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Physiological perspectives on the biological effects of the toxic substance that kills fish in the ocean

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ABSTRACT

A unicellular microalga known as heterosigma akashiwo has the potential to kill large numbers of both wild and farmed fish globally, causing significant economic losses. Environmental factors including salt, light, and temperature had a big impact on how *H. akashiwo* bloomed and how deadly it was. While one-factor-at-a-time (OFAT) approaches, which only alter one variable at a time while holding others constant, were used in earlier studies, a design of experiment (DOE) approach, which is more precise and efficient, was used in the current study to examine the simultaneous effect of three factors and their interactions. To examine the impact of salinity, light intensity, and temperature on the toxicity, lipid production, and protein production of *H. akashiwo*, the study used a central composite design (CCD). In contrast to standard approaches that use the entire organism, a yeast cell assay was created to evaluate toxicity and provides quick and convenient cytotoxicity evaluations using a lesser number of samples. According to the results, *H. akashiwo* is most hazardous at 25 °C, 17.5 % salinity, and 250 mol photons per square metre per second of light. At 25 °C, a salinity of 30, and a light intensity of 250 mol photons m2 s1, the highest concentrations of lipid and protein were discovered. Warm water mixing with river input that is lower in salinity hence has the potential to improve H. akashiwo toxicity, which is consistent with environmental studies linking warm summers to situations with heavy runoff that pose the biggest threat to aquaculture enterprises.

Keywords: Heterosigma akashiwo; Toxicity; Saccharomyces cerevisiae; Salinity; Light

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INTRODUCTION

Over the past few decades, dangerous algal blooms caused by the golden-brown unicellular ichthyotoxic raphidophyte Heterosigma akashiwo have been often seen in coastal waters all over the world [1]. In several regions of the world, including North America (including Canada and the United States), intermittent *H. akashiwo* blooms are to blame for the demise of wild and cultivated fish. This species causes an annual loss of resources of several million dollars [2]. *H. akashiwo* blooms in British Columbia, Canada; alone cost the fisheries stock more than $20 million during a four-month span in 1997 [3].

It is unclear what toxin or mechanism causes *H. akashiwo* and other ichthyotoxic raphidophytes to harm fish. Four potential mechanisms have been proposed thus far as the causes of the fish deaths: (1) *H. akashiwo*'s mucous secretion causes fish to suffocate by covering their gills (2) the production of compounds that act like brevetoxin neurotoxins and damage fish gills (3) the production of reactive oxygen species (ROS) like superoxide, hydrogen peroxide, and hydroxyl radicals that affect fish gills, and (4) the production of substances that cause hemolysis and hemagglutination, which lyses blood cells [4].

Toxicity measurement

Since no single measurable criterion has been agreed upon by the research community, determining the amount of toxicity in *H. akashiwo* is a challenging process [5]. The general consensus is that blooms of *H. akashiwo*, when they come into contact with fish in cages or embayments, will rapidly and efficiently kill the fish, leaving floating carcasses. Fish that have died are found to have skin sores, mucous on the surface of their gills, and signs of asphyxiation, according to necropsies [6]. They are present in both. The most prevalent phytoplankton, *H. akashiwo*, would amass at these sites after the incident and might not even be the cause [7].

DISCUSSION

The findings show two things: first, yeast cells can be used as a suitable proxy to assess the toxicity of *H. akashiwo*, providing advantages like a quicker measurement process, a smaller measurement area, and the use of fewer resources [8, 9]. Secondly, the design of experiment (DOE) approach could forecast a better comprehension of the interaction between various stressor factors on *H. akashiwo* under realistic environmental conditions. As a result, we will be able to forecast how different environmental factors will

affect the occurrence and level of toxicity of *H. akashiwo*, which is important for the environment, aquaculture facilities, and general public health [10].

CONCLUSION

H. akashiwo's toxicity is dependent on the growth conditions rather than being inherent. Maximum cellular toxicity is caused by scientific combinations of many environmental elements, such as salinity, temperature, and light under ideal circumstances. The results demonstrated that the DOE technique may be utilised as a suitable tool to assess the impact of different conditions, such as temperature, salinity, and light, on the toxicity of *H. akashiwo*. At 25 °C, a salinity of 17.5, and a light intensity of 250 mol photons m2 s1, which represent the warm water mixing with lower salinity river input, *H. akashiwo* reaches its greatest level of toxicity. These results are in agreement with environmental studies that the circumstances that worry aquaculture operations the most are hot summers and heavy runoff. The yeast bioassay was a highly sensitive indicator of the toxicity of *H. akashiwo*, according to the results of the study. This procedure is practical and economical due to the tiny sample volume needed and the speed at which the test may be completed. Additionally, numerous samples that are simple to prepare can be evaluated concurrently. It was shown that the *H. akashiwo* toxin is contained inside the cellular compartment of cells and that centrifuging cells to break them up and sonicating the resuspended pellets released more toxin, increasing the level of yeast cell mortality.

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