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Efficacy of Coconut Water as a Seed Priming Agent for Enhancing Germination and Emergence of Rice

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Abstract. Low-cost, eco-friendly seed priming agents are increasingly sought after to improve rice (*Oryza sativa* L.) germination and establishment, especially for farmers with limited resources. Coconut water contains growth-promoting hormones such as cytokinins and gibberellins, but the optimal concentration and soaking duration for rice seed priming remain unclear. This study evaluated the effectiveness of coconut water at different concentrations and soaking times in enhancing germination, emergence, and early seedling growth. A one-factorial experiment, in a Completely Randomized Design (CRD) with three replications, was conducted under greenhouse conditions, testing four coconut water concentrations (25%, 50%, 75%, and 100%) and two soaking durations (12 and 24 hours), along with distilled water and untreated controls. Germination factors (percent germination, mean germination time, germination uniformity) and emergence and growth traits (percent emergence, shoot length, stem diameter, biomass) were measured. Results showed that priming with 25% coconut water for 12- 24 hours achieved the highest germination rate (97.33%), the fastest mean germination time (38.87 hours), and the most uniform germination. These were statistically similar to priming with distilled water but better than untreated seeds (86.67%). Emergence reached 100% in seeds primed with either 25% coconut water or distilled water, along with significant improvements in shoot length (32.74 cm), stem diameter (5.28 mm), and shoot biomass (fresh weight: 1.60 g; dry weight: 0.61 g). Higher coconut water concentrations (≥50%) did not improve performance and sometimes reduced growth, likely due to osmotic stress. Root biomass was unaffected by the treatments. These findings suggest that 25% coconut water is a practical, affordable, and sustainable alternative to synthetic priming agents. It promotes faster, more uniform germination and stronger early shoot growth without harming seed viability. This method is particularly suitable for smallholder rice farmers looking to improve crop establishment in resource-limited conditions.

Keywords: Coconut water; Germination; Rice; Seedling emergence; Seed priming

1.0 Introduction

Rice (*Oryza sativa* L.) is a vital food crop for over half of the global population, particularly in Asia, where it is a key part of daily diets and food security (Tang et al., 2022). As demand for rice continues to rise with growing populations, achieving high, stable yields has become a significant challenge. Successful rice production relies on fast and uniform seed germination, followed by strong seedling growth, as these early stages greatly affect the final yield potential (Zhang et al., 2023). However, in many rice-growing areas, especially in developing countries, low germination rates and uneven seedling emergence limit productivity. Poor seed quality, harsh environmental conditions, and limited access to expensive agricultural inputs often worsen this issue.

Seed priming is a technique used before planting to enhance seed metabolism before germination. It has garnered attention as a practical method for accelerating germination, improving seedling vigor, and increasing resilience to environmental stress (Nile et al., 2022). By initiating the biochemical processes necessary for germination, priming enables seedlings to grow more uniformly and earlier, thereby reducing their vulnerability to early-stage stresses. While researchers have extensively studied chemical priming agents (Yadav et al., 2023), recent work has begun to focus on natural, low-cost alternatives that support sustainable agriculture.

Coconut water is the nutrient-rich liquid found in both mature and immature coconuts. It contains cytokinins, minerals, amino acids, and sugars that can promote plant growth and development (Lakmali & Seran, 2022). Studies on crops such as okra (Lakmali & Seran, 2022) and jujube (Talpur et al., 2024) have demonstrated that coconut water can enhance germination rates and seedling vigor. These findings suggest that the nutrients in coconut water encourage germination and boost early plant growth, making it a promising natural priming agent.

Despite encouraging results from other crops, there is limited research specifically on the use of coconut water for rice seed priming. Previous studies have demonstrated its effectiveness in enhancing germination and early growth in crops such as okra (Lakmali & Seran, 2022), jujube (Talpur et al., 2024), Kamagong (Origenes & Lapitan, 2020), and rice (Ruth Olivya et al., 2021; Catada et al., 2016). In rice, Ruth Olivya et al. (2021) reported that coconut water, either alone or combined with biological agents, significantly improved germination rate, reduced mean germination time (MGT), and enhanced seedling vigor indices. Similarly, Catada et al. (2016) found improved germination and seedling emergence using naturally occurring priming agents, including coconut water. However, most of these studies either tested a single concentration or soaking duration or focused on other crops rather than systematically evaluating rice under controlled conditions. As a result, the optimal concentration of coconut water and the ideal soaking time for rice seed priming remain unclear. This gap limits the practical recommendations available to smallholder farmers who could benefit from affordable, natural priming methods. Therefore, the present study was conducted to systematically determine the effects of different coconut water concentrations and soaking durations on rice seed germination, emergence, and early seedling growth.

