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Peran Propack sebagai penstabil air untuk meningkatkan kelangsungan hidup dan perilaku benih ikan mas pada transportasi tertutup jangka panjang
[Propack as a water stabilizer to improve survival and behavior of Common carp fry under prolonged closed transportation]

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ABSTRACT | The study evaluated the effectiveness of Propack tablets, a water stabilizer containing lime, zeolite, and clay, in improving the survival of Common carp (*Cyprinus carpio*) juveniles during 30-hour closed transportation at different stocking densities. A Completely Randomized Design (CRD) with five treatments and four replications was used: P0 (45 fish/bag, without Propack), P1 (45 fish/L with Propack 50 ppm), P2 (60 fish/L with Propack 50 ppm), P3 (75 fish/L with Propack 50 ppm), and P4 (90 fish/L with Propack 50 ppm). Each bag contained 1 L of water and a 1:2 water–oxygen ratio. Observed parameters included survival rate, behavioral responses (scores 1–4), and water quality (pH, dissolved oxygen, ammonia, temperature). P1, which corresponds to the recommended SNI density for tilapia seed (45 fish/L) with Propack addition, achieved the highest survival (87.75%), stable behavior (scores 1–1.5), and favorable water quality (pH 8.0–8.4, DO 6.47 mg/L, ammonia 0.5 ppm). Higher densities (⩾60 fish/L) showed decreased survival and more stressful behavior, accompanied by lower DO and increased ammonia. These results indicate that Propack is effective to maintain water quality and survival at the standard SNI density, but is not sufficient to fully compensate for overcrowding at higher densities.

Key words | *Carp*, density, propack, waterquality, transport

ABSTRAK | Penelitian ini mengevaluasi efektivitas tablet Propack, penstabil air yang mengandung kapur, zeolit, dan tanah liat dalam meningkatkan kelangsungan hidup juvenil ikan mas (Cyprinus carpio) selama transportasi tertutup 30 jam pada kepadatan tebar yang berbeda. Penelitian menggunakan Rancangan Acak Lengkap (RAL) dengan lima perlakuan dan empat ulangan, yaitu P0 (45 ekor/kantong tanpa Propack), P1 (45 ekor/L + Propack 50 ppm), P2 (60 ekor/L + Propack 50 ppm), P3 (75 ekor/L + Propack 50 ppm), dan P4 (90 ekor/L + Propack 50 ppm). Setiap kantong diisi 1 L air dengan rasio air–oksigen 1:2. Parameter yang diamati meliputi kelangsungan hidup, respons perilaku (skor 1–4), dan kualitas air (pH, oksigen terlarut, amonia, dan suhu). Perlakuan P1, yang setara dengan kepadatan standar SNI untuk benih ikan nila (45 ekor/L) dengan penambahan Propack, menghasilkan kelangsungan hidup tertinggi (87,75%), perilaku stabil (skor 1–1,5), serta kualitas air yang baik (pH 8,0–8,4, DO 6,47 mg/L, amonia 0,5 ppm). Kepadatan lebih tinggi (⩾60 ekor/L) menurunkan kelangsungan hidup dan memperburuk respons stres, disertai penurunan DO dan peningkatan amonia. Hasil ini menunjukkan bahwa Propack efektif mempertahankan kualitas air dan kelangsungan hidup pada kepadatan standar SNI, namun belum mampu mengatasi dampak kelebihan kepadatan.

Kata kunci | Ikan mas, kepadatan, propack, kualitasair, transportasi

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INTRODUCTION

Propack tablets are a new innovation in transporting fish, especially fish fry at the Jambi Freshwater Cultivation Center. This product aims to offer effective and practical solutions for cultivation businesses. Propack is made from 70% lime, 20% zeolite and 10% clay, molded into tablets and dried at 100°C for 2 hours. The chemical compounds in Propack function to bind carbonic acid (HCO_3^-), maintaining water pH stability, ensuring oxygen availability, and supporting fish metabolic stability during transportation (Suratno *et al.,* 2023). Fish transportation methods are broadly categorized into dry and wet systems, where in wet transportation water serves as the primary medium and can be further classified into open and closed systems (Nani *et al.,* 2015).

