« Workshop on Aquatic food products and new marine value chains »

FOOD 2030 CONFERENCE

Potential of New Algae Value Chains for Food

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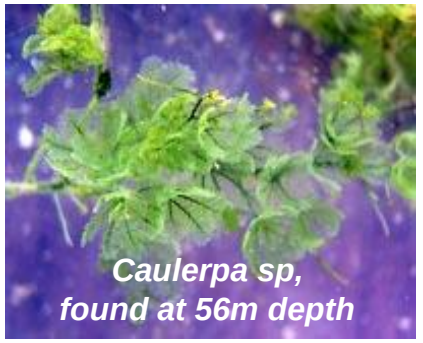
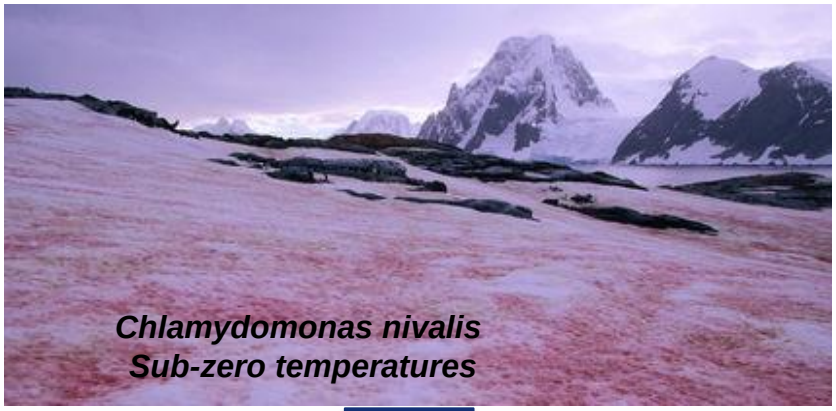
12 October 2016

Facts and Figures

80,000 – 100,000 different algal species (~25,000 macroalgae)

But only ~200 used world-wide





Uses

Chlorella in bread

Spirulina drinks

Dunaliella capsules

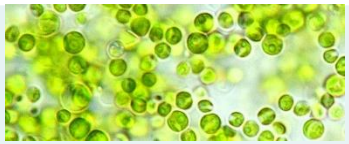
Spirulina powders, capsules

Microalgal cooking oils

Seaweed foods a long history

Alga	High value molecule	Whole alga
Dunaliella	β-carotene	Food supplement
Haematococcus	Astaxanthin	Food supplement/ingredient
**Arthrospira platensis*	Phycocyanin	Dried alga food supplement
Nannochloropsis	EPA	
Schizochytrium	DHA	
Chlorella		Dried alga food; ingredient/supplement
Pavlova, Phaeodactylum, Chaetoceros, Skeletonema etc		Living feed for aquaculture

****Arthrospira,*** *known as* ***Spirulina****, has been described by the World Health Organization as one of the greatest superfoods on earth*

	Chlorella	Spirulina	Dunaliella
Alga			
Into large-scale commercial	1960s	1970's	1980's
Tonnes (dw) p.a.	2,000	5,000	3,000

