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Significance of Microalgae Biotechnology: Production of Omega-3 Microbial Oils from Marine Thraustochytrids

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Thraustochytrids are multicellular fungal-like aquatic protists that originate all over the ocean. They're renowned for producing higher-value omega-3 polyunsaturated dietary fats (-3-PUFAs), such as docosahexaenoic acids (DHA), along with hydrolytic enzymes. Omega-3 dietary fats with a long chain Human, and also marine fish species, require Eicosapentaenoic Acid (EPA) and DHA to survive. Fish oil is direct current. For the production of microbial oils from marine habitats, a new and sustainable usage of EPA and DHA is required. Thraustochytrids are single-celled eukaryotic microbes that may accumulate larger quantities of lipids. Omega-3-rich oils have industrial and commercial importance, owing to their advantages to human health and the environment. Fish is the major source of omega-3 dietary fats. The renaissance of attention in omega-3 as practical foods in this developing industry has increased the need for alternate sources of omega-3. These lipids are necessary for brain and retinal functional development as well as the prevention of cardiovascular and Alzheimer's illnesses. The worldwide demand for omega-3 productions, chiefly DHA, has increased significantly in the recent decade as a result of the rising usage of these lipids as a significant component of infants nourishing methods and supplementation. The polyunsaturated dietary fats produced from oleaginous microalgae have aids over the others PUFA supplies including such fish's oils, which are odourless and not reliant on fish's supplies. The generation of omega-3 oils from marine habitats is discussed in this study, which has several advantages.

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1. INTRODUCTION

Carbohydrates, proteins, colours, and lipids are among the many important substances found in microalgae. They are now regarded as prospective contributions to the expansion of the world's bio-economy because of their ability to create vendible, higher value-adding commodities from lower values goods as fuel. Furthermore, microalgae may develop on lower-cost substrates like commercial by-products or effluents, leading in the removal of pollutants while simultaneously developing economically valuable bio-compounds. The non-seasonality, lack of climatic dependency, and lack of requirement for agricultural production for setting up and maintaining microalgae bioreactors are all key advantages of this substrate. Omega-3 fatty acid consumption has become more popular across the world [1]. Flaxseed oil, for example, has more than 39.90 percent α-linolenic acid (ALA found in plant oils) that has been used to treat dermatitis, muscular contusions, and atherosclerosis in certain medicinal formulations. As a result, one of the most important properties of ALA is that it serves omega-3 long chains. Unlike marine sources, terrestrial plants lack n3 LC. [2].

All people and marine fish species require the n3, longer chains polyunsaturated dietary fats PUFA, DHA and EPA. Currently, fish oils are the major source of dietary fats [3].The omega-3 fatty acids in algal oil relief to reduce the threat of cardiovascular disease. EPA and DHA help lower blood pressure and triglycerides as well as improve blood vessels work.

Since fish oil production can indeed be expanded any further, microbial alternatives are projected to play a significant role in delivering these essential n3 fatty acids to growing marine aquaculture and the population increase. Thraustochytrids are unique in that they should store DHA in triacylglycerides found in fat precipitations, and Aurantiochytrium and Schizochytrium, in especially, are good DHA providers [4]. Comparable to the procedures for other oleaginous bacteria, lipids accumulations are started after important nutrients, such as nitrogen, inhibits cellular development.

