SEAWEEDS, A DOUBLE-SIDED SECTOR, BETWEEN MATURITY AND DEVELOPMENT

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SEAWEED

IN LINE WITH GLOBAL, EUROPEAN AND NATIONAL POLICIES AND CONSUMER DEMAND
11,000 species

200 species consumed as food

< 20 species cultivated

6 species = 90% of production

<table>
<thead>
<tr>
<th>Brown Seaweed</th>
<th>Red Seaweed</th>
<th>Green seaweed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saccharina japonica</td>
<td>Kappaphycus alvarezii</td>
<td>Enteromorpha clathrata</td>
</tr>
<tr>
<td>Undaria pinnatifida</td>
<td>Eucheuma spinosum</td>
<td>Monostroma nitidum</td>
</tr>
<tr>
<td>Sargassum fusiforme</td>
<td>Gracilaria</td>
<td>Caulerpa</td>
</tr>
<tr>
<td>Saccharina latissima</td>
<td>Porphyra</td>
<td>Ulva</td>
</tr>
<tr>
<td>Alaria esculenta</td>
<td>Palmaria palmata</td>
<td>Codium</td>
</tr>
</tbody>
</table>

Species in bold together represent ca 90% of total production
Worldwide production of aquatic plants per type (FAO, 2017)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Red algae</th>
<th>Other aquatic plants</th>
<th>Green algae</th>
<th>Brown algae</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>China</td>
<td>Indonesia</td>
<td>Indonesia</td>
<td>China</td>
</tr>
</tbody>
</table>
SEAWEED PRODUCTION
WILD HARVEST VS CULTIVATION

Variability of the resource and risk

Origin
Beachcast
Wild harvest
Open culture
Closed culture

Price

Applications
Fertiliser
Feed

Food
Colloids

Health
Cosmetics
SEAWEED PRODUCTION

BENEFITS - ECOSYSTEM SERVICES

Bioremediation via:
Carbon capture = 266-284 kg of C/T of dry seaweed + Nutrient Uptake + Oxygenation
Increase biodiversity, provide additional habitats, food and shelter

Climate potential illustrated – CO₂ uptake by kelp farming
Norway’s emission in 2019: 50.3 mill t CO₂

SINTEF/NHO (2019). NYE MULIGHETER FOR VERDISKAPING I NORGE
The seaweed biorefinery
An industrial process in constant improvement

2002 – 2012 ----- 2 000 T/year capacity
One main extraction technology from one species
Monoproduct

MONALISA #3025/F1055

Solvent free

2012 – 2019 ----- 6 000 T/year capacity
Multi Species Seaweed Biorefinery
Several product lines based on seaweed
The seaweed biorefinery v3
An industrial process in constant improvement

A CONTROLLED VALUE CHAIN FROM THE SEA TO FINAL PRODUCTS

2019 – Today ---- 10 000 T/year capacity
Multi Species Seaweed Biorefinery
Several product lines based on seaweed

Know how:
- Extraction
- Complexation
- Stabilisation

Collection
Washing
Phase separation
Hydrolysis
Extraction
Characterization
Quality control
Final products
Consumers
Réculte
Lavage
Séparation de phase
Hydrolyse
Extraction
Caractérisation
Contrôle qualité
Produits finis
Consommateurs

Solvent free

zero waste
1. A NATURAL RESOURCE COMING FROM THE SEA

A controlled and sustainable value chain

- Harvest
- Washing
- Phase separation
- Hydrolysis
- Extraction
- Characterisation
- Final product
- Quality control

Quality control
Drivers
✔ Natural
  • GMO-free
  • Solvent-free
  • Pesticide-free
  • Nano particule-free

✔ Not from animal sources
  • Vegetarieren
  • Vegan

✔ No major allergens
  • without gluten
  • without lactose

✔ Local production
  • Improved traceability
  • Food safety

Limits
✔ Regulations
  • Low number of species
  • Strict regulations on contaminants

Ressource of choice
Not a niche market
History
First discovery of Agar in the 17th century in Japan
Description of carrageenan in 19th century Europe
Industrial production started in US and Europe in 1930ies and expanded during the Second World War

Current situation
Market still expanding
Process innovation to reduce generation of coproducts

Applications:
- Food
- Textile and paint industry, Cosmetics
- Pharmaceutical products
- Biomaterials
- Packaging
- Biochemistry

Table 1. The market for seaweed-derived hydrocolloids, agars, alginates, and carrageenans [1].

<table>
<thead>
<tr>
<th>Product</th>
<th>Global Production (ton/year)</th>
<th>Retail Price (US$/kg)</th>
<th>Approximate Gross Market Value (US$ million/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agars</td>
<td>10,000</td>
<td>18</td>
<td>191</td>
</tr>
<tr>
<td>Alginates</td>
<td>50,000</td>
<td>12</td>
<td>339</td>
</tr>
<tr>
<td>Carrageenans</td>
<td>60,000</td>
<td>16.1</td>
<td>626</td>
</tr>
</tbody>
</table>

TEXTILES

VITADYLAN™
Contains minerals from seaweed

The secret of Vitadylan™ lies in its pure, natural seaweed. It can only be harvested every two years in the crystal-clear waters of Iceland, so the amount available is strictly limited. The seaweed is then dried and finely ground with a special jet mill. The fine powder can subsequently be woven into the fibers using a secret, patented procedure to retain all ingredients in the final fabric. Seaweed (Ascosphyllum nodosum) contains one of the highest amounts of vitamins, minerals and trace elements of all natural products. One ton of Iceland contains the minerals and 400 US Gallon of seawater. By using the seeds in our material and with a highly advanced process, the power of the seaweed within our material is maximized.

