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Review

# Bivalves as future source of sustainable natural omega-3 polyunsaturated fatty acids

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## Highlights

- Bivalve lipids are high quality lipid sources.
- Expansion of bivalve farming worldwide can fulfil the omega-3 LC-PUFA demands.
- Selective breeding of bivalves can enhance the lipid quality and production.

## Abstract

The increasing global population poses a huge challenge to food security, especially in terms of providing adequate sustainable and affordable high quality lipids. This article reviews the sources of natural omega-3 LC-PUFA and identifies the future direction for producing high

quality lipids to meet growing market demands. Generally, bivalve lipids are high quality source of lipids that are beneficial to human health, regardless of species and habitat. There is also reason to believe that the development of bivalve farming worldwide, selective breeding of bivalves to increase the accumulation of omega-3 LC-PUFA and practising efficient usage of bivalve lipids can meeting some, if not all, of the growing demand for omega-3 LC-PUFA. Such information will aid to establish a promising source of high quality natural omega-3 LC-PUFA and ensure that all consumers have access to sufficient omega-3 LC-PUFA at an affordable price to support a healthier and balanced diet.

## Introduction

Our ancestors consumed omega-3/omega-6 long chain polyunsaturated fatty acids (LC-PUFA) at a ratio of roughly 1.00 (Tocher, 2015). It also indicates that ancient and modern hunter-gatherers are at much lower risk of modern inflammatory diseases, including heart disease, cancer and diabetes, which are the leading causes of death and morbidity today (Bhardwaj, Verma, Trivedi, Bhardwaj, & Shukla, 2016). During the evolution of humans, the composition of lipids and the proportion of omega-6 and omega-3 LC-PUFA in the diet changed significantly. Consumption of high saturated fats and linoleic acid (LA, omega-6 LC-PUFA) from meats and vegetable oils, respectively reduced overall omega-3 LC-PUFA intake relative to omega-6 LC-PUFA (Simopoulos, 1994). Over the past 150years, increased intake of omega-6 LC-PUFA has been associated with an increased in heart disease, which has contributed to the development of a healthy diet concept that balances omega-3 to omega-6 LC-PUFA (Simopoulos, 2008). To date, multiple lines of scientific evidences have confirmed the beneficial effects of dietary omega-3 LC-PUFA (eicosapentaenoic acid (20:5n-3, EPA) and docosahexaenoic acid (22:6n-3, DHA)) on human health (Calder, 2018, Gil et al., 2012, Poudyal et al., 2011).

Traditionally, the wild capture fishery is the main source of omega-3 LC-PUFA in human diet. Despite this, the capacity of wild capture fisheries is insuficient to meet the growing demand for seafood (Food and Agriculture Organisation (FAO). 2016, 2016). Due to the unprecedented increase in demand, the supply of fish in wild capture fisheries has declined, which has attracted interest in fish aquaculture. Traditionally, omega-3 LC-PUFA rich pellets made from fishmeal and fish oil have been used in fish aquaculture. However, as the demand for aquaculture products increases, these unsustainable marine ingredients have been replaced by sustainable alternatives of terrestrial sources (low in omega-3 LC-PUFA). As a result, the lipid quality of the aquaculture products was partially impaired and the level of omega-3 LC-PUFA was lowered, thereby reducing the ratio of omega-3/ omega-6.

As consumers prefer natural products rather than synthetic products, the market demand for natural omega-3 LC-PUFA is increasing, so there is an urgent need to find alternative sources of natural omega-3 LC-PUFA. In this context, the present review summarizes potential alternative sources of natural omega-3 LC-PUFA and proposes future direction of natural omega-3 LC-PUFA industry based on available scientific evidence. Such information will aid to establish a promising source of natural omega-3 fatty acids and ensure that all consumers have access to sufficient EPA and DHA at an affordable price to support a healthier and balanced diet. To the best of our knowledge, this article is the first comprehensive review of the future production of natural omega-3 LC-PUFA, which is economically relevant, sustainable and environmental friendly.



## Section snippets

### Current natural sources of Omega-3 LC-PUFA and its constrains

Omega-3 LC-PUFA cannot be sufficiently biosynthesized by humans and must therefore be acquired from the diet, with marine fish being a source of virtually all the human dietary EPA and DHA sources. Over the past 50years, the world's population and the total fish supply for food consumption have grown at a rate of 1·6% per year and 3·2% per year, respectively. Therefore, it is expected that fish in capture fisheries are in perilous decline due to overfishing (Williams & Burdge, 2006). According …

### Alternative sources of natural Omega-3 LC-PUFA

Since the omega-3 LC-PUFA is mainly from the marine environment, it seems logical to start looking for alternative sources there. Few synthetic omega-3 LC-PUFA products (Tocher, Betancor, Sprague, Olsen, & Napier, 2019) and transgenic yeast, Yarrowia lipolytica, have been used for commercial scale production of omega-3 LC-PUFA (Xie, Jackson, & Zhu, 2015). However, consumers tend to prefer natural omega-3 products over synthetic and genetically modified organisms (GMOs), thus these options are …

