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The diatom-derived aldehyde decadienal affects life cycle transition in the ascidian *Ciona intestinalis* through nitric oxide/ERK signalling

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1. Summary

Polyunsaturated aldehydes (PUAs) are fatty-acid-derived metabolites produced by some microalgae, including different diatom species. PUAs are mainly produced as a wound-activated defence mechanism against microalgal predators or released from senescent cells at the end of a bloom. PUAs, including 2,4-*trans*-decadienal (DD), induce deleterious effects on embryonic and larval development of several planktonic and benthic organisms. Here, we report on the effects of DD on larval development and metamorphosis of the ascidian *Ciona intestinalis*. *Ciona* larval development is regulated by the cross-talking of different molecular events, including nitric oxide (NO) production, ERK activation and caspase 3-dependent apoptosis. We report that treatment with DD at the competence larval stage results in a delay in metamorphosis. DD affects redox balance by reducing total glutathione and NO levels. By biochemical and quantitative gene expression analysis, we identify the NO-signalling network affected by DD, including the upregulation of ERK phosphatase *mkp1* and consequent reduction of ERK phosphorylation, with final changes in the expression of downstream ERK target genes. Overall, these results give new insights into the molecular pathways induced in marine organisms after exposure to PUAs during larval development, demonstrating that this aldehyde affects key checkpoints of larval transition from the vegetative to the reproductive life stage.

2. Introduction

Diatoms are photosynthetic unicellular microalgae contributing up to 45% of total oceanic primary production and playing key roles in the transfer of energy through marine food chains [1]. The reason for their ecological success still remains a matter of discussion, and different mechanisms have been proposed to explain their widespread occurrence in the oceans. One main reason may be because they have evolved a chemical defence system which can potentially affect both predators and competitors. Indeed, different diatom species are able to produce a wide range of secondary metabolites belonging to the oxylipin family including polyunsaturated aldehydes (PUAs) with toxic effects on reproductive processes in grazing organisms such as crustacean copepods [2–4], echinoderms [5,6] and filter-feeding organisms such as ascidians [7]. These metabolites are the end-products of a lipoxygenase/hydroperoxide lyase metabolic pathway, initiated by damage of algal cells as would occur through grazing [8]. Briefly, cell damage activates lipase enzymes, causing the release of polyunsaturated fatty acids from cell membranes, which are then immediately oxidized and cleaved to form PUAs, including 2,4-*trans*-decadienal (DD). This aldehyde, in particular, is produced by some diatoms (e.g. *Thalassiosira rotula*,

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