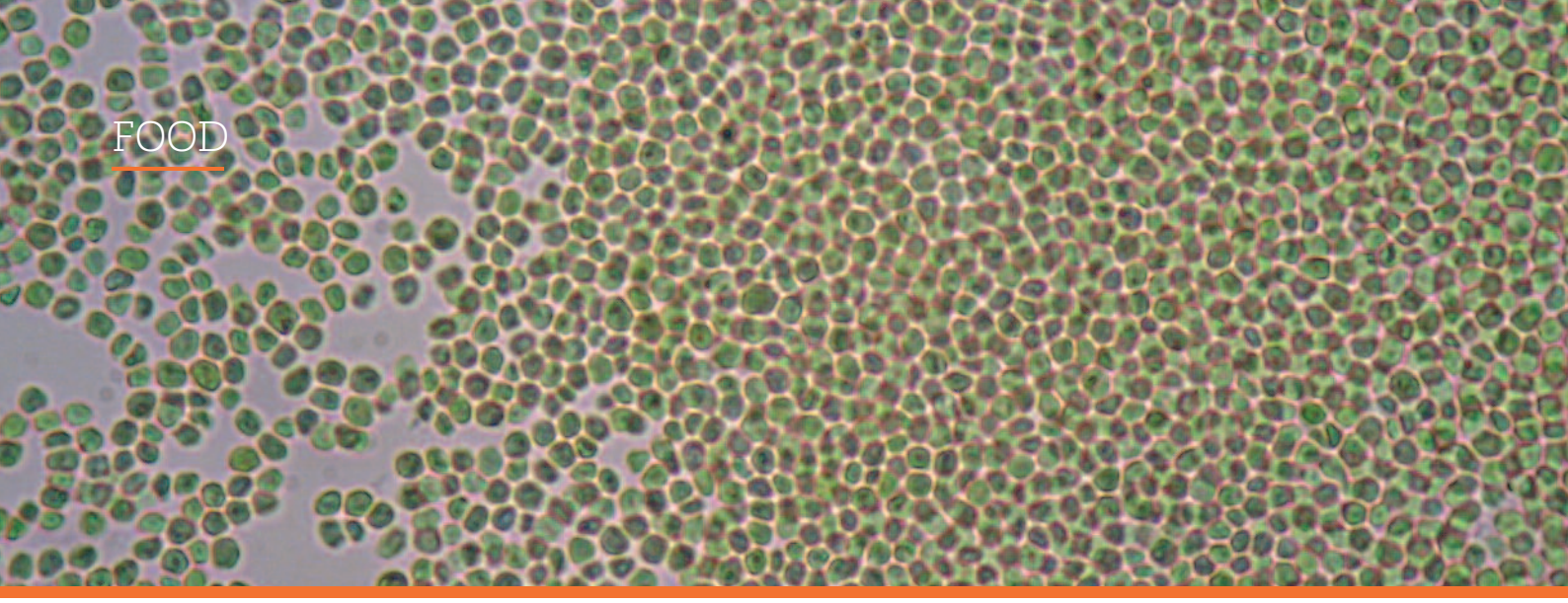


Enhancing the food value of microalgae

As part of an EU project, TEAGASC researchers are examining types of microalgae, which are among the richest and most sustainable sources of nutrients.

It is now believed that more than 4,000 species of microalgae exist and just a few hundred of these have been investigated, which suggests that they are one of the most unexplored groups in the world. Thus, more research needs to be done to assess the relatively unknown reservoir of novel compounds, and the full potential of these organisms. Microalgae have been established as a good source of proteins and other high-value compounds such as carbohydrates, lipids, vitamins, pigments, minerals and bioactive compounds. In this regard, although the microalgae industry is growing very quickly, more attention needs to be paid to the by-products after protein extraction to make the most of the initial biomass.

Relevance of microalgae

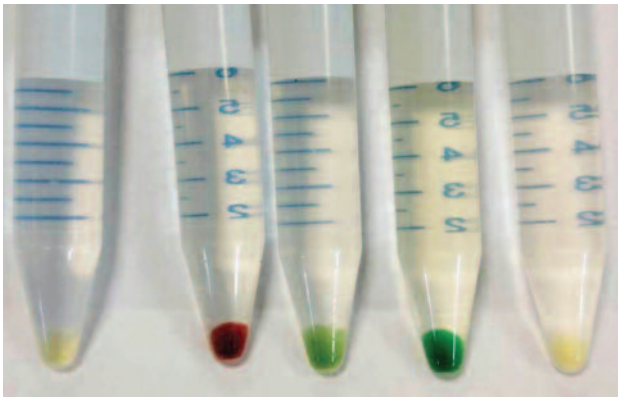
Microalgae represent one of the most promising sources of new food products and applications but there are also other factors that make the microalgae business very attractive:

- microalgae present a higher yield rate of biomass production than traditional crops of vascular plants;
- they have high adaptability to be grown in different conditions (e.g., marine and freshwater);
- they present the flexibility to be produced using different systems (e.g., naturally in lakes, open ponds, photobioreactors);
- microalgae can be cultivated everywhere, even on non-cultivable lands (e.g., desert, seashore);
- they are a photosynthetic microorganism, so they reduce atmospheric CO_2;
- if the entire conditions of production are controlled, there is no seasonality and variability of the final product is almost null; and,
- microalgae can be used to remove excess nutrients from water (e.g., phosphorus, nitrogen and potassium), reducing the cost of production.

