15th International Seaweed Conference EU
Seagriculture
16 - 18 JUNE 2026
GOTHENBURG, SWEDEN

CHALMERS

Towards seaweed as a key player in our future food system!

Ingrid Undeland

Professor of Food Science

Department of Life Sciences-Food and Nutrition Science, Chalmers University of Technology, SE

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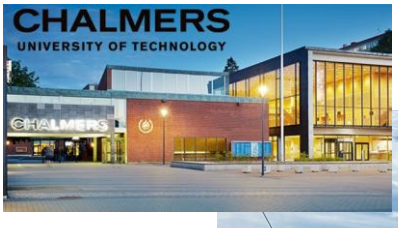

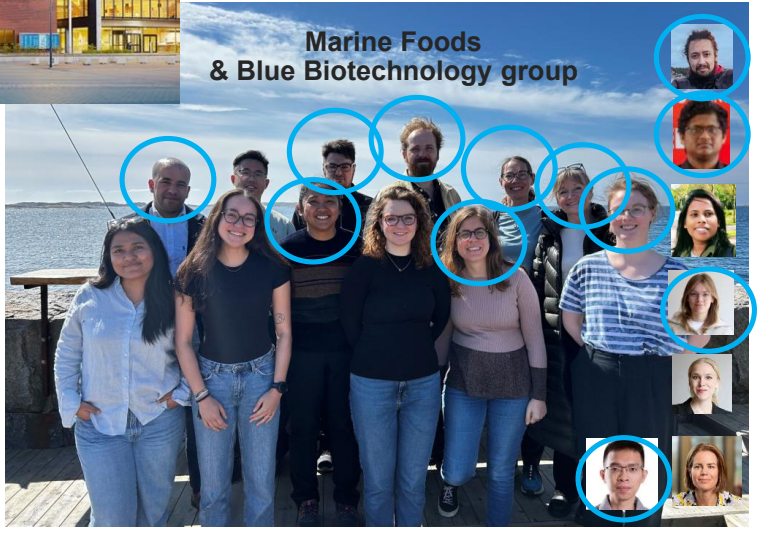

Our seaweed journey since 2013

seafarm

SWEAWEED

CirkAlg

BioAssess

AlgaeSynthesis

SensAlg

MAREFINE

Seaweed4GutHealth

SUSWEED

AlgFlavor

SWAP

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UNIVERSITY OF GOTHENBURG

KTH VETENSKAP OCH KONST

Kristianstad University

Uppsala universitet

NORDIC SEAFARM

SWEDEN PELAGIC

RI. SE

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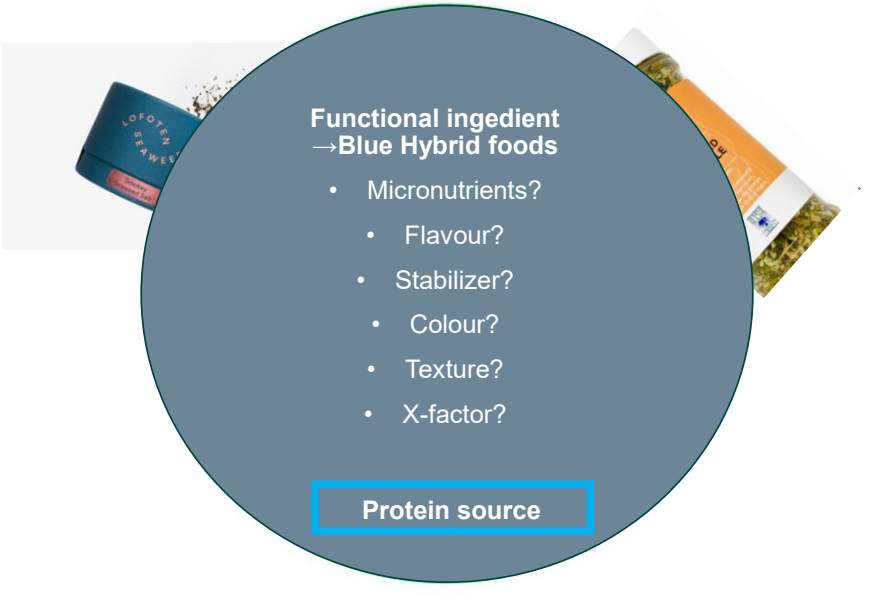
Seaweed –the chameleon!



