

Application of mussel freshwater shells lime with different particle size percentages in media culture of pangasius catfish

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ABSTRACT

Lime was composed of different particle sizes. This research aimed to determine the optimal particle-size distribution of mussel freshwater shell lime to increase the pH of swamp water and assess its effect on catfish survival and growth. This research used a completely randomized design with six treatments and three replications. The treatment consist of calcite lime as a control with a percentage of retained lime at sieve 10 mesh 20.7%, 20 mesh 22.7%, 60 mesh 55.3%, and passed 60 mesh 1.3% (P0), mussel freshwater shells lime with retained on 10 mesh 40%, 20 mesh 20%, 60 mesh 20%, and passed 60 mesh 20% (P1), retained on 10 mesh 20%, 20 mesh 40%, 60 mesh 20%, and passed 60 mesh 20% (P2), retained on 10 mesh 20%, 20 mesh 20%, 60 mesh 40%, and passed 60 mesh 20% (P3), retained on 10 mesh 20%, 20 mesh 20%, 60 mesh 20%, and passed 60 mesh 40% (P4), retained on 10 mesh 20.7%, 20 mesh 22.7%, 60 mesh 55.3%, and passed 60 mesh 1.3% (P5). The results showed that the application of mussel freshwater shells lime with particle size percentages retained on 10 mesh 20%, retained on 20 mesh 20%, retained on 60 mesh 20%, passed 60 mesh 40% (P4) was the best treatment that can increase the swamp water pH from 5.11 to 7.60, absolute growth of weight and length of 7.86 g and 5.56 cm, respectively, and survival rate 96.33%.

Keywords: lime, mussel freshwater, pangasius, pH, swamp

INTRODUCTION

Swampland is naturally inundated with water, periodically or continuously for long periods, due to obstructed drainage systems (Khodijah, 2015). The obstacle to cultivating catfish in swamp water is its low pH. According to the National Standardization Agency (2002), the pH value of water for pangasius catfish cultivation ranges from 6.5 to 8.5. The results of measuring the pH value of swamp water in the reservoir pond of the Aquaculture Laboratory and Experimental Pond, Aquaculture Study Program, Faculty of Agriculture, Sriwijaya University, in December 2023 were 3.99 (Ramadhini, 2024), in May 2024 it was 4.82 (Wati, 2024), and in April 2024 it was 4.88 (Yanti, 2024). Water with a low pH cannot support the growth and survival of fish; therefore, efforts are needed to increase pH, among other methods, by liming. Several types of lime that have been proven to increase water pH include

blood clam shell lime (Jubaedah et al., 2017; Jubaedah et al., 2020; Marsi et al., 2025), golden snail shells (Jubaedah et al., 2018, & Tanbiyaskur et al., 2024). An alternative lime that can also be used to increase the pH of fish culture media has been studied: mussel freshwater shells (Jubaedah et al., 2019; Yanti, 2024). Freshwater mussel shells contain calcium carbonate (CaCO_3), which can increase water pH (Karnkowska, 2005). The CaO and MgO content resulting from calcining mussel freshwater shells at 800°C is 60.33% CaO and 19.82% MgO (Jubaedah et al. 2019).

The application of mussel shell lime with a dose of 15 mg/L equivalent to CaO is the best dose that can optimize the pH of swamp water with an initial pH of 4.88 to 7.64 on the 30th day of fish culture, absolute weight growth of 13.14 g, absolute length growth of 5.79 cm and survival of pangasius catfish of 98.09% (Yanti, 2024). Lime is available in different particle sizes. The combination of lime particle sizes can determine

the lime's efficiency (Boyd, 1990). Smaller particles have a greater surface area relative to their weight than larger particles; therefore, smaller agricultural lime particles react more quickly than larger particles. According to Wurts & Masser (2013), smaller lime particles react faster and dissolve more quickly than larger particles.

The results of Wati's research (2024), the application of golden snail shell lime with a percentage of sieving results retained in 10 mesh as much as 20%, retained in 20 mesh as much as 20%, retained in 60 mesh as much as 20%, and passed 60 mesh as much as 40% is the best treatment in swamp water for pangsius catfish culture media for 30 days with a dose of 10 mg/L equivalent to CaO able to optimize the pH of swamp water from 4.82 to 7.45 on the 30th day of culture, 100% fish survival, absolute weight growth of 11.29 g, and absolute length growth of 5.56 cm. The objective of this research was to determine the optimal particle size distribution of mussel shell lime to increase the pH of swamp water used as a medium for cultivating pangasius catfish.

