Susan L. Holdt, Associate Professor, DTU Food

What happens to compounds during processing and preservation of seaweed?

Menu

Compounds and preservation

Processing
- Gentle drying
- Drying (sun-dried, thermal, fermentation)
  - pigments and ash

Preservation
- Storage trial

Iodine- fate through processing

Mainly address *Saccharina latissima*

Conclusions (will also come along the presentations)

Ongoing research

Compound stability

- Polysaccharides (sugars)
  - Hot water extraction
- Proteins
- Minerals/trace elements
  - iodine and inorganic arsenic- hot water
- Lipids
  - oxidation
- Polyphenols
- Pigments
  - Heat and light sensitive
- Vitamins
  - Heat sensitive

Seaweed available for consumer

- Shelf-life
  - