Microalghe negli alimenti: stato dell'arte e prospettive future

Vincenzo Fogliano

Food Quality & Design, Wageningen University

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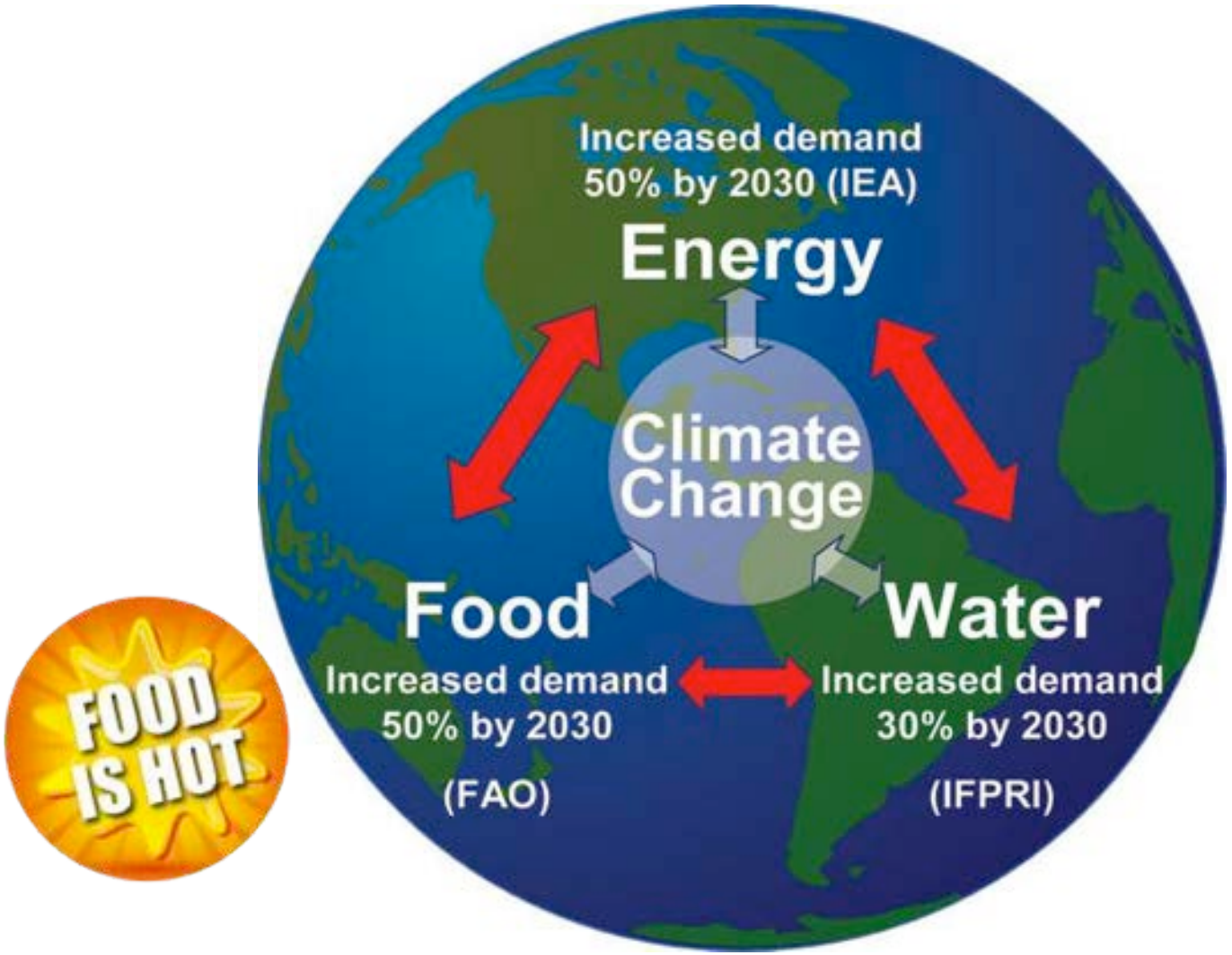
Pordenone, 27 January 2017

