
# EU4ALGAE - WG2 - Market Research



👉 **Objective**:

Provide a better view of the market:

- What can we do with which type of algae produced in the EU ?
- Complete document with a list the different types of production systems versus species
- Versus outside the EU ?

👥 **Contributors**

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🔎 **Disclaimer**

This document is only a draft, so errors may appear.
If you spot one, reach out to me so that we can correct it 👇
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Best,
Arnaud

# Production Systems

👉 *Let's start with a short review of existing microalgae cultivation systems*

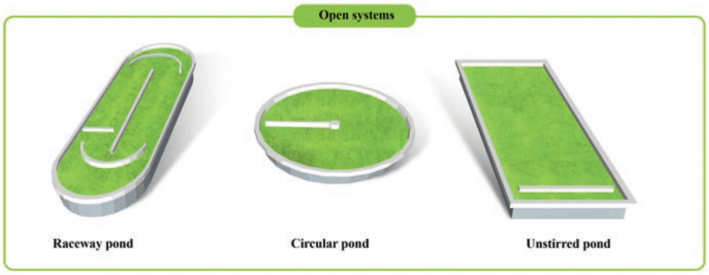
**Microalgae**, mostly unicellular green organisms, grow on sunlight and CO2, and need minerals and vitamins for growth – they grow autotrophically. In addition, some microalgae can grow on carbon sources when there is no light available – thus they grow heterotrophically or in mixotrophy. *For details see the position paper 'What are Algae' of the EABA. (https://www.what-are-algae.com/)*

There are several types of microalgae production systems to produce autotrophic microalgae - these systems can be divided in 2 categories:

- Open systems, where the water surface is exposed to ambient air
- Closed systems where the algae culture is protected by glass or plastic or other material from the surrounding environment.
- Heterotrophic microalgae are grown in steel-fermenters in the dark by adding carbon as energy source.

## Open systems

In these open-air systems algae cultures are exposed to sunlight in shallow ponds where CO2 can be inserted by technical means. In open systems, mostly extremophile algae strains are grown (high salinity, high pH) as it is hard to fully control evaporation or biogenic contamination. Covers can protect algae from rain.




***Examples of different types of pond systems for outdoor microalgae cultivation***

> *Djamal, Zerrouki & Henni, Abdellah. (2019). Outdoor Microalgae Cultivation for Wastewater Treatment. 10.1007/978-3-030-13913-1_5. Available here [accessed 26 April, 2023]*

- **Open ponds**: This is the most common and oldest method of growing microalgae. Algae are grown in large, shallow, open-air ponds with ambient environmental conditions such as light, temperature and CO2 Nutrition is typically added to the setup. These ponds can be stirred (usually in circular ponds) or unstirred, so left to drift freely.
- **Raceway ponds**: These are a type of open pond that utilizes a continuous circular flow of water to reduce the need for mechanical mixing. There are various techniques available to move the culture through the system by Paddle wheels or other mechanical means. They can be scaled up to commercial production.
- **Cascade PBR** – Cascade raceway ponds: by allowing a thin film of algae-culture flowing down an inclined surface, microalgae get a maximum of surface radiation to grow exponentially, and at the same time, this technology allows efficient gas exchange without the need of inputting CO2 or washing out O2. A hybrid system between raceway ponds and the cascade PBR is the cascade raceway pond, where the algae culture is flowing in an inclined oval raceway pond for increased productivity.

*Schematic diagram of a cascade where a thin layer (ca. 1 cm) of suspension flows along declined surface*

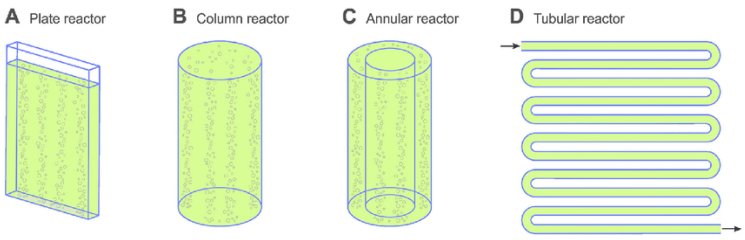
*Ojamäe, Karin. "Growth physiology and photosynthetic performance of green microalgae mass culture grown in a thin-layer cascade." (2011)*

# Closed systems

These are completely enclosed production systems that can be controlled to optimize the growth of microalgae.