The creation of dietary supplements has been the topic of intense new analysis - a reflection of the desire for a better living – due to consumer demand for nutraceutical supplements. Omega-3 oil is particularly significant amongst many food/supplements, as indicated by medical organizations' recommendations, that could give fitness advantages [5]. The global omega 3 market was worth USD 2.10 billion in 2020, and it is anticipated to grow at an annual rate rate of growth (CAGR) of 7.8 percent between 2020 and 2028. Increasing occurrences of Cardiovascular Diseases (CVDs) and shifting dietary habits are key factors that drive increased product consumption.This equates to 1.3 thousand tonnes of metric tonnage consumed annually by humans. There is a shortfall in omega-3 oil production as a result of rising omega-3 oil intake, while fish remains the primary source. The lack of fish oil supplements is due to a scarcity of pelagic fish and a mismatch between the creation and use of nutraceuticals oil. Omega-3 and omega-9 saturated fats are found in algae oil. The *oil* can be extracted from *algae* using a mechanical press. These fatty acids have the ability to reduce inflammation (swelling), increase the levels of certain fats in the blood, and improve brain function. Increased usage of omega-3 in developing economies has exacerbated this discrepancy [6]. As a result, it's critical to seek out alternate sources of functioning lipids, lowering reliance on fish as a raw material, which can't keep up with demand for current flow or anticipated need.

Low-cost substrates in the medium of operation, such as industrial/domestic effluents, by-products, and residue, are one approach to reduce costs. A further method, founded on the bio-refinery idea and adapted to microalgae-based bioprocesses, makes use of such a microalgae's different products to maximize the value collected from the whole process, with both the objective of getting a targeted value 0. The efficiency of the entire process may be considerably improved in this way since high added value bio-compounds such as PUFAs, carotenoid, protein, and other bio-compounds can contribute to the long-term viability of microbiological ethanol production [7]. Barrier fluidity, metabolic processes, transporters, and eicosanoids are all affected by PUFAs. PUFA are important components of the human nourishment and are thought to have a lot of health benefits. The medical, nutraceuticals, cosmetics, culinary, and feed sectors have all expressed interest in the beneficial properties of some-3 PUFAs [8].

Dietary fats, chiefly C16:0 and C14:0, are formed by dietary fats synthases (FAS) enzyme complex in Thraustochytrids, whereas DHA's and docosapentaenoic acids are created by PUFA synthase enzymes complexes. Thraustochytrids also include C16:1 and smaller quantities of unsaturate C18 and C20 lipids, which are most certainly produced by FAS products. Notwithstanding years of investigation, the mechanisms that control the determination of the concentration of the two metabolic enzymes, as well as the rearrangement of oxygen transport between them, remains unexplained. This understanding is done in order to increase DHA manufacturing. Preceding research suggests that culture circumstances, including such temperatures, oxygen levels, and carbon restriction, alter FAS more quickly than PUFA-synthase [9]. Low oxygen levels, for instance, raised the DHA percentage in lipids, but mostly because FAS synthesis was lowered, whereas DHA production was unaffected. Unfortunately, several of the DHA-production investigations by thraustochytrids have not included dissolved oxygen measurements, making data interpretation problematic. FAS and PUFA synthesis, the two enzymatic combinations utilized by thraustochytrids for fatty acid synthesis, utilize the identical precursors: acetyl-CoA and NADPH power reductions. Transcriptome research may reveal which chemical stages in the production of predecessors, DHA, and triacylglycerides (TAG) are transcriptionally organized. After N-depletion, gene variants in TAG construction and lipid body membrane production were significantly increased in the marginally elevated. No increase of precursor genes (NADPH, acetyl-CoA) has been reported in thraustochytrids or Y. lipolytica [10]. M. alpine, on the further side, showed a robust increase of the NADPH producing oxidative phosphorylation cycle (PPP) enzymes after lipid accumulation [11].

