COMPARATIVE FUNCTIONAL CHARACTERIZATION OF TWO SUPEROXIDE DISMUTASES (*SjSOD1* AND *SjSOD2*) IN *Scomber japonicus*

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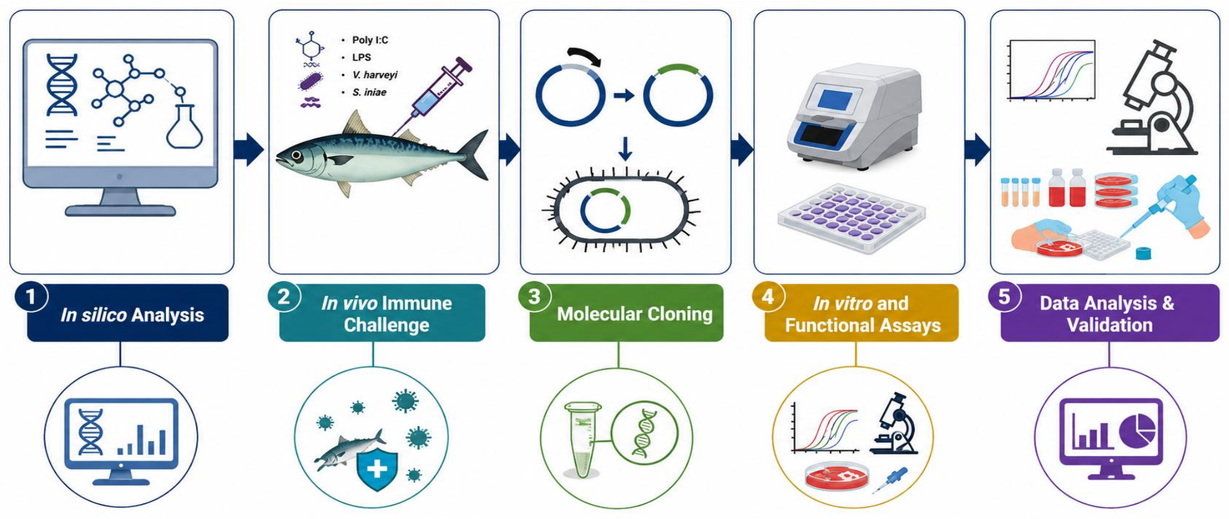
Abstract

Superoxide dismutases (SODs) are essential antioxidant metalloenzymes involved in oxidative stress regulation and immune defense. In this study, *SjSOD1* and *SjSOD2* from *Scomber japonicus* were molecularly characterized and functionally analyzed. Both genes were constitutively expressed in multiple tissues and significantly upregulated following immune stimulation. Functional assays demonstrated enhanced cell proliferation, anti-inflammatory responses, and improved tolerance against heavy metal-induced oxidative stress. Comparative analyses revealed stronger cytoprotective effects in SjSOD2, highlighting the importance of mitochondrial antioxidant defense in stress adaptation.

Key Objectives

This study aimed to molecularly characterize *SOD1* and *SOD2* from *Scomber japonicus* and evaluate their functional roles in antioxidant defense and immune regulation. Tissue-specific expression, immune-responsive expression patterns, effects on cell proliferation and inflammation, and protective roles against oxidative stress were comparatively analyzed to identify the functional differences between the two SOD isoforms.