In Indonesia, technical guidelines such as SNI 7584:2010 and related standards provide recommendations for seed transport, including ideal densities, water volume, and water–oxygen ratios (Badan Standardisasi Nasional, 2010). For tilapia seed of around 6 cm, a recommended density is 45 fish per liter, which is considered a safe reference under standard conditions. However, wet transportation requires high water volume, increasing space and energy needs due to the weight of water-filled containers (Nani *et al.,* 2015). Farmers often raise stocking densities beyond these recommendations to increase the number of fish transported per trip, which accelerates water quality deterioration (declining dissolved oxygen, pH fluctuation, and ammonia accumulation) and causes stress, lower survival, and economic losses (Fauzi *et al.,* 2019; Syamsunarno *et al.,* 2019).

Several innovations have been explored to overcome transportation problems, including anesthetics, plant extracts, oxygen-enriched systems, and water quality modifiers (Midihatama *et al.,* 2018; Karim *et al.,* 2018). These approaches aim to reduce metabolic activity, stabilize water quality, or mitigate stress responses. Propack represents one such innovation, formulated specifically to stabilize pH and maintain dissolved oxygen by binding carbonic acid, thereby supporting more stable environmental conditions in closed transportation systems (Putra *et al.,* 2025). Beyond transportation, its ability to maintain pH and buffer against acidification suggests potential benefits for other aquaculture activities requiring stable water quality, such as nursery phases, short-term holding, or live fish marketing.

Freshwater fish inhabit rivers, lakes, and reservoirs, which differ fundamentally from marine environments, especially in salinity; freshwater typically ranges between 0–5 ppm compared to 30–40 ppm in seawater (Dyldin *et al.,* 2020; Kolwalkar and Deb, 2023; Putra, 2021). To maintain homeostasis in this hypotonic environment, freshwater fish have evolved specialized mechanisms for osmoregulation and ion balance. Among commercially important freshwater species, common carp (*Cyprinus carpio*) is one of the most widely cultivated globally (Darwis *et al.,* 2019; El Rahimi *et al*., 2019). It is favored for its tender texture, thick fillets, and high nutritional value (Wihardi *et al.,* 2014), and serves as an important protein source in developing regions such as Indonesia. Growing consumer demand requires large-scale production and efficient distribution of carp fry, but limited adoption of innovative transport technologies contributes to an imbalance between market demand and available seed supply (Lake *et al.,* 2019).

Under the current SNI-based recommendations for tilapia seed stocking density, carp seed transportation is generally arranged around densities considered safe (45 fish/L), yet economic drivers encourage attempts to increase density. Therefore, it is necessary to evaluate whether water-quality stabilizers such as Propack can safely support higher stocking densities than the standard reference without compromising survival and welfare. Based on these considerations, this research was conducted to evaluate the effectiveness of Propack application in closed transportation of common carp juveniles at different stocking densities. Specifically, the study aimed (i) to assess the impact of Propack (50 ppm) on survival, behavior, and water quality of carp fry transported for 30 hours, and (ii) to determine whether Propack can maintain acceptable survival at densities equal to or higher than the standard reference density (45 fish/L). The findings are expected to provide practical recommendations for improving transportation protocols and potentially increasing transport efficiency while maintaining fish health in aquaculture supply chains.

