J. Vet. Malaysia (2024) 36(1): 30-32

Short Communications

ANAESTHETIC EFFECTS OF SODIUM BICARBONATE ON RED TILAPIA JUVENILE FISH (*Oreochromis* spp.)

A.H. MUHAMMAD HANIF[1], H.C. CHEN[1*] AND M.T. NUR-DIYANA[2]

[1]*Department of Companion Animal Medicine and Surgery, Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*

[2]*Department of Veterinary Clinical Studies, Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43300, Serdang, Malaysia.*

SUMMARY

Red tilapia fish (Oreochromis spp.) is one of the major species in the aquaculture industry in Malaysia. Sodium bicarbonate is widely available, and has been suggested as potential to anaesthetise fish safely. This study evaluates the potential of sodium bicarbonate immersion to induce anaesthesia in red tilapia juvenile fish. A total of 40 fish were randomly assigned into four groups. The four treatment groups were 25 g/L, 50 g/L, and 75 g/L sodium bicarbonate, and 150 ppm tricaine methanesulfonate (MS-222). Fish were recovered once attained surgical (Stage IV) anaesthesia, or 15 minutes of immersion, whichever earlier. Fish in 25 g/L and 50 g/L sodium bicarbonate achieved only light anaesthesia (Stage III) within the 15 minutes. Fish in 75 g/L sodium bicarbonate and MS-222 reached surgical anaesthesia at 195 ± 88 and 418 ± 74 seconds, respectively. All 40 fish regained normal swimming patterns within 10 minutes of recovery. However, all fish exposed to sodium bicarbonate died within 2 days post-recovery, while all fish in MS-222 survived. Results suggest sodium bicarbonate can induce light to surgical anaesthesia. However, the 100% mortality post-recovery from sodium bicarbonate raises safety concern on its use in red tilapia juvenile fish.

Keywords: Anaesthesia, juvenile fish, sodium bicarbonate, tilapia (Oreochromis spp)

INTRODUCTION

Anaesthetic agents have been used in fishery operations to facilitate handling and alleviate stress and are important for sampling and surgery. Tricaine methanesulfonate (MS-222) is a commonly used fish anaesthetic and is approved by the U. S. Food and Drug Administration for aquaculture (USDA, 2024). Although effective, it requires a 21-day withdrawal period, prompting the search for alternatives.

Sodium bicarbonate is inexpensive and is widely available. Studies on greenhead tilapia (Hasimuna et al., 2020) and Mozambique tilapia (Gabriel et al., 2020) seemed to suggest that sodium bicarbonate can anaesthetise tilapia fish safely. The use of sodium bicarbonate in Malaysian fisheries remains unexplored. This study aims to evaluate the anaesthetic effects of sodium bicarbonate in red tilapia juvenile fish

MATERIAL AND METHODS

Ethics approval was obtained from Universiti Putra Malaysia Animal Care and Use Committee (UPM/IACUC/AUP-U002/2023). A total of forty red tilapia 3-inch juvenile fish (*Oreochromis* spp.) were bought from a local farmer. The fish were randomly placed into two water tanks (36" x 18" x 19"). Each tank was further divided into two, using a fenestrated plastic divider. Thus, there were four (4) groups, with ten fish each. Fish were acclimatised for 2 days and fasted 24 hours prior to the day of the experiment.

Treatment groups consist of three different concentrations of sodium bicarbonate, at 25, 50 and 75 g/L. Tricaine methanesulfonate (MS-222; Syncaine®, Syndel) at 150 ppm was used as a control. Sodium bicarbonate powder (Arm & Hammer, Church & Dwight Co., Inc., USA) was purchased from a local mart. Two 1-litre transparent tanks were used as the anaesthetic and recovery chambers, respectively. The water used for the anaesthetic immersion and recovery was taken from the same tank where the fish were acclimatised.

Each fish was anaesthetised and recovered individually. The time taken to reach various stages of anaesthesia, as described in Table 1, was recorded.

