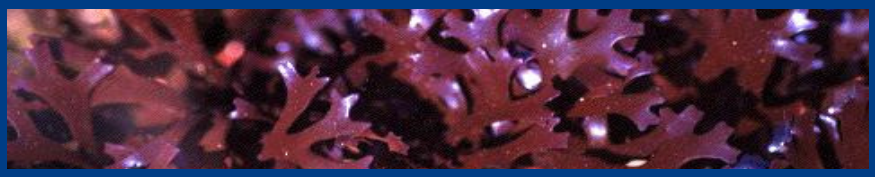
Cultivation of *Chondrus crispus* in Denmark

- production potential, quality and food safety



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[3] CP Kelco A/S

Chondrus crispus – Irish/carrageen moss

Carraigín = ”small rock” (Gaelic)

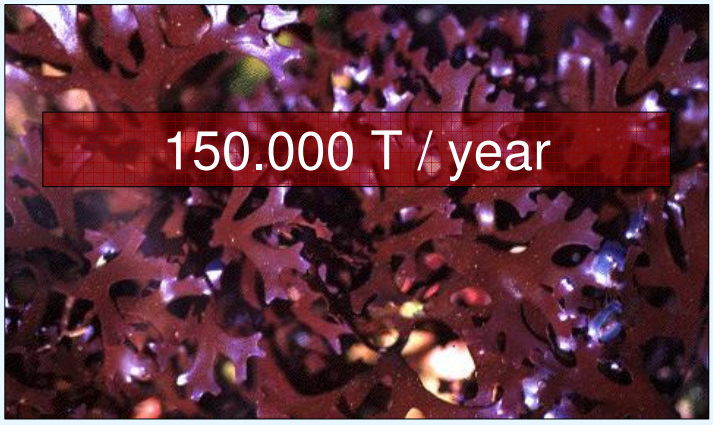

Photo: www.cybercolloids.net

Carrageenan (E407)

Price: up to 200 USD per kg

Photo: www.eurogum.dk

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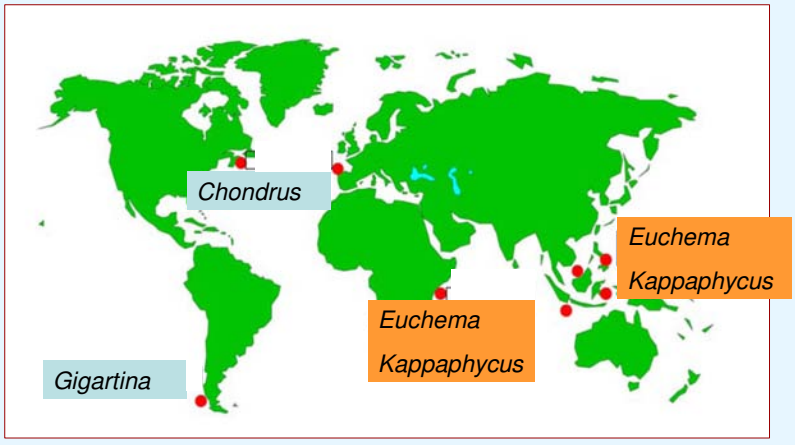
Carrageenan – alternative ressources



Cold water species = **15 %**

Warm water species = **85 %**

Carrageenan (E407)



