Microalgae as a novel, non-animal source of long-chain omega-3 fatty acids and vitamin D

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Charlotte Jacobsen and Emil Gundersen from the National Food Institute at the Technical University of Denmark emphasize the need for new plant-based sources of omega-3 fatty acids and vitamin D3, highlighting microalgae as a promising option and discussing the challenges in harnessing it

Long chain omega-3 fatty acids and vitamin D: The animal-bound nutrients

As the world population continues to expand, so will the global demand for feed and food production. To be consistent with planetary boundaries, this future production must be mainly plant-based. However, transitioning to a mainly plant-based diet poses certain nutritional challenges. The lack of long-chain omega-3 fatty acids and vitamin D in plants is one of them. These compounds have important health benefits related to brain and bone development, and their absence in our diet can have serious health consequences.

Our primary dietary sources of these nutrients are fish and seafood products, chicken eggs, and animal-based oil supplements. This calls for a need to explore and develop new, non-animal sources. One alternative could be microalgae.

Microalgae:

A nutritional powerhouse Microalgae are photosynthetic microorganisms that can be found in all water-containing environments. Most of them are found in the ocean, and these marine microalgae play a vital ecological role as the ocean's main primary producers. They are also of great interest from a food perspective due to their outstanding nutritional composition. In addition to being rich in protein and essential amino acids, microalgae also produce the two long-chain omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). They contain numerous minerals and vitamins and several antioxidative pigments, which are already used commercially (Torres-Tiji et al., 2020). In our ongoing research project 'MASSPROVIT', we have recently demonstrated that a species named Nannochloropsis oceanica can contain up to 50% protein, 4% EPA, and high levels of vitamin K2 (Gundersen et al., 2024). Previously, we have also shown that this species can produce vitamin D3 when exposed to UV radiation (Ljubic et al., 2020). This combination of fatty acids and vitamins gives N. oceanica biomass a nutritional quality comparable to many saltwater fish. This is unsurprising, since these fish accumulate all their omega-3 fatty acids and vitamin D through the marine food web, starting with microalgae (phytoplankton).

Land-based microalgae production as a source of these compounds would have several environmental benefits. Replacing ocean-based harvesting and cultivation of fish would reduce pressure on wild fish stocks and substitute for locally polluting aquaculture. Microalgae production on land would take place in raceway ponds or photobioreactors with full control of the nutrient input and output. These systems could be placed in areas not suited for the cultivation of other crops and utilize local seawater sources. As a result, it would not compete with traditional agriculture for fertile soil and freshwater resources.

Challenges and the way forward

So why is this type of superfood not already a common ingredient in feed and food production? One major obstacle is high production costs, a result of the many controlled processes involved in producing microalgal biomass. However, this obstacle is likely to shrink in size with continued process optimization and upscaling of industrial production systems (Barbosa et al., 2023). Another major hurdle in using bulk microalgae biomass as a source of omega-3 and vitamin D is organoleptic properties such as the vibrant green color and the ‘fishy’ odor and taste. Lastly, biomass from microalgae like N. oceanica is challenged by an overall low digestibility. This means that only a small fraction of the intracellular omega-3 and vitamin D is made accessible during digestion. This problem can be addressed through additional processing, using so-called cell disruption to open the cells and render the nutrients more accessible (Bernaerts et al., 2020). Another strategy is to refine the biomass into several fractions, for example, by performing a subsequent oil extraction, separating the omega-3-rich oil and vitamin D from the remaining protein-rich biomass. In our upcoming research project ‘AlgaeVita’, both concepts will be applied as we develop an up-scaled process for producing microalgae oil rich in EPA and vitamin D3. Hopefully, this project and similar research efforts abroad will unlock the full potential of microalgae as a sustainable, non-animal source of omega-3 fatty acids and vitamin D.

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