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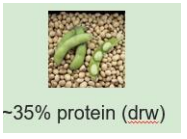

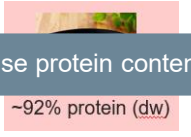

Raise protein content & Protein ingredient recovery

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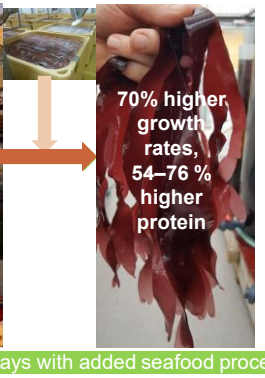
Protein boosting by cultivation with liquid seafood side streams

Poster!



14 days with added seafood process waters

Now to be up-scaled in the SWAP project

R. Wang

Post harvest cultivation in herring process waters → 30-40% higher biomass yields and protein levels raised **3-5 times up to 38%** !

Stedt, K., et al. *Frontiers in Marine Science*, 2022, *9*, 988523.; Steinhagen et al., *Future Foods*, 100347, 2024; Stedt, et al., 2022. *Algal Research*, *63*, p.102647; Stedt, K., et al. (2025). *Algal Research*, 104371..

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Ulva –a future protein provider?

- Higher **productivity** than soybean: ≥4.0[a] vs 2.5 tons dw ha^{-1} year^{-1}
- Highly **adaptable** to different abiotic factors
- Positive results with **protein boosting**
- But, protein trapped in **complex cellular architecture** and presence of **antinutrients**

→ Extraction of a protein ingredient

[a]Open-sea farmed *U. fenestrata*. Personal communication from Nordic Seafarm;

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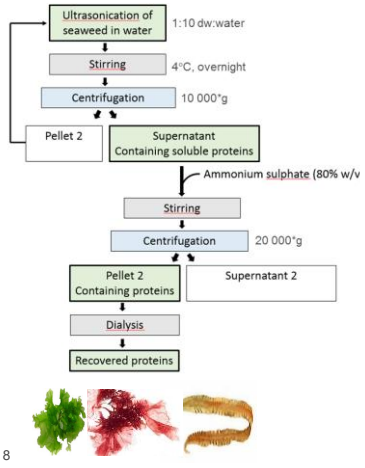
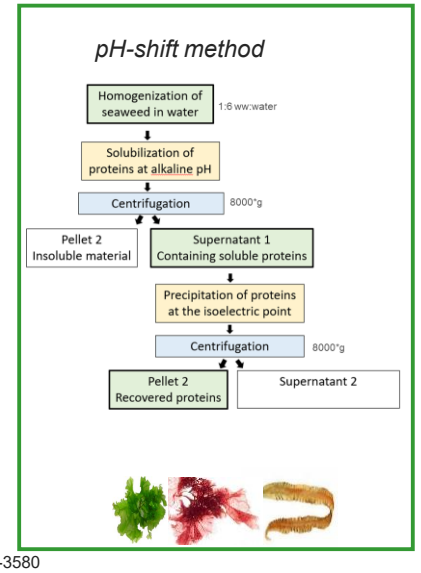
Hanna Harrysson

Comparison of the pH-shift method to other methods using *Porphyra, Ulva, Saccharina*

