Biosynthesis of Polyunsaturated Fatty Acids in Marine Animals

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Abstract

Omega-3 (ω3 or n–3) long-chain polyunsaturated fatty acids (PUFA) including eicosapentaenoic acid (EPA, 20:5n–3) and docosahexaenoic acid (DHA, 22:6n–3) are important components for multiple physiological and biochemical processes in vertebrates. These fatty acids have traditionally been believed to be almost entirely originated from marine microbes such as microalgae, heterotrophic protists and fungi, as their endogenous capacity to synthesise C_{18} PUFA, namely linolenic acid (LA, 18:2n–6) and α-linolenic acid (ALA, 18:3n–3) from monounsaturated fatty acids (MUFA) such as oleic acid (OA, 18:1n–9). These important biosynthetic processes are catalysed by a key enzyme named ωx (or methyl-end) desaturases, which have almost exclusively been described in abovementioned microbes in the marine ecosystem. Only a few animal (e.g. nematodes) have known to possess ωx desaturases but their overall distribution within the animal kingdom has not been precisely investigated. In our studies, we conducted comprehensive retrieval of ωx desaturase gene orthologues from public nucleotide databases using several bioinformatic techniques. As a result, a plethora of invertebrates within Cnidaria, Rotifera, Mollusca, Annelida and Arthropoda were identified as their possession of ωx desaturases. The phylogenetic analysis showed potential involvement of horizontal gene transfer (HGT) event for the evolution of animal ωx desaturases. Functional characterisation using yeast heterologous expression system revealed that animal ωx desaturases demonstrated that the biosynthetic capability of LA from OA and ALA from LA. Furthermore, several animal ωx desaturases showed activity to biosynthesise a series of n–3 long-chain PUFA from their n–6 counterparts, including biosynthesis of physiologically important EPA from arachidonic acid (ARA, 20:4n–6). Given their global distribution and abundance in the marine ecosystem, these findings challenge the widely accepted dogma established on the n–3 long-chain PUFA production in the marine ecosystems. In addition, the invertebrates with ωx desaturases have the potential to be used for live prey as well as feed ingredients for the aquaculture production as a source of n–3 long-chain PUFA, essential nutrients for most of commercially important marine fish.

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