Chondrus - harvest

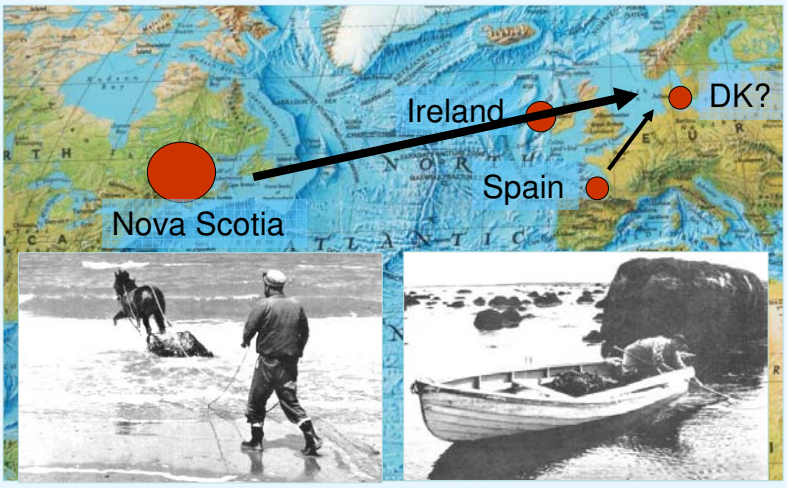
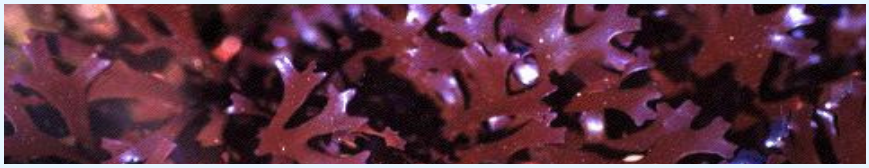


Photo: www.greatdreams.com & www.fao.org

Cultivation of *Chondrus* in Denmark?

- **How much can we produce?**
- **How do we optimise growth and production?**
- **How do we optimise yield and quality of carrageenan?**
- **Can we sell it?**
- **Does it pay?**



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Experiments

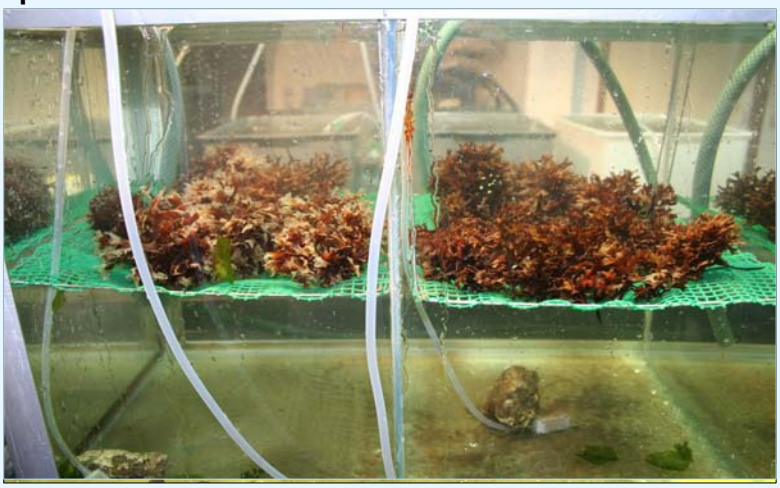
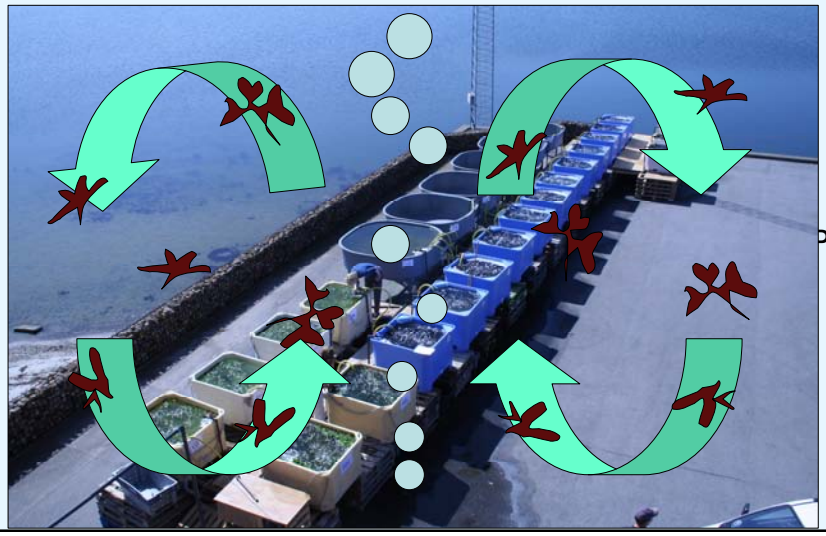