Table 1. Stages of anaesthesia and recovery in fish

Condition	Stages	Description
Anaesthesia	I	Sedation
	II	Partial loss of equilibrium, uncoordinated movement followed by active, erratic swimming
	III	Total loss of equilibrium
	IV	Anaesthesia, loss of activity, fish fails to respond to tail pinch
Recovery	I	Opercular movement without body movement
	II	Regular opercular movements and gross body movements beginning
	III	Equilibrium regained and swim normally

Criteria of stages adapted from Abbas et al. (2006)

*Corresponding author: Assoc. Prof. Dr. Chen Hui Cheng (H.C. Chen); Email: chen@upm.edu.my

Editorial history:
Paper received: 30 October 2024
Accepted for publication: 11 December 2024
Issue Online: 26 December 2024

Once Stage IV anaesthesia, or 15 minutes of immersion, was reached, fish were transferred to the recovery chamber. Recovery stages were recorded until Stage III recovery. Following the return of the normal swimming pattern, fish were transferred into a 10-litre tank for an additional 12-hour monitoring before returned to the main tank.

Data were analysed using Statistical Package for Social Sciences (SPSS version 27.0, IBM Corp). After checking for normality and homogeneity of variance, a one-way analysis of variance (ANOVA) was performed, followed by a post-hoc Tukey test to check on treatment effects on the induction and recovery times. Significance was set at $p < 0.05$ for all tests.

RESULTS AND DISCUSSION

The induction times to reach the various stages of anaesthesia are summarised in Table 2. All fish treated with sodium bicarbonate did not exhibit sedation characteristic of Stage I anaesthesia. The first observable anaesthetic effects were hyperactivity and excitement, which was taken as Stage II anaesthesia. Fish in 75 g/L sodium bicarbonate took the shortest time to reach Stage II, III and IV, while those treated with 25 and 50 g/L could not reach Stage IV anaesthesia. They achieved only light anaesthesia (Stage III) within 15 minutes of immersion. Fish in 75 g/L sodium bicarbonate and MS-222 reached surgical anaesthesia at 195 ± 88 and 418 ± 74 seconds, respectively.

Following anaesthesia, all fish attained equilibrium and swam normally in the recovery tank. The anaesthesia recovery times of fish are summarised in Table 3. Fish exposed to 75 g/L sodium bicarbonate took the longest time to fully recover, compared to the lower concentrations, and MS-222. Post-recovery, fish in the sodium bicarbonate groups were observed to be less active and responsive to food, compared to the MS-222 group. All the fish in sodium bicarbonate groups died within 2 days, while all fish in MS-222 survived the 7-day observation period post-recovery.

In this study, fish exposed to sodium bicarbonate did not show initial sedation or tranquillisation, but hyperactivity and excitement. Signs of hyperactivity and excitement were interpreted as Stage II anaesthesia. However, fish in the 75 g/L reacted violently when first placed into the induction chamber; raising concerns on whether the 'perceived Stage II" was in fact, aversive behaviour to the sudden exposure to high carbon dioxide concentrations.

Table 2. Anaesthesia induction times (seconds) of red tilapia juvenile fish exposed to 25, 50, 75 g/L and 150 ppm of MS-222

Stage	Concentration (g/L)			
	25	50	75	MS-222 (150 ppm)
I	N/A	N/A	N/A	62 ± 15
II	132 ± 46^{c}	54 ± 14^{a}	38 ± 9^{a}	99 ± 16^{b}
III	339 ± 110^{c}	82 ± 20^{a}	94 ± 28^{a}	185 ± 49^{b}
IV	N/A	N/A	195 ± 88^{a}	418 ± 74^{b}

Data are mean ± standard deviation. ^{a,b,c} Means within row with different superscripts differed significantly at $p < 0.05$. N/A indicates the stage of anaesthesia is not exhibited/achieved

Table 3. Anaesthesia recovery times (seconds) of red tilapia juvenile fish exposed to 25, 50, 75 g/L and 150 ppm of MS-222

Stage	Concentration (g/L)			
	25	50	75	MS-222 (150 ppm)
I	81 ± 44^{a}	88 ± 24^{a}	119 ± 82^{a}	66 ± 26^{a}
II	115 ± 48^{a}	180 ± 110^{a}	322 ± 160^{b}	113 ± 29^{a}
III	179 ± 61^{a}	288 ± 103^{ab}	402 ± 162^{b}	223 ± 62^{a}

Data are mean ± standard deviation. ^{a,b,c} Means within row with different superscripts differed significantly at $p < 0.05$.

Findings on higher concentrations of sodium bicarbonate resulted in faster induction but longer recovery are consistent with other studies (Altun et al., 2009; Gabriel et al., 2019; Hasimuna et al., 2020; Hasimuna et al., 2021). However, the 100% mortality within 2 days following anaesthesia with sodium bicarbonate in the present study contradicts the good report by previous studies. Closer examinations revealed that fish in previous studies were not induced until Stage IV anaesthesia, which is defined as no response to tail pinch in the present study. Fish in previous studies were also immersed in the sodium bicarbonate solution for shorter durations. For example, juveniles of *Oreochromis macrochir* in 25 g/L were reported as fully anaesthetised between 2-3 minutes, and thereafter, were recovered (Hasimuna et al., 2021). In the present study, fish in 25 g/L were immersed for up to 15 minutes as they did not attain Stage IV anaesthesia. The longer duration of immersion in sodium bicarbonate in the present study may have caused more stress and physiological disturbances, resulting in 100% mortality post recovery. Further work on the resultant carbon dioxide and oxygen level in the water, along with blood gas, acid-base, electrolyte and cortisol level in the fish may document extent of physiological disturbances to the mortality.

CONCLUSION

In conclusion, this study showed that there is significant difference in the induction and recovery times at different concentrations of sodium bicarbonate on red tilapia juvenile fish (*Oreochromis spp.).* However, 100% mortality post-recovery raised safety concern on its use in red tilapia juvenile fish. Future work should explore the potential and safety of sodium bicarbonate on different exposure time limits, fish sizes, and other local aquaculture species in Malaysia

CONFLICT OF INTEREST

None of the authors of this paper has financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper

ACKNOWLEDGEMENTS

The authors wish to acknowledge all the staff of the Aquatic Laboratory, Department of Veterinary Clinical Studies, Faculty of Veterinary Medicine, Universiti Putra Malaysia for their help in completing this research project.

FUNDING

This study was self-supported.

REFERENCES

Abbas, H.H.H., Abdel-Gawad, A.S. and Akkr, A.A. (2006). Toxicity and efficacy of lidocaine as an anesthetic for Nile tilapia; *Oreochromis niloticus.* Pakistan Journal of Biological Sciences, 9: 2236-2242.

Altun, T., Bilgin, R., and Danabaş, D. (2009). Effects of sodium bicarbonate on anaesthesia of common carp (*Cyprinus carpio L., 1758*) juveniles. Turkish Journal of Fisheries and Aquatic Sciences, 9(1).

Gabriel, N. N., Erasmus, V. N., and Namwoonde, A. (2020). Effects of different fish sizes, temperatures and concentration levels of sodium bicarbonate on anaesthesia in Mozambique tilapia (*Oreochromis mossambicus*). Aquaculture, 529, 735716.

Hasimuna, O. J., Monde, C., Mweemba, M., and Nsonga, A. (2020). The anaesthetic effects of sodium bicarbonate (baking soda) on greenhead tilapia (*Oreochromis macrochir*, Boulenger 1912) broodstock. The Egyptian Journal of Aquatic Research, 46(2), 195-199.

Hasimuna, O. J., Monde, C., Bbole, I., Maulu, S., and Chibesa, M. (2021). The efficacy of sodium bicarbonate as an anaesthetic agent in *Oreochromis macrochir* juveniles. Scientific African, 11, e00668.

U.S. Food & Drug Administration. (2024, February 2). Approved Aquaculture Drugs. https:// www.fda.gov/animal-veterinary/aquaculture/approved-aquaculture-drugs