrogen pada pemeliharaan ikan nila Oreochromis niloticus dalam sistem resirkulasi: Konfigurasi desain bioreaktor.* Master Thesis. Program Pascasarjana, Institut Pertanian Bogor, Bogor.

Suptijah, P., 2006. *Deskripsi karakteristik fungsional dan aplikasi kitin kitosan*. Undergraduate Thesis. Departemen Teknologi Hasil Perairan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, Bogor.

Teguh, D.O., 2003. *Pembuatan dan analisis film bioplastik dari kitosan hasil iradiasi kitin yang berasal dari kulit kepiting bakau*. Undergraduate Thesis. Universitas Pancasila, Jakarta.

Thariq, M.R.A., Fadli, A., Rahmat, A. and Handayani, R., 2016. Pengembangan kitosan terkini pada berbagai aplikasi kehidupan: review. *Seminar Nasional Teknik Kimia*, pp.49-63. http://repository.unri.ac.id/xmlui/handle/123456789/8819

Thesiana, L. and Pamungkas, A., 2015. Uji performansi teknologi recirculating aquaculture system (RAS) terhadap kondisi kualitas air pada pendederan lobster pasir *Panulirus homarus*. *Jurnal Kelautan Nasional*, *10*(2), pp.65-73. http://dx.doi.org/10.15578/jkn.v10i2.6158

Thesiana, L., Adiyana, K., Zulkarnain, R., Moersidik, S.S., Gusniani, I. and Supriyono, E., 2020. Ecofriendly land-based spiny lobster (*Panulirus sp.*) rearing with biofilter application in recirculating aquaculture system. *IOP Conference Series: Earth and Environmental Science, 404*, 012082. https://doi.org/10.1088/1755-1315/404/1/012082

Wong, A.O.L., Zhou, H., Jiang, Y. and Ko, W.K.W., 2006. Feedback regulation

DOI : 10.20473/jafh.v11i3.34929

of growth hormone synthesis and secretion in fish and the emerging concept of inpituitary feedback loop. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, *144*(3), pp.284–305. https://doi.org/10.1016/j.cbpa.2005.11.021

Zonneveld, N., Huisman, E.A. and Boon, J.H., 1991. *Prinsip-prinsip budidaya ikan*. Gramedia Pustaka Utama, Jakarta, p.318.