This study aimed to evaluate the effectiveness of coconut water as a seed priming agent in enhancing germination, emergence, and early seedling growth in rice (*Oryza sativa* L.). It will specifically examine how different concentrations of coconut water affect germination rate, emergence speed, and seedling vigor to determine the optimal concentration for maximum benefits. By offering an affordable, eco-friendly method for improved rice establishment, this research aims to enhance crop productivity, promote sustainable farming practices, and contribute to food security in resource-constrained farming communities.

2.0 Methodology

2.1 Research Design

The methodology was based on previously published procedures (Eraña & Valdez, 2025; Fronda & Valdez, 2025), with modifications to suit the objectives of this study. The study used a Completely Randomized Design (CRD) with three replications and eleven treatments. The treatments included the following: T0, Control (untreated); T1, 12 hours of soaking in distilled water (hydropriming); T2, 12 hours of soaking in 25% coconut water; T3, 12 hours of soaking in 50% coconut water; T4, 12 hours of soaking in 75% coconut water; T5, 12 hours of soaking in 100% coconut water; T6, 24 hours of soaking in distilled water (hydropriming); T7, 24 hours of soaking in 25% coconut water; T8, 24 hours of soaking in 50% coconut water; T9, 24 hours of soaking in 75% coconut water; and T10, 24 hours of soaking in 100% coconut water.

2.2 Research Locale

The experimental procedures were conducted in a greenhouse located on a rice farm in Barangay Maasin, Quezon, Nueva Vizcaya.

2.3 Data Gathering Procedure

A uniform batch of 3,960 rice seeds (NSIC Rc 222) was chosen for both germination and emergence experiments. The seeds were disinfected in a 2% sodium hypochlorite solution for 10 minutes to eliminate surface pathogens. They were then rinsed three times in distilled water to remove residues. Afterward, they were dried with a clean towel and then soaked in their respective priming solutions for either 12 or 24 hours. After washing, the seeds were rinsed again with distilled water. The preparation of the priming agents started with selecting fresh, young coconuts. The outer husks were removed, and the shells were opened to collect the coconut water. This water was filtered through a fine mesh to remove impurities and stored in a clean container. Four concentrations of coconut water—25%, 50%, 75%, and 100%—were created by diluting the extracted coconut water with distilled water as needed. The control treatment consisted of distilled water only (hydropriming). Each solution was measured precisely and placed in clearly labeled plastic cups to avoid confusion among treatments. The pH of each solution was recorded: distilled water measured 7.04, 25% coconut water at 5.60, 50% at 5.47, 75% at 5.38, and pure coconut water at 5.34. Transparent plastic cups, sanitized before use, were used to soak the seeds, ensuring full submersion, and were capped tightly to prevent contamination or spillage during soaking.

Experiment I focused on seed germination in controlled conditions. After soaking and rinsing, seeds were sown in germination boxes lined with two layers of moistened filter paper to maintain consistent moisture. The boxes were placed in a controlled environment with regulated temperature, humidity, and light. Moisture was maintained by spraying distilled water as needed. Germination counts were recorded every 24 hours, and observations continued until germination stabilized. Data included the final percentage of germination, calculated as the proportion of seeds germinated to seeds sown; mean germination time (T_{50}), computed using time-based germination counts; and mean spread of germination time (T_{90}–T_{10}), which represented the uniformity of germination.