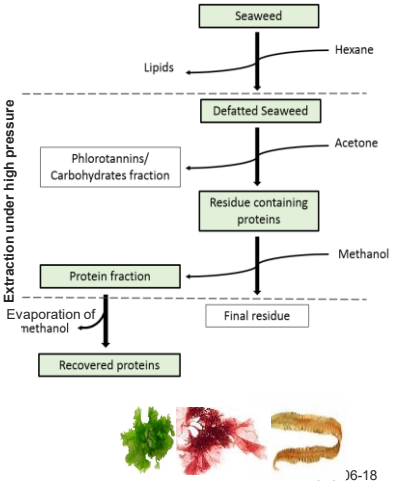
"Traditional method"



pH-shift method



ASE- method



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Harrysson et al. *J Applied Phycol* (**2018**) 30: 3565-3580

8

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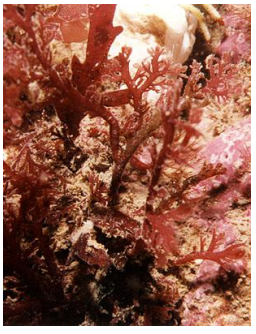
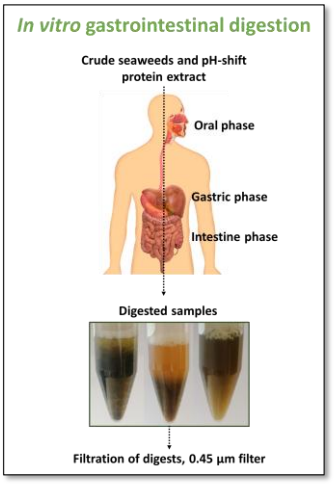
Are extracted proteins more digestible?

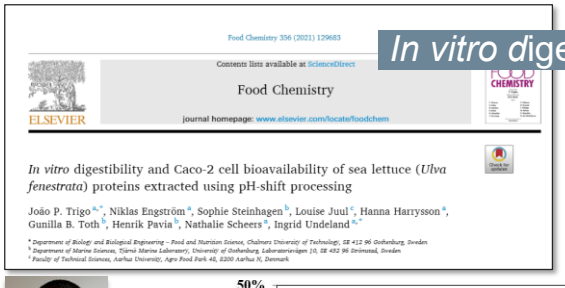




9 Trigo, J. P., Engström, N., Steinhagen, S., Juul, L., Harrysson, H., Toth, G. B., ... & Undeland, I. (**2021**). *Food Chemistry*, *356*, 129683.

I Undeland, Seagriculture, 2026

In vitro digestibility of seaweed proteins



Food Chemistry 356 (2021) 129683

Contents lists available at ScienceDirect

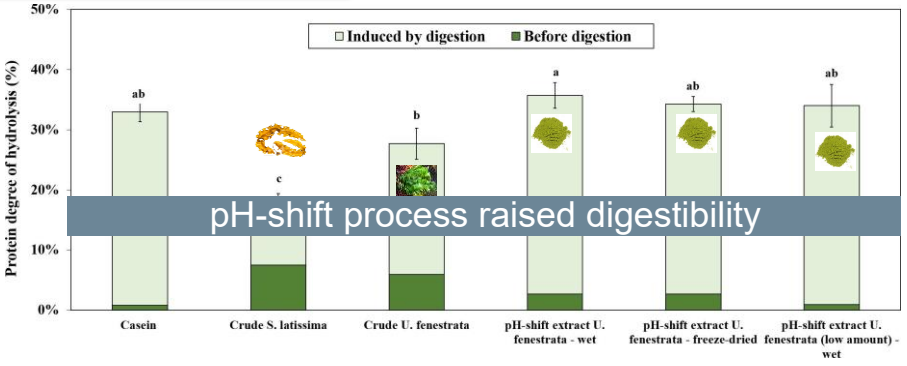
Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

In vitro digestibility and Caco-2 cell bioavailability of sea lettuce (*Ulva fenestrata*) proteins extracted using pH-shift processing

João P. Trigo [a,*], Niklas Engström [a], Sophie Steinhagen [b], Louise Juul [c], Hanna Harrysson [a], Gunilla B. Toth [b], Henrik Pavia [b], Nathalie Scheers [a], Ingrid Undeland [a,*]

Joao Trigo



pH-shift process raised digestibility

10 Trigo, J. P., Engström, N., Steinhagen, S., Juul, L., Harrysson, H., Toth, G. B., ... & Undeland, I. (**2021**). *Food Chemistry*, *356*, 129683.

