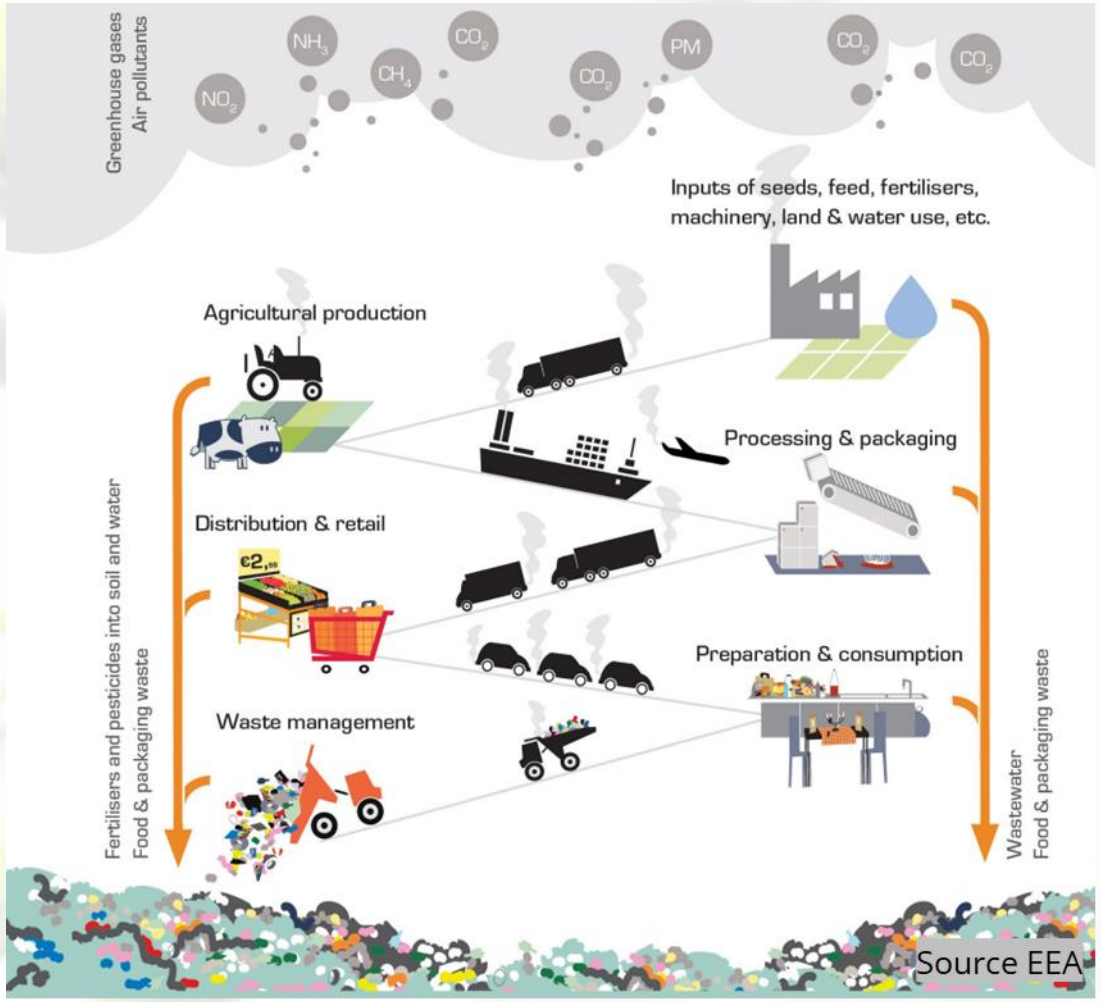
MICROALGAE – A NOVEL SOURCE OF PROTEINS

Nikola Medic, Specialist at Biomass Technology, Bioresources

TEKNOLOGISK
INSTITUT

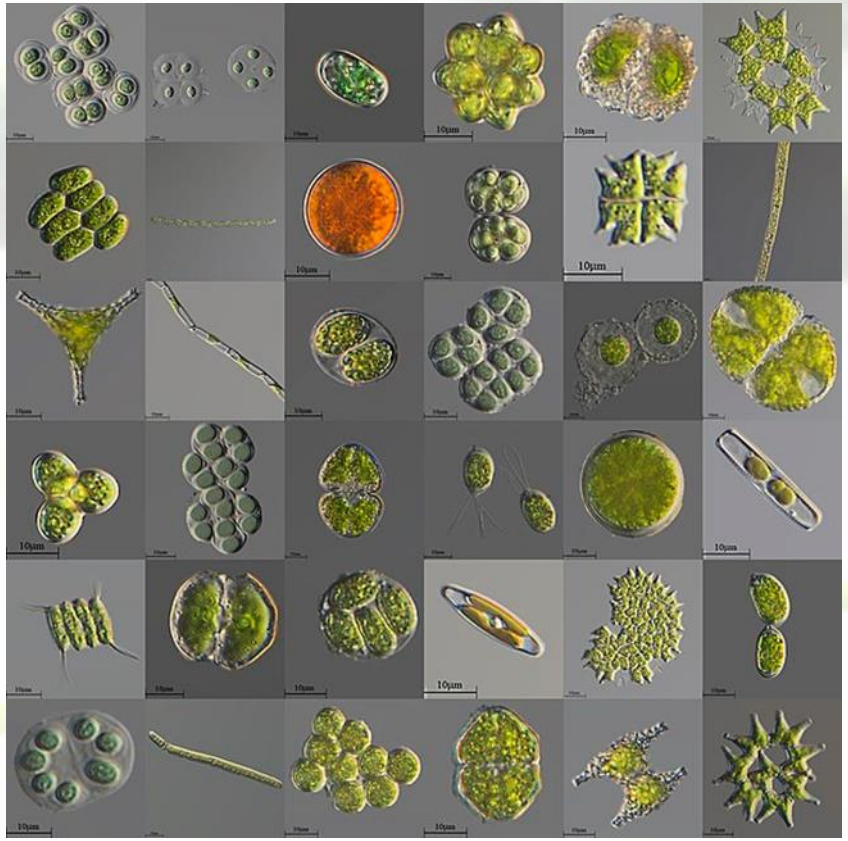
FOOD SECURITY AND PRODUCTION

- increase in global population requires higher food production
- greenhouse gas emissions, the use of pesticides and herbicides, water consumption and land use
- the agricultural sector will require ‘major transformations’ to reach full potential

