Marine BioTech Applications in Industry

FINAL CONFERENCE, SUBMARINER PROJECT

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Agenda

1. What we mean with Marine Biotech
2. Brief introduction to DuPont and DuPont Nutrition & Health
3. Examples of marine biotech applications
4. Outlook

1. What we mean with Marine Biotech

… The application of Science & Technology to living marine organisms, as well as parts, products and models thereof…

BIOTECHNOLOGY IS DEFINED as the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services (OECD). Marine or Blue Biotechnology encompasses the application of biotechnology tools on marine resources.

Marine organisms used for Blue Biotechnology can be both microorganisms, such as bacteria, fungi, and microalgae, or macroorganisms, such as macroalgae and mussels. They are directly used as biomass or as producers of valuable ingredients such as active biological compounds, pigments, antioxidants, vitamins, fatty acids, enzymes, polymers or other biomaterials.

High value marine products and technologies can have a wide range of applications in health, food, feed, cosmetics, aquaculture, agriculture, industrial processes, environmental remediation, environmental monitoring and research tools.

A variety of techniques are used in the field. Among them are the fermentation using bioreactors, microbiological and chemical techniques, as well as cell-, gene-, protein- and other molecule-based techniques.

Source: Submariner Compendium
http://www.submariner-project.eu

We are applying our science to find solutions to some really BIG challenges…

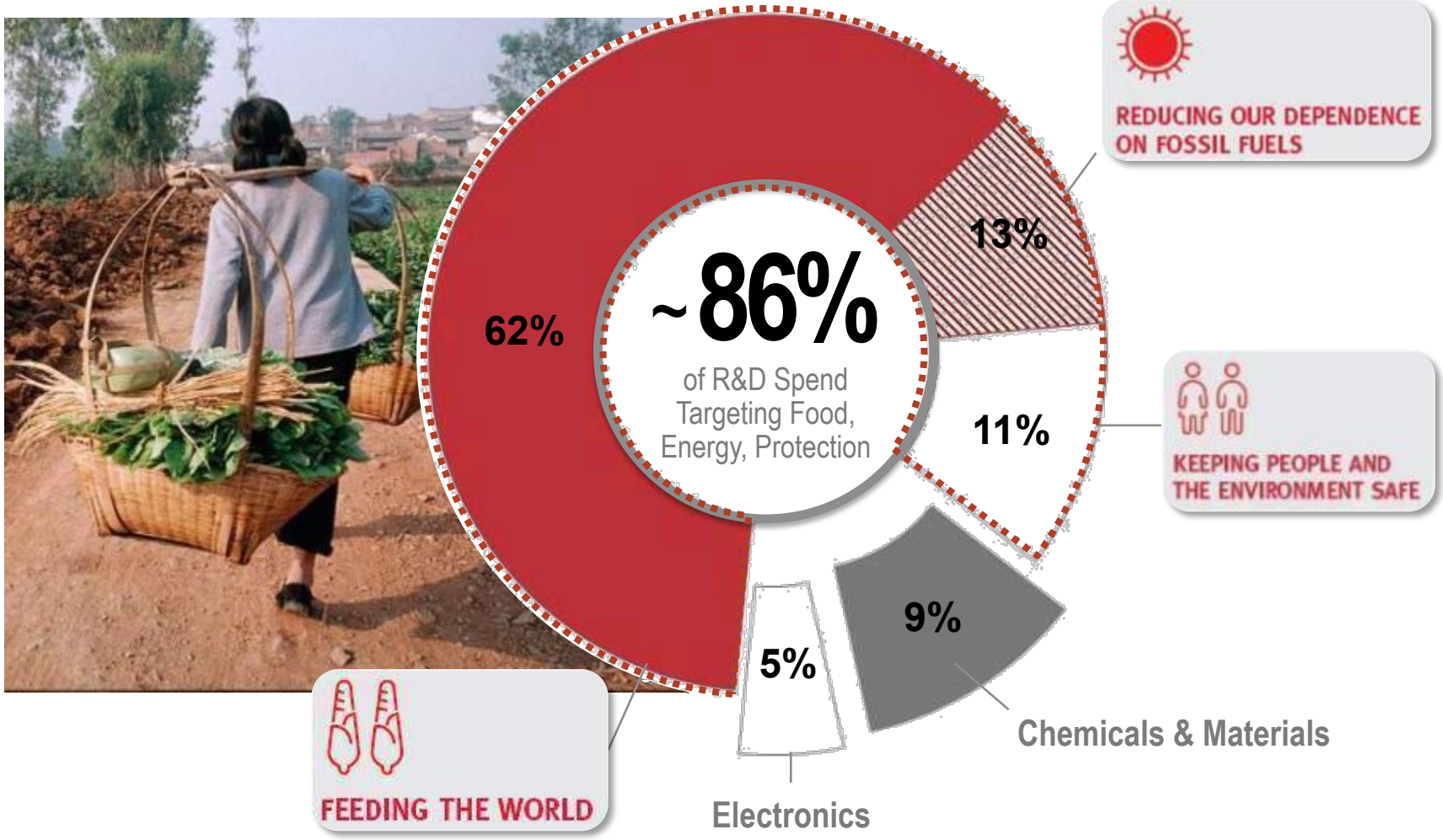
Feeding the World

Reducing Our Dependence On Fossil Fuels

Keeping People and the Environment Safe