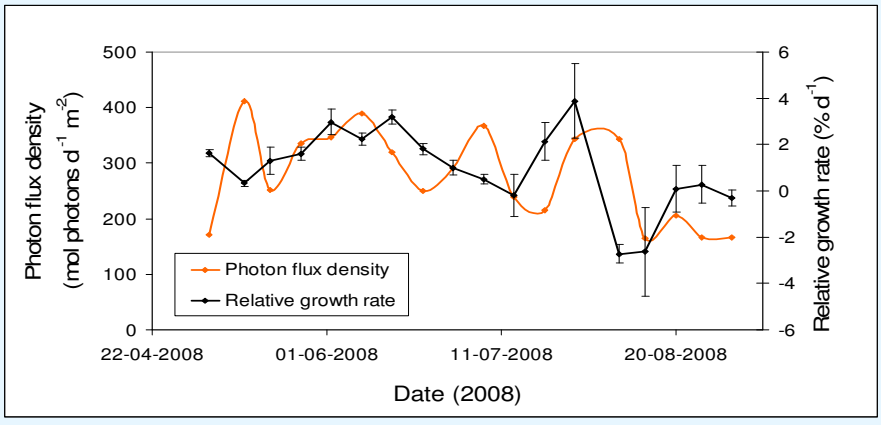
Photo: Michael Bo Rasmussen, DMU

Landbased tumblecultures



Landbased cultivation

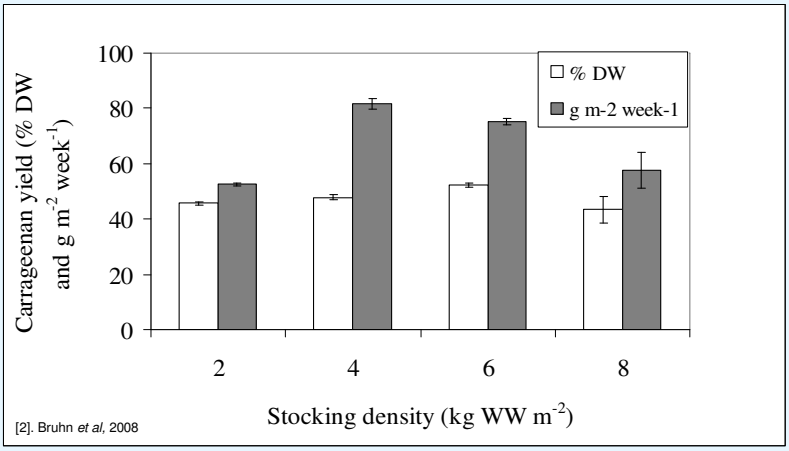
- **Growth rates up to 4% d^{-1}** [1, 2]
- **30 T seaweed (DW) $year^{-1}$ ha^{-1}**
- **14 T carrageenan $year^{-1}$ ha^{-1}**



[1]. Bidwell *et al*, 1985 [2]. Bruhn *et al*, 2008

Landbased cultivation

- **Optimal stocking density: 4-6 kg m^{-2}**



[2]. Bruhn *et al*, 2008

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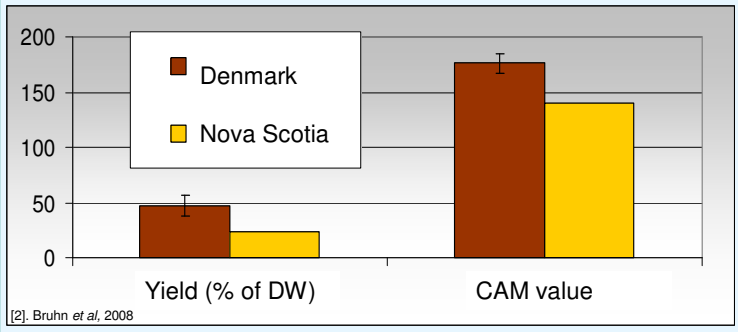
Landbased cultivation