Hanna Harrysson

Comparison of the pH-shift method to other methods using *Porphyra, Ulva, Saccharina*

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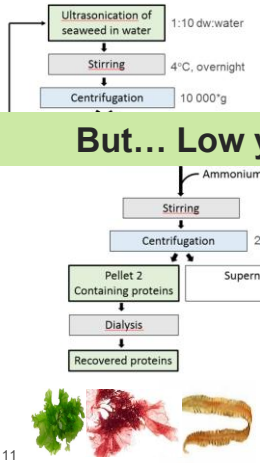
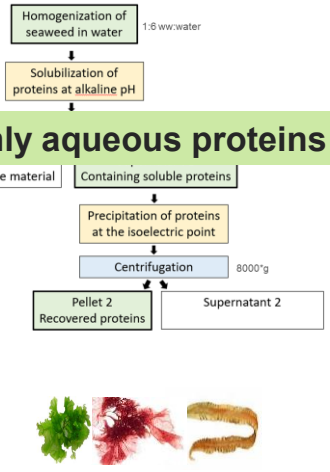
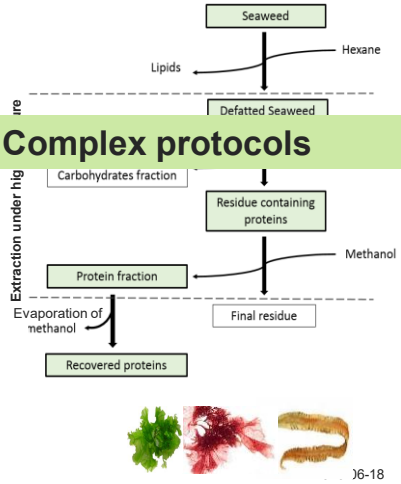


pH-shift method



ASE- method



But… Low yield - Mainly aqueous proteins - Complex protocols

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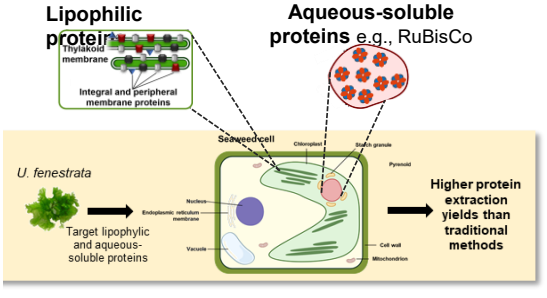
Harrysson et al. *J Applied Phycol* (**2018**) 30: 3565-3580

Can we recover both aqueous and lipophilic proteins?



Dr Joao Trigo

CirkAlg

Aim: Develop an efficient and more simplistic protein extraction method than current alternatives

Hypothesis: *Sequential use of surfactant-containing and alkaline solutions would solubilize lipophilic and aqueous-soluble proteins, thus increasing total extraction yields*

Figure from: JOÃO P. TRIGO PhD-thesis, Chalmers 2024 SEAWEED AS A SUSTAINABLE SOURCE OF FOOD PROTEIN *Maximizing seaweed protein content, protein recovery, and nutritional quality*

Food Chemistry 464 (2025) 141839

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

A new method for protein extraction from sea lettuce (*Ulva fenestrata*) via surfactants and alkaline aqueous solutions

João P. Trigo [a,*], Sophie Steinhagen [b], Kristoffer Stedt [b], Annika Krona [c], Simone Verhagen [a,d], Henrik Pavia [b], Mehdi Abdollahi [a], Ingrid Undeland [a]