Food security: A massive challenge



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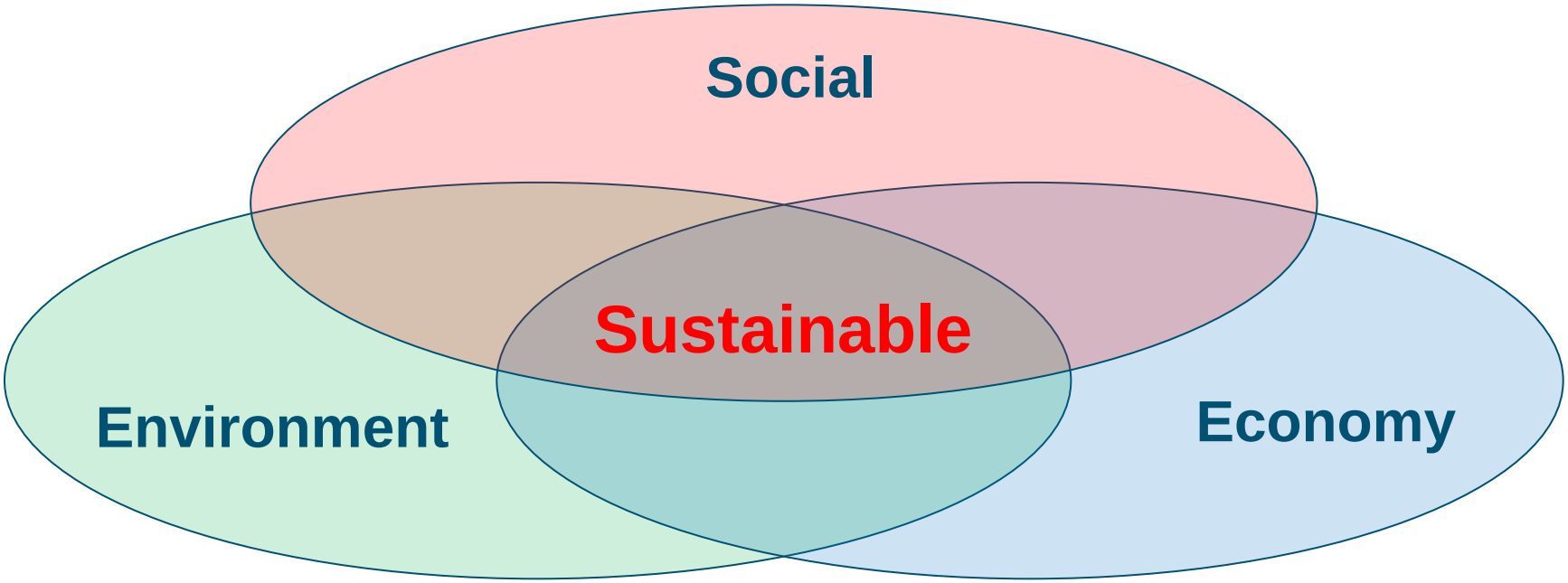
Outlook towards 2050

- 2,4 billion people more in 2050
- Average income is rising in many developing countries
- Food consumption per person increases
- Food demand increases by more than 50% (1,1%/year)
- There is a shift towards more animal products in the diet
- Undernourishment 800 million people (decreasing)