Plus a handful of others

Microalgae: <20,000 Total tonnes (dw) p.a

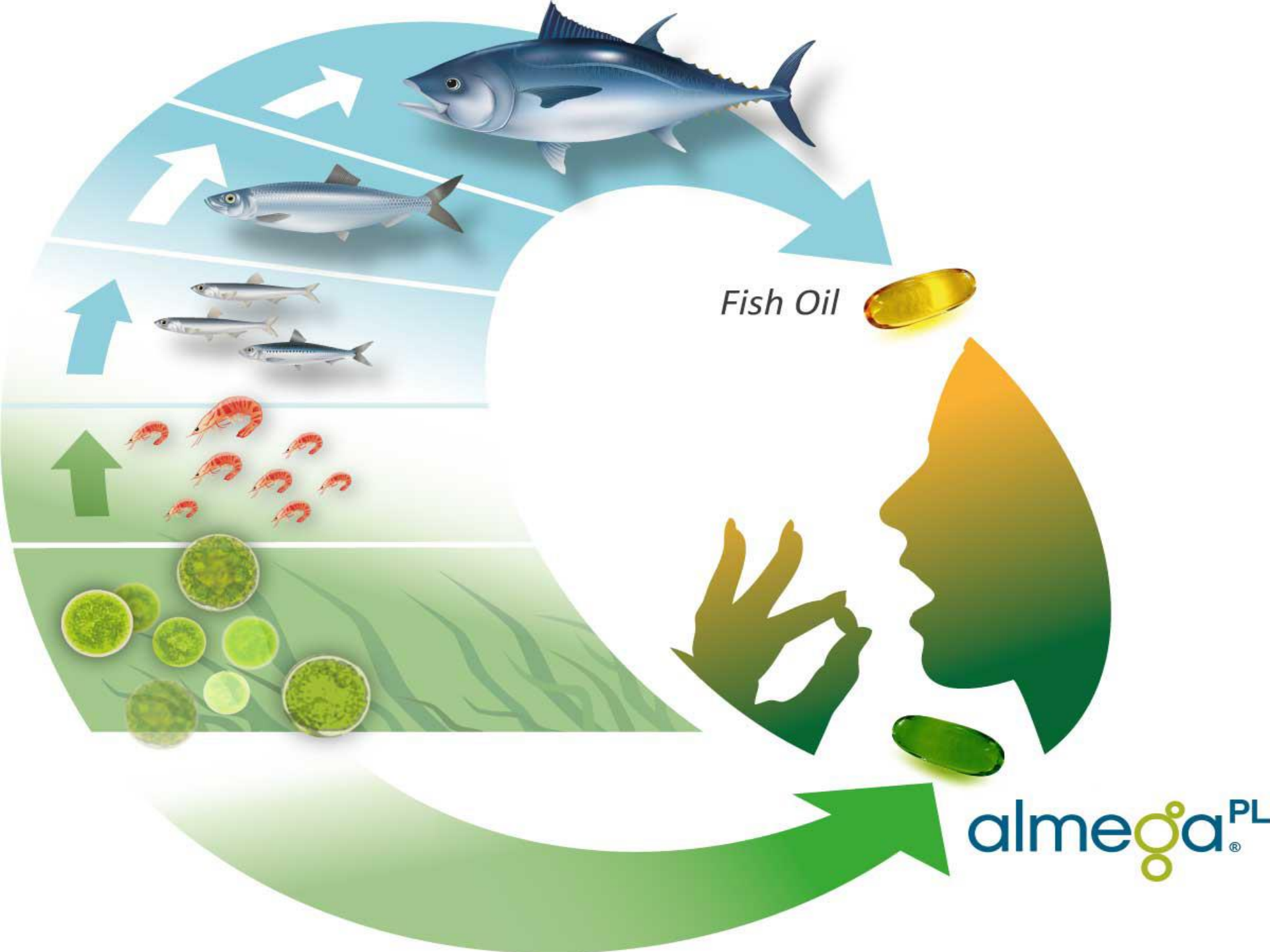
Macroalgae: ~100 x more

Wheat: ~70,000 x more

Value as Food

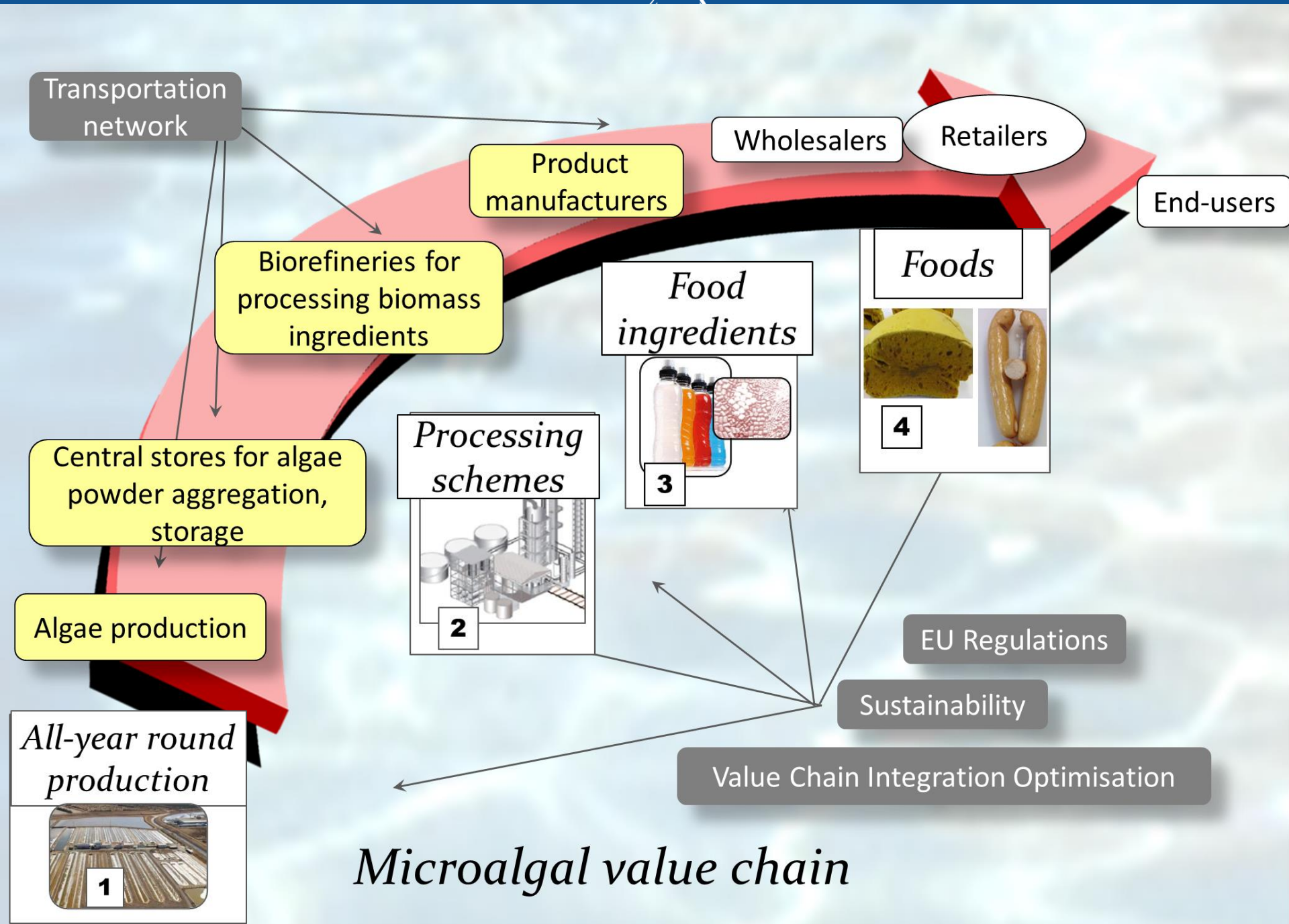
Species	Protein	Carbohydrates	Lipids
A. platensis	63	15	11
D. salina	57	32	20
C. vulgaris	51-58	12-17	14-22
Nannochloropsis	28	36 (β-glucan)	18
H. pluvialis	48	27	15
Soya	37	30	20

- Amino acid profile acceptable
- Carbohydrates – starch - available
- Fatty acids (C12-C22) – include DHA and EPA PUFAs


Fish Oil
almega PL®

STATE OF KNOWLEDGE:
MAIN CHALLENGES REGARDING THE TOPIC?
MAIN GAPS IN RESEARCH?