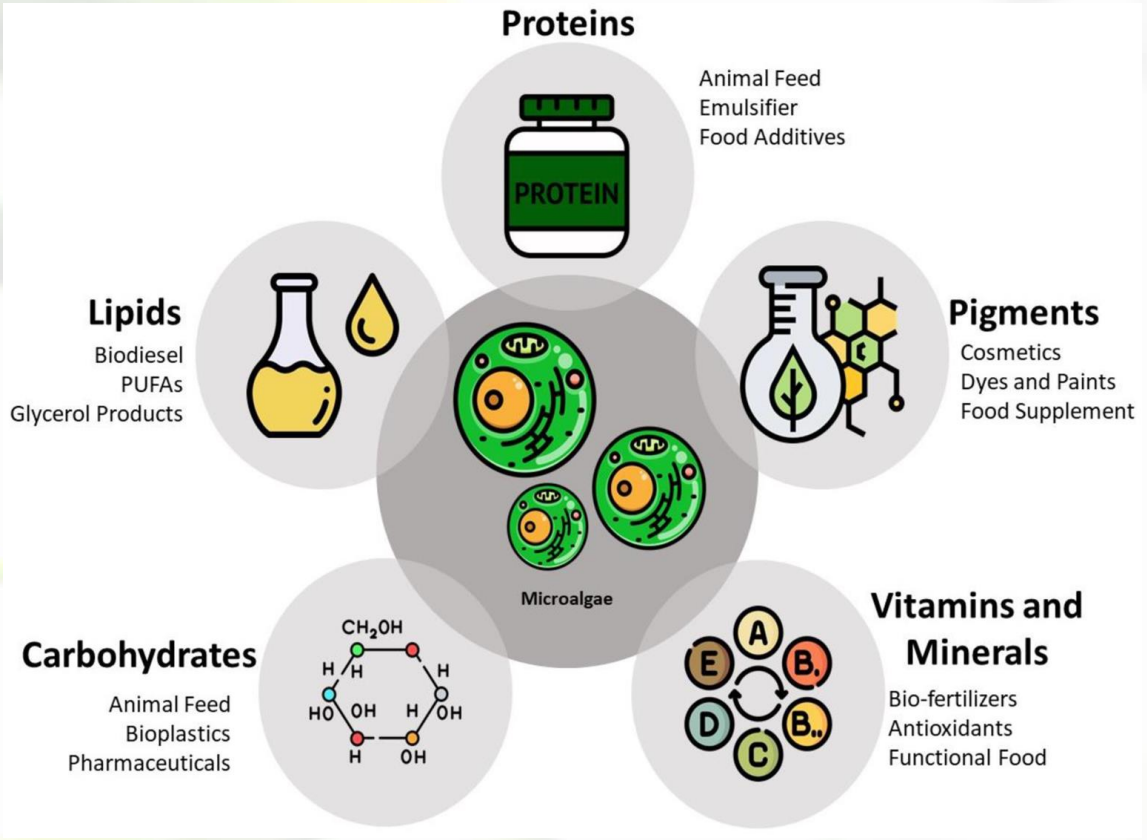


TEKNOLOGISK INSTITUT

MICROALGAE



