BUILDING STRESS RESILIENCE IN INTENSIVE AQUACULTURE THROUGH PRECISION NUTRITION: PATHWAY INTEGRATION, TRANSLATIONAL SCREENING, AND TARGETED NUTRIENT DELIVERY

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Introduction

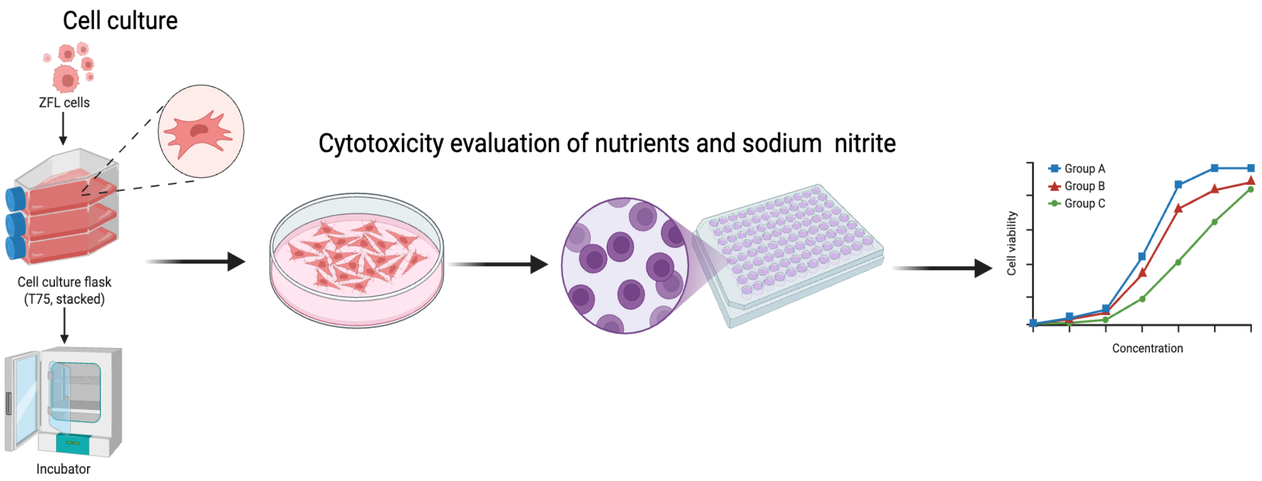
- Nitrite is a common waterborne toxicant in intensive aquaculture, disrupting redox balance, inducing inflammation and impairing liver function in fish.
- Nutritional strategies are increasingly used to enhance fish robustness against stress-related damage.
- Candidate nutrients were selected as based on their reported antioxidant, anti-inflammatory, immunomodulatory or hepatoprotective properties.
- ZFL cell model offers a useful in vitro platform for rapidly comparing these nutrients and identifying the most promising candidate for mitigating environmental stress-related damage before in vivo validation.

Objective

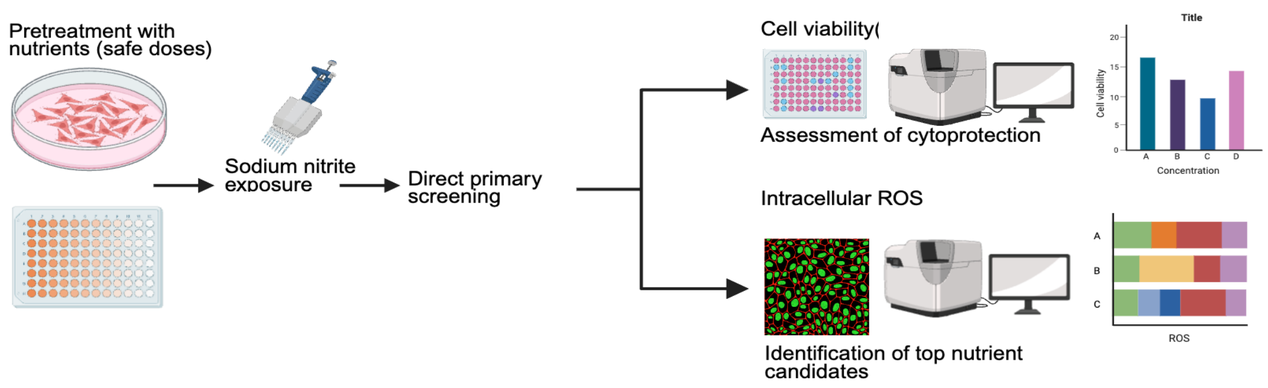
- To establish a sodium nitrite-induced stress model in ZFL cells to mimic nitrite-associated cellular damage relevant to aquaculture conditions.
- To compare candidate nutrients for their protective effects against nitrite-induced cellular damage.
- To identify the most effective nutrient for further validation as a nitrite stress-mitigating strategy in aquaculture.

