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STUDY ON THE EFFECTIVENESS OF BANANA STEM PITH (*Musa paradisiaca*) AS A NATURAL ANESTHETIC IN THE WET TRANSPORTATION OF WHITE SEABASS (*Lates calcarifer*) JUVENILE

STUDI EFEKTIVITAS HATI BATANG PISANG (*Musa paradisiaca*) SEBAGAI ANESTESI ALAMI DALAM TRANSPORTASI BASAH BENIH KAKAP PUTIH (*Lates calcarifer*)

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Abstract

Live fish transportation can induce physiological stress, characterized by increased blood glucose levels and decreased survival rates. This study aims to evaluate the effectiveness of banana pseudostem extract (*Musa paradisiaca*) as a natural anesthetic for the wet transport of Asian seabass (*Lates calcarifer*) fry. Observed parameters include induction time, sedative time, blood glucose levels, fish survival, and water quality. The results showed that treatment P3 exhibited the best balance, with an induction time of 10.5 minutes, sedative time of 7 minutes, blood glucose levels of 140 mg/dL, and a survival rate of 90%. Increased ammonia levels were observed after transport, particularly in P5 (0.034 mg/L), while P3 had a lower NH_3 level (0.010 mg/L), indicating better water conditions. Banana pseudostem extract was proven effective as a natural anesthetic in reducing fish stress during transport, with P3 as the optimal treatment.

Keywords: Natural anesthetic, fish transport, Lates calcarifer, banana pseudostem, blood glucose

Abstrak

Transportasi ikan hidup dapat menyebabkan stres fisiologis, yang ditandai dengan peningkatan kadar glukosa darah dan penurunan tingkat kelangsungan hidup. Penelitian ini bertujuan untuk mengevaluasi efektivitas ekstrak hati batang pisang (*Musa paradisiaca*) sebagai anestesi alami dalam transportasi basah benih ikan kakap putih (*Lates calcarifer*). Parameter yang diamati meliputi waktu induksi, waktu sedatif, kadar glukosa darah, kelangsungan hidup ikan, dan kualitas air. Hasil penelitian menunjukkan bahwa perlakuan P3 memiliki keseimbangan terbaik, dengan waktu induksi sekitar 10,5 menit, waktu sedatif 7 menit, kadar glukosa darah 140 mg/dL, dan kelangsungan hidup mencapai 90%. Peningkatan kadar amonia setelah transportasi diamati, terutama pada P5 (0,034 mg/L), sedangkan P3 memiliki kadar NH_3 yang lebih rendah (0,010 mg/L), menunjukkan kondisi air yang lebih baik. Ekstrak hati batang pisang terbukti efektif sebagai anestesi alami dalam menekan stres ikan selama transportasi, dengan P3 sebagai perlakuan optimal.

Kata Kunci : *Anestesi alami, transportasi ikan, Lates calcarifer, hati batang pisang, kadar glukosa*

1. Introduction

White snapper (*Lates calcarifer*) is one of the highly economically valuable fishery commodities and is widely cultivated in various countries, including Indonesia, Australia, and Thailand (Adi *et al*., 2022). This fish has rapid growth, tolerance to various environmental conditions, and good nutritional content, making it the top choice in the aquaculture industry (Saleky and Dailami, 2021). Global white snapper production continues to increase, with the Food and Agriculture Organization (FAO) reporting that in 2022, *Lates calcarifer* aquaculture production reached more than 150,000 tons per year (Sifatullah *et al.*, 2023). However, to optimize productivity and sustainability in aquaculture, intensification of production systems needs to be developed, one of which is through the provision of high-quality seeds. One of the main factors in the successful provision of broodstock and seeds is the transportation of live fish. Fish transportation is the process of moving fish from one location to another for distribution, grow-out, or restocking of waters (Monica and Mardiana, 2019; Perdana *et al.*, 2024). In this process, changes in environmental conditions must be minimized to reduce stress and mortality rates in transported fish. The main problems in aquaculture are the availability of seeds and their distribution to various cultivation locations. Therefore, innovation is needed in fish transportation systems that can overcome these challenges, increase seed survival, and support the sustainability of the aquaculture industry.

Fish transport systems are generally divided into two types, namely open systems and closed systems (Mbuilima *et al*., 2024). In open systems, the water in the transport container is

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continuously renewed, allowing for a stable supply of oxygen (O_2) and the removal of carbon dioxide (CO_2) and metabolic waste. In contrast, closed systems use a fixed volume of water during transport, so that O_2 levels tend to decrease due to fish respiration, while CO_2, ammonia (NH_3/NH_4^+), and metabolic acids increase, which can cause a decrease in pH and physiological stress in fish (Hidayat *et al.*, 2020). In addition, water temperature in closed systems is more difficult to control, which can accelerate fish metabolism and increase oxygen consumption. Based on the transport medium, transportation systems are also divided into dry systems and wet systems (Puspito *et al.*, 2021). Dry systems rely on high humidity with pure oxygen, but without water, thereby suppressing fish metabolism (Mellisa *et al.*, 2023). Meanwhile, wet systems use water as the main medium, maintaining the osmoregulation balance of fish, but require stricter control of water quality parameters to prevent stress and mortality (Puspito *et al.*, 2021).

Anesthesia is an important strategy in reducing stress in fish during transport by suppressing metabolic activity and oxygen consumption without compromising their health (Wulandari *et al*., 2022). Fish anesthesia techniques consist of the use of synthetic chemicals and natural anesthetics. Synthetic anesthetics such as *benzocaine,* MS-222 (*tricaine methanesulfonate)*, and *lidocaine* are often used because of their rapid effectiveness in reducing fish activity (Pramono *et al.*, 2022). However, their use has limitations such as toxicity at high doses, relatively high costs, and residues that can impact fish health and the environment (Monica and Mardiana, 2019). As an alternative, natural anesthetics from plants such as clove oil (*Syzygium aromaticum)* (Mbuilima *et al.*, 2024), tea leaf extract (*Camellia sinensis)* (Putri *et al.*, 2022), and petaicina (*Leucaena leucocephala)* are increasingly being used (Hidayat *et al.*, 2020). Bioactive compounds such as eugenol, flavonoids, and saponins in these natural ingredients have the potential to suppress fish activity without significant side effects (Hidayat *et al.*, 2020).

Banana stem (*Musa paradisiaca*) is a promising source of natural anesthesia because it contains saponins, compounds that have a sedative effect on fish (Khudzaifi *et al*., 2023). Previous studies have shown that a 3% banana stem extract can cause Nile tilapia (*Oreochromis niloticus)* to collapse within 25–60 minutes, with a recovery time of 28–50 minutes, while larger fish lose consciousness within 82–93 minutes with a recovery time of 58–90 minutes (Puspito *et al.*, 2021). Additionally, research on catfish (*Hemibagrus nemurus)* showed that a 1% dose of banana stem extract resulted in a 94.43% survival rate during dry transport with an anesthesia duration of 76 minutes and a recovery time of 7 minutes (Wulandari *et al.*, 2022). Therefore, this study will be conducted to examine the effectiveness of banana stem (*Musa paradisiaca)* as a natural anesthetic in wet transport of white snapper (*Lates calcarifer)* fry.

2. Materials and Methods

2.1. Time and Place

This study was conducted in November-December 2024 at the Fish Hatchery and Breeding Laboratory, Faculty of Marine Science and Fisheries, Syiah Kuala University, Banda Aceh. The extraction was carried out at the Chemistry Laboratory, Faculty of Teacher Training and Education, Syiah Kuala University. The location for collecting white snapper fish seeds was at the Brackish Water Aquaculture Center (BPBAP) Ujung Batee, Aceh Besar.

2.2. Equipment and Materials

The equipment needed for this study included a thermometer, aerator, *rotary evaporator*, pH indicator, water test kit, scale, small scoop, bucket, aquarium, glucometer, plastic, stopwatch, UV-vis spectrophotometer, and syringe. The materials used in this study included banana stems, 96% ethanol, and white snapper fish seeds.

2.3. Research Method

This study used a completely randomized design (CRD) with five treatments and four replicates. The treatments consisted of a control without extract (Treatment A) and four treatments with banana stem extract at different concentrations, namely 5% (Treatment B), 10% (Treatment C), 15% (Treatment D), and 20% (Treatment E) (Pratama *et al.,* 2017). This design aimed to evaluate the effectiveness of various extract concentrations in inducing anesthesia and their impact on fish survival during

2.4. Research Procedure

2.4.1 Banana stem liver extraction process

Banana stem liver extract was prepared at the Chemistry Laboratory of the Faculty of Teacher Training and Education. Banana stems were washed, dried, cut into small pieces, and then ground into powder. A total of 300 grams of powder was macerated in 3000 ml of 96% ethanol for 72 hours, then filtered. The filtrate is evaporated using *a rotary evaporator* at a temperature of 68–69°C until a thick extract is obtained, then stored in a freezer until ready for use (Khudzaifi *et al.*, 2023).