MATERIALS AND METHODS

Location and Time

This research was conducted in the Aquaculture and Experimental Pond Laboratory, Aquaculture Study Program, Fisheries Department, Faculty of Agriculture, Universitas Sriwijaya. Calcination was conducted in the Basic Fisheries Laboratory, Aquaculture Study Program, Fisheries Department, Faculty of Agriculture, Sriwijaya University. CaO and MgO analyses were conducted at the Balai Standardisasi dan Pelayanan Jasa Industri Palembang. Calcium analysis was conducted at PT. Binasawit Makmur, Sampoerna Agro Palembang. The research was conducted from December 2024 to January 2025.

Research Tools and Materials

The research tools used included: 4mx3mx1m concrete ponds, 80 L bucket, pH meter, DO meter, spectrophotometer, thermometer, furnace, filter paper, digital scale, ruler, blower, blender, sieves (10, 20, & 60 mesh), plastic container, Atomic Absorption Spectrophotometer (AAS), hotplate, filter holder, and pump. The materials used included: pangasius catfish measuring 5±0.5 cm in initial length cm as the research object, swamp water as a cultivation medium, mussel freshwater shell lime (CaO content=88.59% and MgO=0.38%), calcite lime as a liming material, commercial feed with a protein content of 39-41% as fish feed, potassium permanganate as a pond disinfectant, chemicals for CaO and MgO lime test materials, alkalinity, calcium, and ammonia.

Research Method

The experimental design used was a completely randomized block design with six treatments and three replications. The treatments included a control (P₀) containing calcite lime and treatments (P₁, P₂, P₃, P₄, & P₅) containing mussel shell lime at different lime sizes and efficiency levels (Table 1).

Research Preparation

The research preparation stages included preparation of the container, mussel freshwater shell lime, and water for the fish culture media. Mussel freshwater was sourced from mussel traders in the Tanjung Raja area. The experimental unit consisted of 18 buckets with a total volume of 80 liters. Before use, the buckets were cleaned and disinfected using potassium permanganate, then rinsed and dried. The water for the fish culture media was taken from the reservoir pond at the Aquaculture Laboratory, Universitas Sriwijaya. Before use, the water was incubated for 24 hours in a 4 m x 3 m x 1 m concrete pond. After that, the water was transferred to a 60 L bucket.

Table 1. Treatments and the resulting lime efficiency levels

	Particle Size (mm)	Efficiency ^{*)}	Treatments (% Particle Size)					
			P ₀	P ₁	P ₂	P ₃	P ₄	P ₅
Retained 10 <i>mesh</i>	≥1.70	0.036	20.7	40	20	20	20	20.7
Retained 20 <i>mesh</i>	0.85-1.69	0.127	22.7	20	40	20	20	22.7
Retained 60 <i>mesh</i>	0.25-0.84	0.522	55.3	20	20	40	20	55.3
Passed 60 <i>mesh</i>	≤0.24	1.000	1.3	20	20	20	40	1.3
Efficiency level (%)			33.8	34.4	36.2	44.1	53.7	33.8

Note: ^{*)}Boyd (1990)

Applying Mussel Freshwater Shell Lime

Ardilah (2021) describes the mechanism for making mussel freshwater shell lime. The mussel freshwater shell lime was collected, cleaned, and dried, then calcined in a furnace for 3 hours at 900°C. After cooling for 24 hours, the mixture was ground in a blender and sieved through 10-, 20-, and 60-mesh sieves. To obtain the desired particle size, the blending time was carried out in stages: 53, 95, and 155 seconds. Furthermore, all the sifting results are combined by treatment and stored in plastic containers. The amount of lime for each particle size is adjusted based on the treatment from the sieving results. The lime samples were analyzed for CaO and MgO content, with results of 88.59% CaO and 0.38% MgO. The lime from mussel shells was added to the fish culture medium at the best dose according to Yanti (2024), which was 15 mg/L equivalent to CaO, and the rearing medium water was incubated for 4 days. During incubation, water pH was measured daily.