[a] Department of Life Sciences - Food and Nutrition Science, Chalmers University of Technology, Gothenburg, Sweden
[b] Department of Marine Sciences - Tjärnö Marine Laboratory, University of Gothenburg, Strömstad, Sweden
[c] RISE - Research Institutes of Sweden, Agriculture and Food, Gothenburg, Sweden
[d] Department of Agrotechnology and Food Sciences - Biobased Chemistry and Technology, Wageningen University and Research, Wageningen, The Netherlands

- 3.4 times higher protein yields with **a surfactant**!
- Protein ingredient also up-concentrated in **Vit B12 and omega-3**

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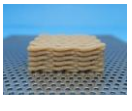




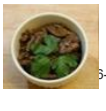

The blue-green sustainable proteins of seaweed may soon be on your plate

THU, NOV 14, 2024 07:00 CET

Report this content

G. Beltrame

Poster!

Can we co-extract other high-value molecules?

Multiple products from the same raw materials

- Increase revenue
- Diversify applications
- Currently, we evaluate **different orders of extraction for the below three compound groups**

MAREFINE

pigments

- Bioactives
- Food additives

ulvan

- Bioactives
- Biomaterial sciences, e.g. wound dressing

proteins

- Food industry

Beltrame et al. In manuscript

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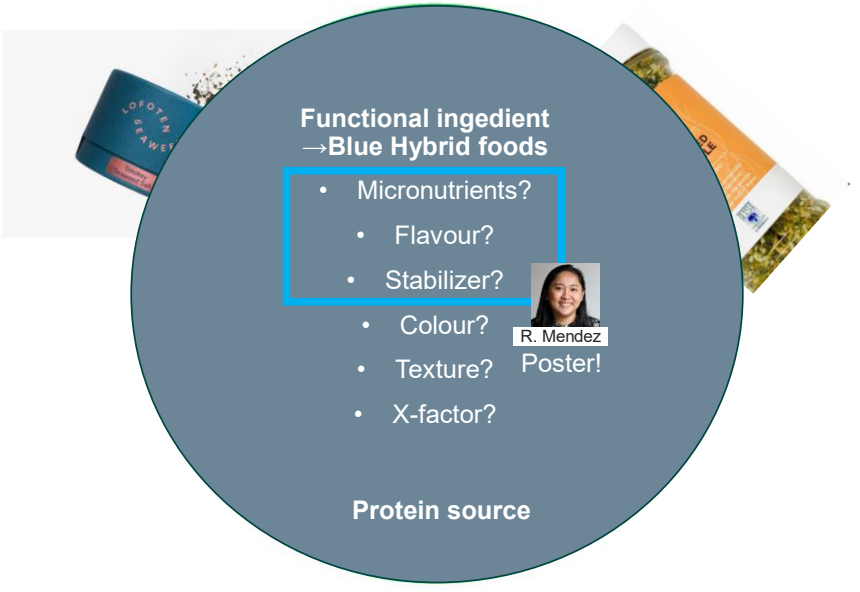
Seaweed –the chameleon!



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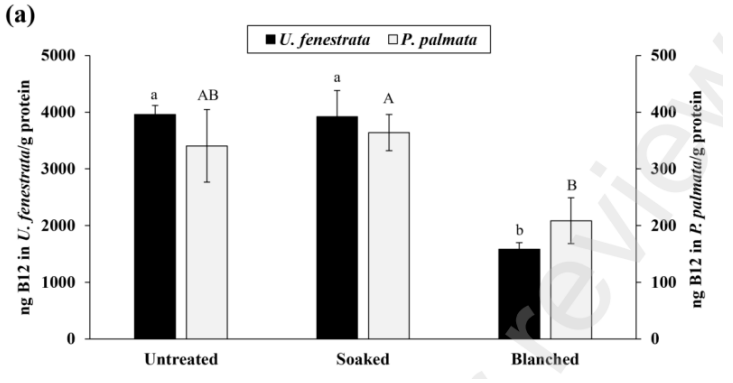
U. fenestrata –highly promising source of vegan vitamin B12



- *Ulva* contained 681 ng B12/g dry weight (in other study up to 800 ng/g)
- **5g dried** non-blanched *Ulva* biomass can provide **112% of RDI vitamin B12*** (4µg B12/day)
- Even after blanching; *Ulva* qualify for an EU nutritional claim as **"High in Vitamin B12"****

Trigo, J. P. et al. 2025 *Food Chemistry*, *483*, 144302 *Cofactor in **DNA synthesis & fatty acid and amino acid metabolism**. Important for normal functioning of the **nervous system** & in the maturation **of red blood cells** in the bone marrow. **AI of B12 according to EFSA guidelines

U. fenestrata –highly promising source of vegan vitamin B12

RDI 4 µg (2.4 µg in the US)

~35ng B12/g dw → 133 g needed

Beef 60 ng/g dw

~70ng B12/g dw → 57 g needed

~600-800ng B12/g dw → 5g enough

~1400ng B12/g dw → 2.8 g enough

Trigo, J. P., Chamlagain, B., Thorén, J., Strand, R., Juanola, M. V. L., Steinhagen, S., ... & Undeland, I. (2025). Sea lettuce (Ulva fenestrata) as a rich source of cobalamin (vitamin B12)–both as processed whole biomass and as an extracted protein ingredient. *Food Chemistry*, *483*, 144302.

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Food Chemistry 483 (2025) 144302

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Short communication

Sea lettuce (*Ulva fenestrata*) as a rich source of cobalamin (vitamin B12) – both as processed whole biomass and as an extracted protein ingredient

João P. Trigo [a,*], Bhawani Chamlagain [c], Jonatan Thorén [a], Rebecca Strand [a], Mar Vall-llosera Juanola [a], Sophie Steinhagen [b], Alexandra Kinnby [b], Gunilla Toth [b], Susanna Kariluoto [c], Ingrid Undeland [a]

[a] Department of Life Sciences - Food and Nutrition Science, Chalmers University of Technology, Gothenburg, Sweden
[b] Department of Marine Sciences - Tjärnö Marine Laboratory, University of Gothenburg, Strömstad, Sweden
[c] Department of Food and Nutrition, University of Helsinki, Helsinki, Finland

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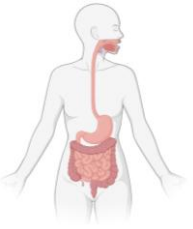
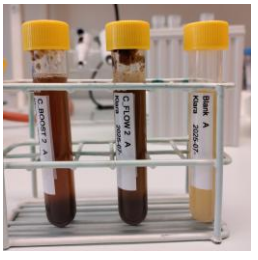
Role of *P. palmata* morphology; and other red species for vitamin B12 and element bio-accessibility *in vitro*



Colaconema



21 Helgesson et al., *In manuscript*

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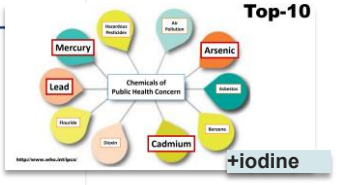
EU nutritional claim **"High in XX"** (>30% of RDI/100g wet biomass) possible for **vitamin B12, iodine, magnesium, iron, selenium**
–also applies to a 5g portion of dried Ulva!



Toxicological concerns: a **5g portion** of dried Ulva contribute to 41–91%, 9–97%, 6– 15%, and 21–46% of the TDI for iodine, inorganic arsenic, cadmium, and lead, respectively

22 **RDI** Recommended daily intake; **TDI**, Tolerable daily intake

2026-06-18

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Flavour!

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CHALMERS

Kristianstad University

Uppsala universitet

Cabbage/sulphury

Grassy Nutty Seaweed Ocean

Umami Bitter Salty Sour

Poster & Elevator pitch!