In spite of all these advantages, just a few microalgae have been harvested and commercialised as "generally recognised as safe" (GRAS) in the United States, and in Europe a couple of strains of microalgae have been approved as novel food and/or novel food ingredients. In Ireland, *Chlorella vulgaris* (chlorella) and *Arthrospira platensis* (spirulina) are the best known. They can be found easily at a reasonable price in health food stores and consumed in different formats, tablets and powder being the most common. The popularity of these two microorganisms is so high that they were classified recently as 'superfoods' (Castello *et al.*, 2018, van den Driessche *et al.*, 2018) along with blueberries and kale, among other products. But, what does superfood mean? Superfood is a non-scientific term commonly used for marketing purposes in the media and in blogs, where people attempt to describe food with a high content of vitamins, minerals and antioxidants. The closer scientific term to define such edible products is "functional foods", which can be effective in preventing or treating different diseases due to the presence of bioactive compounds. In particular, chlorella is a single unicellular alga with powerful health properties due to its high content in protein, amino acids, pigments and antioxidants, which may help prevent several illnesses. It is estimated that about 5,000 tons are cultivated per year. On the other hand, spirulina production is a bit higher, at around 12,000 tons per year. Spirulina could be one of the most complete foods, containing abundant protein (about 60% of the total content), vitamins, pigments, good fatty acids and minerals. Also, it has a total phenolic content that is sometimes even higher than the most consumed vegetables and fruits, enhancing human health.

EnhanceMicroAlgae

Researchers at Teagasc have shown that the application of novel extraction techniques such as ultrasound, enzymes and microwave-assisted extraction techniques can enhance the extraction of proteins and other bioactives from microalgae. EnhanceMicroAlgae (High added-value industrial opportunities for microalgae in the Atlantic Area – Enhanced Microalgae) is an ongoing project with a budget of €2.45 million, aiming to make the most of microalgae in the Atlantic area, with several partners based in Spain, Portugal, France, the UK and Ireland. The objective is to enhance the value of this resource by transferring the latest developments in this field to the business sector, thereby facilitating production of large biomass volumes, using new species and optimising production processes in line with different final products such as fatty acids, pigments and polyphenol extraction for human nutrition, led by Teagasc.



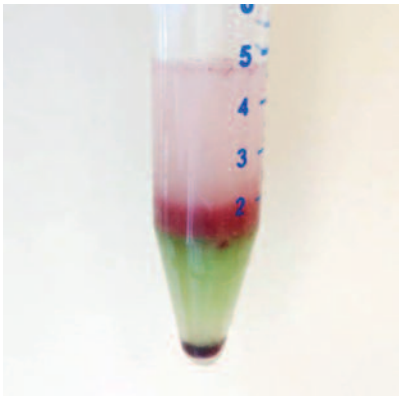


FIGURE 1 (left): Extraction of fatty acids from different microalgae strains.

FIGURE 2 (right): Pigments extracted from Porphyridium purpureum.

Fatty acid supplements

Fatty acids are essential for living organisms, and good polyunsaturated fatty acids (PUFAs) can be sourced from fish oil. PUFAs are beneficial in reducing the risk of coronary heart disease and might be beneficial in the treatment of certain autoimmune diseases such as multiple sclerosis, among other benefits. However, the use of fish oil as a source of PUFAs has some drawbacks:

- fish are being depleted due to overexploitation of fish reserves;
- fish can accumulate toxic compounds such as heavy metals, which can be transferred to the fish oil;
- fish oil has an unpleasant smell and taste;
- the PUFAs extracted are instable due to oxidation, losing their good properties; and,
- it is not a suitable product for the vegan and vegetarian market.

As a result of these disadvantages, research into new matrices to find alternatives is being carried out. Fish are rich in PUFAs due to their diet. Hence, lines of research are driven by microalgae that are the first link of the fish trophic chain and a very rich source of PUFAs. At Teagasc, we are using new, less-investigated strains, such as *Nannochloropsis oculata*, *Scenedesmus obliquus* and *Porphyridium purpureum*, to enhance the extraction of fatty acids (**Figure 1**).

Antioxidants, pigments and polyphenols

Nowadays, there are concerns due to problems associated with the unsafe effects of artificial colourants. There is a wide range of microorganisms pertaining to different families of microalgae (diatoms, green algae, golden algae and blue-green algae cyanobacteria) and each one produces different pigments that may have antioxidant activity and can be used as a natural source to replace synthetic colourants in the food, cosmetic, nutraceutical, and pharmaceutical industries. **Figure 2** depicts the extraction of two pigments from *P. purpureum*.

The task of Teagasc regarding the characterisation of bioactive compounds in microalgae is carried out in nutraceutical facilities. The work will be done following antioxidant guided tests; the initial microalgae biomass will be extracted and divided into different fractions, using techniques such as dialysis, flash chromatography, etc. The fractions that present higher antioxidant activity will be the remarkable ones to be further studied.

Acknowledgements

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