Fish Culture

Fish were stocked on the fifth day after a four-day incubation period at a stocking density of 1 fish/L and acclimatized for 10-15 minutes. During culture, the fish were fed commercial feed with a protein content of 39-41%. Feeding was carried out at satiation, three times daily: 8:00 AM, 12:00 PM, and 4:00 PM. The fish were reared for 30 days.

Observed Variables

The variables observed in this study included water quality (pH, alkalinity, calcium, ammonia, dissolved oxygen, and temperature), absolute length and weight growth, and fish survival.

Data Analyzed

Data on pH, alkalinity, ammonia, dissolved oxygen, absolute weight, and length growth, and fish survival were tested using analysis of variance. If significant, the Least Significant Difference (LSD) test was used. Water calcium data were analyzed descriptively. Morning and afternoon temperature data during culture were analyzed using the T-test.

RESULTS

Power of Hydrogen (pH)

The pH values obtained during the incubation period (4 days) were presented in Table 2. pH increased at the beginning of incubation, although it tended to decrease again on the third day, except for P₀, which continued to increase until the fourth day.

Table 3 presents the pH values during fish culture (days 0, 10, 20, and 30). The relative pH value continued to decrease, but on days 10, 20, and 30, it remained within the optimal range for pangasius catfish culture, as defined by the National Standardization Agency (2002), namely 6.5-8.5.

Table 2. Results of LSD_{α0.05} water pH during the incubation period

Treatments	Water pH During Incubation Day			
	1	2	3	4
P ₀	7.37 ^a ± 0.03	7.69 ^a ± 0.02	7.92 ^a ± 0.04	8.14 ^a ± 0.04
P ₁	9.56 ^b ± 0.04	9.95 ^b ± 0.03	9.64 ^b ± 0.03	9.27 ^b ± 0.02
P ₂	9.64 ^c ± 0.03	10.07 ^c ± 0.04	9.86 ^c ± 0.03	9.33 ^c ± 0.04
P ₃	9.75 ^d ± 0.02	10.16 ^d ± 0.02	9.95 ^d ± 0.03	9.47 ^d ± 0.03
P ₄	9.88 ^e ± 0.04	10.20 ^d ± 0.03	10.15 ^e ± 0.02	9.78 ^f ± 0.01
P ₅	9.79 ^d ± 0.04	10.18 ^d ± 0.02	10.12 ^e ± 0.02	9.54 ^e ± 0.02
LSD _{α0.05}	0.06	0.05	0.05	0.05

Note: Means followed with the same letters within rows are not significantly different based on the LSD at p<0.05

Table 3. Results of LSD_{α0.05} water pH during fish culture

Treatments	Water pH During Fish Culture Day-0, 10, 20 and 30			
	0	10	20	30
P ₀	8.13 ^a ± 0.03	7.55 ^a ± 0.03	6.74 ^a ± 0.04	6.71 ^a ± 0.05
P ₁	9.25 ^b ± 0.03	7.71 ^b ± 0.02	7.16 ^b ± 0.04	7.06 ^b ± 0.01
P ₂	9.26 ^b ± 0.03	7.77 ^c ± 0.02	7.31 ^c ± 0.03	7.23 ^c ± 0.02
P ₃	9.46 ^c ± 0.02	7.68 ^b ± 0.04	7.44 ^d ± 0.03	7.42 ^e ± 0.03
P ₄	9.77 ^e ± 0.02	7.91 ^e ± 0.03	7.68 ^e ± 0.02	7.60 ^f ± 0.02
P ₅	9.54 ^d ± 0.01	7.83 ^d ± 0.02	7.39 ^d ± 0.02	7.34 ^d ± 0.01
LSD _{α0.05}	0.04	0.05	0.06	0.05

Note: Means followed with the same letters within rows are not significantly different based on the LSD at p<0.05