MATERIAL AND METHODS

Experimental Design

This research began on March 2024 at laboratory of seed and reproduction the Faculty of Maritime Affairs and Fisheries, Syiah Kuala University, Banda Aceh City, Aceh Province. This study implemented a Completely Randomized Design (CRD) method consisting of 5 treatments and 4 replications. The treatments and concentrations applied in this study were adapted to research by Suratno *et al.* (2023) The research design was as follows:

Control Treatment (P0)= juvenile density of 45 ind/L without Propack

Treatment 1 (P1) = juvenile density of 45 ind/L and Propack dose of 50 ppm

Treatment 2 (P2) = juvenile density of 60 ind/L and Propack dose of 50 ppm

Treatment 3 (P3) = juvenile density of 75 ind/L and Propack dose of 50 ppm

Treatment 4 (P4) = juvenile density of 90 ind/L and Propack dose of 50 ppm

Study Procedures

Test Fish Preparation

A total of 1.300 common carp juveniles (3–5 cm) were obtained from the Glory Pulo Nusa showroom. The fish were first acclimated for 24 h in holding tanks with continuous aeration, during which their general health status (swimming pattern, response to feed and external stimuli) was observed. After acclimation, the fish were starved for 24 h to reduce metabolic activity and clear residual feed from the digestive tract.

Health assessment was conducted visually by examining swimming behavior, body orientation, response to gentle mechanical stimuli (light tapping on the tank or gentle disturbance), and external morphology (skin, scales, fins, and gills). Fish selected for the experiment were required to meet the following criteria: active and balanced swimming, strong and immediate response to stimuli, absence of wounds, deformities, or visible lesions on the body and fins, normal body coloration, and bright red gills without excessive mucus. Individuals that appeared weak, unresponsive, showed abnormal swimming (tilting or upside-down), or exhibited any clinical signs of disease were excluded. Based on this selection procedure, 1.260 common carp juveniles that met the health and normality criteria were retained for use in the experiment.

Packing Process

According to SNI 7584:2010, common carp fry are packaged using polyethylene (PE) plastic bags with a thickness of 0.06–0.10 mm and a size of 60 × 40 cm. Each bag was labeled to indicate treatment, stocking density, and replication. In this study, the recommended SNI density for carp fry of approximately 6 cm (45 fish/L) was used as the reference density, and higher densities (60, 75, and 90 fish/L) were tested to evaluate the effect of increasing stocking density above this standard.

Plastic bags were filled with 1 L of pre-prepared water and then supplied with oxygen at a water:oxygen volume ratio of 1:2. Propack tablets were added to the designated treatments at a dose of 50 ppm before the bags were sealed. The primary function of Propack in this context was to stabilize water pH and help maintain adequate dissolved oxygen levels during transport by binding carbonic acid, thereby buffering pH changes over time.

After water and oxygen were added and Propack applied according to the treatment, the plastic bags were tightly sealed with rubber bands to create a closed transportation system. Initial water quality measurements were then carried out before transportation, including temperature, dissolved oxygen (DO), pH, and ammonia concentration. Temperature was monitored to ensure that it remained within the acceptable range for common carp fry during transport, while pH and DO were specifically observed to evaluate the stabilizing effect of Propack under different stocking densities.

Transportation Process

The transportation simulation was conducted for 30 hours around the city of Banda Aceh to mimic long-distance live fish transport conditions. The plastic bags containing the packed fish fry were arranged horizontally on the back of a pick-up truck, placed on top of a rubber carpet mat to reduce direct vibration and mechanical shock. The load was then covered with a tarpaulin to protect the bags from direct sunlight, rain, and wind exposure, thereby reducing abrupt environmental changes.

Although no styrofoam boxes were used, particular attention was given to minimizing temperature fluctuations during transport. The vehicle was operated mainly during periods with relatively stable ambient temperature, and the bags were arranged so that no bag was directly exposed to the metal surface or direct solar radiation. Water temperature was measured at the start and at the end of the 30-hour transportation period for each treatment to ensure that it remained within the acceptable range for common carp fry and to evaluate the impact of the transportation process on thermal conditions inside the bags.

Observation of Test Fish

Common carp fry were observed for survival and behavior at 3-hour intervals throughout the 30-hour transportation period in the plastic bags (Suratno *et al*., 2023). At each observation time (0, 3, 6, 9, 12, 15, 18, 21, 24, 27, and 30 h), the number of live fish in each bag was counted and behavioral responses were evaluated based on the established scoring criteria (scores 1–4). Survival data were recorded as the total number of live fish per bag, while behavior was assessed visually by observing swimming activity, responsiveness to gentle mechanical stimuli, position in the water column, and signs of stress (e.g. gasping or resting at the bottom). These observations were used to calculate survival rate at the end of the experiment and to determine the average behavior score for each treatment over time.