Autotrophic microalgae utilize co2 from the atmosphere and light as feedstock for biodiesel production, sequestering an average of 1.83 kg CO2 kg1 dry microalgae, whereas the material is a source of carbon and energies. Finding CO2 emissions during heterotrophic production is difficult, however, 0.1–4 kg CO2 kg1 dry microalgae may be estimated [12]. Autotrophic microalgae cultivations minimise greenhouse gas (GHG) emissions by consuming CO2 and producing O2, as well as enhancing the use of cultivation practices. On damaged, marginal, and non-agricultural sites, it is feasible to develop less expensive phototrophic microalgae growth methods, such as outdoor raceways, while maintaining the usage of high-value lands and agricultural productivity regions. Photoautotrophic cultures, on the other hand, have a number of drawbacks: I a nonstop and hygienic water source is necessary; (ii) deprived bright dispersion in the crop might arise, that is increased with depths, and is exacerbated when intense cultivation produces self-shading, leading in light limitations for the cells, eventually leading to low biomass output; (iii) severe infiltration, competitiveness, infection, and predation by the other organisms, making pure microalgae farms difficult to maintain; (iv) dependency on seasonal and meteorological conditions, and (v) difficulties collecting microalgae biomass owing to low biomass concentration; Photobioreactors (PBR) may be utilized to overcome these restrictions, allowing for the controlled development of microalgae cultivation practices and the maintenance of pure harvests destined for pharmaceutical manufacturing [13]. That being said, such systems frequently have drawbacks, such as a high initial infrastructure spending and ongoing maintenance; when maximum crop quantities are being used, it is difficult to sustain an effective electricity dispersion via cultural identity, which is exacerbated by the formation of biofilms on PBR surfaces, which gives rise to light restriction climates; and when large crop portions are used, it is harder to manage a high energy dispersion via culture, which is exacerbated by the manufacture of biofilms on PBR surfaces, which ultimately leads to. Furthermore, maintaining high performance in the growth of autotrophic microalgae in PBR at higher latitudes necessitates heating equipment and costly greenhouse infrastructures, raising process costs. By shifting from the equatorial to 40 degrees north, an autotrophic process yield penalty of 33% is computed.

Furthermore, omega-3-rich thraustochytrid microbial lipids have emerged as an encouraging option for bridging the n-3 LC-PUFA supply and demand imbalance. Thraustochytrids are a kind of heterotrophic algae that may grow in controlled environments and collect EPA and DHA-rich internal fats. They can be utilized in fortified snacks and drinks, dietary supplements, baby formulae, clinical nutritional and medical goods, medicines, and pet diets for both humans and animals. Even vegetarians and individuals with sensitivities to fish and crustaceans can benefit from thraustochytrides because they include antioxidant, carotenoid, astaxanthin, and saponins at the same time. DHA-rich oils from thraustochytrids are presently on the market as nutritional enhancements T. [14].

2. LIPIDS IN HUMANS NOURISHMENTS

A bioactive compound-rich diet is vital for maintaining decent well-being. Improvement in eating habits has been increasingly important in recent decades for a growing segment of the population that consumes processed foods yet requires them to be appropriate. The latest and growing demand for food products unsaturated fats has been highlighted as part of this trend. Nonetheless, a rise in omega-6 PUFA intake in Western diets was accompanied by a reduction in omega-3 PUFA, which is not healthy [15]. These chemicals must coexist in a regulated quantity in the body, according to supervisory actions and the Foods and Agricultural Association. If the intake has medicinal purposes, this ratio may change. Despite excessive trans-fat consumption, the average proportion has been very popular in recent generations, at 15/1 [16]. The growth of illnesses including cardiac and neurological diseases, but also inflammation and cancers, are linked to rises in the proportion.

Recent research has made significant progress in underrepresenting the significance of PUFAs in maintaining and increasing human health and well-being, as well as a growing interest in so-called foods. Cellular membranes, brain function, and nerve impulse transmission all require PUFAs. These lipids are particularly significant since they are not produced by the body and are involved in the transmission of ambient oxygen to the manufacture and cellular responses of blood plasma on haemoglobin. PUFAs are also utilized to make bioactive compounds characteristics, and several of these actions can help keep the heart healthy. According to certain studies, PUFA consumption boosts electronics products and memory in both newborns and adults. Alzheimer's illness, inflammatory bowel problems, and various malignancies can all benefit from PUFAs. Long-chain PUFA biosynthesis in humans is aided by dietary alpha-linolenic acid (ALA) [17]. According to the FAO/WHO, people need to consume around 6% and 11% of the overall calorie content of their diet in order to get enough PUFA.