## LC-PUFA content in bivalves

Marine bivalves are rich in omega-3 LC-PUFA, and their diet mainly contains marine phytoplankton, which is the primary producer of omega-3 LC-PUFA (Pirini et al., 2007). In addition to phytoplankton, bivalves can also obtain lipids from other high omega-3 LC-PUFA food sources such as debris, bacteria, micro- and mesozooplankton (Tan & Ransangan, 2016d). However, the lipid and fatty acid composition of marine bivalves is affected by the taxonomic relationship (species and nutrient habits) and …

## Biosynthesis of Omega-3 LC-PUFA in marine bivalves

It is worth noting that marine bivalves are not only rich in LC-PUFA, but also capable of biosynthesized omega-3 LC-PUFA endogenously (Liu et al., 2014, Liu et al., 2014, Liu et al., 2013, Ran et al., 2018). The biosynthesis of omega-3 LC-PUFA in marine bivalves involves a series of aerobic elongation and desaturation reactions. Genes involved in omega-3 LC-PUFA biosynthesis have been identified and characterized in several marine bivalve species, including the noble scallop *C. nobilis* (Liu et …

## Efficient usage of bivalve Omega-3 LC-PUFA

Consumers should increase the efficiency of the bivalve omega-3 LC-PUFA usage by practicing the proper omega-3 LC-PUFA intake habits and cooking methods. The omega-3 LC-PUFA intake habits (consumption of low dose omega-3 LC-PUFA daily or high dose omega-3 LC-PUFA once or twice per week) can affect the bioavailability of omega-3 LC-PUFA. Early human nutrition studies compared daily constant doses of omega-3 LC-PUFA with twice weekly omega-3 LC-PUFA dose and found no difference in omega-3 LC-PUFA …

## Discussion

In the ocean, omega-3 LC-PUFA is biosynthesized by microorganisms and phytoplankton. Some marine fish, including sardines and salmons, can accumulate large amounts of omega-3 LC-PUFA by consuming microalgae cells in the ocean. Due to overfishing, the availability and sustainability of omega-3 LC-PUFA in wild capture fisheries has been questioned. In order to address this issue, several potential natural omega-3 LC-PUFA alternative sources have been identified, but due to the high cost, the lack …

## Conclusion

In conclusion, the literature provides compelling evidence that consumption of omega-3 LC-PUFA is beneficial to health. Regarding excellent chemical composition, omega-3/omega-6 ratio and PUFA/SFA ratio, most bivalves are good sources of high quality lipids, which are beneficial to human health, regardless of species and habitat. We have reason to believe that the expansion of bivalve farming worldwide and the use of selective breeding methods to enhance the beneficial traits of higher omega-3 …

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

## Acknowledgement

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## Statement of each author's contributions

Karsoon Tan wrote the manuscript; Hongyu Ma, Shengkang Li, and Huaiping Zheng editing for English grammar. …

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## References (106)

T. Alkanani *et al.*

Role of fatty acids in cultured mussels, Mytilus edulis, grown in Notre Dame Bay, Newfoundland

Journal of Experimental Marine Biology and Ecology (2007)

K.K. Asha *et al.*

Biochemical profile of oyster *Crassostrea madrasensis* and its nutritional attributes
Egyptian Journal of Aquatic Research (2014)

I.M. Berquin *et al.*
Multi-targeted therapy of cancer by omega-3 fatty acids
Cancer Letters (2008)

L.M. Browning *et al.*
Compared with daily, weekly *n*-3 PUFA intake affects the incorporation of eicosapentaenoic acid and docosahexaenoic acid into platelets and mononuclear cells in humans
The Journal of Nutrition (2014)

M. Caers *et al.*
The Chilean scallop *Argopecten purpuratus* (Lamarck, 1819): II. Manipulation of the fatty acid composition and lipid content of the eggs via lipid supplementation of the broodstock diet
Comparative Biochemistry and Physiology (1999)

L. Deutsch *et al.*
Feeding aquaculture growth through globalization: Exploitation of marine ecosystems for fishmeal
Global Environmental Change (2007)

S. Dridi *et al.*
Seasonal variation in weight and biochemical composition of the Pacific oyster, *Crassostrea gigas* in relation to the gametogenic cycle and environmental conditions of the Bizert lagoon, Tunisia
Aquaculture (2007)

M.T. García-Arias *et al.*
Cooking-freezing-reheating (CFR) of sardine (*Sardina pilchardus*) fillets. Effect of different cooking and reheating procedures on the proximate and fatty acid compositions
Food Chemistry (2003)

S. Ghasemifard *et al.*
Review: Omega-3 long chain fatty acid “bioavailability”: A review of evidence and methodological considerations

Progress in Lipid Research (2014)

Y. Gong *et al.*

Digestibility of the defatted microalgae *Nannochloropsis* sp. and *Desmodesmus* sp. when fed to Atlantic salmon, *Salmo salar*

Aquaculture Nutrition (2017)

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>
> …Table 3 summarizes the fatty acid content of some diet microalgae for bivalve culture. Total composition of microalgae bait is not directly related to its nutritional value, but some ingredients such as PUFAs and sterols are crucial nutrients for the growth of bivalve mollusks [73,76]. It has been reported that PUFAs, especially n-3 fatty acids (such as DHA and EPA) play an important role in the nutrition of bivalve [52,71]….

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