Looking at the whole value chain



Microalgal value chain

All-year round production

European Commission

Upstream cultivation – at scale

CO_2 supply

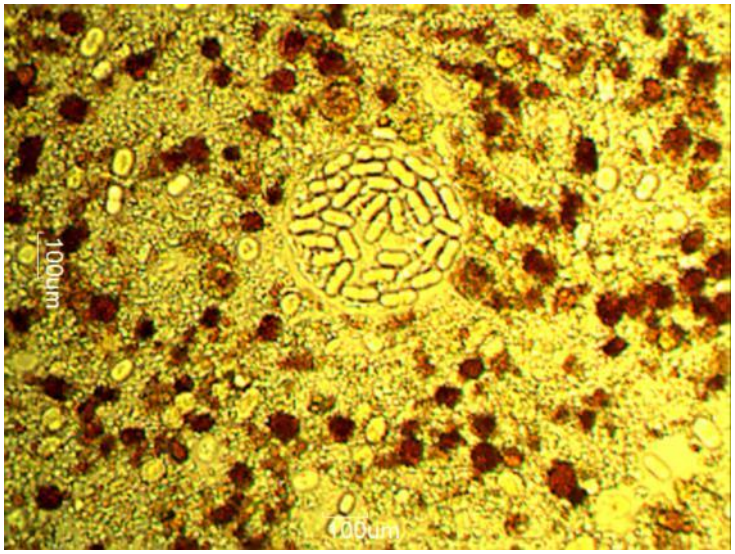
nutrients | temperature | water

irradiance | Mixing rate | O_2 accumulation

- Microalgal biomass productivity should be ~25 g $m^{-2}d^{-1}$.
- <10 g $m^{-2}d^{-1}$ is normally achieved

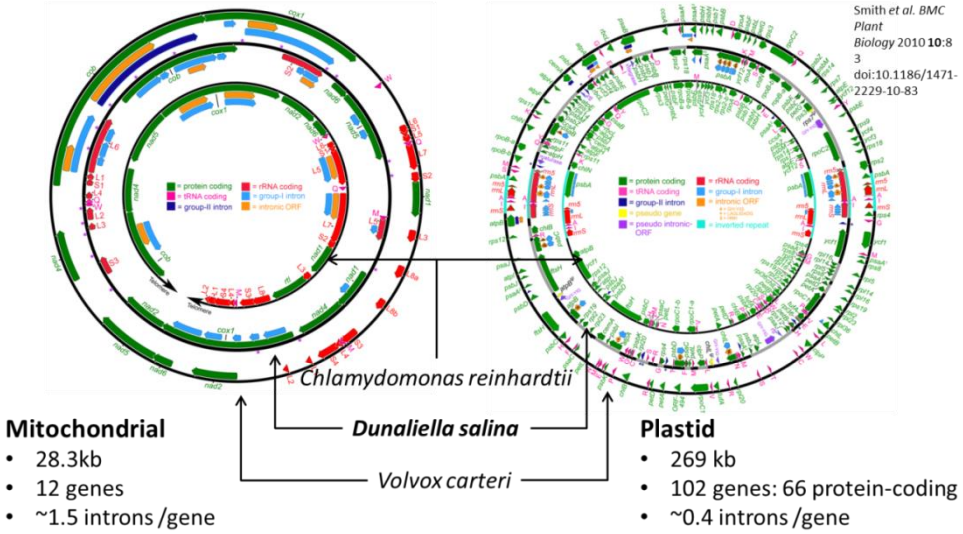
Site-specific biological surprises, which need to be controlled

Fragility of algae, which needs to be respected



What to grow? Strains

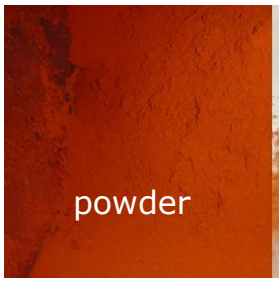
- *Complex genomes & confused taxonomy*
  - **Genome sequence information lacking**
  - **Possible horizontal gene transfer as well**

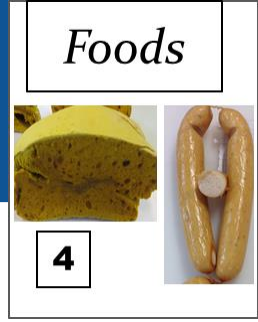


Processing "know-how" is new

- *Harvest large volumes*
- *Feedstock variability*
- *Experience in handling algal powders, pastes at scale*
- *New technologies –no organic solvents*
- *Shelf-life*
- *Analysis*





New food applications needed

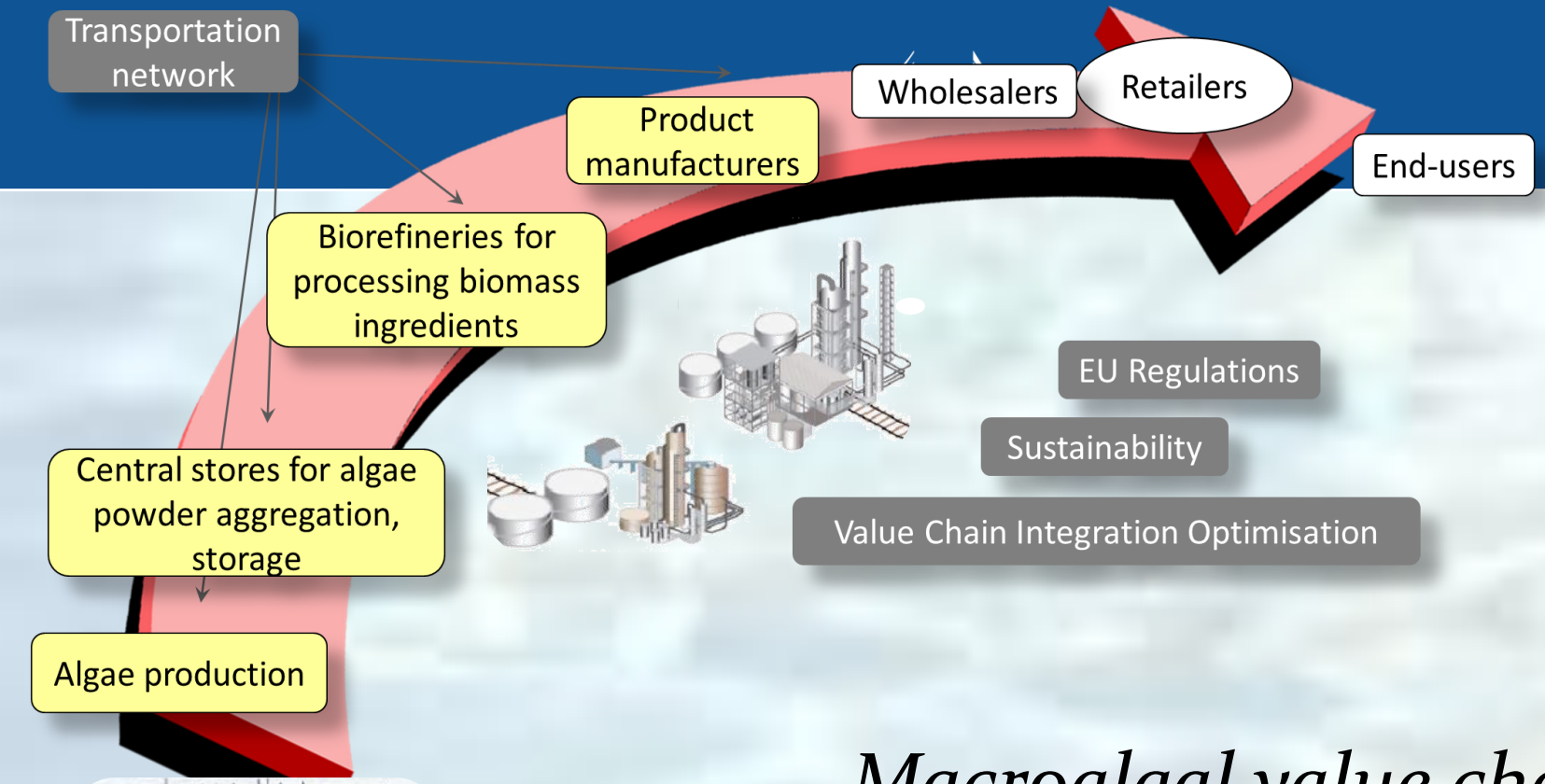
Increasing amounts of algal process residue

- *Performance in blends*
- *Texture*
- *Taste*
- *Smell*
- *Shelf-life*

Different fractions of algal process residue

Fish sausage data courtesy H. Hondo, M. Ehmell, SP

Bread data courtesy, M Berta, I Koelewiin, T Malin SP



Macroalgal value chain: similar challenges

- *Which varieties to breed?*
- *Alien species, diseases?*
- *Complex coastal management?*
- *Biomass seasonality – storage?*
- *Processing methods?*
- *Regulations, sustainability, optimisation*

Milledge JJ, Harvey PJ (2016) Potential process 'hurdles' in the use of macroalgae as feedstock for biofuel production in the British Isles. J Chem Technol Biotechnol 91:2221-2234

Highlights from workshop discussion

- *Production - what types and where? Climate change may bring increased saline water areas on land*
- *Processing know-how is still underdeveloped*
- *Farming know-how needs to be conducted in a cost-effective manner*
- *Contamination needs to be managed*
- *Genomics opportunities exist for developing non-GMO strains*

WHAT ARE THE MAIN NON-TECHNICAL BARRIERS (E.G. REGULATORY, MARKET COSTS, SOCIAL)?

- ***Novel Foods Regulation*** *(EU) 2015/2283, 25 Nov 2015*
- ***Consumer acceptance*** *– China has a long history of acceptance; Europe, novel*
- ***Skills*** *–to increase investment confidence in algae production for food*
- ***Spatial planning*** *– where can we cultivate what/at what scale?*
- ***Value chain integration optimisation -*** *– across all parts of the chain*
- ***Proof of sustainability:*** *(C footprint, water footprint, nature conservation, social implications).*
- ***Knowledge –*** *awareness raising that aquaculture could benefit if the commodity price / sustainability can be met*
- ***Business Models*** *– can we learn from Asia?*
- ***Investor confidence –****especially in farming*
- ***Costs of producing food as commodity***

SCIENTIFIC PRIORITIES FOR DEVELOPING FURTHER THE SECTOR?

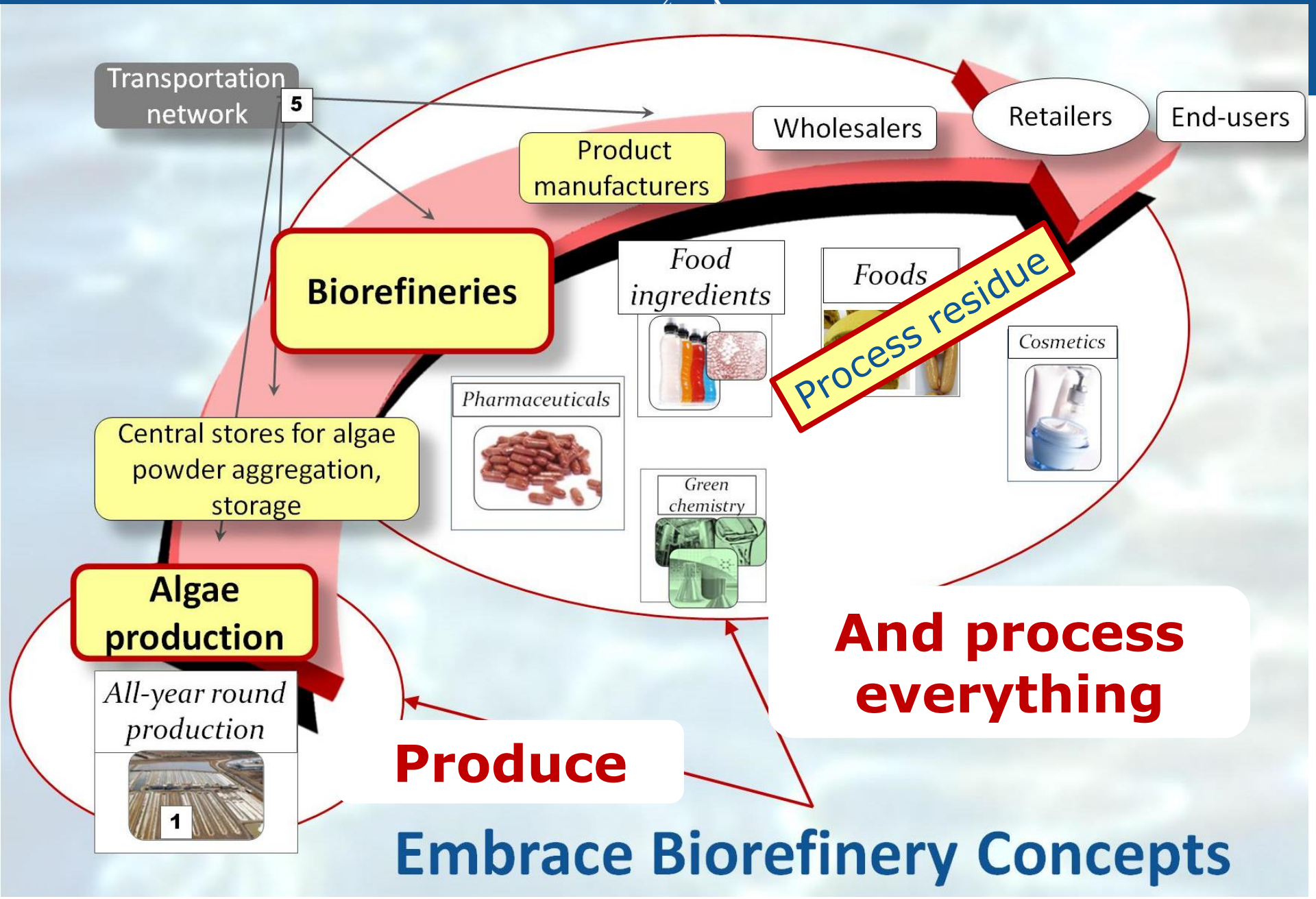
European Commission

Area	Scientific Priority
Upstream	• Develop large-scale systems • Increase photoautotrophic growth rate • Sustainable all-year-round production • Develop low-cost, continuous harvesting • Manage process water • Co-operate: North-South
Strains	• Increase knowledge of algal metabolism and regulation to *design* • Embrace CRISPR/Cas9 technology for genome editing
Downstream	• Develop large-scale high volume processing • Use non-fossil safe processing solvents
Products	• Capitalise on trend for natural products, healthy sustainable eating, meeting EU regulations • Develop a Biorefinery approach with a Product Platform of high-value products as well as commodities
Value chain	• Replace fish feed soya with algae biorefinery residues • Increase value of outputs, decrease costs of inputs, sustainably

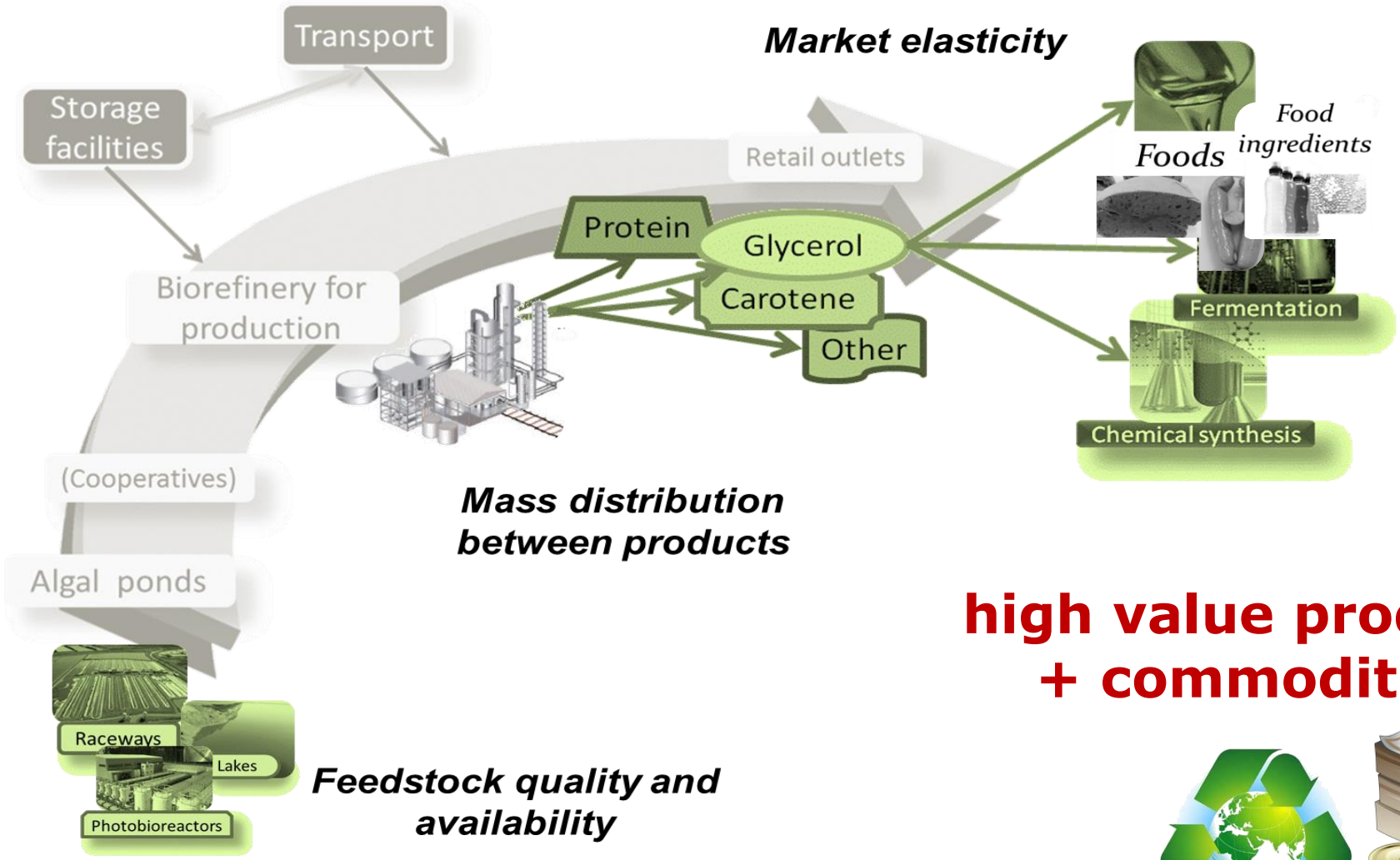
POSSIBLE ACTIONS AT SHORT AND MEDIUM TERM TO HELP AND/OR EXPAND THE SECTOR

Possible actions at short and medium term to help and/or expand the sector

1. *Consumer campaign:*
   - **Chefs,**
   - **"VIPs"**
   - **Policy Makers,**
   - **Investors**
2. *Education*
3. *Biorefineries approaches*
4. *Demonstrator projects*


Transportation network
5
Wholesalers
Retailers
End-users
Product manufacturers
Biorefineries
Food ingredients
Foods
Process residue
Cosmetics
Pharmaceuticals
Green chemistry
Central stores for algae powder aggregation, storage
Algae production
All-year round production
1
And process everything
Produce
Embrace Biorefinery Concepts

Understand, develop
Product platform *and* Markets



high value products + commodities

And apply sustainability assessments to improve algae pathways including LCA, carbon and water footprints

D-Factory Consortium

www.d-factoryalgae.eu/

D-Factory: Funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 613870
MacroBioCrude: Funding from EPSRC http://gtr.rcuk.ac.uk/projects?ref=EP%2FK014838%2F1

Thank You

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