Table 4. Alkalinity

Treatments	Alkalinity (mg/L)/day		Calcium (mg/L)/day	
	0	30	0	30
P ₀	21.33 ^a ± 3.06	66.00 ^a ± 2.00	9.33	15.97
P ₁	26.67 ^b ± 1.15	74.67 ^b ± 1.15	14.06	26.07
P ₂	30.67 ^c ± 1.15	84.00 ^c ± 2.00	16.56	20.37
P ₃	34.00 ^{cd} ± 2.00	88.00 ^d ± 2.00	17.19	29.43
P ₄	41.33 ^e ± 2.31	94.00 ^e ± 2.00	19.38	29.74
P ₅	37.33 ^d ± 1.15	90.00 ^d ± 2.00	17.40	29.66
LSD _{α0.05}	3.75	3.35		

Note: Means followed with the same letters within rows are not significantly different based on the LSD at $p < 0.05$

Alkalinity and Calcium (Ca)

The alkalinity and calcium (Ca) values increased relatively on the final day (day 30) compared to the initial day of fish culture (day 0) (Tables 4 & 5). The smaller particles, alkalinity, and Ca increased relatively. Meanwhile, with the same particle-size composition in P₀ (calcite) and P₅ (mussel shell limestone), the alkalinity and Ca content in mussel shells are relatively higher than in calcite.

Ammonia and Dissolved Oxygen

Ammonia and dissolved oxygen levels tended to increase on the final day of fish culture (day 30) (Tables 5 & 6). Statistically, treating mussel shells with different particle-size percentages and calcite as a control had no significant effect on ammonia and dissolved oxygen levels.

Table 5. Ammonia

Treatments	Ammonia (mg/L)/day	
	0	30
P ₀	0.045 ± 0.002	0.080 ± 0.007
P ₁	0.047 ± 0.002	0.082 ± 0.006
P ₂	0.046 ± 0.001	0.077 ± 0.011
P ₃	0.046 ± 0.001	0.091 ± 0.038
P ₄	0.045 ± 0.003	0.082 ± 0.004
P ₅	0.045 ± 0.005	0.074 ± 0.006

Table 6. Dissolved oxygen

Treatments	Dissolved Oxygen (mg/L)/day	
	0	30
P ₀	6.37 ± 0.15	7.40 ± 0.10
P ₁	6.40 ± 0.10	7.30 ± 0.10
P ₂	6.40 ± 0.10	7.43 ± 0.12
P ₃	6.50 ± 0.10	7.37 ± 0.06
P ₄	6.53 ± 0.21	7.43 ± 0.12
P ₅	6.47 ± 0.06	7.37 ± 0.06

Temperature

The water temperature of the fish culture medium tends to increase during the day compared to the morning (Table 7). The T-test results show that water temperature during daylight was significantly higher than in the morning.

Table 7. Temperature

Treatments	Temperature (°C)	
	Morning	Daylight
P ₀	25.63 ^a ± 0.06	27.47 ^b ± 0.12
P ₁	25.67 ^a ± 0.06	27.53 ^b ± 0.06
P ₂	25.67 ^a ± 0.06	27.63 ^b ± 0.12
P ₃	25.73 ^a ± 0.06	27.57 ^b ± 0.12
P ₄	25.73 ^a ± 0.06	27.53 ^b ± 0.12
P ₅	25.70 ^a ± 0.17	27.53 ^b ± 0.15

Note: Means followed with the same letters within rows are not significantly different based on the LSD at $p < 0.05$

Survival and Growth of Fish

The survival rate and absolute fish growth were shown in Table 8.

Table 8. Survival and absolute growth of fish

Treatments	Survival Rate (%)	Absolute Growth of	
		Length (cm)	Weight (g)
P ₀	83.00 ^a ± 5.00	4.13 ^a ± 0.05	5.68 ^a ± 0.18
P ₁	83.33 ^a ± 3.51	4.76 ^{bc} ± 0.16	6.83 ^b ± 0.35
P ₂	90.00 ^b ± 2.00	4.99 ^{cd} ± 0.25	6.93 ^{bc} ± 0.22
P ₃	94.00 ^{bc} ± 2.65	5.17 ^d ± 0.23	7.31 ^c ± 0.29
P ₄	96.33 ^c ± 1.15	5.56 ^e ± 0.05	7.86 ^d ± 0.23
P ₅	92.67 ^{bc} ± 4.51	4.69 ^b ± 0.07	6.64 ^b ± 0.25
LSD _{α0.05}	6.08	0.28	0.46

Note: Means followed with the same letters within rows are not significantly different based on the LSD at $p < 0.05$

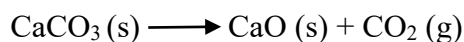
The survival rate of fish obtained during fish culture was categorized as high (above 80%) (Table 8). Based on the analysis of variance results, differences in the percentage of mussel shell lime particles significantly affected the survival and absolute growth (weight and length) of the fish.