Closed systems are also called Photobioreactors (PBRs). These systems can have various shapes and geometries, but all of them have an input-possibility for CO2 and a de-gasing possibility to get rid of the O2 generated during photosynthesis and growth of microalgae under light conditions. The microalgae culture is moved through the system by different technical solutions to allow mixing for equal exposure of algae to the light and nutrition. PBRs can work with sunlight or artificial light depending on the site of installation – there are open air PBRs as well as PBRs operated in warehouses. Microalgae grown in PBRs often of superior quality as compared to open ponds because they have a lower risk of biogenic or environmental.

Closed systems include:

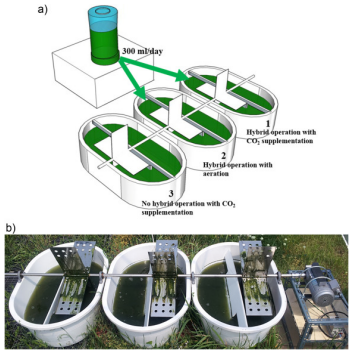



*Examples of common closed photobioreactor geometries.*
*A) Plate reactor. B) Column reactor. C) Annular reactor. D) Tubular reactor. A to C: rising bubbles generate a flow as well as provide mixing and aeration. D: suspensions are typically driven by a pump. Aeration and mixing of tubular reactors are usually done by airpump or air-lift systems.*

Algae Biotechnology - Green Cell-Factories on the Rise - Scientific Figure by Hallmann, A. (2015). On ResearchGate. Available here [accessed 26 April, 2023]

- **Flat panel reactors**: In these reactors, which can be very efficient due to thin liquid layers between glass plates, algae are being mixed by air loaded with CO2. A special case of these PBRs is the Green Wall technology where between fence like structures algae are bubbled in plastic bags. Advantage of this special system is the efficient way of cleaning the system mb using fresh bags for every new culture cycle with the disadvantage of not being very environmentally friendly.

- **Airlift reactors**: In these PBRs, the algae culture is mixed with CO2 fortified air in bubble columns of various diameters and of various heights. There are column or annular PBRs, where in the case of the column microalgaes are in a simple tube, in the case of the annular reactors, this tube has a hole in its center, usually to store a light source. One disadvantage of this geometry is the limited light penetration into the culture in cases where the columns have a big diameter.
- **Horizontal tubular reactors**: this PBR type is widely present in the microalgae production field. In glass or ‘plastic’ tubes, which are stacked or arranged in coils, algae are being pumped over a certain distance to take up light and CO2 before they come back to the pumping station where O2 is being stripped, and new CO2 injected. Some microalgae species which are sensitive to sheer stress can only be hardly grown in this type of PBRs due to the pump-force which is needed to move the culture over several 100m.




***Hybrid operation of photobioreactor and wastewater-fed open raceway ponds.*** Yun et al. (2018)

## Hybrid Systems

There are also Hybrid systems, a combination of open ponds and PBRs, which gets the benefits of both systems. For example, algae are grown in PBRs to reach high densities, then transferred to open ponds to complete their growth cycle.

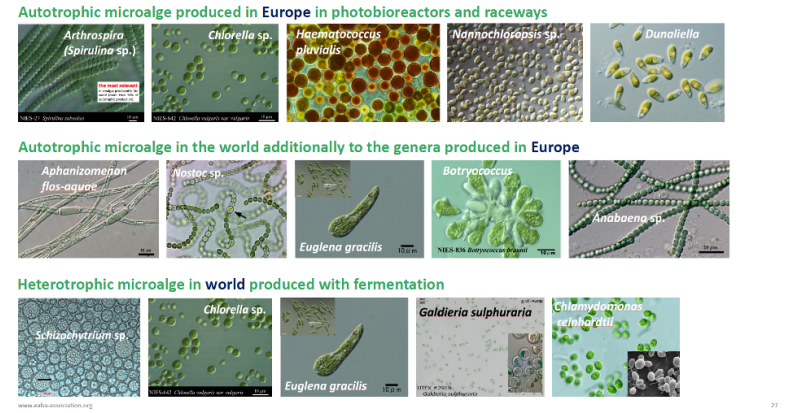
**In conclusion , each of these systems has its advantages and disadvantages, and the choice of system will depend on factors such as the type of algae being grown, the desired product, and the available resources.**

# European Microalgal Production

👉 Now let’s look at the taxonomy aspect: what are the microalgae widely produced in Europe? Why are other less present?