2.4.2 Preparation of fish and test containers

This study used 200 white snapper fry measuring 5–7 cm as test animals. Each container was filled with 10 fish and 5 liters of water (Sifatullah *et al*., 2023). Before treatment, the fish were fasted for 24 hours to reduce metabolic excretion. The fish were placed in containers consisting of packaging and maintenance containers. The packaging containers were 30×43 cm plastic packing containers, while the maintenance containers were 10-liter jars with a water volume of 5 liters equipped with aerators. The fish were then transported by vehicle for 8 hours.

2.4.3 Measurement of induction and sedative times

The measurement of induction and sedative times was carried out by observing the fish's response to anesthesia in various concentrations of banana stem extract. The induction time was calculated from the moment the fish was placed in the anesthetic solution until it lost its balance. Sedation time was measured from the moment the fish were transferred to clean water until they showed a normal response again. The time was recorded using a stopwatch, and the parameters were observed based on the stages of anesthesia (Syamsiyah *et al.*, 2022).

2.4.4 Blood Glucose Level Test

The blood glucose level test was performed using a SINOCARE Safe AQ PRO I glucometer. Blood samples were taken from the fish using a sterile needle, then dripped onto a test strip (Syamsiyah *et al*., 2022). The strip containing the blood sample was inserted into the glucometer for analysis. The blood glucose level results were displayed digitally in mg/dL.

2.5. Calculation of Fish Survival Rate

Fish survival refers to the percentage of fish that survive until the end of the study. The survival rate is calculated using the following formula (Melanie *et al*., 2023).

$$SR\ (\%) = \frac{N_t}{N_0}\ x\ 100\%$$

Explanation:
SR = Fish survival rate (%)
Nt = Number of fish alive at the end of the study
N_0 = Initial number of fish

2.6 Water Quality Analysis

The water quality analyzed in this study included the parameters of dissolved oxygen (DO), pH, ammonia, and temperature. Measurements were taken using a pH tester, *dissolved oxygen* (DO) meter, UV-vis spectroscopy, and thermometer. Temperature, pH, and DO measurements were taken *in situ* at 8:00 a.m. Water quality observations were made before transport, after transport, and during the seven-day maintenance period. Water quality analysis was performed descriptively to understand the dynamics of environmental parameter changes that could affect fish conditions during transport and maintenance.

2.7. Data Analysis

Data on induction period, sedation, survival rate, and blood glucose were analyzed using statistical tests, including normality, homogeneity, additivity, and ANOVA. If the effect was significant ($P < 0.05$) or very significant ($P < 0.01$), the analysis was continued with Duncan's test and orthogonal polynomial test to determine the optimal dose. Water quality data were analyzed descriptively.

3. Results and Discussion

3.1. Induction time and sedative

Induction time reflects the speed of fish response to anesthetic compounds and is a key indicator of anesthesia effectiveness (Pramono *et al*., 2020). Based on Figure 1a, significant differences in induction time between treatments indicate a strong influence of banana stem extract concentration on the penetration of active compounds into the nervous system of white snapper fish. Treatment P2 showed the longest induction time (≈14.5 minutes), indicating that the extract concentration at that level was not yet effective enough to penetrate the epithelial tissue and reach the target receptors in the central nervous system. Increased doses in P3 and P4 accelerated the onset of anesthesia (10.5 and 6.5 minutes), while P5 showed the fastest effect (≈5 minutes) because high concentrations accelerated the diffusion of lipophilic molecules into the neuron membrane, causing a drastic decrease in the fish's metabolic activity and oxygen consumption (Puspito *et al.*, 2021). However, excessive induction speed can cause oxidative stress and osmotic homeostasis disruption if not balanced with adequate recovery time. This is important in the context of live fish transport, where anesthesia must work quickly but remain safe for physiological balance (Pramono *et al.*, 2020). Therefore, these results confirm that the effectiveness of natural anesthesia is greatly influenced by the interaction between dose, diffusion rate, and the fish's metabolic capacity to neutralize the active compounds in the extract (Puspito *et al.*, 2021).