Innovating to feed the world

$2 billion R&D Spend in 2011

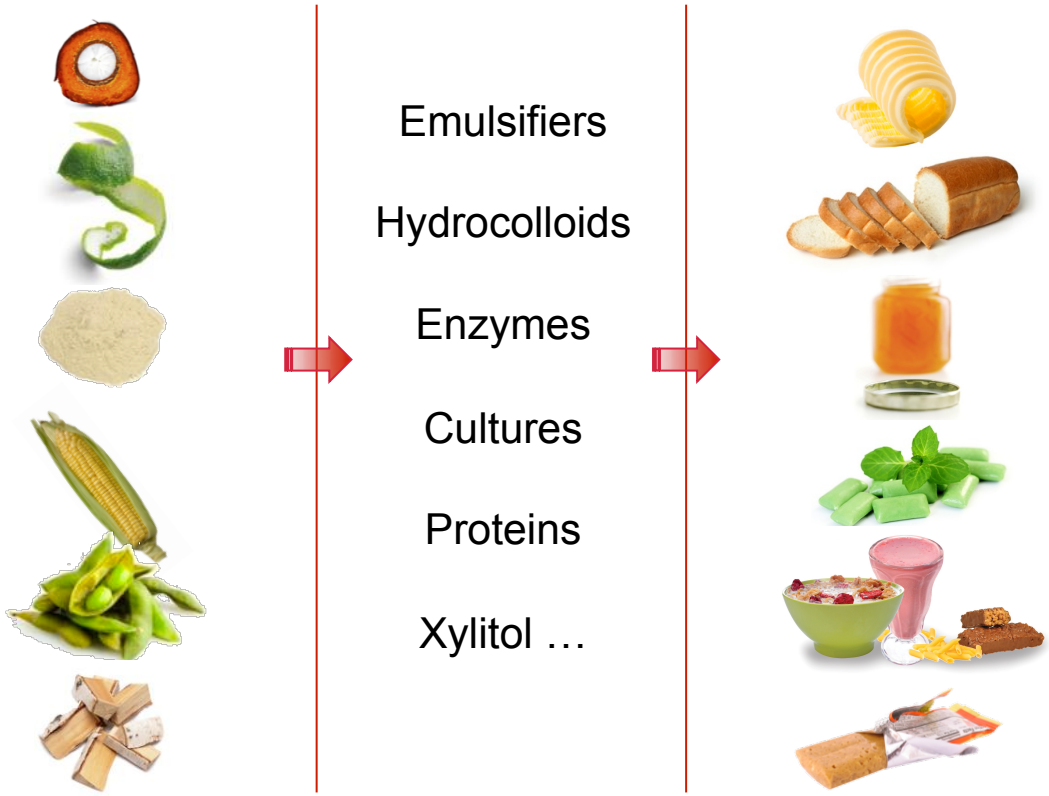


Nutrition & Health

What we do

We take renewable raw materials to create food ingredients that …

…food manufacturers use to create safe, nutritious and healthy products



Molecular Diagnostics Systems ensure food is safe from pathogens

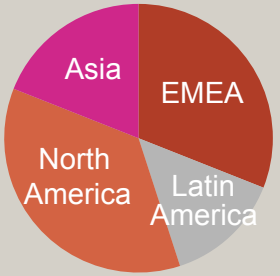
Business description

Approx. 7200 employees

Capabilities

- Over 100 sites
- Over 50 manufacturing sites
- Over 20 research and innovation centers

Sales by region



2011 Sales of $3.5B

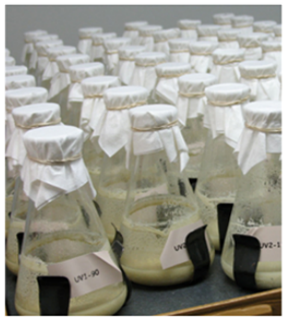
DuPont Nutrition & Health

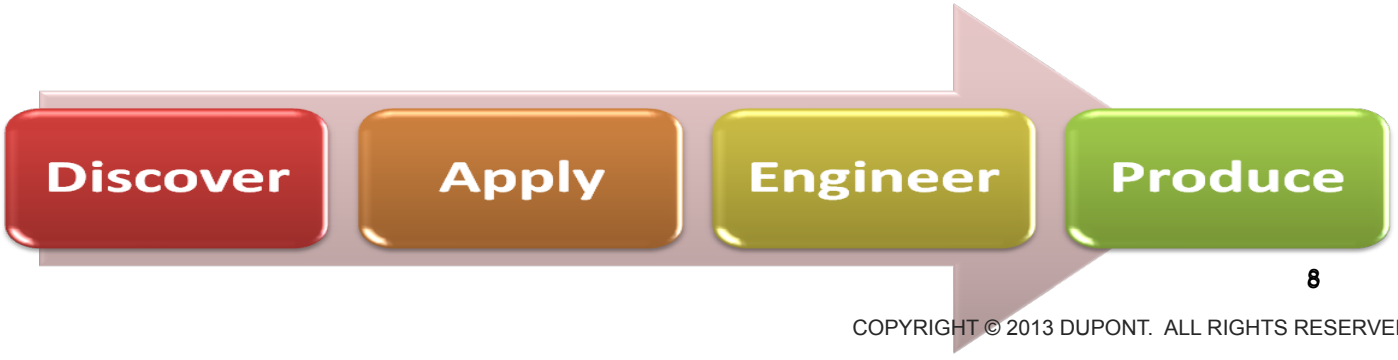
Globally, our ingredients can be found in …

…every 2nd ice cream	…every 2nd infant formula	…every 2nd nutrition bar	…every 3rd cheese	…every 4th loaf of bread
				