- **Protein boosting** with herring process water → ↑ green colour intensity ↓ bitterness, ↓ grassiness ↑ seaweed odour and ↑ total intensity
- **Washing;** none or small difference in sensory attributes (↓saltiness)
- **Blanching;** → milder flavour, e.g., ↓marine flavour, ↑ sulfury, ↑ flour-like notes & ↓bitterness, ↓salty, ↓sour, thus, more versatile
- **Storage in dried form;** ↓ green colour, ↓ seaweed flavour; ↑ saw dust & ↑ "rosehip soup"
- Higher **oil content** of carrier emulsions→ ↓grassy odour

Trigo, J.P. et al. 2024. *Future Foods*, *9*, p.100370; Wendin, K. et al., 2024. *Future Foods*, *10*, p.100431; Rauf Dahlstedt, S.R. et al. 2026. *Future Foods*, *13*, p.100995

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Hanna Harrysson

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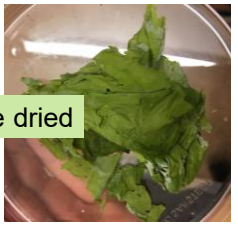
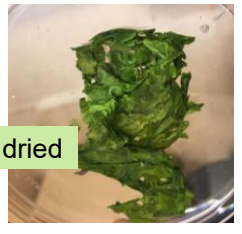
Green colour after 290 days

	Dark	Light
Freeze dried		
Oven dried		

Harrysson, H. et al. (2021). *Algal Research*, *56*, 102295.

2026-06-18

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The role of seaweed in foods dictates preferred characteristics!

Seaweed is the base | Seaweed is a significant ingredient | Seaweed is a very small part

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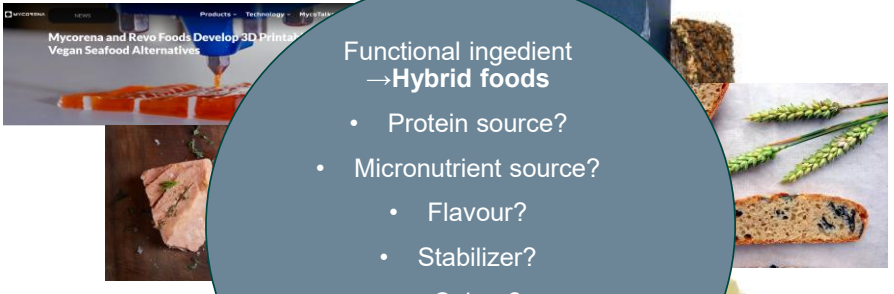
The role of seaweed in foods dictates preferred characteristics!

Seaweed flavour wanted? | Seaweed flavour not wanted?



Functional ingedient
→**Hybrid foods**

- Protein source?
- Micronutrient source?
- Flavour?
- Stabilizer?
- Colour?
- Texture?
- X-factor?

Tune cultivation & handling depending on role!


Thanks!
undeland@chalmers.se
BBI JU
FORMAS
VINNOVA
tillväxt verket
EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden
LEADER
VÄSTRA GÖTALANDSREGIONEN
Sustainable Blue Economy Partnership
innovatum science park
KTH
ILVO
RI.SE
VTT
WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON
DTU
UNIVERSITY OF GOTHENBURG
RE-BLUE
blå mat
CENTRUM FÖR FRAMTIDENS SJÖMAT
BlueGreen
SeaSide
Seaweed4 GutHealth
Pelagic 2.0
EcoOyster
SensAlg
MAREFINE
AlgFlavor
SUSWEED
SWEDEN PELAGIC
NORDIC
SEAFARM
VegMe
Freshly Made Vego
PELAGIC SEAFOOD
BIO-AQU
GEA
OATLY!
Livsmedelsverket
NATIONAL FOOD AGENCY, SWEDEN
AQUAFOOD
ALFA LAVAL
Flottweg
KLÄDESHOLMEN
SPF
SWEDISH PELAGIC FEDERATION PRODUCENTORGANISATION

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