The sedative time pattern (Figure 1b) shows an inverse relationship with induction time. An increase in extract dose causes a decrease in induction time but prolongs the sedative phase, as seen in P5 (≈12 minutes) compared to P2 (≈4 minutes). This phenomenon indicates that the bioactive compounds in banana stem extract have a two-stage pharmacokinetic effect: rapid induction of anesthesia and slow elimination from the fish's body. These findings are consistent with the report by Taemnanu *et al.* (2024), which states that the duration of sedation depends on the efficiency of biotransformation and excretion of anesthetics through the gills and liver. In the P2–P3 treatment, the balance between induction and sedative times was ideal, allowing fish to recover gradually without experiencing loss of balance or severe hypoxia. Conversely, the excessively long sedative duration in P5 indicated a risk of active compound accumulation in tissues, increasing post-anesthesia stress and reducing survival rates (Al Jumadi *et al.*, 2024). These conditions are consistent with the results of Puspito *et al.* (2021) and Syamsiyah *et al.* (2022) that high anesthesia concentrations slow down detoxification metabolism due to the accumulation of phenolic or alkaloid residues in fish plasma. Therefore, although banana stem extract has potential as an effective natural anesthetic, the optimal dose must be considered to provide sufficient sedative effects without disrupting the physiological recovery and osmotic balance of fish.

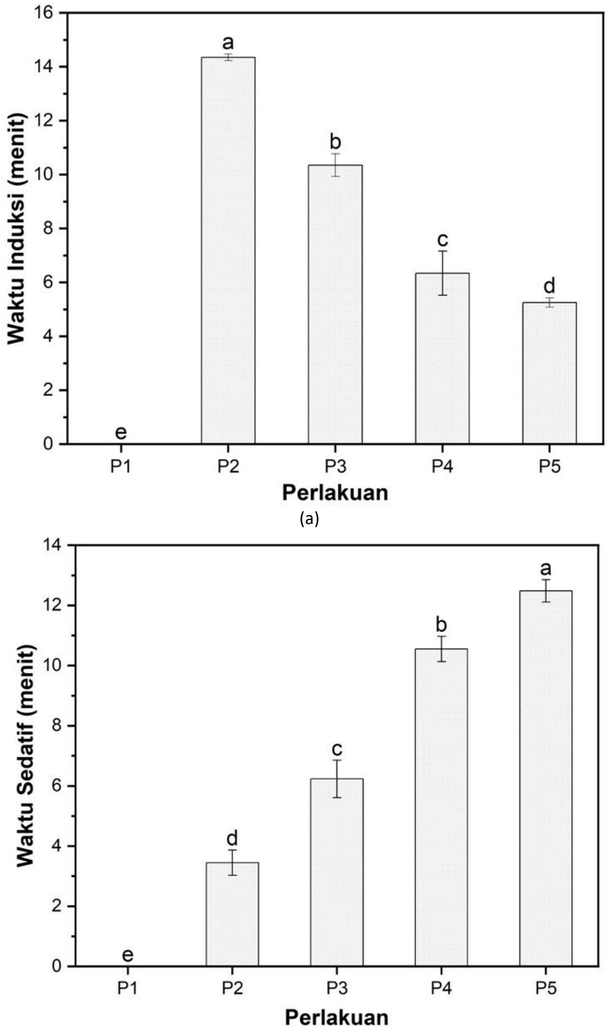

Figure 1. Time profile of (a) induction and (b) sedation of white snapper using banana stem extract anesthesia

3.2. Blood Glucose Level Test

Blood glucose levels are an important indicator in assessing the physiological stress levels of fish during transport, as they are directly related to the endocrine response to stressful environmental conditions. Based on Figure 2, there are significant differences between treatments in the blood glucose levels of white snapper. t P1 showed the highest glucose level (≈185 mg/dL), followed by t P2 (≈175 mg/dL), indicating that fish in these groups experienced acute stress due to increased metabolic and hormonal activity. The increase in blood glucose under stressful conditions is caused by the release of cortisol and catecholamine hormones, which trigger glycogenolysis in the liver to produce quick energy to maintain homeostasis during transport (Arlanda *et al.*, 2019; Chilmawati and Amalia, 2022). Conversely, the lower glucose levels in P3 (≈140 mg/dL) indicate that the fish were in a more stable physiological condition, with relatively balanced metabolic and hormonal activity, suggesting that the anesthetic dose in this treatment was effective in suppressing the stress response without inhibiting normal metabolic function. Treatment P4 (≈150 mg/dL) still showed relatively good stability, while P5 again showed an increase in glucose levels (≈175 mg/dL), which was not significantly different from P1 and P2, indicating that excessive anesthetic concentrations can cause overstimulation of the endocrine system. Overall, these results show that the optimal post-transport glucose level range is between 140–150 mg/dL, as indicated by treatments P3 and P4, where the fish experienced minimal stress but still had sufficient energy reserves for the recovery process (Syamsiyah *et al.*, 2022). Thus, the anesthetic concentrations in both treatments can be categorized as the most efficient in maintaining the physiological balance of white snapper fish during the transportation process (Wulandari *et al.*, 2022).