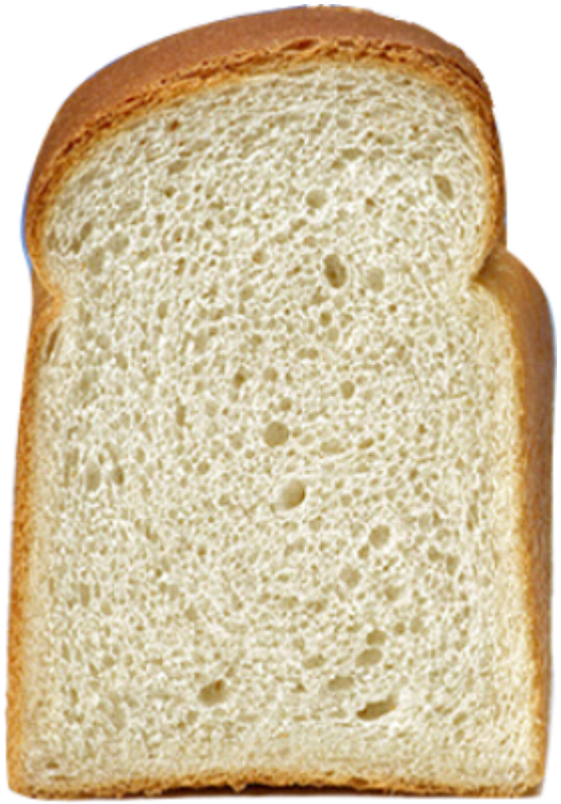
Hexose Oxidase from *Chondrus crispus*

- **Source**: The red seaweed *Chondrus crispus*
- **Molecular weight**: 126 kDa (by gel filtration), 71 kDa by SDS-PAGE
- **Production**: Heterologous expression in different hosts
- **Applications**: Bakery