Experiment II examined seedling emergence and growth. A greenhouse was built with bamboo poles for the frame, covered with UV-resistant polyethylene, and fitted with garden nets for ventilation. Inside, the temperature was maintained between 25-30°C and the humidity between 60-80%, as monitored by thermometers and hygrometers. The soil was analyzed in the College of Agriculture's soil laboratory. The soil analysis report revealed the following macronutrient content: pH 5.47, indicating acidic soil; organic matter at 0.45%, which is low; available phosphorus at 1.57 ppm, also low; and exchangeable potassium at 7.10 ppm, which is moderate. Primed seeds from each treatment were sown into cups to a depth of 1 cm, with one seed per cup and 20 per replication. The seedlings were grown in the greenhouse under regular watering and monitored conditions, with labels indicating their respective treatments. For Experiment II, data collection included the final percentage of emergence seven days after sowing; the total number of leaves per seedling, counted two weeks after emergence; mean shoot length measured from the stem base to the tip of the longest leaf at 28 days; stem diameter measured 1 cm above the stem base using a caliper; and leaf color determined using a standardized color chart at 28 days. Additional growth parameters measured at 28 days included shoot fresh weight, shoot dry weight after oven-drying at 70°C for 24 hours, root fresh weight, and root dry weight obtained by oven-drying at the same temperature and duration.

2.4 Data Analysis

Data were analyzed using analysis of variance (ANOVA) with Statistical Tool for Agricultural Research (STAR) software. Differences between means were analyzed using the Duncan Multiple Range Test (DMRT) at the 5% significance level ($P = 0.05$).

2.5 Ethical Considerations

This study did not require an ethical review board approval because it used only plant materials. However, standard ethical procedures in agricultural research were followed, including the safe disposal of experimental waste, the responsible use of chemicals, and the sourcing of seeds suitable for the study. The study did not use endangered species or genetically modified organisms (GMOs).

3.0 Results and Discussion

The results presented in this section highlight the effects of different concentrations of coconut water and soaking durations on the germination performance and early seedling growth of NSIC Rc 222 rice variety.

Percent Germination

The highest germination rates were observed in T1, T2, and T7, reaching 97.33%. This indicates that pre-soaking in distilled water and 25% coconut water effectively improves seed viability. All soaking treatments significantly boosted germination compared to the untreated seeds, which had a rate of 86.67%. Treatments T3, T5, and T6 did not result in higher germination rates and were statistically similar to one another. Increasing coconut water concentration beyond 25% does not provide additional benefits. This study confirms that coconut water enhances seed germination, consistent with earlier research. Ruth Olivya et al. (2021) reported that coconut water, either alone or combined with biological agents, significantly increased germination percentage and vigor in rice seeds. Similarly, Catada et al. (2016) found that coconut water was adequate for priming rice seeds, producing results comparable to those obtained with regular water.

Table 1. *Summary Matrix for Measured Germination Parameters of Rice (Oryza sativa L.) Seeds as Influenced by Priming in Water and Coconut Water for 12 and 24 Hours*

Treatments	Percent Germination	Mean Germination Time (T50, H)	Mean Spread of Germination (T90-T10, H)
T1	97.33^{a}	42.12^{ab}	34.97^{a}
T2	97.33^{a}	40.09^{de}	35.19^{a}
T3	94.33^{ab}	52.54^{bcde}	39.43^{a}
T4	91.00^{ab}	55.34^{cde}	45.69^{a}
T5	93.00^{ab}	57.33^{ab}	36.78^{a}
T6	96.00^{ab}	42.73^{abc}	34.41^{a}
T7	97.00^{a}	40.4^{ab}	31.79^{a}
T8	94.00^{ab}	38.87^{a}	36.15^{a}
T9	90.00^{ab}	43.55^{cde}	38.31^{a}
T10	90.66^{ab}	45.22^{abcd}	41.17^{a}
Untreated	86.67^{b}	64.89^{e}	79.93^{b}
CV (%)	**3.52**	**9.35**	**6.51**

*Means within a column having a standard letter are not significantly different at 5 % level by DMRT.

Mean Germination Time (T50, H)

The fastest germination occurred in T8 (38.87 h) and T2 (40.09 h). This shows that soaking in 25–50% coconut water can significantly speed up germination. Most treated seeds had a mean germination time that was considerably shorter than that of the untreated group (64.89 h). Slower germination was observed in T4 (55.34 h) and T5 (57.33 h), indicating that higher concentrations may reduce this advantage and that T4 and T5 were not significantly better than the control. Ruth Olivya et al. (2021) reported that coconut water treatments in rice significantly reduced mean germination time (MGT) and T50, indicating faster and more uniform germination due to the presence of growth-promoting substances and cytokinins. Similarly, Talpur et al. (2024) found that coconut water priming improved germination percentage, germination index, seedling vigor, and root development in jujube seeds, supporting the present study's findings that natural priming agents enhance early growth by regulating hormones such as cytokinins and gibberellins.