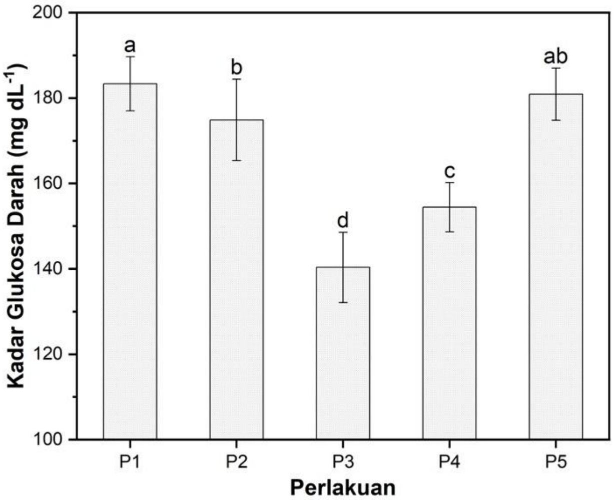

Figure 2. Blood glucose level test of white snapper after transportation

3.3. *Survival Rate*

The survival rate of white snapper after transport is a comprehensive indicator of the effectiveness of anesthesia and the physiological balance of fish in coping with environmental stress. Based on Figure 3, treatment P3 showed the highest survival rate (≈ 90%), followed by P4 (≈ 75%), P2 and P5 (≈ 65%), and P1 (≈ 50%). These results indicate a close relationship between physiological parameters (induction time, sedation time, and blood glucose levels) and the fish's post-transportation resilience. In P3, moderate induction time (~10.5 minutes), short sedation time (~7 minutes), and low glucose levels (~140 mg dL^{-1}) reflect stable metabolic conditions, where fish are in a sufficient state of anesthesia to suppress motor activity without inhibiting respiration or circulation. These conditions minimize the release of stress hormones such as cortisol and catecholamines, thereby suppressing excessive glycogenolysis (Syamsiyah *et al.*, 2022). In contrast, fish in P1 experienced acute stress due to not being anesthetized, as reflected in the highest glucose levels (~185 mg dL^{-1}), which indicated increased metabolic activity and physiological fatigue (Wulandari *et al.*, 2022). Thus, the balance between anesthesia depth and recovery duration is a key determinant of the success of live fish transport.

The relationship between anesthetic effectiveness and fish survival was also evident in treatments P2 and P5, which only achieved a survival rate of around 65%. In P2, the long induction time indicated that the anesthetic concentration was not yet effective enough to suppress stress activity, while in P5, the excessive dose caused excessive sedation time (~12 minutes) and prolonged the recovery phase. These conditions show that both insufficient and excessive anesthesia have the potential to reduce survival rates due to physiological homeostasis disturbances (Syamsiyah *et al.*, 2022). In treatment P4, the survival rate of around 75% indicates that moderate anesthesia concentrations are still capable of maintaining respiratory stability and energy metabolism during transport. These results are in line with Wulandari *et al.* (2022), who confirmed that the success of fish transportation is greatly influenced by the ability of anesthesia to suppress stress responses without inhibiting post-anesthesia recovery. Overall, treatment P3 proved to provide the most optimal results, as it produced a balance between induction time, sedative time, blood glucose levels, and the highest survival rate. These findings reinforce the hypothesis that the use of banana stem extract as a natural anesthetic can improve the efficiency of white snapper transportation through the mechanisms of reducing physiological stress and stabilizing energy metabolism. With proper dose determination, this approach has the potential to be applied to sustainable commercial-scale aquaculture fish transportation.