Study Parameters

Survival Rate (SR)

The calculation of survival rates in this study was carried out based on the formula proposed by Dachi *et al*. (2018) and Putra *et al*. (2022) as follows:

SR (%)=(Number of Fish at the End of Research)/(Number of Fish at the End of Research) x100

Fish Behavior

Observations of fish behavior were carried out qualitatively using the scoring system presented in Table 1, and the overall condition of the fish in each treatment was interpreted based on the average behavior score shown in Table 2 (Suratno *et al*., 2023). At each observation time, all fish in each bag were visually examined and classified into one of four behavioral categories (scores 1–4) according to their response to gentle mechanical stimulation, swimming activity, position in the water column, and visible signs of stress or mortality.

The number of fish in each behavior category (score 1, 2, 3, or 4) was counted for every bag, and the proportion (percentage) of fish in each category was then calculated relative to the total number of fish in that bag. A weighted average behavior score was obtained for each bag using these proportions, and the mean ± SD of this score was then calculated for each treatment and observation time. The qualitative interpretation of fish condition followed the ranges in Table 2, where lower scores indicate highly responsive fish with no or few deaths, and higher scores indicate reduced responsiveness and increased mortality.

Table 1. Fish Behavior Based on Scoring Values

No	Observation	Scoring
1	Responding to shocks, fish move quickly, tend to scatter	1
2	Responding to the shock, the fish scatter, while some fish pant.	2
3	Less responsive to shocks, fish pant, some fish settle to the bottom and go limp, with a few cases of death.	3
4	Unresponsive to shocks, limp, tend to collect at the bottom, reverse swimming position, and many die.	4

Table 2. Fish condition based on average score

Average score value	Fish quality
1.0-1.5	The fish were very responsive and none died.
1.6-2.5	Fish are responsive and experience few deaths.
2.6-3.5	The fish are less responsive and the mortality rate is moderate.
3.5-4.0	The fish did not respond and many deaths occurred.

Water Quality Measurement

Water quality was measured consistently across all treatments using the same set of parameters. In this study, water temperature, dissolved oxygen (DO), pH, and ammonia concentration were recorded at two time points: (i) before Propack tablets were added and transportation was initiated, and (ii) after 30 hours of closed-system transportation. Measurements were conducted on the water inside each plastic bag to capture the actual conditions experienced by the fish.

The recorded water quality data were then analyzed using analysis of variance (ANOVA) with a significance level of 5% to evaluate the effect of different stocking densities and Propack application among treatments.

RESULTS

The study observed significant variations in the survival rates of Common carp (*Cyprinus carpio*) fry after 30 hours of transportation across different treatments. Treatment P1 demonstrated the highest survival rate at 87.75 ± 5.31%, significantly outperforming all other groups, treatments P0 (50.25 ± 8.26%) and P2 (58.00 ± 3.55%) showed moderate survival rates. The lowest survival rates were recorded in P3 (36.50 ± 4.43%) and P4 (33.75 ± 6.29%), which did not differ significantly from each other. These results indicate that P1 was the most effective treatment in enhancing the survival of carp fry during transportation, whereas P3 and P4 were the least favorable. The intermediate performance of P0 and P2 suggests that while they provided some benefit, further optimization may be needed to match the efficacy of P1 (Table 3).

Table 3. Results of observations of survival rate parameters for carp (*Cyprinus carpio*) fry during 30 hour transportation.

Treatment	Survival Rate (%)
P0	50.25 ± 8.26^{b}
P1	87.75 ± 5.31^{c}
P2	58.00 ± 3.55^{b}
P3	36.50 ± 4.43^{a}
P4	33.75 ± 6.29^{a}

Note: Different superscript values in the table above indicate that there is a significantly different effect between treatments (P<0.05) and the ± sign indicates the standard deviation. in P1 the control treatment (density 45 individuals) while in P2 the density was 60 individuals (dose 50 ppm), P3 the density was 75 individuals (dose 50 ppm).