Mean Spread of Germination (T90- T10, H)

The narrowest and most consistent germination times were observed in T7 (31.79 h) and T6 (34.41 h). All soaking treatments significantly reduced the spread of germination compared to the untreated seeds (79.93 h). Treatments such as T3, T4, and T10 also improved synchronization but did not differ significantly from the other treated groups. These results demonstrate that soaking, especially in 25% coconut water for 24 hours, leads to substantially more uniform germination. This study aligns with Talpur et al. (2024), who showed that priming Jujube seeds with 30% coconut water for 11 hours improved the germination rate, index, and seedling vigor, resulting in uniform, synchronized germination. Similarly, Chuwang et al. (2019) found that coconut water supports consistent seedling emergence. Its cytokinin content boosts seed vigor and water uptake, encouraging uniform germination.

Percent Emergence

The percent emergence was highest in the T2 and T1 treatments, both achieving 100% emergence. This shows that soaking rice seeds in 25% coconut water or distilled water significantly increased emergence rates. Even at higher concentrations of coconut water (T3, T4, T5), emergence remained high at 90% to 95%, though slightly lower than in T1 and T2 treatments. The untreated seeds had the lowest emergence at 83.33%. This highlights the importance of soaking in either distilled water or coconut water to improve seed emergence. The increased seed emergence observed in this study supports Catada et al. (2016), who found that natural priming agents, such as coconut water, improved rice seedling emergence. The cytokinin and gibberellin content likely boosts metabolic activity and enzyme activation, leading to faster and more uniform emergence. Origenes and Lapitan (2020) also reported that coconut water improved seedling height, leaf number, and root collar diameter, proving its effectiveness in both germination and early seedling growth.

Table 2. *Summary Matrix for Measured Emergence Parameters of Rice (Oryza sativa L.) Seeds as Influenced by Priming in Water and Coconut Water for 12 and 24 Hours*

Treatments	Percent Emergence	Number of Leaves	Mean Shoot Length (mm)	Stem Diameter (mm)	Leaf Color	Shoot Fresh Weight (g)	Shoot Dry Weight (g)	Root Fresh Weight (g)	Root Dry Weight (g)
T1	100.00[a]	3.87	32.32[a]	5.20[a]	3.43	1.45[a]	0.50[a]	0.82	0.15
T2	100.00[a]	3.9	32.74[a]	5.28[a]	3.6	1.60[a]	0.61[a]	0.82	0.16
T3	95.00[a]	3.7	31.17[a]	5.11[a]	3.3	0.86[b]	0.19[b]	0.64	0.12
T4	93.33[ab]	3.67	31.14[a]	5.21[a]	3.5	0.85[b]	0.17[b]	0.7	0.14
T5	90.00[ab]	3.57	29.94[ab]	5.19[a]	3.47	0.83[b]	0.20[b]	0.67	0.12
T6	96.67[a]	3.87	32.64[a]	5.26[a]	3.4	1.31[a]	0.50[a]	0.84	0.18
T7	96.67[a]	3.83	32.10[a]	5.20[a]	3.47	1.33[a]	0.57[a]	0.67	0.15
T8	95.00[a]	3.83	31.04[a]	5.18[a]	3.77	0.86[b]	0.16[b]	0.53	0.15
T9	90.00[ab]	3.9	30.86[a]	5.17[a]	3.6	0.87[b]	0.18[b]	0.84	0.25
T10	93.33[ab]	3.83	30.94[a]	5.06[a]	3.67	0.77[b]	0.16[b]	0.82	0.15
Untreated	83.33[b]	3.67	26.36[b]	3.59[b]	3.03	0.46[b]	0.10[b]	0.47	0.08
CV (%)	**4.09**	**6.51**	**4.1**	**5.81**	**9.5**	**13.85**	**17.11**	**20.9**	**9.85**

*Means within a column having a standard letter are not significantly different at 5 % level by DMRT.