Method

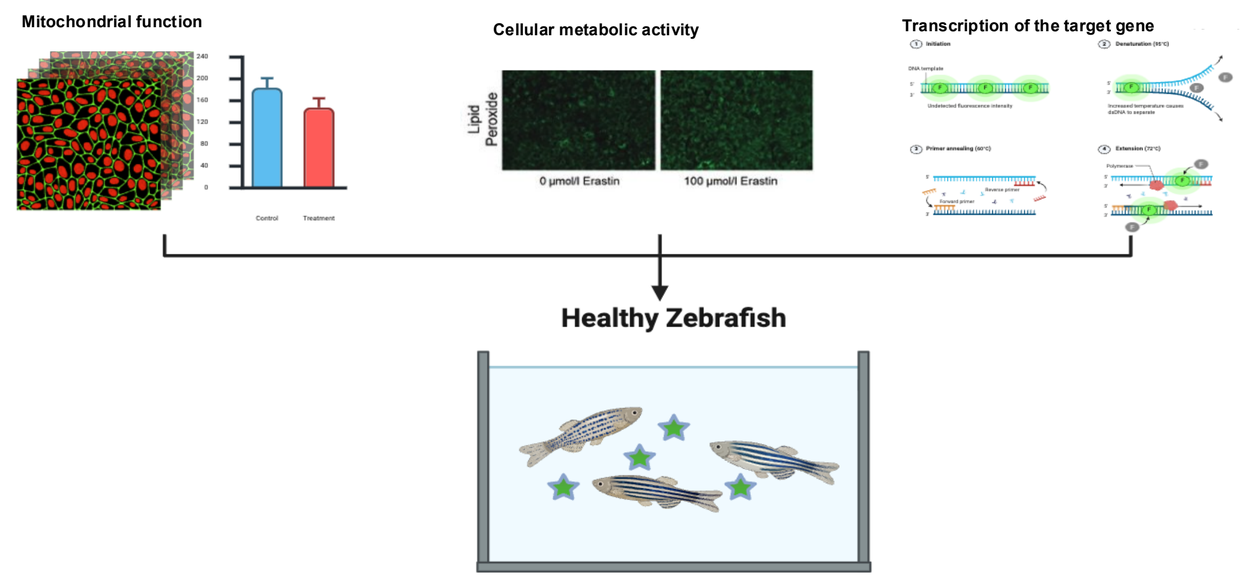
1. Preliminary experiment



2. Pre-screening and protection assessment



3. Further validation of shortlisted nutrient

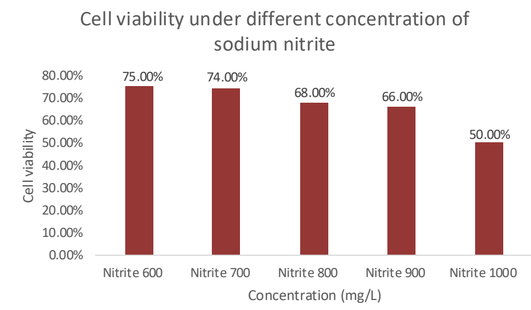


- ZFL cells were used to establish an in vitro sodium nitrite stress model.
- Nutrients were screened to identify non-toxic working concentrations.
- Cells were pretreated with each nutrient before sodium nitrite exposure.
- Cell viability and ROS were used as primary screening indicators.
- Top candidate(s) were further validated the mitochondrial function, cellular metabolic activity, and transcription level of the target gene.

Results and Discussion

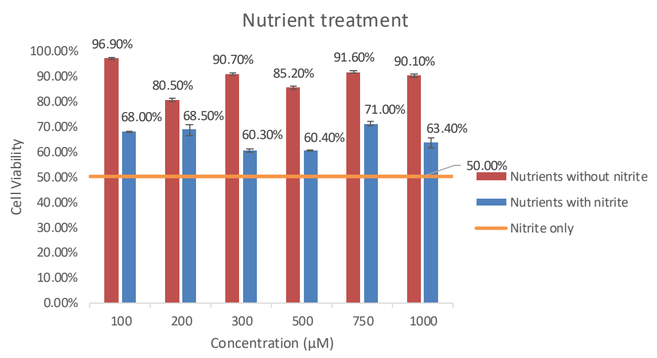
1. Cell viability of sodium nitrite and nutrients

1.1 LC50 of sodium nitrite



— Nitrite reduced ZFL cell viability in a dose-dependent manner, and 1000 mg/L was considered an appropriate challenge range for subsequent nutrient screening.

1.2 Validation



— The nutraceutical partially restored ZFL cell viability under nitrite challenge in a concentration-dependent manner. The strongest protective effect was observed at 750 μM, where cell viability increased to 71.0%, suggesting that this concentration may be optimal for further validation.

Conclusion

- **A ZFL cell-based in vitro platform was established for rapid screening of candidate nutrients against sodium nitrite-induced stress.**
- **Cell viability was successfully used as a primary indicator to compare the protective effects of six nutrients.**
- **This study provides a practical preliminary strategy for identifying promising nutritional interventions to mitigate nitrite-related stress in aquaculture.**

Reference:

[1] CRC Crit. Rev. Environ. Control 1981, 11, 2, 163–188.

[2] Rev. Aquac. 2020, 12, 4, 2268–2283.

[3] Fish Shellfish Immunol. 2019, 89, 83–90.