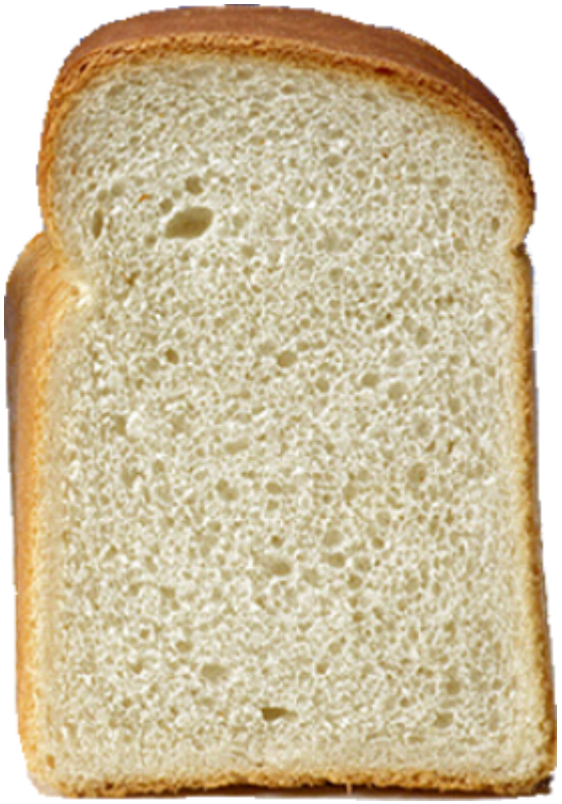




US no-time dough



90 U/kg flour
Hexose Oxidase

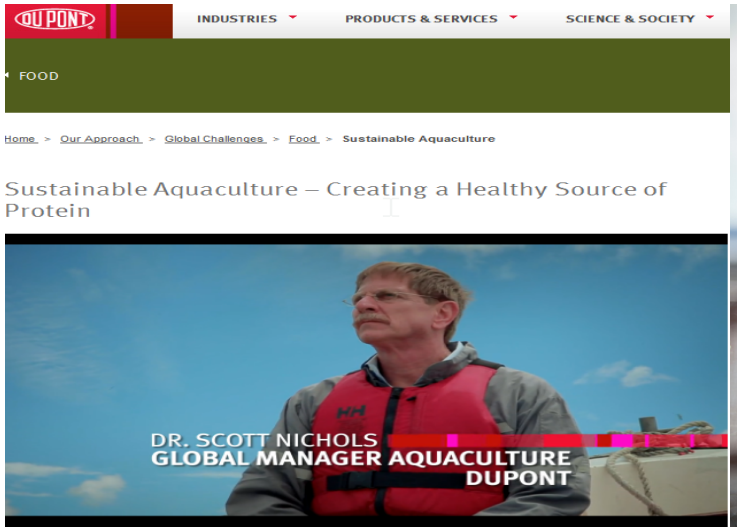


30 ppm
Potassium Bromate

Antibrowning effect of HOX

Yeast containing omega-3 for fish feed

- Omega-3 demands are increasing as consumers focus on health and wellness.
- The total omega-3 market is growing 10-12% per year
- Primary source of omega-3s is wild-caught ocean fish, which are processed to produce fish oil directly or are used as feed in aquaculture
- DuPont uses metabolically engineered oleaginous yeast *(Yarrowia lipolytica*) to produce a clean and sustainable source of omega-3
- By using the omega-3 rich yeast in the salmon's diet, DuPont and AquaChile together reduce the dependency on feeder fish by 75%.



DuPont N&H has a global sourcing network to secure seaweed raw materials and carrageenan extracts

- Production in Chile
- Access to more than a dozen seaweed species (incl. species from overseas)
- A multitude of carrageenan extracts based on different raw materials and process conditions

Different seaweeds have different carrageenan content

Seaweed	Origin	κ content
Kappaphycus alvarezii[1]	Tropical waters	90%
Chondrus crispus	North Atlantic	70%
Gigartina skottsbergii	South America	59%
Sarcothalia crispata	South America	57%
Eucheuma denticulatum[2]	Tropic waters	4%
Sarcothalia crispata[3]	South America	0 %

[1] Considered as pure kappa carrageenan
[2] Considered as pure iota carrageenan
[3] From separate live stage of seaweed, 100 % lambda

DuPont's production facility in Pargua

Carrageenan – Summary

Carrageenan is a hydrocolloid derived from red seaweeds

Carrageenan has three unique functional features

- Supreme gelling agent
- Protein interaction at neutral pH
- Synergies with other polysaccharides

Carrageenan has two distinctive E-numbers

- E407 – refined carrageenan
- E407a – semi-refined carrageenan

Alginate – Summary

Alginate is a hydrocolloid derived from brown seaweeds

Alginate has three unique functional features

- Cold soluble
- Cold gelling
- Heat-stable gelling (in contrast to carrageenan)

Alginate has six distinctive E-numbers

- E400 – alginic acid
- E401 – sodium alginate
- E402 – potassium alginate
- E403 – ammonium alginate
- E404 – calcium alginate
- E405 – propylene glycol alginate (PGA)*