- **Quality**
  - **high yield: 47 % (23%)**
  - **good quality: CAM-value: 176 (140)**
  - **clean raw material – semirefined carrageenan**



[2]. Bruhn *et al*, 2008

Landbased cultivation

- **Economy**
  - **Income:** **1.2 mio DKR year^{-1} ha^{-1}**
  - **Costs:** **8.5 mio DKR year^{-1} ha^{-1}**
  - **Costs (theoretical) [1]:** **0.9 mio DKR year^{-1} ha^{-1}**

[1]. Bidwell *et al*, 1985

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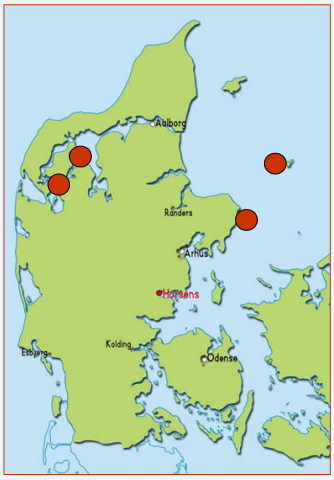
Cultivation in open sea



- July and August
- 2 * 2 locations +/- exposure
  - Limfjorden : Salling / Lysen
  - Kattegat : Anholt / Grenå
- Neutral to negative growth rates
  - epiphytes!
  - Mexico up to 2,4% [3]
- Carrageenan yield and quality as in landbased cultivation

Photo: Michael Bo Rasmussen, DMU [3] Zertuche-Gonzalez *et al.* 2001

Laboratory experiments

Photo: Michael Bo Rasmussen, DMU

- Impact of light and nitrogen
  - 30 tanks of 3 litres
  - 2 light intensities
    (35, 120 µE)
  - 5 N concentrations
    (5,20,50,100,200 µM N)

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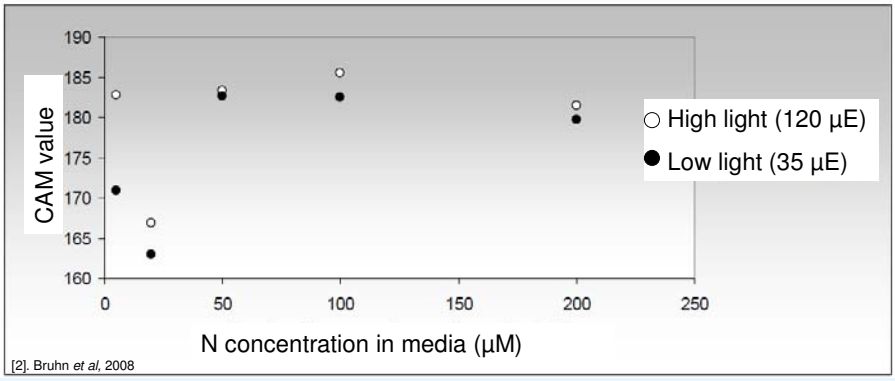
Laboratory experiments