## Species of Microalgae produced in Europe

In Europe microalgae are produced auto- and heterotrophically. For heterotrophic growth mostly Chlorella sp is being used. Of these Chlorella strains, natural mutants are available which are being ‘yellow’ as they don’t possess Chlorophyll which is usually giving the green color to the cells. This yellow Chlorella is being used for food preparations (like bread spreads or mayonnaise) due to its high protein content.




The majority of the European Microalgae production is autotrophic – driven by sunlight or by artificial light – depending on the region where they are produced.

Commercially most successful is the cultivation of **Haematococcus pluvialis** which is being used for the production/extraction of *Astaxanthin*, a natural antioxidant used in nutraceuticals, cosmetics, and pharmaceutical applications.

***Arthrospira/Spirulina*** is a Cyanobacterium which is being used for nutraceutical and food applications.

***Chlorella***, like ***Spirulina****,* is being used in the nutraceutical market and for small scale food applications whereas ***Nannochloropsis sp*** is rather being used in the feed sector for aquafeed special preparations. We can also cite that ***Nannochloropsis***, is also commonly used for the production of biofuels. Cultivation of the two of these species can be both in photobioreactors and in open-raceways.

## Upcoming species in the EU

Because of different reasons, some species, are only now starting to be produced in Europe.

One of these species is ***Dunaliella****. **Dunaliella** is* known for its appreciation of harsh environments (such as extreme luminosity, hypersalinity, low oxygen & nitrogen) can be cultivated in both open or closed systems, yet it is mainly used in open raceways. It is known for its high levels of beta-carotene, which is used as a food colorant and as a source of vitamin A.

Credit: *aquaportail.com*

It's presence in Europe has been limited for a long time, probably due to specific growth conditions and limited demand, but is starting to establish as viable choice. In addition to academic interest (such as in Greenwich) several private actors are acting on it, such as *A4F Algae for Future* (Portugal), *Monzón Biotech S.L.* (Spain), BlueBioTech Group (Germany) and *ALGALIMENTO SL* (Spain). Chinese actors has shown a strong interest in *Dunaliella* for quite some time already and have also been exporting to the European market.

**Of course there are many species of microalgae that are currently not commonly produced in the European Union. The reasons for this can vary, but some possible factors include:**

1. **Unsuitability for local conditions**: Some microalgae species may not be well-suited for cultivation in the EU due to factors such as climate, water availability.
2. **Lack of demand**: If there is no significant demand for a particular microalgae species in the EU, it is unlikely to be produced in large quantities.
3. **Regulatory restrictions**: Some microalgae species may be subject to regulatory restrictions in the EU due to concerns about their potential environmental impact or safety.

4. **Economic considerations**: If the cost of producing a particular microalgae species in the EU is high compared to importing it from elsewhere, it may not be economically viable to produce it locally.

**Examples of microalgae species that are not commonly produced in the EU include:**

1. **Isochrysis** is commonly used for aquaculture, but it is not widely produced in the EU yet due to its still relatively low demand and the availability of alternative feed sources. BlueBioTech Int. (Germany) and Microphyt (France) are using it.
2. **Tetraselmis**: Very similarly to Isochrysis, this species, cultivated for aquaculture purposes, is yet to meet wider production in the EU because of its moderate nutritional value and the availability of other feed sources. BlueBioTech Int. (Germany), Allma/Allmicroalgae (Portugal), Global Biotech S.L.(Spain) also cultivates it.
3. **Botryococcus**: Its high lipid content make it a great candidate for biofuel production, but because of its moderate growth rate and the availability of alternative biofuel sources, it is not widely cultivated in the EU yet.
4. ***Euglena gracilis****:* Eventhough this species has been used for ages in Asia (particularly Japan) and the USA, it is only very recently that the European Food & Safety Agency (EFSA) has opened the door for *Euglena* to enter the European food market as supplements (Official Document). Also, its high flexibility and resistance make *Euglena gracilis* a great candidate for biofuel production: they are less lipid-rich but have faster growing rates.

Both ***Isochrysis*** and ***Tetraselmis*** are gaining traction thanks to regulatory encouragements from the European Commission (Granting Isochrysis project and Tetraselmis approved as Food Supplements) thanks to there recently proven health benefits, but this traction is still relatively slow. Also is worth mentioning that some non-european companies such as Cyanotech Corporation (Hawaii), DIC Corporation (Japan), PT Pure Nusantara (Indonesia), Algix (USA) use specific strains of microalgae that are not common in Europe.