Behavior

The behavioral scoring data in Table 4 reveal clear differences in responsiveness of common carp fry among treatments over the 30-hour transportation period. P1 consistently showed low average scores (≈1.0–1.5), indicating highly responsive fish with no or very few deaths according to the criteria in Table 2. In contrast, P0 and P4 reached behavior scores of about 3.0 at the end of transport, reflecting less responsive fish and higher mortality, consistent with more severe stress conditions. P2 and P3 generally maintained intermediate scores (mostly 1.0–2.0), indicating that fish remained responsive but experienced some mortality.

Table 4. Mean behavior score of common carp (*Cyprinus carpio*) fry for each treatment during 30-hour transportation

Treatment	Observation Time									
	3 h	6 h	9 h	12 h	15 h	18 h	21 h	24 h	27 h	30 h
P0	1	1	1	2.5	2	2.5	2	1.8	3	3
P1	1	1	1	1	1	1	1	2	2	1.5
P2	1	1	1	1	1.3	1	1.3	1.3	2	2
P3	1	1	1	1	1	1	1.8	1.3	1.5	2
P4	1	1	1	1	2	1.5	1.8	1.5	3	3

Note: Values represent the mean behavior score per treatment and observation time, based on the scoring criteria in Table 1 (scores 1–4). Overall fish condition is interpreted using the average score ranges in Table 2.

These behavior patterns are in line with the survival data, confirming that P1 was the most favorable treatment, while P0 and P4 were the least favorable for maintaining acceptable behavioral condition during transportation.

Water Quality Parameters

Water quality parameters measured during the research included pH, DO, Ammonia and temperature. Based on this research, water pH was observed, observed at the beginning of the research and every 3 hours for 30 hours. The pH of the water during the transportation process in all treatments experienced changes. Based on the results of pH observations, the average value for each treatment (3 hours) ranged from 7.5 ± 0.40 to 8.1 ± 0.62, treatment (6 hours) ranged from 7.9 ± 0.25 to 8.1 ± 0.25, treatment (9 hours) ranged from 7.5 ± 0.00 to 8.3 ±0.00, treatment (12 hours) ranged from 7.9 ± 0.25 to 8.0 ± 0.00, treatment (15 hours) ranged from 8.0 ± 0.00 to 8.3 ± 0.28, treatment (18 hours) 8.0.00 to 8.4 ± 0.62, treatment (21 hours) 7.4 ± 0.47 to 8.4 ± 0.25, treatment (24 hours) 7.3 ± 0.28 to 8.0 ± 0.00, treatment (27 hours) 7.3 ± 0.28 to 8.0 ± 0.00, treatment (30 hours) 6.9 ± 0.25 to 8.0 ± 0.00. The results of observations of pH meter parameters during the research can be seen in Table 5.

Table 5. Results of pH observations every 3 hours

Treatment	Water pH										Standard
	3 Hr	6 Hr	9 Hr	12 Hr	15 Hr	18 Hr	21 Hr	24 Hr	27 Hr	30 Hr	
P0	8.0±0.2	8.1±0.25^{a}	7.5±0.00^{a}	8.0±0.00^{a}	8.0±0.00^{a}	8.4±0.62^{a}	7.4±0.47^{a}	7.3±0.28^{a}	7.3±0.28^{a}	6.9±0.25^{a}	6.5-8.5 (Wihardi *et al.*, 2014)
P1	8.1±0.6	8.1±0.25^{a}	8.0±0.00^{a}	8.0±0.00^{a}	8.3±0.28^{a}	8.3±0.28^{a}	8.4±0.25^{a}	8.0±0.00^{b}	8.0±0.00^{b}	8.0±0.00^{b}	
P2	7.9±0.4	7.9±0.25^{a}	7.9±0.00^{a}	8.0±0.00^{a}	8.1±0.25^{a}	8.1±0.25^{a}	8.1±0.25^{a}	8.0±0.00^{b}	8.0±0.00^{b}	8.0±0.00^{b}	
P3	7.9±0.2	8.1±0.25^{a}	8.0±0.00^{a}	7.9±0.25^{a}	8.0±0.00^{a}	8.0±0.00^{a}	8.1±0.25^{a}	8.0±0.00^{b}	8.0±0.00^{b}	8.0±0.00^{b}	
P4	7.5±0.2	8.1±0.25^{a}	8.3±0.00^{a}	8.0±0.00^{a}	8.1±0.25^{a}	8.1±0.25^{a}	7.9±0.62^{a}	8.0±0.00^{b}	8.0±0.00^{b}	8.0±0.00^{b}	