Number of Leaves

There were no significant differences in the number of leaves across treatments. Most groups, including T1, T2, T3, and others, showed a similar number of leaves, ranging from 3.57 to 3.9 leaves. This consistency indicates that the soaking treatments did not significantly affect leaf formation. It suggests that leaf numbers are less sensitive to changes in coconut water concentration or soaking duration than other growth factors. Origenes and Lapitan (2020) found that coconut water increased leaf width and shoot growth but did not significantly affect leaf number. They attributed this to cytokinins promoting cell division and shoot formation, without consistently supporting leaf production. Similarly, Wahyono et al. (2020) reported that, despite containing hormones such as auxins and cytokinins, coconut water did not consistently promote leaf formation across different species. In this study, higher coconut water concentrations (25% to 75%) showed a trend toward increased leaf numbers. However, the differences were not statistically significant, suggesting limited effects on leaf count at the tested levels.

Mean Shoot Length

The mean shoot length was significantly higher in T2 (327.4 mm) and T6 (326.43 mm), indicating that soaking in 25% coconut water or distilled water promoted optimal shoot growth. These treatments resulted in longer shoots than T3, T4, and T5, which showed shorter lengths, especially in T5 (299.43 mm). This suggests that moderate coconut water concentrations (25%) are most effective for supporting shoot growth, while higher concentrations (75%, 100%) might cause osmotic stress, limiting shoot elongation. Findings from this study align with previous research showing that coconut water priming can significantly increase plant height. Ruth Olivya et al. (2021) reported that rice seeds treated with *P. fluorescens*, *T. viride*, and coconut water produced the longest shoots (8.21 cm), demonstrating that coconut water enhances shoot growth through improved metabolic activity and cell division. Likewise, Catada et al. (2016) found that rice seeds primed in water or coconut water for 12 hours achieved greater seedling height, likely due to enzyme activation and the growth hormones present in coconut water.

Stem Diameter

Significant differences in stem diameter were observed across treatments. T2 (5.28 mm) and T6 (5.26 mm) had the widest stems, indicating that soaking rice seeds in 25% coconut water or distilled water enhanced stem growth. The T3, T4, and T5 treatments resulted in narrower stems, with T5 (5.19 mm) showing the smallest diameter. This suggests that moderate coconut water concentrations (25%) support better stem growth, while higher concentrations do not significantly improve this parameter and may even hinder stem thickness. Origenes and Lapitan (2020) found that Kamagong seeds treated with coconut water produced seedlings with the largest root collar diameter (RCD); Treatment 2 had a mean RCD of 3.98 mm, compared to 3.75 mm in Treatment 3 and 3.48 mm in the control using plain water—this underlines coconut water's superior effect on early stem growth. Similarly, Tandoh et al. (2025) reported increased stem girth in soybean seedlings, especially in the Afayak variety, when seeds were primed with coconut water for 4 hours, further confirming its effectiveness as a natural priming agent.

Leaf Color Measurement
There were no significant differences in leaf color measurement across treatments. All treatments, including T1 (3.43), T2 (3.6), T3 (3.3), and others, demonstrated similar leaf color values. The untreated seeds had a comparable leaf color value (3.03), indicating that while there were slight variations in leaf greenness, they were not statistically significant. These results align with Wahyono et al. (2020), who found that varying concentrations of coconut water (0% to 75%) did not significantly affect key vegetative traits in cocoa, including leaf area, leaf number, shoot diameter, and shoot count. The lack of significant changes, particularly in leaf area and number—traits related to chlorophyll development and light absorption—suggests that coconut water's bioactive compounds may have limited effects on leaf pigmentation and chlorophyll production.

Shoot Fresh Weight
The shoot fresh weight was highest in T2 (1.6 g) and T6 (1.31 g), suggesting that soaking in 25% coconut water or distilled water promoted better shoot development and biomass accumulation. In contrast, T3, T4, and T5 showed reduced fresh weight, particularly in T5 (0.83 g). Soaking rice seeds in 25% coconut water or distilled water yielded the best results for shoot biomass. Zainudin and Adini (2019) noted that the interaction between coconut water concentration and seed immersion time significantly affected leaf fresh weight. The increase in leaf biomass suggests that coconut water priming enhances papaya growth, likely by improving seed activation and nutrient uptake. Their study also reported a highly significant increase ($P<0.001$) in stem fresh weight in primed seeds compared to untreated ones.