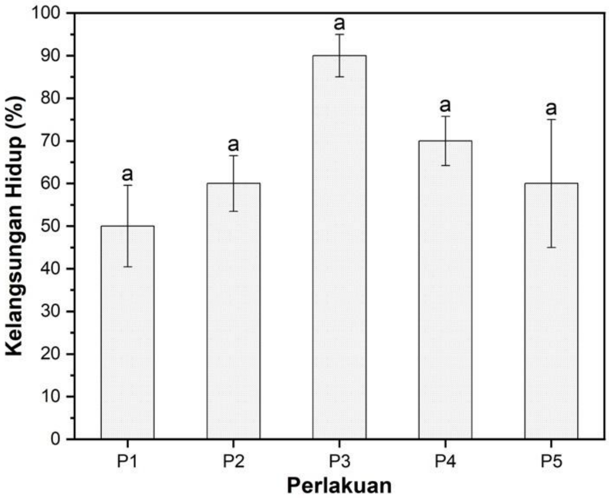

Figure 3. *Survival rate of white snapper after transportation*

3.4. *Water Quality Analysis*

Water quality is an important factor that determines the success of live fish transportation because it directly affects the physiological stability and stress levels of fish during transport. Based on Table 1, the water temperature parameters before and after transportation were relatively stable in the range of 27–32°C, which is still within the optimal range for white snapper. This temperature range indicates that the transportation system is capable of maintaining thermal stability, thereby preventing thermal stress that can trigger increased metabolism or excessive oxygen consumption. Dissolved oxygen (DO) values also indicate acceptable conditions, ranging from 5.2–5.5 mg/L, indicating that aeration or oxygen diffusion during transport is effective in maintaining fish respiration. Meanwhile, the pH of the water only fluctuated slightly in the range of 7.6–8.1, which still supported the physiological functions of the fish, especially ionic balance and enzymatic activity. However, the parameter that showed a significant change was the ammonia (NH_3) level, which increased after transportation from 0.005 mg/L to 0.034 mg/L in treatment P5. This increase is associated with the accumulation of fish metabolic waste due to respiratory and excretory activities during the transport period, especially in treatments with longer sedative times (Syamsiyah *et al.*, 2022). High ammonia can be toxic because it disrupts ion balance and reduces the oxygen-binding capacity of the blood, thereby worsening the fish's stress condition. Conversely, P3 showed the lowest NH_3 level (0.010 mg/L), indicating that the anesthetic dose in this treatment effectively suppressed metabolic activity without inhibiting excretion, resulting in more stable water conditions (Wulandari *et al.*, 2022). Thus, the balance between water environment stability and anesthetic effectiveness is key to the success of white snapper transportation, where P3 has been proven to provide the most ideal conditions for maintaining water quality and fish health.

Table 1.
Water quality of white snapper before and after transportation

Parameter	Before Transportation	After Transportation				
		P1	P2	P3	P4	P5
Temperature (°C)	27-32	27-32	27-31	27-32	27-32	27-32
DO (mg/l)	5.2-5.4	5.2-5.5	5.2-5.4	5.2–5.4	5.2–5.5	5.2–5.5
pH	7.8-8	7.7-8.1	7.7-8	7.6-7.9	7.7–8.1	7.7-8
NH_3 (mg/l)	0.005	0.021	0.016	0.010	0.022	0.034

4. Conclusion

The results of this study indicate that banana stem extract (*Musa paradisiaca*) is effective as a natural anesthetic in the wet transport of white snapper (*Lates calcarifer*) seeds, with the P3 treatment as the optimal condition. P3 has the best balance between induction time (10.5 minutes) and sedative time (7 minutes), more stable blood glucose levels (140 mg/dL), and the highest survival rate (90%). The correlation between blood glucose levels and survival rates shows that treatment with excessively long sedation times (P5) or without anesthesia (P1) causes higher stress, resulting in increased glucose levels and decreased fish survival. Additionally, water quality after transport changed, with the highest ammonia (NH_3) levels in P5 (0.034 mg/L), while P3 had lower NH_3 levels (0.010 mg/L), indicating more optimal transport conditions. Thus, the use of banana stem extract can be an environmentally friendly natural anesthetic alternative in fish transportation, helping to reduce stress, maintain physiological stability, and increase the survival rate of white snapper fry. Further studies are needed to optimize the extract dosage for wider application in aquaculture.

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