Macroalgae

Crop Fact Sheet

Macroalgae, more commonly known as seaweeds, are multicellular plant-like organisms found in aquatic environments. They can be broadly divided into three groups based on their colour: green (*Chlorophytae*), brown (*Phaeophytae*) and red (*Rhodophytae*). Macroalgae can be made into a wide range of chemicals and high value products, and in the future could be a valuable source of heat and power.

Cultivation

Globally, around 1 million tonnes of macroalgae were collected from wild stocks in 2008[1]. Wild harvesting of macroalgae is usually done by hand or using mechanised cutters.

There are some concerns about the potential impacts of wild macroalgae harvesting on marine biodiversity and more research is urgently needed. In addition, material harvested from the wild can be of variable quality, in terms of its age and contamination from stones and other seaweeds.

Wild harvesting is unlikely to be feasible for the production of seaweed at the scale required for large-scale industrial purposes, therefore, cultivation will be required[2].

Around the globe, over 15.7 million tonnes of macroalgae and aquatic plants were cultivated in 2008[1].

The majority of cultivation to date has utilised long line systems, which consist of vertical strings (droppers) suspended from a horizontal string held up by a series of buoys. More recently, flexible seaborne structures have been developed for macroalgae cultivation.

Global Production

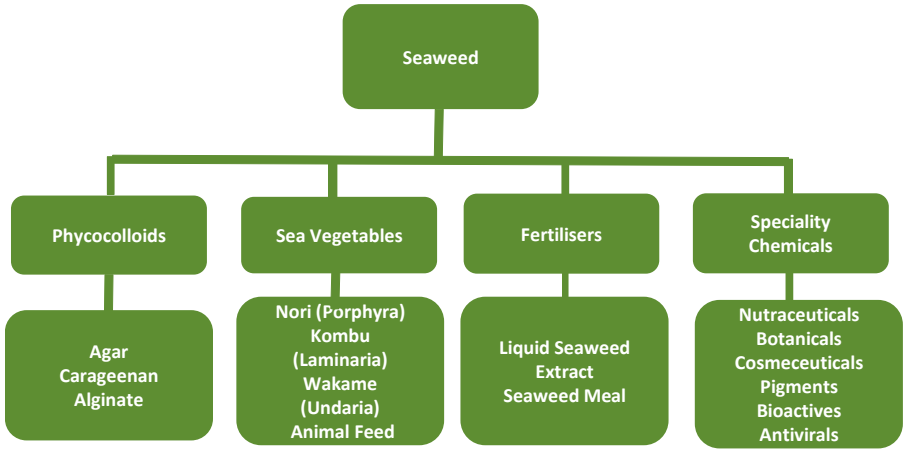
Asian countries dominate production, accounting for 99% of global production in 2008[1]. China alone accounted for 63% of total global production[1]. Much of this was derived from cultivated macroalgae.

The principal European producers are France, Ireland and Norway, with smaller amounts harvested in Portugal and Spain[1]. The majority of European production of macroalgae is derived from wild harvested stocks, with only small-scale cultivation in France.

The UK macroalgae industry is small and is currently restricted to Scotland. Less than 15,000 tonnes of macroalgae are harvested each year in the UK, predominantly from wild stocks of *Ascophyllum nodosum*.

Current Applications

Macroalgae can be used to produce a wide range of products, including pharmaceuticals, cosmetics, food and agrichemical applications, as shown in the diagram below.



In 2008, the total macroalgae market was $7.4 billion[1]. The largest market for macroalgae was the sea vegetable market, which was worth around $5.3 billion in 2006[3].

The phycocolloid market accounted for some $650 million whilst the phycosupplements industry (including fertilisers and speciality chemicals) was worth around $53 million[3].

Potential Markets

Macroalgae can be used to generate renewable energy and because they are normally grown at sea, the conflicts with food production are likely to be less direct than with land-based biomass crops. However, more information is needed on the environmental impacts of large-scale macroalgae production.

Macroalgae are ideally suited to anaerobic digestion as they have a high moisture content and lack lignin. *Laminaria* species for example, produce methane yields comparable to sugar cane and five times greater than cow slurry.

Some species of macroalgae contain high level of carbohydrates, although in most cases, these differ from the carbohydrates in land-based crops. Carbohydrate fermentation has the potential to produce a range of chemicals including ethanol, butanol, succinic acid, lactic acid and 1,3 propandiol. Projects are underway in Chile, South Korea and the USA investigating the potential of ethanol and butanol production from macroalgae[4].

Macroalgae are not ideally suited for thermochemical conversion processes, as the amount of energy needed to dry them is often greater than the energy yield of the resulting product. Hydro thermal processing technologies may be feasible but their use in the production of fuels or energy from macroalgae is at an early stage of development.

Fuels and energy are also low value products and it is estimated that macroalgae costs would need to decrease by more than a quarter of current prices to make these economic to produce.

Integrated biorefineries could allow sufficient scale of operations to enable economic production of energy and fuels from macroalgae with one or a number of high value co-products, such as carrageen, agar or alginates being sold separately[5]. The scale of operation would however, need to be carefully considered to ensure that higher value chemical markets do not become saturated.

Macroalgae are already used for an impressive range of products. They could also have a number of so far unknown applications, including novel pharmaceuticals and bioactive compounds for cosmetic and nutritional purposes.

Research Requirements

Macroalgae cultivation on long lines is commercial at significant scales in China (~10 million tonnes per year) and small-scale experiments (up to 1 tonne production) with *Laminarian* seaweed on long lines in the UK have shown promising results. However, specific actions are needed to:

- Identify sites with suitable access, nutrient profile and temperature for algal cultivation.
- Scale-up trials over multiple sites and over a number of years to demonstrate the feasibility of large scale production in the UK.
- Assess the sustainability of macroalgae cultivation and harvesting, esp. with regard to marine biodiversity and coastal wave dynamics.
- Provide costs associated with large-scale macroalgae cultivation to show technology viability and bottlenecks for development.

Methods for the utilisation of macroalgae also need development, especially for biological conversion processes. Specific research is needed to:

- Assess geographical, seasonal and plant wide variations in total sugar content, type of sugars and inhibitory substances found in macroalgae.
- Develop microorganisms and processes which can ferment macroalgal sugars to chemicals and fuels. These should be tolerant of the high salt contents and compounds, such as polyphenols which can hinder chemical production.

Image courtesy of Dupont

Further Information

1. FAO (2008) Fisheries and Aquaculture Statistics www.fao.org/docrep/013/i1890t/i1890t.pdf

2. James, M.A. (2010) A Review of Initiatives and Related R&D Undertaken in the UK and Internationally Regarding the Use of Macroalgae as a Basis for Biofuel Production and Other Non-Food Uses Relevant to Scotland. Report Commissioned by Marine Scotland, 79pp.

3. Chopin, T., and Sawhney, M., (2009) Seaweeds and their Mariculture. www.gipescado.com.br/arquivos/seaweeds.pdf

4. Lane, J. (2010) With a Little Kelp from my Friends: Macroalgae Projects, Concepts Bloom. Biofuels Digest. http://biofuelsdigest.com/bdigest/2010/06/23/with-a-little-kelp-from-my-friends-macroalgae-projects-concepts-bloom/

5. Bruton, T., Lyons, H., Lerat, Y., Stanley, M., and Bo Rasmussen, M. (2009) A Review of the Potential of Marine Algae as a Source of Biofuel in Ireland. Sustainable Energy Ireland.