Carbonate alkalinity induces stress responses and renal and metabolic disorders in Nile tilapia: mitigation by camel whey protein hydrolysate diet

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Abstract

Alkaline stress is a major concern in aquaculture that badly affects the aquatic species' health and hemostasis. This research investigated the effect of carbonate alkalinity exposure on the gills and kidney organs as important organs for hemostasis, as well as the ameliorative role of camel protein hydrolysates (CPH) as dietary additives against alkaline

stress detrimental impacts in Nile tilapia (*Oreochromis niloticus*). The fish ($n = 160$) were divided into four groups (G1, G2, G3, and G4), with the control (G1) fed a basal diet, while G2 was fed a basal diet supplemented with 75 g CPH/kg and was reared in freshwater (carbonate alkalinity of 1.4 µmol/L, pH = 7.19). The G3 and G4 were reared in alkaline water (carbonate alkalinity of 23.8 µmol/L, pH = 8.65) and fed the same diets as G1 and G2 for 30 days, respectively. The fish were stocked under a water temperature of 26.4 ± 1.5 °C, and the diets were introduced to the fish three times daily at a rate of 4% of their body weight. The results of this research showed that alkaline exposure increased kidney function parameters (creatinine, urea, and uric acid), glucose, and cortisol levels in the exposed fish. Alkaline exposure reduced the blood electrolytes level (calcium, magnesium, sodium, potassium, and chloride) and branchial antioxidant enzymes (superoxide dismutase, catalase, glutathione peroxidase, and reduced glutathione) and elevated malondialdehyde level in the exposed fish. Significant downregulation of the branchial expression of Na^+/K^+ ATPase α-3 subunit (0.17-fold), calcium/calmodulin-dependant protein kinase 1 β (0.23 fold), chloride channel protein 2 (0.38-fold), solute carrier family 12 a 2 (0.33-fold), and solute carrier family 4 a 4 (0.21-fold) was in the fish-reared under carbonate alkalinity stress. Alkaline exposure induced severe histopathological changes in the gills and kidney tissue architecture including inflammatory, circulatory, degenerative, and progressive responses. Supplementation of the Nile tilapia diet with 75 g CPH/kg ameliorated renal function and balanced the blood electrolytes, glucose, and cortisol levels in the alkaline-exposed fish. Modulation of the branchial gene expression profile and improving the gills and kidney microstructure were consequences of feeding on CPH diets during alkaline stress situations. Overall, fortifying the Nile tilapia diets with 75 g CPH/kg helps the fish restore their hemostasis and metabolic status during alkaline stress exposure which enables the sustainable culture of this species in such conditions.

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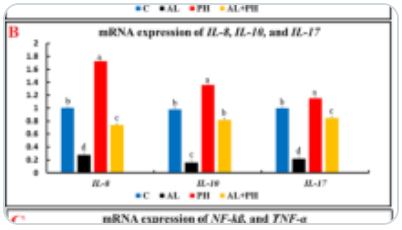

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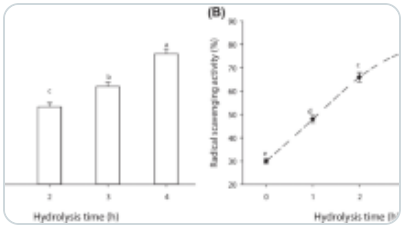

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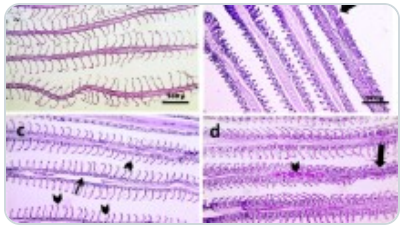

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Data availability

No datasets were generated or analysed during the current study.

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Contributions

R. E.I., A.A.A., E.M.Y., A.A.M., T. K., A.O., M. M. M. M., S.J. D., and Y.M. A: conceptualization, data curation, formal analysis, investigation, methodology, resources, validation, visualization, and writing review and editing. REI: Writing original draft. All authors read, reviewed, and approved the final manuscript.

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Ethics declarations

Ethics approval

The Institutional Animal Care and Use Committee of Zagazig University, Egypt, approved the experimental protocol (ZU-IACUC/2/F/393/2023), and all applicable institutional standards were followed when caring for and using animals in this study.

Consent to participate

All authors have participated in this work.

Consent for publication

All authors review and approve the manuscript for publication.

Conflict of interest

The authors declare no competing interests.

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