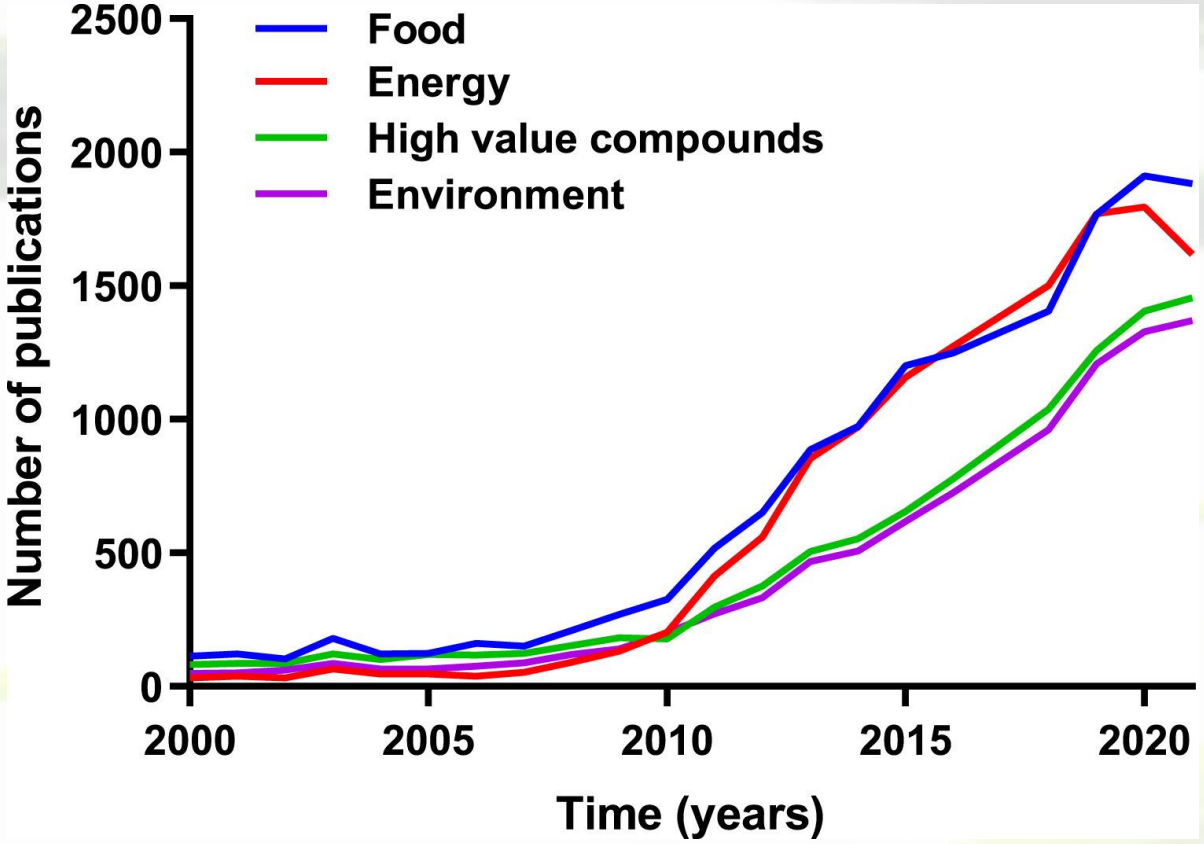
Diversity of microalgae
(photo credit: Alexander Klepnev)