Methodology



Results

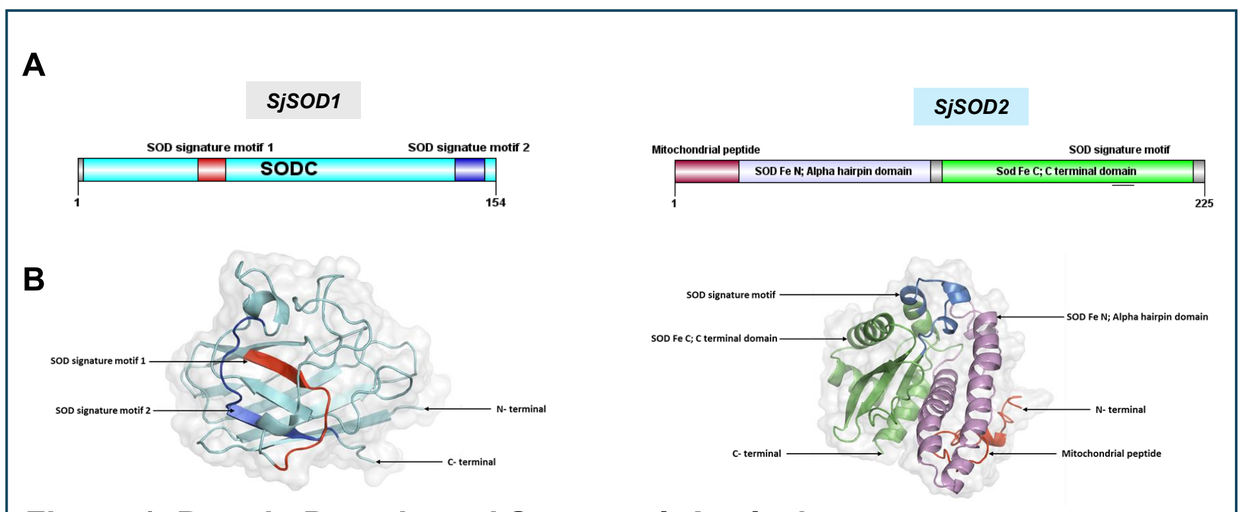


Figure 1. Protein Domain and Structural Analysis

(A)Conserved SOD superfamily domains in *SjSOD1* and *SjSOD2*.

(B) 3-D structure of SjSOD1 and SjSOD2 protein.

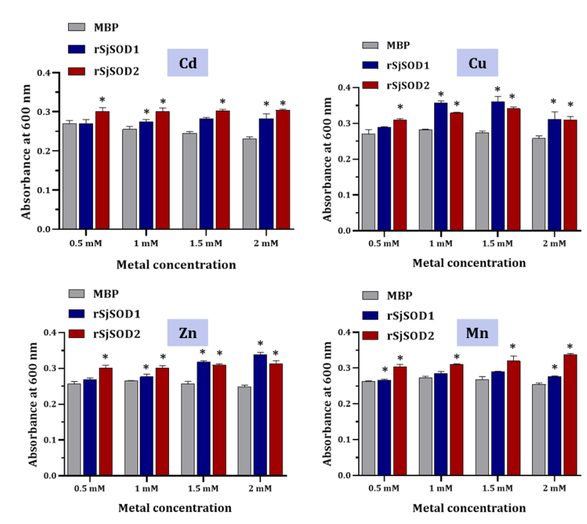


Figure 3. Cyto-protective effects of recombinant SjSOD1 and SjSOD2 against heavy metal-induced oxidative stress..

Both isoforms effectively attenuated metal-induced toxicity, with rSjSOD2 generally providing superior cyto-protection suggesting its critical role in mitigating environmental oxidative stress.