Whenever looking at international regulatory references for DHA and DHA daily consumption, it's crucial to remember that omega-3 ingestion in certain parts of the globe is still substantially lower, if not non-existent than that of the required 500 mg/day (Fig. 1). Coastal countries such as Indonesia and certain Scandinavian countries are outliers since their diets are harmful to the marine organisms and their average consumption is equivalent to or over the necessary omega-3 threshold. As consumers' awareness of vegan desserts and regulatory agencies' guidance have boosted the adoption of these foodstuffs, will become more prevalent in people's day-to-day life.

3. HETEROTROPHIC METABOLISM: CARBON UPTAKE AND LIPID SYNTHESIS

Microorganisms take up organic matter, which is decomposed in heterotrophic metabolism in the same way bacteria do. Microalgae that are heterotrophic eat organic carbon to produce energy. The ultimate output of this route, pyruvates, is produced in the cytosols and is the consequence of the recently imported conversion of glyceraldehyde-3-phosphate to the cytoplasm. Isocitrate dehydrogenase, a TCA cycle enzyme that catalyzes oxidative decarboxylation by isocitrate, is generally AMP-dependent in oleaginous genera, under nitrogen-limiting circumstances, enabling AMP concentrations to degrade. The production of palmitic (16:0) or stearic acids essentially completes this process (18:0). Flexural strength and desaturation sequences, which comprise elongases and meet regularly, are complicated in the synthesis of long chains of fatty acid, particularly PUFAs [18]. Only fungus and microalgae take the ability to manufacture lipids with more, which makes them appealing.

In respect of fatty acid synthesis, eukaryotes oleaginous creatures' capacity to generate a substantial amount of lipids is comparable to that of non-oleaginous mammals. Under nutrient-limited but carbon-excess circumstances, meanwhile, a constant supply of acetyl-CoA and NADPH for reversed half-oxidation fatty acid synthesis is required [19]. Heterotrophic microalgae that grow in aerobic environments breathe, which happens when glucose is fully oxidized [20]. Algal media produced from carbons and nitrogen origins, for example, glucose, requires effective oxygenation of the crops in order to achieve higher biological mass productivity, as power is consumed for respiratory. To facilitate the system expensive and culturally sustainable when using heterotrophic microorganisms for lipid production, it's critical that the species choose (i) grow on fairly cheap sterilised media and (ii) illustrate the strength to tolerate hydrostatic stresses possible in standard fermentation processes.

4. OMEGA-3 AND THE NECESSITY FOR NEW ALTERNATIVES

Oil, which is high in DHA, is nowadays a common component in a wide range of nutraceutical and practical foodstuffs, and their obtainability has broadened people's consumption horizons, as they seek out more balanced meals rich inactive substances. Because marine species are the primary source of DHA (omega-3), high daily intake adherence indicates a high shellfish diet. Consuming seafood or seafood-derived oils, on the other hand, has certain drawbacks: Because certain fish species are polluted with chemicals from the environment, such as dioxins, mercury toxicity, and hexavalent chromium, eating of marine creatures has been linked to a risk to human health. These are usually hydrophobic pollutants that develop in lipid bodies in the marine food web [21]. Furthermore, fish oils might well have unfavorable properties for human ingestion, such as a distinctive odour and hydroperoxides, which indicates sensory consistency loss and shorter shelf life. As a result, vegetarians cannot consume fish oil.

Fish oil is the most common source of DHA in functional meals. EPA and DHA are also important constituents in the feed for marine Aquaculture, human usage, and other smaller uses like hydrogenation and industrial processes are among its applications (Fig. 2). Aquacultures are the industry that utilizes the maximum fish oils, accounting for around 70% of world consumption [22]. Fish farmers have been replacing farmed fish and fatty acids with proteins and plant-based oils due to increases in the price of fish feed in the previous few years, leading to a drop in desire for fish oil in aquaculture, with only a 17 percent anticipated growth from 2015 to 2025. Human consumption, on the other hand, will grow by about 80% in the same timeframe, depending on present trends, and EPA and DHA concentrations are decreased by 30–50%. Furthermore, a ratio of 5 to 10, but near to 1, influences the omega-3/omega-6 ratio.