Application of the different products produced by microalgae
(Safi et al., 2014 Icons by Freepik from flaticon.com)

TEKNOLOGISK INSTITUT

MICROALGAE AND FOOD PRODUCTION



Number of publications classified by different microalgae applications (Chen et al., 2022) .

TEKNOLOGISK
INSTITUT

MICROALGAL VALUE CHAIN

STRAIN SELECTION

CULTIVATION

UPSTREAM PROCESS

HARVESTING AND DEWATERING

CELL DISRUPTION

PROTEIN EXTRACTION

PRODUCT

DOWNSTREAM PROCESS

Kim et al. 2022

TEKNOLOGISK INSTITUT

MICROALGAE AND FOOD PRODUCTION

- most promising source for new food products

Land use (m^2/kg protein):

- Microalgae 1.7–5.4
- Eggs 26–135
- Beef 76–166
- Pork 40–76

Free off:

- herbicides
- antibiotics
- hormones
- pesticides

Rich in:

- protein,
- polyunsaturated fatty acids
- pigments
- vitamins

TEKNOLOGISK INSTITUT

MICROALGAE AS A SOURCE PROTEIN

- promising way to close the predicted 'protein gap'
- protein content → species, strain, cultivation conditions
- microalgal biomass protein content 30 – 80 %
- amino acid profile of several microalgal species matches the reference profile of a well-balanced protein (WHO/FAO)