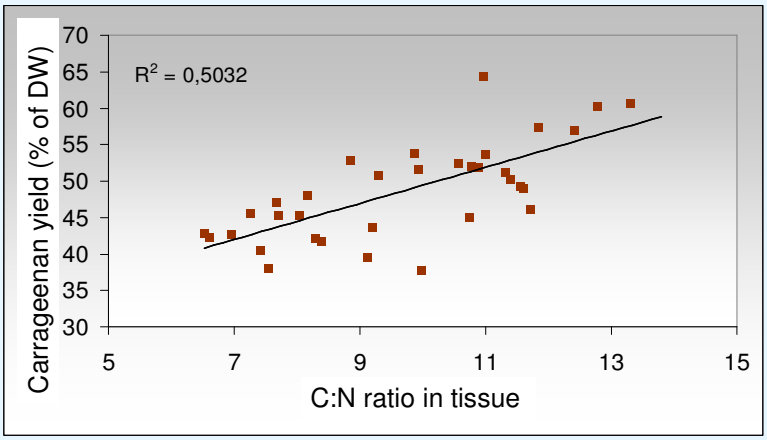
- High light doubled growth rates and had positive effect on CAM value



[2]. Bruhn *et al*, 2008

Laboratory experiments

- Carrageenan yield increases with N-limitation (Neish effect)[4]



[2]. Bruhn *et al*, 2008. [4] Neish *et al*, 1977,

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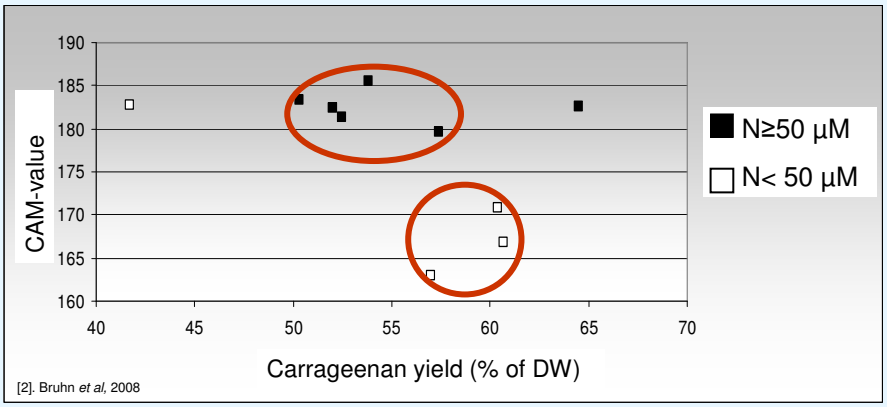
Laboratory experiments

- N: trade-off between carrageenan quality and yield



[2]. Bruhn *et al*, 2008

Food safety

- **Limit values – refined carrageenan**
  - **Pb** (Lead) **5 ppm**
  - **Cd** (Cadmium) **2 ppm**
  - **Hg** (Mercury) **1 ppm**
  - **As** (Arsenic) **3 ppm (EU) / 2 ppm (USA)**

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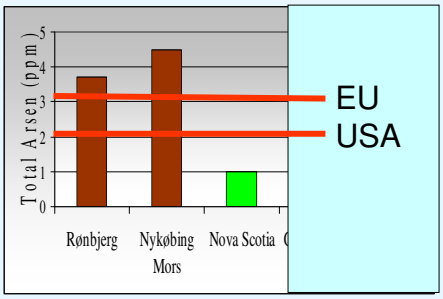
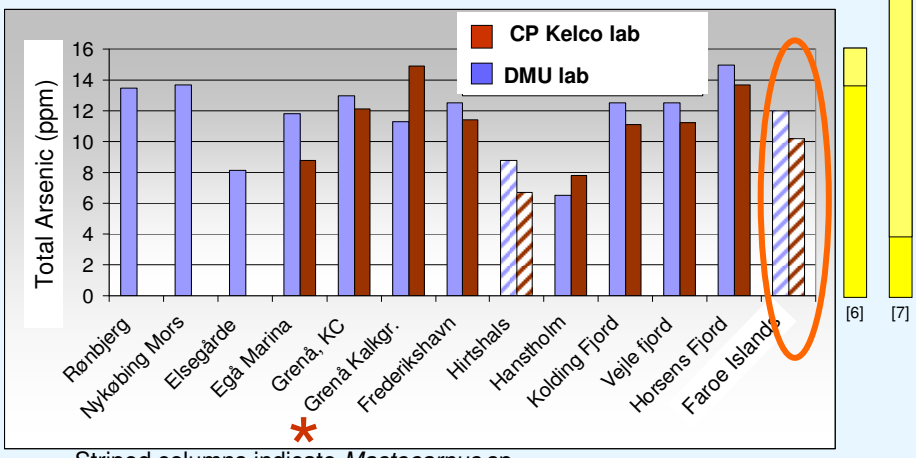
Arsenic