A sachet whose shelf-life matches the shelf-life of its content. Cool huh? Our Ooho sachets are 100% made of seaweed and plants, which means that they naturally biodegrade in only 6-8 weeks. You can throw them up in general waste, or even in your home compost!

The power of algae in a lyocell fiber.

From kelp, AlgiKnit extracts alginate and combines it with other renewable biopolymers to produce yarn, which is strong enough and stretchable enough to be knitted by hand or by machine to be used in textile manufacturing. The final product can be dyed with natural pigments.
SEAWEED in Agriculture
Biostimulant & Elicitation of plant defenses for better nutrition & higher crop resilience

Drivers

✔ Natural
  • Stimulate soil life
  • Improve root development
  • Improve root mycorrhization

✔ Effects on plant health and nutrition
  • Sustain soil microbial diversity & functions
  • Improve plant development (growth, photosynthesis, yield)
  • Improve stress resistance (drought, temperature)

✔ Effects on final product
  • Nutrient composition of plant biomass
  • Crop quality parameters

KEY MECHANISMS TARGETED BY ALGAL BASED BIOSTIMULANTS

Whole Plant Responses

Algal Derivatives

Shoot Targets
  • Stomatal Regulation
  • Xylem Hydraulic Conductance

Root Targets
  • Root Zone Water Availability
  • Root Ethylene & Auxin Levels

Shoot vs. Root Response to Algal Biostimulants

SPAD chlorophyll index value along drought stress experiment:

- Watering OFF
- Biostimulant Spray
- Watering ON
Seaweed inside fertilizer: doing more with same fertilizer level

Seadry + MIP OLMIX technologies together improve NPK fertilizer efficiency (TNT = control, MIP = OLMIX technology, dolomite, DAP, SK = Potassium sulfate) fertilizers alone or with OLMIX technology. Mean yield value of 3 independent GEP randomized6 replicates each field trials.
Market
• Consumer demand for local production and traceability
• Allow market access – for seaweed to become mainstream

Environment
• Preserve habitats by harvesting less and better
• Alleviate the effect of eutrophication, sea acidification, increased CO$_2$ and global warming

Product quality
• Strain selection for increased levels of nutrients, active molecules and disease resistance
• Improved standardization

Innovation
• In local species
• New applications

Society
• Creation of jobs
• Improvement of diet and health

How to learn from previous errors and stimulate diversity, development of local species, and allow a commercial activity?
## SEAWEED CULTIVATION
WHY IS IT NOT A BOOMING INDUSTRY?

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
</tr>
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<tbody>
<tr>
<td>• In line with current values</td>
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<tr>
<td>• Network of small but established companies</td>
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<tr>
<td>• Positive effects on surroundings</td>
<td></td>
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<tr>
<td>• Positive effects of seaweed products..</td>
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<tr>
<td>• Close interaction with research</td>
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<tr>
<td></td>
<td>• Few species: cultivation and for food</td>
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<tr>
<td></td>
<td>• Accession to consessions</td>
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<tr>
<td></td>
<td>• Investment in cultivation techniques &amp; management of seaweed life cycle</td>
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<tr>
<td></td>
<td>• Market development</td>
</tr>
<tr>
<td></td>
<td>• Cost</td>
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</tbody>
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<table>
<thead>
<tr>
<th>OPPORTUNITIES</th>
<th>THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ecosystem services and combatting climate change</td>
<td></td>
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<tr>
<td>• Consumer demand</td>
<td></td>
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<tr>
<td>• Creation of jobs</td>
<td></td>
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<tr>
<td>• High innovation</td>
<td></td>
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<tr>
<td>• High potential for strain selection</td>
<td></td>
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<tr>
<td></td>
<td>• Appearance of diseases</td>
</tr>
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<td></td>
<td>• Unknown impact of upscaling</td>
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<td></td>
<td>• Competition with other activities</td>
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<td></td>
<td>• Need for diversification</td>
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<td></td>
<td>• A high focus on risks</td>
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SEAWEED MARKET
ESTIMATED TO CONTINUE TO GROW

In 2017, Red seaweed accounted for the highest market share and is anticipated to grow at a CAGR of 12.3% from 2018 to 2024.

Hydrocolloids application segment is anticipated to grow at the highest CAGR of 13.5% from 2018 to 2024.

Commercial Seaweed Market Report 2020-2026 | Global Trends
Published Date: July 2020 | 270 Pages | Report ID: GMI1658

CAGR: Compound Annual Growth Rate

https://www.alliedmarketresearch.com/seaweed-market
Thank you for your attention!

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