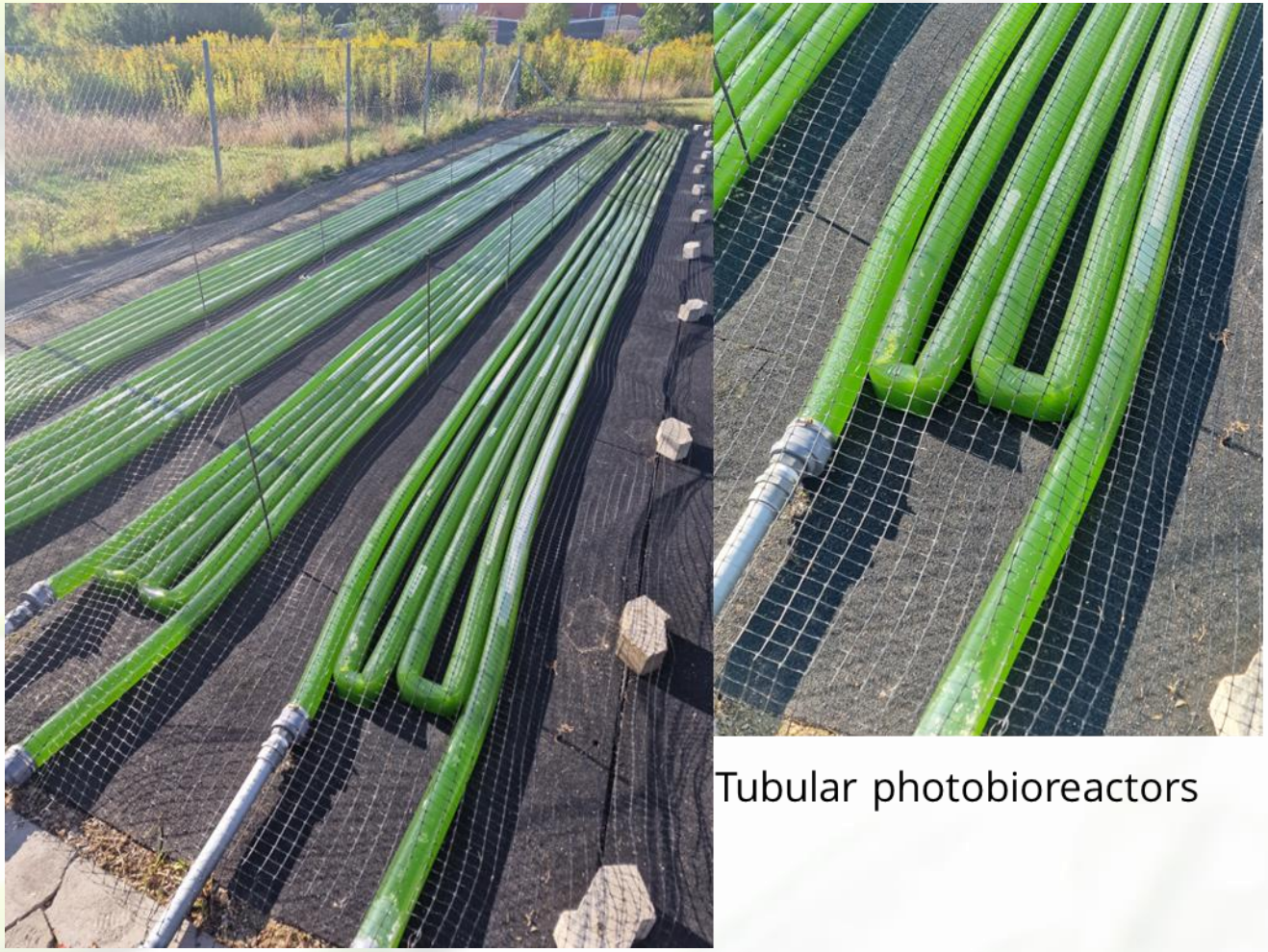
MICROALGAE	MASS PERCENT (%)	OTHER PROTEIN PRODUCT	MASS PERCENT (%)
Chlorella vulgaris	51 – 58	dried skimmed milk	36
Galdieria sulphuraria	62	soy flour	37
Tetraselmis chui	31 – 46	chicken	24
Nannochloropsis oceanica	35 – 44	fish	24
Dunaliella salina	50 – 80	peanuts	26

MICROALGAE AS A SOURCE PROTEIN

- direct use of microalgal biomass as single-cell protein (SCP) is limited by **digestibility**
- **rigid cellulosic cell wall**
- *Dunaliella* → lack a cell wall → advantageous as a protein feedstock
- ongoing studies in digestibility and biomass pre-treatment
- chlorophyll content – **green pigment**