DISCUSSION

Power of Hydrogen (pH)

The water pH measurements during the incubation period (Table 2) show that in all treatments, pH increased from an initial 5.11 on the first day of incubation, then decreased, except for P₀, which continued to increase until the fourth day of incubation. The increase in water pH was caused by the reaction of lime with water. The CaO content of mussel shell lime was

88.59%. The calcined mussel shell lime changed the CaCO_3 content to CaO with the reaction equation:



According to Surest et al. (2012), the reaction of CaO lime with water (H_2O) forms $\text{Ca}(\text{OH})_2$. This reaction increases the concentration of hydroxide ions (OH^-), thereby increasing the water's pH from its initial pH. On the 3rd day of incubation, the decrease in pH of the water given mussel freshwater shell lime is thought to occur because CaO can cause a very rapid increase in pH compared to calcite (Wurts & Masser, 2013). In addition, liming directly in water allows lime to dissolve easily and react quickly, raising pH rapidly. However, lime is suspected to be used up relatively quickly, leading to a rapid decrease in pH.

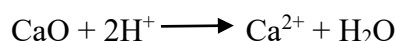
The analysis of variance results showed that treatments with different particle-size percentages of mussel freshwater shell lime significantly affected water pH on days 1, 2, 3, and 4 of incubation. The results of $\text{LSD}_{\alpha 0.05}$ test (Table 2), showed that on day 1st and 4th, the pH value of the water treated with mussel freshwater shell lime with a percentage of sieving results retained in 10 mesh of 20%, retained in 20 mesh of 20%, retained in 60 mesh of 20% and passed through 60 mesh of 40% (P_4) was significantly higher than the water pH value in other treatments. On the second day, the pH value of water treated with mussel shell lime with a percentage of sieving results retained at 10 mesh of 20%, retained at 20 mesh of 20%, retained at 60 mesh of 20% and passing through 60 mesh of 40% (P_4) was significantly higher than the pH value of water in treatments P_0 , P_1 , and P_2 , but not significantly different from P_3 and P_5 . On the third day, the pH value of water treated with mussel freshwater shell lime with the percentage of sieving results retained in 10 mesh as much as 20%, retained in 20 mesh as much as 20%, retained in 60 mesh as much as 20% and passed 60 mesh as much as 40% (P_4) was significantly different higher than the pH value of water in treatments P_0 , P_1 , P_2 and P_3 , but not significantly different from P_5 . The higher the percentage of small lime particles (retained on 60-mesh and

passed through 60-mesh), the higher the pH value. The results of the analysis of variance showed that the treatment with different particle-size percentages in mussel freshwater shell lime significantly affected water pH on days 0, 10, 20, and 30 of fish culture. The results of the $\text{LSD}_{\alpha 0.05}$ test (Table 3) showed that the water pH on days 0, 10, 20, and 30 of culture in the application of mussel shell lime with the percentage of sieving results retained in 10 mesh as much as 20%, retained in 20 mesh as much as 20%, retained in 60 mesh as much as 20% and passed 60 mesh as much as 40% (P_4) was significantly higher than the water pH value in other treatments. Smaller particles have a larger surface area per unit weight than larger particles, so smaller agricultural lime particles react faster than larger ones (Boyd, 1990). According to Wurts and Masser (2013), small lime particles react and dissolve more quickly than large particles. However, on the 10th day of culture, all treatments were within the optimum pH range for catfish. According to the National Standardization Agency (2002), the optimum pH for pangasius catfish is 6.5-8.5.