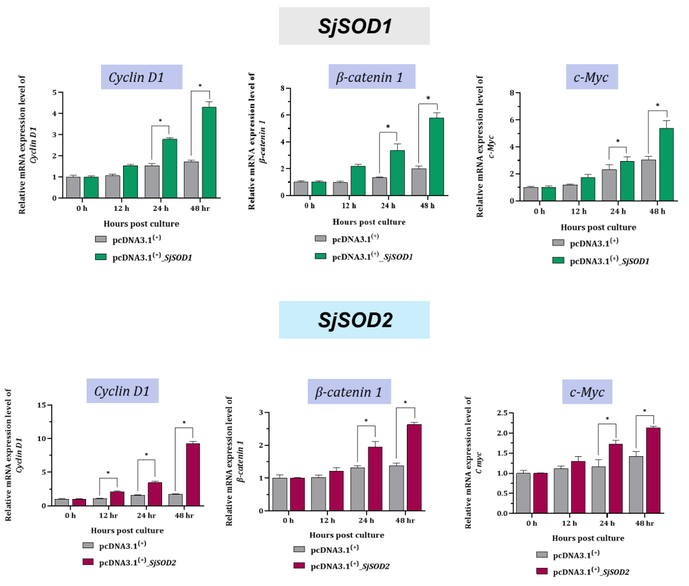


Figure 4. Effects of *SjSOD1* and *SjSOD2* overexpression on cell proliferation and migration in FHM cells.

Both genes exhibited significant up-regulation of cell proliferation- related genes suggesting it's contribution on cell growth and migration.

Figure 2. Spatial and Temporal expression analysis of *SjSOD1 and SjSOD2*

(A) The tissue distribution analysis reveals the highest expression of *Both SjSOD genes* in heart, followed by the brain and muscles. Different letters (e.g., a, b, c) indicate significant differences ($p<0.05$) based on Tukey's HSD test following ANOVA.

(B) The expression of both *SjSODs* were analyzed following immune challenges with LPS, Poly I:C, *V. harveyi* and *S. iniae*. Both genes were significantly ($p<0.05$) up-regulated upon immune stimulants. *SjSOD2* shows rapid and strong upregulation suggesting the critical role of mitochondria upon immune activation.

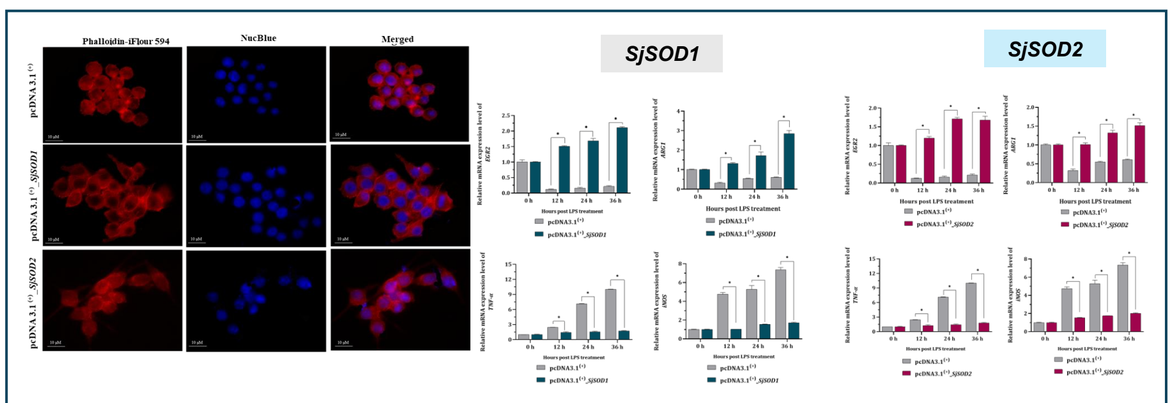


Figure 5. Effects of *SjSOD1* and *SjSOD2* overexpression on macrophage polarization and inflammatory response in RAW 264.7 murine macrophage cells.

This assay further demonstrate that both genes significantly modulate anti-inflammatory signaling (M2 morphology) by suppressing pro-inflammatory markers while up-regulating anti-inflammatory genes.

Conclusion

This study demonstrates that *SjSOD1* and *SjSOD2* are vital components of the *Scomber japonicus* antioxidant system, playing multifaceted roles in cellular homeostasis, immune regulation, and stress adaptation. Ultimately, these results provide valuable insights into the roles of *SjSOD1* and *SjSOD2* in fish health and immunity, contributing to a broader understanding of the immune-related regulatory mechanisms crucial for maintaining teleost health. Further, these findings highlight the specialized importance of mitochondrial antioxidant defense in managing environmental and inflammatory stressors in marine species.

References

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