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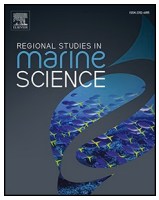

Physio-biochemical and metabolomic analyses of the agarophyte *Gracilaria salicornia* indicates its tolerance to elevated pCO_2 levels

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ABSTRACT

Gracilaria salicornia is an agar-producing red macroalga commonly found growing in the intertidal and upper subtidal on various substrates with distribution across the Indo-Pacific. The ability of *G. salicornia* to survive under harsh conditions suggests potential use as a candidate for sustainable farming and alternative source of livelihood for the local coastal communities under future climate conditions. An earlier study investigated the effects of future predicted pCO_2 level on the photosynthesis and respiration of *G. salicornia* but studies on the metabolomic responses of this alga to constant elevated pCO_2 level is lacking. Here, elevated pCO_2 level was simulated on *G. salicornia* for 14 days to compare its growth, photosynthetic efficiency, pigment content, agar properties and metabolite composition under current pCO_2 level (~pH 8.1) and end-of-century future-predicted (~pH 7.8) pCO_2 level. The observed biomass growth, coupled with unaffected photosynthetic parameters and agar-related properties underscore *G. salicornia*'s ability to adapt to higher pCO_2 levels. The modulation of metabolites showcases the alga's adaptive strategies at elevated pCO_2 whereby stress-mediating compounds such as gallic acid and oxalic acid were increased while stress-indicating metabolites such as serine, glycine, and ascorbic acid did not show significant changes. Interestingly, the metabolome profile imply that the alga regulates its metabolism according to culture duration rather than the pCO_2 level.

1. Introduction

Fishery-based livelihoods for millions of coastal communities around the world are vulnerable to adverse climate change impacts (Salik et al., 2015; Payne et al., 2021; Huynh et al., 2021). The decline in fish landings is generally attributed to pollution, overfishing, coastal development, habitat degradation and unapproved methods of fishing, compounded by an additional stressor viz. climate change which is expected to continue. Yet, adaptive capacity or climate change preparedness for these communities living in the rural areas, especially in the developing countries is limited (Salik et al., 2015; Hobday et al., 2016). Nonetheless, climate change presents opportunities for some species, and seaweed has been proposed as a candidate for sustainable livelihood of the coastal communities (Rebours et al., 2014; Sultana et al., 2022). Diversification of coastal livelihoods can be adopted to reduce climate risk by tapping into the indigenous natural resources, specifically alternative species with a lower-climate hazard.

Gracilaria is a genus of red algae (Rhodophyta) widely cultivated in warm water regions (Ollando et al., 2019) which include China, Indonesia, Chile, Vietnam, and South Korea, primarily as the source for high yield and good quality agar (Tan et al., 2020). Statistics from FAO (Cai et al., 2021) indicate that *Gracilaria* is among the top three genera of red seaweeds cultivated worldwide, with 3,639,833 tonnes wet weight produced, generating a first-sale value of USD 2 billion in 2019 alone. Agar extracted from agarophytes, i.e., agar-containing seaweeds, is widely used as a gelling and thickening agent in the food industry, agar

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