Shoot Dry Weight
The shoot dry weight followed a similar trend to fresh weight, with T2 (0.61 g) showing the highest values, followed by T6 (0.5 g). Treatments with 50%, 75%, and 100% coconut water resulted in lower shoot dry weight, especially T5 (0.2 g). This suggests that higher concentrations of coconut water may limit shoot dry matter accumulation. The findings strongly support the hypothesis of Nedunchezhiyan and Bhavyasree (2019) that seed priming with 50% coconut water significantly enhances shoot dry matter production in groundnut (*Arachis hypogaea*). Seeds treated with coconut water exhibited the highest shoot dry matter at 3.68 g per 10 seedlings, surpassing the control and other priming treatments. This aligns with earlier studies that emphasize the positive effects of coconut water on plant growth, mainly due to its content of growth-promoting substances such as cytokinins, enzymes, and other bioactive compounds.

Root Fresh Weight
There were no significant differences in root fresh weight across treatments. Most treatments, including T1, T2, T3, and others, showed similar root fresh weight values (around 0.82 g), while the untreated seeds had the lowest root fresh weight at 0.47 g. This suggests that coconut water concentrations did not significantly affect root fresh weight, and soaking treatments may not significantly influence root biomass in the early stages of seedling growth. This study's results, indicating that soaking seeds in coconut water does not considerably alter root fresh weight, align with findings by Zainudin and Adini (2019) in their research on papaya (*Carica papaya* L.) cv. Calina. They tested various concentrations of coconut water (20% to 100%) but found no significant differences in root fresh weight across treatments. All values remained statistically similar, suggesting a limited impact on root biomass development at the early seedling stage.

Root Dry Weight
There were no significant differences in root dry weight across treatments. The root dry weight values were relatively consistent, with T11 (0.5 g), T2 (0.57 g), and T3 (0.16 g) showing similar results, and others did as well. The untreated seeds had the lowest root dry weight (0.08 g), indicating that soaking treatments supported root development. This study's findings align with results reported by Zainudin and Adini (2019), who studied the effect of coconut water on the germination and growth of papaya seedlings. This suggests that coconut water's influence may be more pronounced in above-ground parameters, such as shoot growth or vigor index. At the same time, its impact on below-ground biomass, particularly root dry matter accumulation, seems limited.

4.0 Conclusion
This study confirmed that priming NSIC Rc 222 rice seeds in 25% coconut water extracted from young, fresh coconuts or distilled water for 12 to 24 hours significantly improved the germination rate, reduced mean germination time, increased emergence, and enhanced shoot growth and biomass accumulation. Higher concentrations of coconut water (50% to 100%) provided no additional benefits and, in some cases, worsened

performance. This underscores the effectiveness of moderate concentrations in maximizing physiological advantages while avoiding osmotic stress.

Coconut water from young coconuts emerges from this research as an affordable, sustainable, and biologically powerful priming agent, rich in cytokinins and gibberellins that promote uniform germination and vigorous early growth. Its use in farming practices could improve crop establishment, lower replanting costs, and ensure synchronized maturity. These benefits are particularly relevant for resource-limited farming communities in coconut-producing regions.

Beyond immediate agronomic improvements, the results have broader implications for seed enhancement methods, agricultural extension services, and sustainable crop production policies. Future research should verify these findings under various field conditions, across multiple rice varieties, and alongside other organic priming agents, while further uncovering the underlying biochemical mechanisms. By merging nature-based innovations with modern farming science, coconut water priming presents a practical pathway toward more resilient, productive, and sustainable rice cultivation systems. This shows that simple, nature-based innovations can lead to meaningful advancements in global food security.

5.0 Contributions of Authors

Author 1: Jonabelle S. Carganilla provided conceptualization of the study, designed the experimental framework, conducted the experiment, collected and analyzed data, and wrote the draft of the manuscript. Carganilla was primarily responsible for the execution and interpretation of the study.
Author 2: Jenny T. Aquino assisted in the conduct of the experiment, supported data collection, and helped in organizing and preparing materials for analysis.
Author 3: Jessica J. Dinay-og provided assistance during the experiment, helped in data gathering, and contributed to the preparation of supporting documentation.
Author 4: Glen Joy L. Cumahling provided assistance during the experiment, helped in data gathering, and contributed to the preparation of supporting documentation.
Author 5: Manolo T. Valdez provided supervision, contributed to the study design, supported statistical analysis and interpretation of results, and reviewed and refined the manuscript. Both authors contributed to the final revision and approved the submitted version of the manuscript.

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7.0 Conflict of Interests

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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