Sustainability

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Our Common Future, 1987



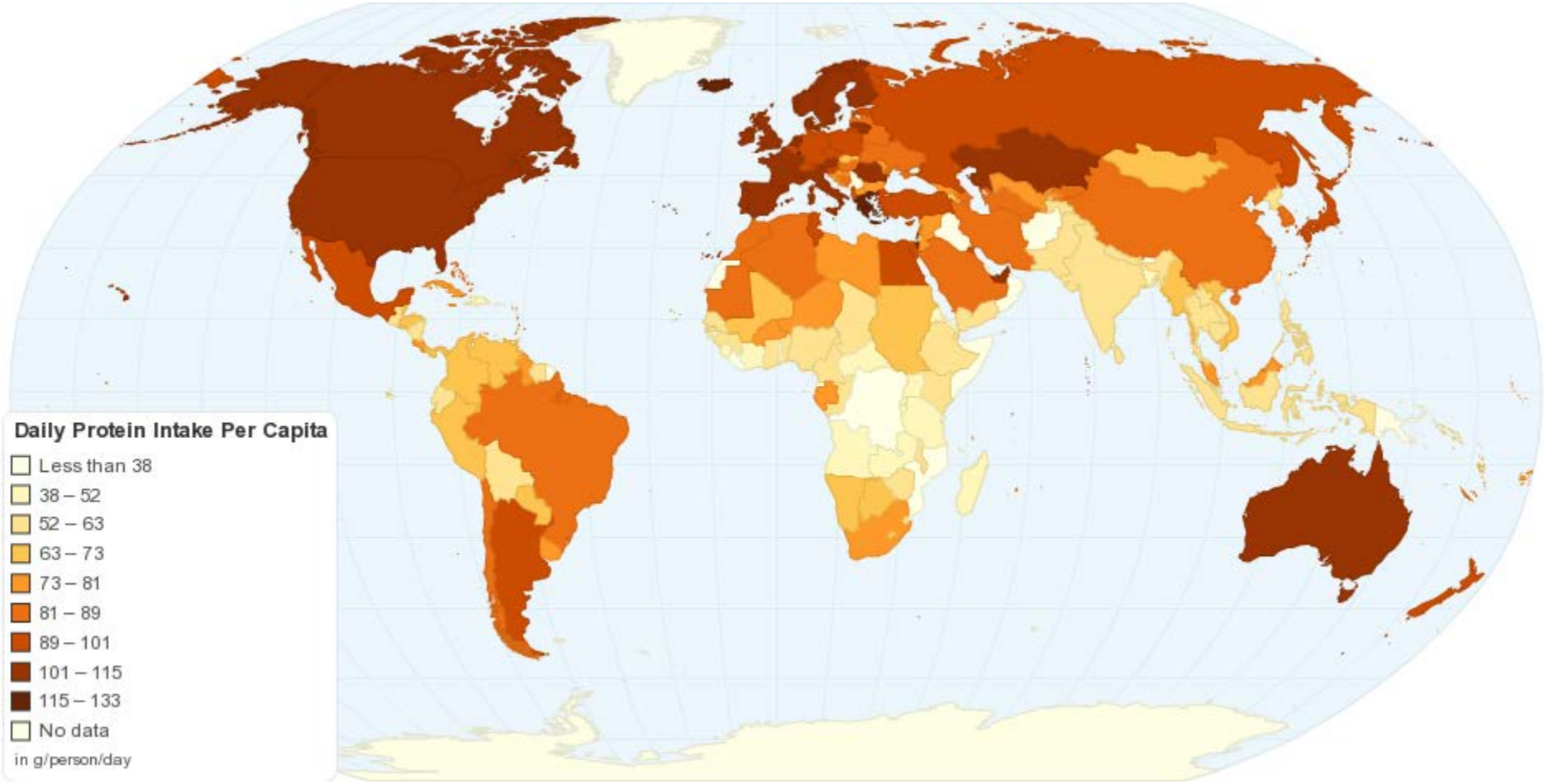
Shifting the paradigm of food security: from calories to nutrients

Importance of protein for food security

FAO 2013

*"As the world's population increases rapidly and against the constraints of limiting land, water and food resources, it is more important than ever to be able to define accurately the **amount and quality** of protein required to meet human nutritional needs"*

Daily protein intake



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We must produce more proteins!

Food security is mainly an issue of proteins

How to provide enough proteins in the diet

The Wageningen SHARP diet principles (EU SHARP project)