# Who are the actors?

## ▼ Chlorella

- **Algae Natural Food**: This Italian company produces organic Chlorella powder for use as a food supplement and functional ingredient in the food industry.
- **Roquette**: This French company produces a range of plant-based ingredients, including a Chlorella-based food coloring called Luminescence.
- **Fermentalg**: This French biotech company produces a range of microalgae-based products, including a Chlorella-based omega-3 supplement
- **Jongerius Ecoduna:** An Austrian company producing Chlorella and Spirulina for the food market as supplements.
- **Allmicroalgae**: This Portuguese company produces Chlorella powder for use in food, feed, and cosmetics applications.

We can also add the American company AlgaVia which has a production facility in Belgium and produces a range of microalgae-based ingredients, including AlgaVia Whole Algae Protein, which is made from a blend of Spirulina and Chlorella

## ▼ Haematococcus Pluvialis

- **Fermentalg**: They also produce an astaxanthin supplement made from Haematococcus pluvialis.
- **Cyanotech Europe**: This European subsidiary of the American company Cyanotech produces BioAstin, a natural astaxanthin supplement made from Haematococcus pluvialis.
- **Algae Natural Food**: They also produce an astaxanthin-rich Haematococcus pluvialis powder for food supplement and functional ingredient in the food industry.
- **AstaReal**: This Swedish company produces AstaReal, a natural astaxanthin ingredient made from Haematococcus pluvialis for use in dietary supplements, functional foods, and cosmetics.

There are also non-european companies producing Haematococcus Pluvialis in Europe such as **Parry Nutraceuticals** (India in Iceland), **Algatechnologies** (Israel in Germany), **Valensa International** (USA in Spain)…

## ▼ Spirulina

- **Allmicroalgae**: This Portuguese company produces Spirulina powder for food, feed, and cosmetics applications
- **Algorigin**: This French company produces organic Spirulina-based supplements and superfoods for human consumption.
- **Mediterranean Spirulina**: This Greek company produces Spirulina powder and tablets for use as a dietary supplement.
- **Necton**: This German company produces organic Spirulina-based supplements for human consumption.
- **Roquette** (FR), **Algae Natural Food** (IT) also produce it, respectively as a food-coloring and food ingredient

As listed before, AlgaVia the American comapny has a production facility in Belgium and produces a range of microalgae-based ingredients, including AlgaVia Whole Algae Protein, which is made from a blend of Spirulina and Chlorella

## ▼ Nannochloropsis

- **Photanol**: This Dutch company produces bio-based chemicals and materials using Nannochloropsis-based photosynthesis technology.
- **Fermentalg** (FR): After Chlorella and Haematococcus Pluvialis also produce DHA-rich Nannochloropsis-based oils for use in dietary supplements, food, and feed applications.
- **Subitec**: This German company produces Nannochloropsis-based oils and biomass for use in food, feed, and energy applications.
- **ALGAplus**: This Portuguese company produces a range of microalgae-based products, including a Nannochloropsis-based feed for aquaculture.

> 👉 DISCLAIMER:
> *For each species, they are dozens of different actors even in Europe, so it is be impossible to include them all in such a short report.*
> *The companies listed here are only an extract of the existing actors and do not reflect any personal preferences or seek to rank them together.*

# European Market Trends

👉 Finally, let's end with a quick trend report for the European mircroalgae market.

According to a different reports, the European microalgae market is projected to grow at a compound annual growth rate (CAGR) between 5.8% to 9.8% from 2023 to 2030, reaching $355.48M to $491M by 2030. In terms of tons produced, the market "is expected to reach 25,465 tons by 2030, at a CAGR of 8.3% during the forecast period 2023–2030" according to Meticulous Research.

This growth is driven by several factors such as :

- **Increasing consumer awareness of the wide range of health benefits of microalgae products**
  Microalgae-based supplements and functional foods are becoming more popular among health-conscious consumers. Theire antioxidant proprieties, vitamins & other nutrients, and their use in supplements / other health products put them under the spotlight.
- **Increasing demand for biofuels and renewable energy sources.**
  Microalgae are a promising source of biofuels, as they can produce large amounts of biomass and can be cultivated on non-arable land. In addition, the high lipid content of some microalgae species makes them a potentially valuable source of biodiesel and other biofuels.
- **Increasing need for alternative food and protein source**
  Microalgae are a rich source of protein and other nutrients, and their cultivation is often more sustainable and environmentally friendly than traditional agriculture. As a result, microalgae-based food products and ingredients are becoming increasingly popular in Europe.

In addition to this, the general optimization of microalgae cultivation technology and processes will also improve greatly the state of the market.

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