Note: Different superscript values in the table above indicate that there is a significantly different effect between treatments (P<0.05) and the ± sign indicates the standard deviation. in P1 the control treatment (density 45 individuals) while in P2 the density was 60 individuals (dose 50 ppm), P3 the density was 75 individuals (dose 50 ppm).

Water quality was evaluated before and after the transportation process, and the results are presented in Table 6. The water quality parameters in Table 6 show significant changes between initial and final transport conditions across treatments. Temperature increased in all groups but remained within the safe range (25–32°C), with P0, P2, and P4 starting slightly warmer (29.7–29.9°C) than P1 and P3

(28.9°C). Dissolved oxygen (DO) levels decreased in all treatments, with P1 maintaining the highest post-transport DO (6.47 mg/L), while P3 and P4 dropped close to the critical threshold (<4.92 mg/L). Ammonia accumulation varied notably, with P0 showing the highest spike (2.00 ppm) and P1–P3 maintaining safer levels (0.5 ppm). These results highlight P1's superior ability to maintain stable water quality, particularly in DO and ammonia control, which likely contributed to its better survival outcomes.

Table 6. Initial and final water quality parameters

Parameter	Treatment	Before	After	Standard
Temperature (°C)	P0	29.7±0.44^{b}	31.0±0.81^{a}	25-32°C (Makaminan, 2011)
	P1	28.9±0.09^{a}	30.2±0.90^{a}	
	P2	29.7±0.52^{b}	30.8±0.17^{a}	
	P3	28.9±0.73^{a}	30.2±0.90^{a}	
	P4	29.9±0.23^{b}	30.1±0.14^{a}	
DO (mg/L)	P0	6.70±0.00^{a}	5.27±0.22^{b}	>4mg/L (Wihardi *et al.,* 2014)
	P1	6.70±0.00^{a}	6.47±0.12^{c}	
	P2	6.70±0.00^{a}	5.40±0.08^{b}	
	P3	6.70±0.00^{a}	4.92±0.12^{a}	
	P4	6.70±0.00^{a}	4.70±0.14^{a}	
Ammonia (ppm)	P0	0	2.00±1.15^{b}	0,2 ppm (Handayani *et al.*, 2020)
	P1	0	0.5±0.00^{a}	
	P2	0	0.5±0.00^{a}	
	P3	0	0.5±0.00^{a}	
	P4	0	0.8±0.00^{a}	

Note: Different superscript values in the table above indicate that there is a significantly different effect between treatments (P<0.05) and the ± sign indicates the standard deviation. in P1 the control treatment (density 45 individuals) while in P2 the density was 60 individuals (dose 50 ppm), P3 the density was 75 individuals (dose 50 ppm).