- **S**ustainable
- **H**ealthy
- **A**ffordable
- **R**eliable
- **P**referable

Table proteins in different foods

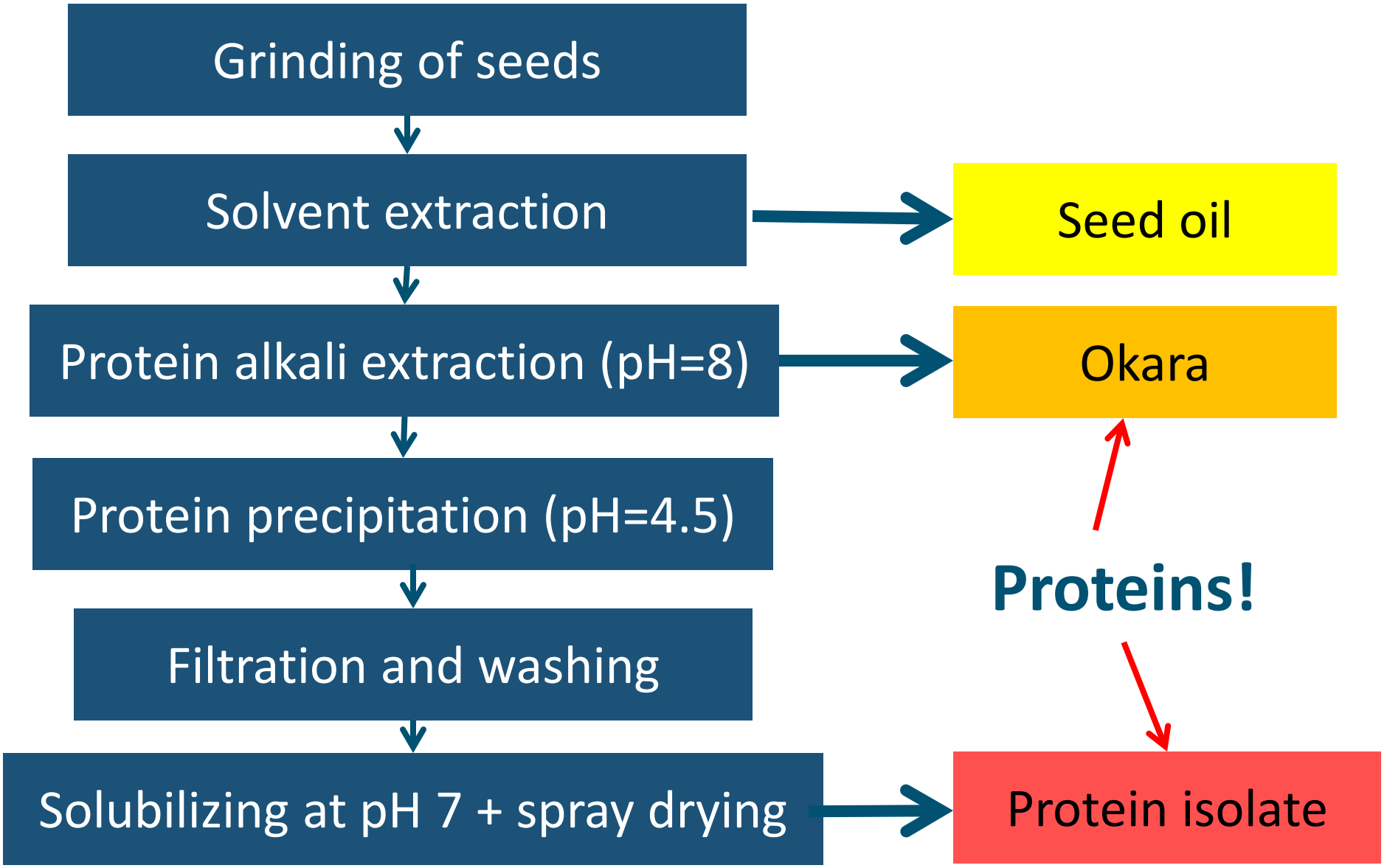
Food	% protein (dry matter)
Meat & fish	67
Eggs	47
Soybean	42
Peanuts	37
Wheat	**12**
Corn	**11**
Rice	**8**

Food	% protein (dry matter)
Insects	40-75%
Microalgae	**25-70%**
Yeast	65-70%
Quorn (mycoproteins)	40-50%
In vitro meat	??
Protein isolates	50-80

Ensure SHARP diet using food? Not realistic.

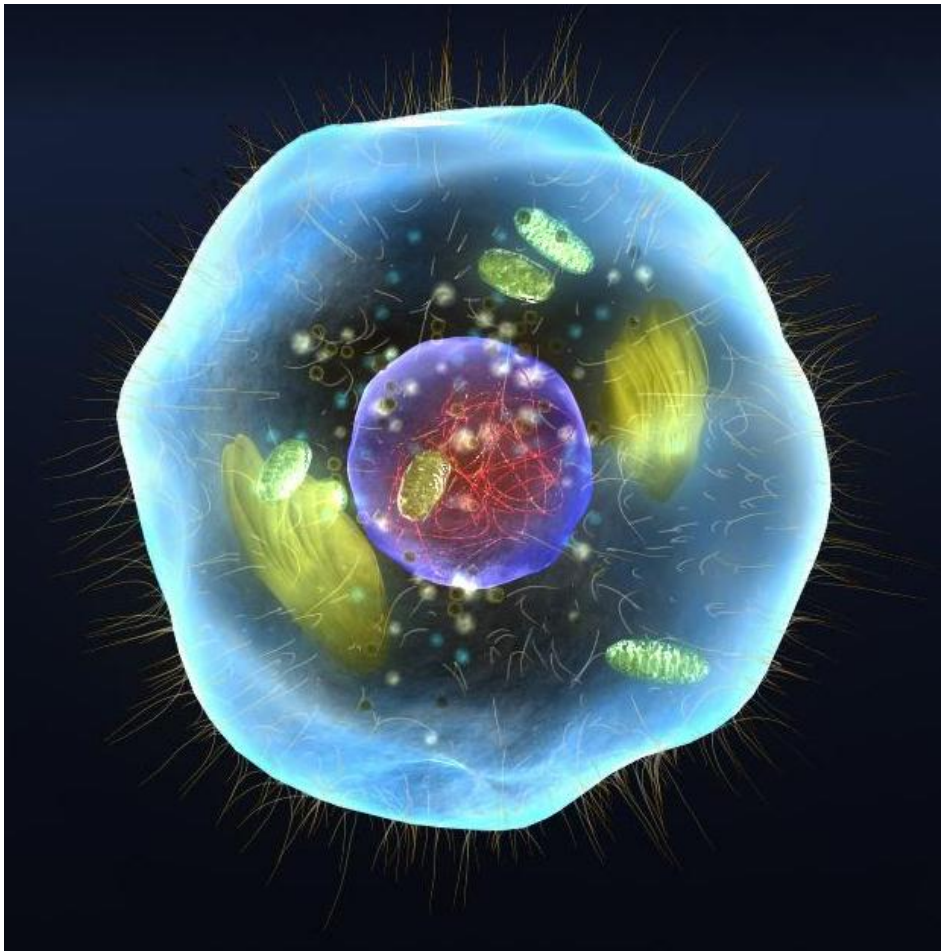
Let's try to do it with protein-rich ingredients

Protein-rich ingredients from Soybean (legumes)



The higher the concentration of proteins in the starting material the easiest is the isolation process

What about single cells?



A list of the micro-organisms used for SCP production

Fungi

- *Aspergillus fumigatus*
- *Aspergillus niger*
- *Rhizopus cyclopium*

Yeast

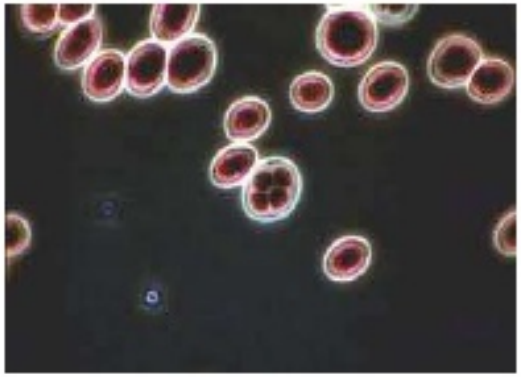
- *Saccharomyces cerevisae*
- *Candida tropicalis*
- *Candida utilis*

Algae

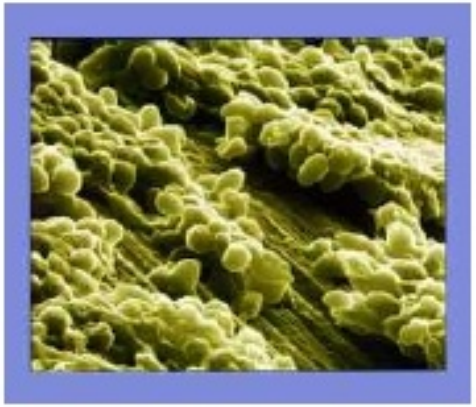
- *Spirulina sps.*
- *Chlorella pyrenoidosa*
- *Chondrus crispus*

Bacteria

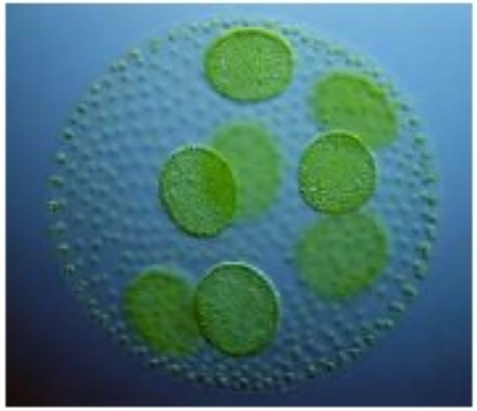
- *Pseudomonas fluroescens*
- *Lactobacillus*
- *Bacillus megaterium*



