

From an applied perspective, the cost advantage demonstrated in Table 9 and the favourable safety profile of *Citrus sinensis* suggest that citrus leaf extracts have practical potential for sustainable aquaculture. However, the variability in phytochemical composition and the limited safety margins observed in some extracts indicate that careful standardisation and dosage control are essential.

In conclusion, this study contributes to the advancement of plant based anaesthesia by providing a comprehensive evaluation of citrus leaf extracts and by clarifying the relationship between phytochemical composition, anaesthetic efficacy, and fish physiology. Further research is required to isolate active compounds, optimise extraction methods, and validate these findings under broader experimental conditions.

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Author Contributions

The authors jointly conceived and designed the study. Experimental procedures, data collection, and laboratory analyses were carried out collaboratively. Data analysis and interpretation were undertaken by the authors, and the manuscript was drafted by the lead author. All authors reviewed and revised the manuscript, approved the final version for submission, and accept responsibility for the integrity of the work.

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