DISCUSSION

The results demonstrate that the highest survival rate (87.75%) was achieved at a stocking density of 45 individuals per liter with 50 ppm Propack treatment (P1), which corresponds to the SNI recommendation for common carp fry transportation at this size (45 fish/L, 1 L water per bag). This finding is consistent with Suratno *et al.* (2023), who reported 81.80% survival at similar densities (40–60 ppm, 45 individuals). Elevated stocking densities during prolonged transport adversely affect water quality parameters, inducing physiological stress responses in fish (Syamsunarno *et al*., 2019). Population density directly influences individual survival rates (Stige *et al*., 2019), as overcrowding increases spatial competition and energy expenditure. Chronic exposure to high-density conditions exacerbates stress through cumulative water quality deterioration (Syamsunarno *et al*., 2019). As noted by Supriyono *et al.* (2015), transport mortality primarily stems from stress adaptation failure secondary to water quality decline, and compromised immune function under transport stress further reduces survival probability (Pratama *et al*., 2018).

The present study shows that Propack does not aim to change the SNI "ideal density", but to optimize water quality and fish welfare within that standard reference and to delay the onset of stress under prolonged closed transportation. At the tilapia seed SNI-based density (45 fish/L), Propack significantly improved survival (87.75%) compared with the control without Propack (50.25%), indicating that even at recommended density, water quality can deteriorate over 30 hours if no stabilizing agent is used. In P0 (45 fish without Propack), declining water quality led to reduced responsiveness and high mortality by the end of transport, whereas P1 maintained good water quality, stable behavior, and high survival. At higher densities (60–90 fish/L), Propack partially mitigated deterioration but could not fully compensate for the strong negative effects of overcrowding, as reflected by lower survival and more severe behavioral disturbance in P3 and P4. These patterns confirm that density remains the primary limiting factor, while Propack acts as a supporting tool to maintain water quality within density limits rather than to justify densities far beyond SNI.

Behavioral observations further support the protective effect of Propack at the standard density. During the initial 3–9 hours of transport, all treatments (P0–P4) exhibited high responsiveness and zero mortality. However, by 12 hours, P0 (control) showed reduced responsiveness and the first mortality events, and after 30 hours, P0 fish became non-responsive with significant mortality ($p < 0.05$). In contrast, P1 (45 fish + Propack) maintained responsiveness up to 24–27 hours with minimal mortality, and even at 30 hours fish remained active with low death rates. P2 (60 fish + Propack) showed sustained responsiveness up to 30 hours, though mortality gradually increased, whereas P3 (75 fish + Propack) displayed declining responsiveness by 30 hours but still relatively lower mortality compared with P4. P4 (90 fish + Propack) exhibited severe stress, with fish becoming non-responsive by 27 hours and experiencing high mortality by 30 hours. These findings align with Rachmawati *et al.* (2010), who identified stress as an adaptive survival mechanism to external stressors, reflecting attempts to restore homeostasis under transport-induced physiological disruption. Thus, Propack clearly improves behavioral stability and delays stress development at appropriate densities, but cannot prevent stress and mortality when density is excessively high.

The role of Propack is closely related to its ability to stabilize acid–base balance and maintain suitable physicochemical conditions. Elevated ammonia concentrations can reduce water pH, increasing acidity and leading to metabolic acidosis (Putra, 2025). Acidosis, characterized by a sharp rise in blood acid levels, impairs respiratory function and may result in mortality during transport. This condition arises primarily from a decline in water pH, which exacerbates acidity. Suratno *et al.* (2023) explained that reduction in water pH is driven by the accumulation of carbonic acid (H_2CO_3), formed through the reaction between water (H_2O) and carbon dioxide (CO_2) excreted by fish during respiration. The Propack formulation contains chemical compounds capable of binding carbonic acid (H_2CO_3), thereby stabilizing water pH, maintaining dissolved oxygen levels, and ensuring consistent metabolic activity in fish throughout the transportation process. In this study, treatments with Propack (P1–P4) maintained pH around 8.0 at the end of transport, whereas P0 experienced a decline to 6.9, indicating higher risk of acidosis and respiratory impairment in the control group.