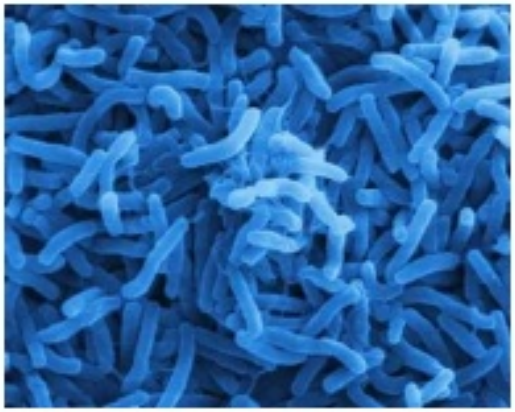
FUNGI



YEAST



ALGAE



BACTERIA

Gli ingredienti da microalghe offrono grandi opportunità....

Food & Function

ROYAL SOCIETY OF CHEMISTRY

REVIEW

Cite this: *Food Funct.*, 2014, 5, 1669

Functional ingredients from microalgae†

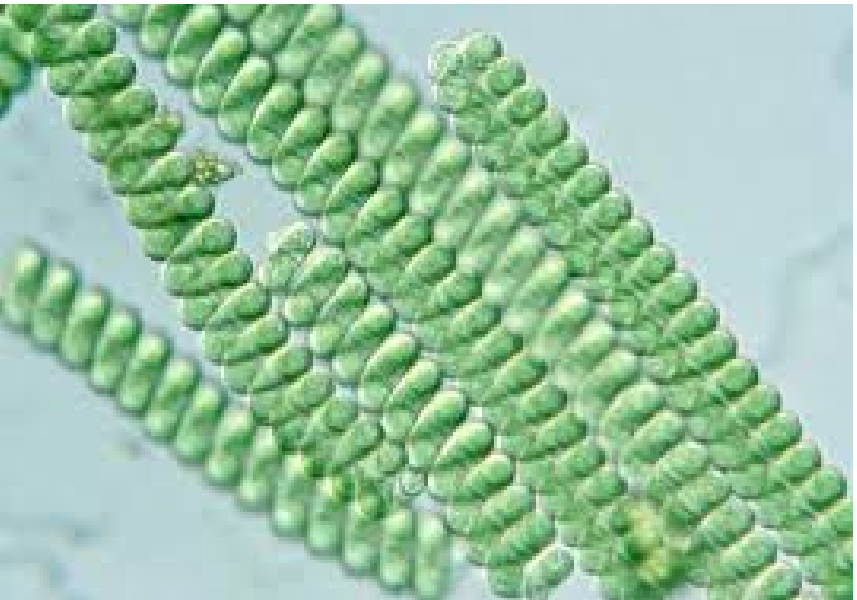
Silvia Buono,*[a] Antonio Luca Langellotti,[a] Anna Martello,[a] Francesca Rinna[a] and Vincenzo Fogliano[b]

Advantages of microalgae

- Very flexible metabolism: could be oriented for the production of protein, lipids, carotenoids, (bio)colorants
- Use of non-arable land (no competition with other food sources)
- Use of waste/salty water
- In some species proteins are relatively easy to extract
- High consumer acceptance

Microalgae for food application

- Several species: Dunaliella, Chlorella and Spirulina
- Protein content up to 70%
- Price of the biomass between 10 and 100 Euro per Kg



Main microalgae commercialized for human nutrition: still a small niche (thousands tons)

Microalga	Products
Spirulina (Arthrospira)	powders, tablets, extracts chips, pasta
Haematococcus pluvialis	powders, extracts
Chlorella	tablets, powders, nectar, noodles
Dunaliella salina	powders β-carotene
Aphanizomenon flos-aquae	capsules, crystals, powder

Microalgae food markets

Healthy Foods

Protein shakes, Juice drinks, Energy bars, cereal products, pasta (relevant amount?)

Food Supplements / Nutraceuticals

Whole microalgae biomass, DHA and EPA oils, antioxidants mixtures.