MICROALGAE PRODUCTION

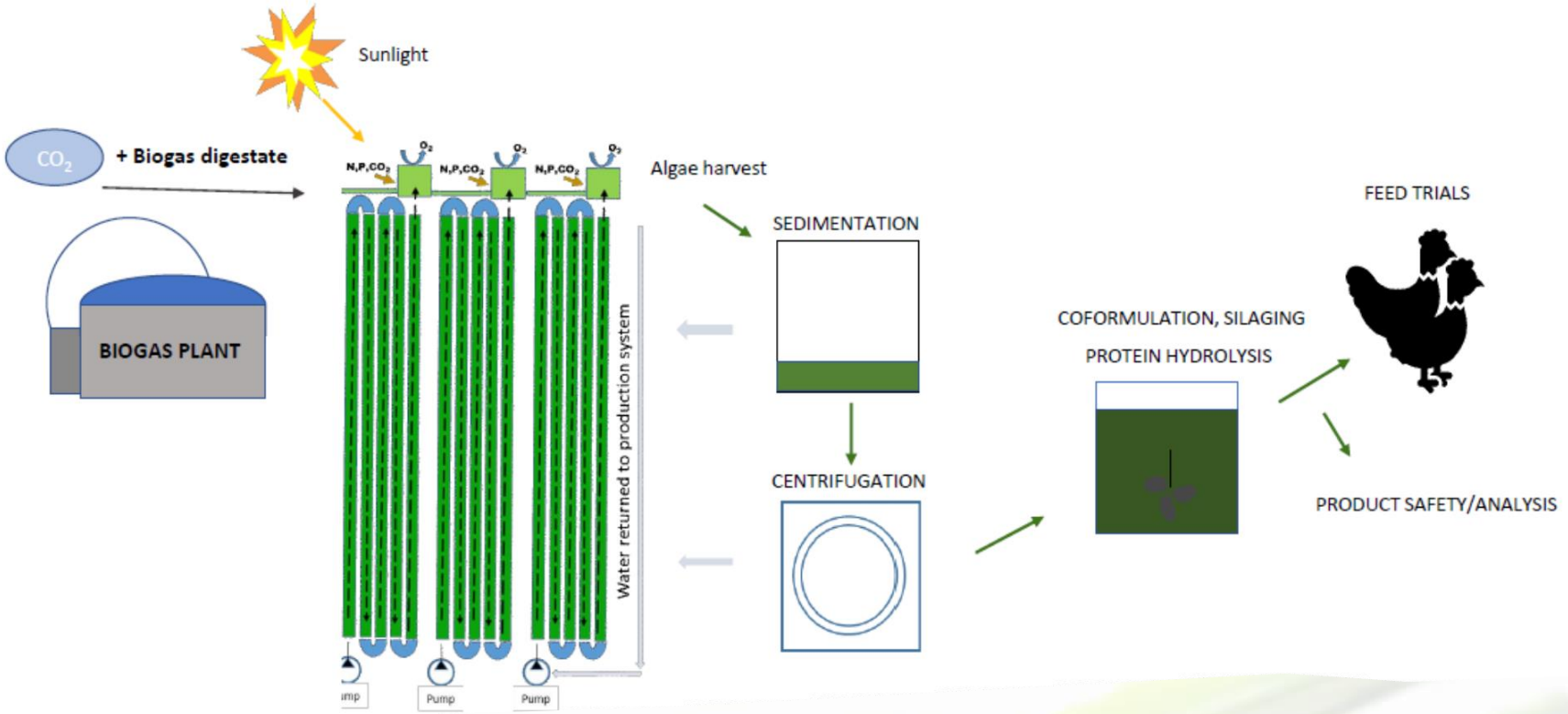
- production of microalgae as SCP requires controlled cultivation
- waste streams of high quality (food and feed producing and processing industry)
- rely on inorganic NP fertilizers → in photobioreactors 100 % efficiency
- mostly used production systems are closed tubular photobioreactors
- mixotrophic cultivation



Tubular photobioreactors

TEKNOLOGISK INSTITUT

REMAPP PROJECT



- 1 ha algae production system will yield about 39 ton algae biomass (dm) and 17 ton protein per year of 10 month of production.
- This will require a supply of in the range of 60 ton CO2 and 545 m^3 biogas digestate.
- Based on the estimated size of the Danish biogas industry in 2020 it is possible to supply a production of 140.570 ton algae protein per year.