Temperature and dissolved oxygen dynamics also illustrate how Propack supports, but does not replace, good transport management. The initial temperature measurements ranged from 28.7°C to 29.9°C, aligning with the SNI standard for carp seed production (No. 01-6137-1999) (Badan Standardisasi Nasional, 1999), which stipulates an optimal growth temperature range of 25–30°C. Final temperature values between 30.1°C and 31.0°C are consistent with Amri (2002), who reported that the ideal water temperature for carp seed transportation, ensuring survival, falls within 20–31°C. Temperature fluctuations during transport may be influenced by mechanical vibrations from the vehicle, where containers closer to the vibration source experience greater molecular collisions in water and increased heat generation (Karim *et al*., 2018). Additionally, rising temperatures accelerate organic waste decomposition, resulting in foul-smelling water, a decline in pH, and elevated ammonia levels (Marium *et al*., 2023), all of which can compromise fish health. Dissolved oxygen (DO) levels at the start of transportation averaged 6.7 mg/L, declining to 4.7–6.5 mg/L by the end. This reduction is attributed to respiratory oxygen consumption by fish, which is not offset by photosynthetic production or atmospheric diffusion (Fauzi *et al*., 2019). Sulmartini *et al*. (2009) demonstrated that carp maintain 100% survival within a DO range of 5.2–6.9 mg/L, confirming that these levels are adequate. In the present study, P1 maintained DO within or close to this favorable range, whereas higher-density treatments, especially P3 and P4, approached the lower limit of tolerance.

The pH profile during transport underlines the specific contribution of Propack to water chemistry stabilization. During the first three hours of monitoring, the average pH across treatments increased to 7.5–8.1, with the lowest pH observed in P4 and the highest in P1 and P0. Between the 21st and 30th hours, water pH in P0 exhibited a gradual decline, consistent with CO_2 accumulation reacting with water to form carbonic acid (H_2CO_3), thereby lowering pH (Suwandi *et al*., 2011). In contrast, all Propack treatments (P1–P4) maintained stable pH levels at approximately 8.0, demonstrating their efficacy in sustaining pH homeostasis throughout the observation period despite different stocking densities. As noted by Suratno *et al*. (2023), Propack functions as a pH stabilizer during transport, ensuring consistent dissolved oxygen availability by preventing acidic shifts. In practical terms, this means that at the Tilapia seed SNI-recommended density (45 fish/L), Propack provides an additional safety margin by stabilizing water quality over long transport duration, reducing stress, and improving survival compared with non-Propack transport. At densities above the SNI standard, Propack still improves water quality relative to what would be expected without any stabilizer, but cannot fully counteract the negative consequences of overcrowding.

Overall, the benefit of Propack in fish transportation is expressed as a combination of improved water quality stability, better behavioral performance, and higher survival at the Tilapia SNI reference density, rather than as a tool to safely increase density far beyond established standards. For producers and suppliers, this implies that integrating Propack into standard Tilapia SNI-based transport protocols can reduce mortality and associated economic losses, increase the reliability of long-distance fry shipments, and help maintain fish health after arrival. For downstream stakeholders, the use of Propack contributes to the delivery of healthier, less-stressed fish, which may translate into better performance in subsequent rearing phases.

CONCLUSION

This study shows that applying Propack at the standard Tilapia SNI-based stocking density (45 juveniles per liter in 1 L water) increases the safety and reliability of common carp (*Cyprinus carpio*) fry transportation over 30 hours. At this usual transport density, the Propack treatment (P1, 50 ppm) achieved the highest survival (87.75%), with stable behavior, minimal stress responses, and favorable water quality (pH 8.0–8.4, DO 6.47 mg/L, ammonia 0.5 ppm), compared with the non-Propack control at the same density (P0), which experienced lower survival, unstable behavior, and deteriorated water quality. Higher densities (⩾60 fish/L) with Propack showed only moderate to poor outcomes, indicating that Propack cannot fully compensate for the negative effects of overcrowding. Therefore, Propack should be considered as a supportive water-quality stabilizer that enhances survival and fish condition under commonly used SNI transport conditions, rather than as a tool to substantially increase stocking density. Maintaining appropriate density together with stable DO, pH, and ammonia levels remains critical for successful live fish transport, and Propack contributes to achieving these conditions during prolonged closed transportation.

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