- **Toxic element**
  - **Inorganic form most toxic**
- **Concentrates in algae** [5]
  - **Highest concentrations in young tissue**
  - **Inorganic form approx 4% of total arsenic in *Chondrus*** [6]
- **Limit values exceeded in refined carrageenan from Danish produced *Chondrus***
  - **EU = 3 ppm**
  - **USA = 2 ppm**

[5] Neff, 1997 [6] Almela *et al*, 2006

Arsenic



Striped columns indicate *Mastocarpus* sp.

[6] Almela *et al*, 2006. [7] Thomson *et al*, 2007

Conclusions

\+

- **High yield**
- **Good quality carrageenan**

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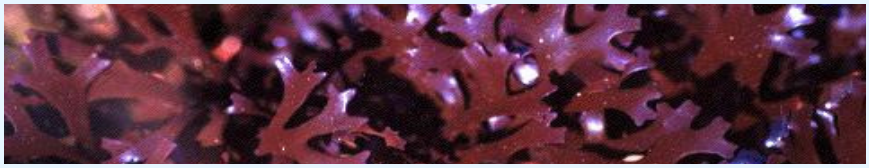
- **Too energy expensive**
- **Too high concentration of arsenic**

Cultivation of *Chondrus* in Denmark?

- **How much can we produce?** — **30 T DW year^{-1} ha^{-1}**
- **How do we optimise growth and production?** — **6 kg m^{-2}. 20+ µM N.**
- **How do we optimise yield and quality of carrageenan?** — **20-50 µM N. High light**
- **Can we sell it?** — **Not at present**
- **Does it pay?** — **Not at present**



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Future challenges?

- **Arsene**
  - **differentiation of limit values: organic / inorganic arsenic**
  - **harvest method – harvest of oldest tissue**
- **Economy**
  - **landbasede tanks – less energy – paused aeration**
  - **cultivation in open sea**
  - **harvest method – harvest of oldest tissue?**

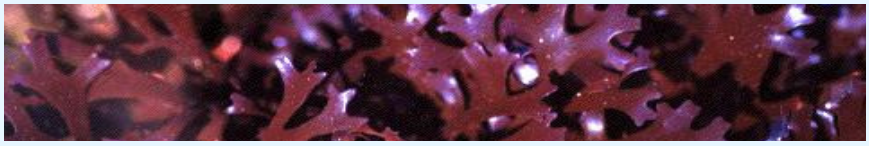

Photo: Jan Krog

Thanks to

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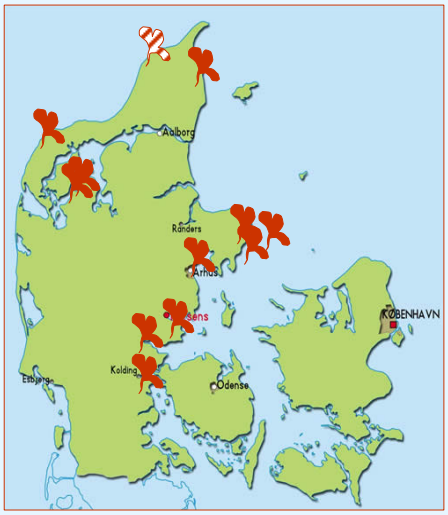
Chondrus - arsenic



Chondrus from 11 locations

Mastocarpus from 2 locations

Air dried *Chondrus*