TEKNOLOGISK INSTITUT

MICROALGAE ON THE MARKET

- European Food market - strict set of rules must be followed – food safety
- submission and approval as Novel food is a time consuming and expensive process
- big barrier to the market
- limited number of microalgae strains and ingredients approved as novel food

Species for novel food	Appl. date	Status	Final decision
Chlorella vulgaris		Consumed prior 1997	Approved 1997
Chlorella pyrenoidosa		Consumed prior 1997	Approved 1997
Chlorella luteoviris		Consumed prior 1997	Approved 1997
Arthrospira platensis		Consumed prior 1997	Approved 1997
Odontella aurita	2002		Approved 2002
Tetraselmis chui	2011		Approved 2014
Nannochloropsis gaditana	2011		Pending
Euglena gracilis	2018	Positive report of EFSA_March_2020	
Additives/supplements			
Ulkenia sp. oil	2004		Approved 2009
Dunaliella salina oil (additive and supplement – E 160a (iv) or food orange5)	1977		Approved 1997
Astaxanthin-Rich Oleoresin from *Haematococcus pluvialis*	2014	Positive report of EFSA_Dez_2019	Approved 2019
EPA-rich oil derived from the microalgae *Phaeodactylum tricornutum*	2016	Negative report of EFSA_June_2019	
Euglena gracilis food supplement		Positive report of EFSA_March_2020	
Phycocyanin from *Arthrospira platensis* (food colorant – additive)			Approved 2013

CHLORELLA ICE CREAM

- made with *Chlorella* protein concentrate
- more B12 and iron than most dairy and plant-based alternatives
- *Chlorella vulgaris* - European Food Safety Authority (EFSA) approved as food ingredients
- white cheese

Sophie's BioNutrients Develops Chlorella Ice Cream with More Iron and B12 Than Cow's Milk

November 10, 2022

©Sophie's BioNutrients

TEKNOLOGISK
INSTITUT

CONCLUSION AND FUTURE DIRECTION

The advantages of growing microalgae:

- minimal land use
- high growth rates
- high content of protein

Cost reduction of microalgae cultivation:

- large-scale application is currently limited by costs
- materials, equipment, power are substantial
- reduce the cost by increasing the photosynthetic efficiency
- strain selection (strain development)

QUESTIONS?

MICROALGAE	MASS PERCENT (%)	OTHER PROTEIN PRODUCT	MASS PERCENT (%)
Chlorella vulgaris	51 – 58	dried skimmed milk	36
Galdieria sulphuraria	62	soy flour	37
Tetraselmis chui	31 – 46	chicken	24
Nannochloropsis oceanica	35 – 44	fish	24
Dunaliella salina	50 – 80	peanuts	26

Species for novel food	Appl. date	Status	Final decision
Chlorella vulgaris		Consumed prior 1997	Approved 1997
Chlorella pyrenoidosa		Consumed prior 1997	Approved 1997
Chlorella luteoviris		Consumed prior 1997	Approved 1997
Arthrospira platensis		Consumed prior 1997	Approved 1997
Odontella aurita	2002		Approved 2002
Tetraselmis chui	2011		Approved 2014
Nannochloropsis gaditana	2011		Pending
Euglena gracilis	2018	Positive report of EFSA_March_2020	
Additives/supplements			
Ulkenia sp. oil	2004		Approved 2009
Dunaliella salina oil (additive and supplement – E 160a (iv) or food orange5)	1977		Approved 1997
Astaxanthin-Rich Oleoresin from *Haematococcus pluvialis*	2014	Positive report of EFSA_Dez_2019	Approved 2019
EPA-rich oil derived from the microalgae *Phaeodactylum tricornutum*	2016	Negative report of EFSA_June_2019	
Euglena gracilis food supplement		Positive report of EFSA_March_2020	
Phycocyanin from *Arthrospira platensis* (food colorant – additive)			Approved 2013