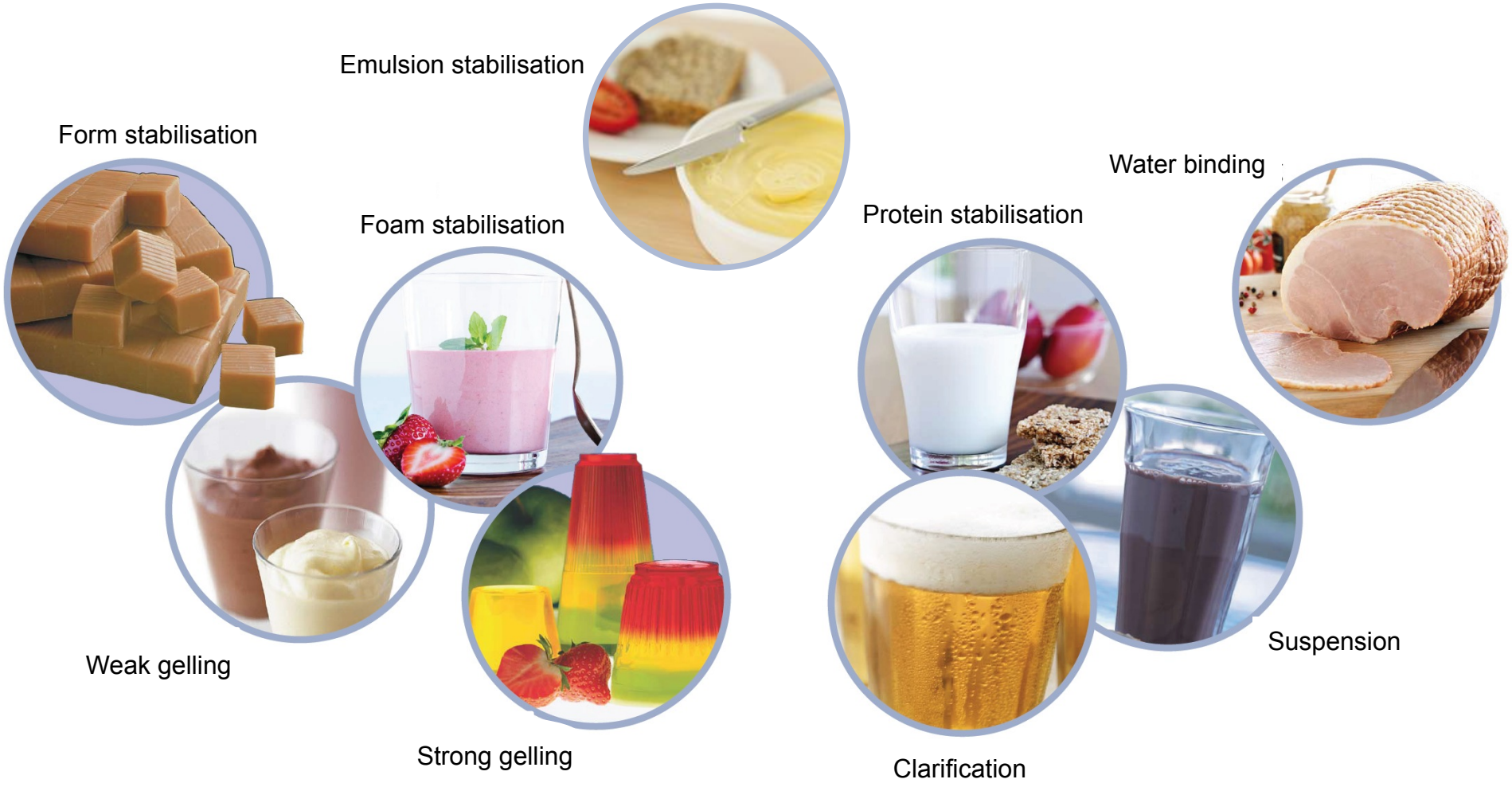
* Alginate derivative, not produced by DuPont

Different seaweeds have different M/G-ratios

Seaweed	Origin	M:G ratio
Laminaria hyperborea	Northern Europe	0.5
Lessonia trabeculata	South America	0.5
Ecklonia maxima	South Africa	1.2
Laminaria digitata	Europe	1.4
Macrocystis pyrifera	California	1.6
Ascophyllum nodosum	North Atlantic	1.8
Laminaria japonica	East Asia	1.9
Durvillea antarctica	Southern Pacific	2.4

DuPont's production facility in Landerneau

DuPont™ Danisco® carrageenans and alginates are tailormade for various food applications



What role will marine biotech play for us moving forward?

- Further understand the role of marine biotechnology in terms of global challenges (e.g. Food & Energy)
- Research sustainable production routes for marine products (e.g. fish and seaweed aquaculture)
- The marine ecosystem as a source of unknown biodiversity

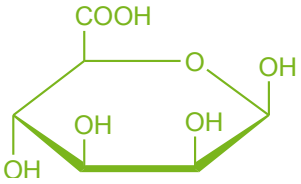
- An important, yet underutilized space for collaboration: …

Appendix

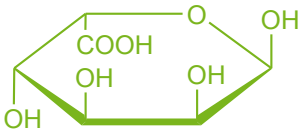
The miracles of science™

Alginates give brown seaweeds their structural integrity

Alginates consist of:



Mannuronic acid (M)



Guluronic acid (G)