Alkalinity and Calcium

The analysis of variance shows that mussel freshwater shell lime particle size at different percentages significantly affected alkalinity on days 0 and 30 of fish culture. The results of the $\text{LSD}_{\alpha 0.05}$ test (Table 4) showed that on days 0 and 30 of fish culture, the alkalinity value in the mussel freshwater shell lime treatment with the percentage of sieving results retained at 10 mesh was 20%, retained at 20 mesh was 20%, retained at 60 mesh was 20% and passed 60 mesh was 40% (P_4) was significantly different compared to the water alkalinity in other treatments. This shows that smaller particles have higher relative alkalinity. According to Boyd et al. (2016), adding lime can neutralize acidity, increasing the alkalinity and hardness of pond water. The higher the pH, the higher the alkalinity (Effendi, 2024). During the culture period, water alkalinity in all treatments was within the optimal range for pangasius catfish culture. According to Mahyuddin (2010), the optimal alkalinity for cultivating pangasius catfish is around 20-500 mg/L.

The calcium concentration of water in all treatments increased on the 30th day compared to the initial day of culture (Table 4). According to Wurts & Masser (2013), adding lime to water can increase calcium levels. The increase in water Calcium due to the addition of lime to the culture medium is based on the reaction equation according to Boyd (1998), as followed:



The calcium of the water obtained on the final day of the fish culture, except for P0 and P2, was categorized as suitable for aquaculture. According to Wurts & Durborow (1992), the optimal range of calcium for fish culture was 25-100 mg/L.

Ammonia and Dissolved Oxygen

The analysis of variance indicates that different mussel freshwater shell lime particle sizes had no significant effect on ammonia and dissolved oxygen during the culture period. Based on Table 5, ammonia ranged from 0.045 to 0.091 mg/L. This value exceeds the ammonia value required by the National Standardization Agency (2002), which is <0.01 mg/L. However, the ammonia value obtained still meets the quality standards for freshwater fish cultivation set by the Government of the Republic of Indonesia (2021), which is 0.5 mg/L. This is also evident in the high fish survival rate (Table 8). Dissolved oxygen levels during cultivation ranged from 6.37 to 7.43 mg/L. This value falls within the optimal range for pangasius catfish, as reported by the National Standardization Agency (2002), which states that the optimal dissolved oxygen level is >4 mg/L.

Temperature

Based on Table 8, the T-test results indicate that the water temperature during morning fish culture was significantly lower than during the day. This is influenced by the research being conducted outdoors; therefore, the water temperature is affected by differences in sunlight intensity between the morning and afternoon. According to Effendi (2024), sunlight entering the water will be absorbed and converted into heat energy. The water temperature during fish

culture ranged from 25.63 to 27.63°C. This temperature value is still within the optimal range for catfish. The temperature range for catfish is around 25-30°C (National Standardization Agency, 2002).

Survival and Growth of Fish

The analysis of variance shows that treatments with different mussel freshwater shell lime particle sizes significantly affect catfish survival, absolute length, and weight gain over 30 days of culture. The results of the further test LSDT_{α0.05} (Table 8), show that the survival of catfish in the application of mussel freshwater shell lime with the percentage of sieving results retained in 10 mesh as much as 20%, retained in 20 mesh as much as 20%, retained in 60 mesh as much as 20% and passed 60 mesh as much as 40% (P₄) is significantly higher than the survival value in treatments P₀, P₁, and P₂, but not significantly different from P₃ and P₅. Nevertheless, the survival obtained in all treatments is high. This is because it is supported by optimal water quality for catfish cultivation. The absolute length and weight growth of pangasius catfish in the application of mussel freshwater shell lime with the percentage of sieving results retained in 10 mesh as much as 20%, retained in 20 mesh as much as 20%, retained in 60 mesh as much as 20% and passed 60 mesh as much as 40% (P₄) were significantly different compared to the value of absolute length and weight growth in other treatments. This shows that smaller lime particles dissolve faster and are utilized by fish. According to Hastuti et al. (2012), catfish can maximize calcium utilization from water for growth. As much as 2.5% of minerals in the body of catfish are calcium that can be absorbed from the aquatic media (Tucker & Hargreaves, 2004).

CONCLUSION

Based on the research results, the application of mussel shell lime with a percentage of sieving results retained in 10 mesh of 20%, retained in 20 mesh of 20%, retained in 60 mesh of 20% and passing through 60 mesh of 40% (P₄) is the best treatment that can optimize the pH of swamp water from 5.11 to 7.60, absolute weight growth

of 7.86 g, absolute length growth of 5.56 cm, and fish survival of 96.33%.

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