Food Ingredient

Proteins, oils, pigments,

Microalgae ingredients: Proteins

- Microalgae biomass have plenty of proteins having a good amino acids profile
- Traditional use for fortifications of cereal based meal
- Digestibility and technological/sensory properties still to be fully investigated

Comparative data on biological value (BV), digestibility coefficient (DC) net protein utilization (NPU) and protein efficiency ratio (PER), of differently processed algae (Becker, 2004; Richmond, 2004)

Alga	Processing	BV	DC	NPU	PER
Casein		87.8	95.1	83.4	2.50
Egg		94.7	94.2	89.1	–
Scenedesmus obliquus	DD	75.0	88.0	67.3	1.99
Scenedesmus obliquus	SD	72.1	72.5	52.0	1.14
Scenedesmus obliquus	Cooked-SD	71.9	77.1	55.5	1.20
Chlorella sp.	AD	52.9	59.4	31.4	0.84
Chlorella sp.	DD	76.6	89.0	68.0	2.00
Coelastrum proboscideum	DD	76.0	88.0	68.0	2.10
Spirulina sp.	SD	77.6	83.9	65.0	1.78
Spirulina sp.	DD	68.0	75.5	52.7	2.10

AD: air dried; DD: drum dried; SD: sun dried.

BV: Biological Value

NET: Net Protein Utilization

DC: Digestibility Coefficient

PER: Protein Efficiency Ratio

Microalgae ingredients: Lipids

In some microalgae, lipids represent more than 50% of the dry weight (biofuel issue)

Some species have an extremely high omega3/omega6 ratio

Good consumer perception

Contents lists available at ScienceDirect

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Functional ingredients produced by culture of *Koliella antarctica*

Vincenzo Fogliano [a,*], Carlo Andreoli [c], Anna Martello [a], Marianna Caiazzo [b], Ornella Lobosco [b], Fabio Formisano [a], Pier Antimo Carlino [a], Giuseppe Meca [a], Giulia Graziani [a], Vittoria Di Martino Rigano [b], Vincenza Vona [b], Simona Carfagna [b], Carmelo Rigano [b]

DHA Oil from *Schizochytrium*

produced by fermentation by Martek Biosciences as food ingredient for infant formulas, prenatal supplements, food and beverage products

Microalgae ingredients: pigments

Pigments allow microalgae to absorb the light at different wavelenght.

Beta Carotene and Xanthophylls.
The most popular Astaxhantin, taken from Haematococcus, which has a deep red color and it is widely used to improve the color of salmon meat

Chlorophyls are green pigments taken from Chlorella, and in general from all green microalgae

Phycobiliproteins are water soluble pigments extracted from blue –green microalgae. The major source is the Spirulina. Color is lost with severe thermal processes

Natural Food Colors and Pigments

Phycocyanin, water soluble blue color, is extracted from *spirulina*

Processed into Lina-Blue® for candies, cakes, gums and other foods that need a natural blue

Other colors are carotenoids from *dunaliella* and astaxanthin from *hematococcus*

Carotenoids and Antioxidants from Algae as Health Food Supplement

astaxanthin from *Haematoccus* and beta-carotene and mixed carotenoids from *Dunaliella*

Microalgae Biological Activity

Anti-Inflammatory

Mineral binding

Antimicrobical

Antioxidant

Antiviral

ACE-inhibitory activity

Antitumoral

Health claim EFSA rilasciato su Spirulina e glucose management

Importanti per nutraceutici e supplementi ma non molto per il food

Bottlenecks in the adoption of microalgae and microalgea ingredients

- **Scale up** of the production is theoretically simple, but it requires specific skills and high investment costs
- **Downstream technologies** are needed to lower the production costs of lipids (milking microalgae)
- **Chain approach** should be implemented (example pasta or other cereal based product)
- **Safety issue** (microalgae toxins by contaminated culture and heavy metals)

Who will win the battle as worldwide protein supplier?

Organism	Pro	Cons
Fungi	Easy to grow & harvest	Lower growth rate and low protein content
Microalgae	Metabolism Versatility Easy to grow & harvest High quality proteins Consumer acceptance	Non digestible cell wall Production costs Heavy metals
Yeast	Easy to scale up Consumer acceptability	Slow growth rate. Low protein content
Insects	Thousands of species. High conversion of feed into edible biomass	Consumer acceptability Scale up of rearing

Microalgae in foods: the time is now?

Thank you for your attention

Research team
Vincenzo Fogliano
Silvia Buono
Luca Langellotti
Anna Martello

Vincenzo.Fogliano@wur.nl

Silvia.buono@unina.it
Anna.martello@unina.it

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