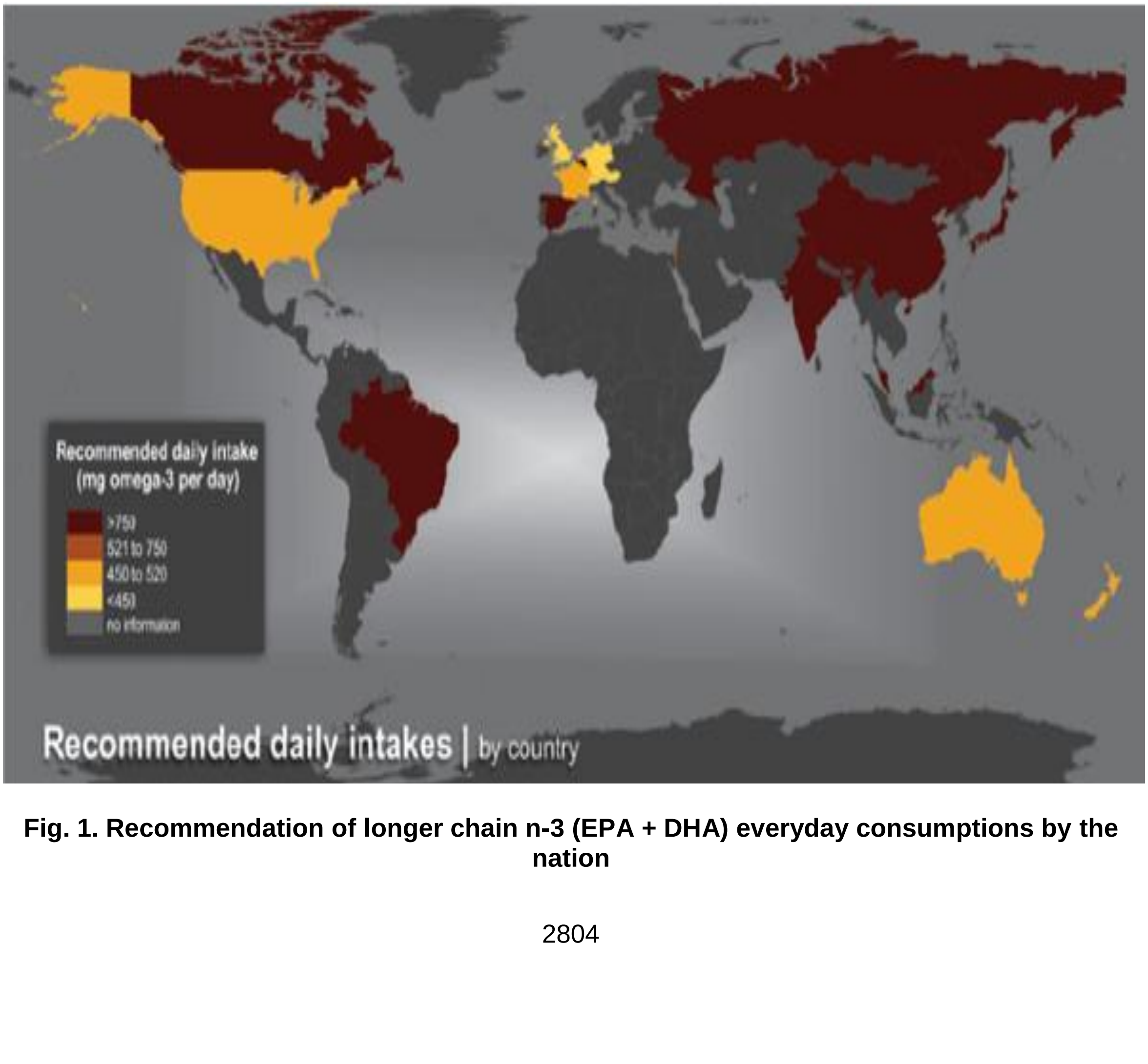

Fig. 1. Recommendation of longer chain n-3 (EPA + DHA) everyday consumptions by the nation

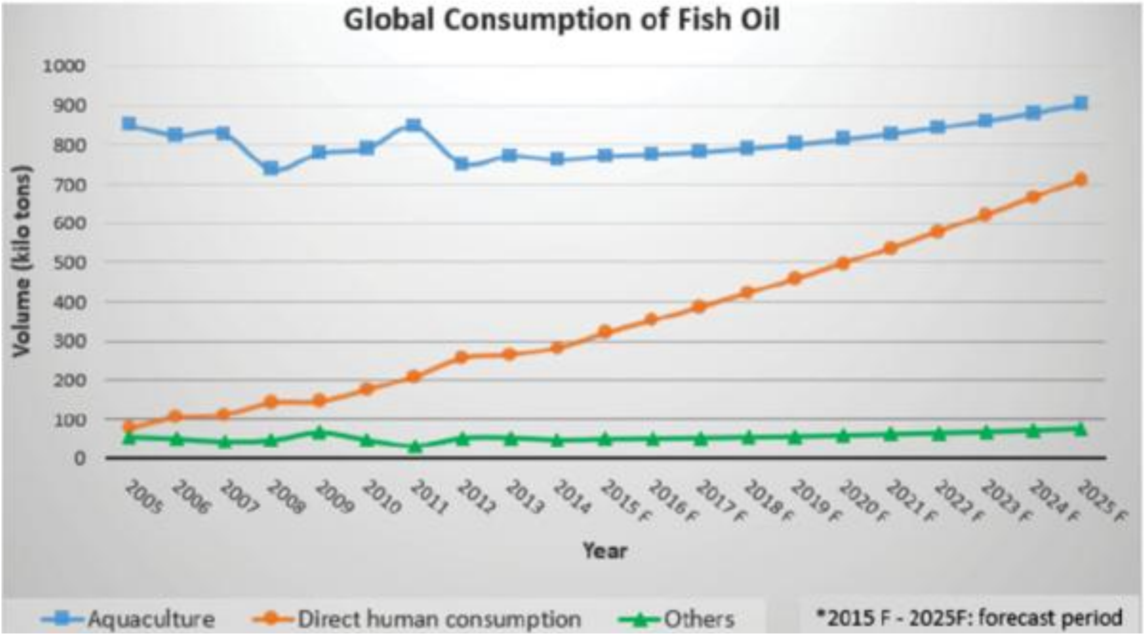

Fig. 2. Worldwide consumption of fish oil over the past era and its future forecasts forecast to 2025, founded on data of 2005-2015

5. DISCUSSION AND CONCLUSION

Health studies of new lipid-accumulating organisms are required for both human and animal consumption. Microbial oils rich in omega-3s is a feasible and safe substitute to fish oils. Microbial oils may also be used as a supplement to vegan diets or by persons who are sensitive to fish and crustacean protein. Several scientific research and publications on the relevance of thraustochytrids in omega-3 development and deployment have been published by universities and institutions. However, only a few institutions throughout the world have been successful in turning their research into patents that can lead to innovation. Omega-3 fatty acids provide several health advantages, including metabolic activities including preserving physiological homeostasis, cardiorespiratory fitness, immunological and inflammatory responses, and brain development. Traditional capture fisheries cannot meet the worldwide demand for omega-3, thus alternates are required to reduce the effect on the environment. Worldwide biodiversity may be able to supply novel high-production oleaginous bacteria that can produce larger quantities of omega-3 and other essential lipids.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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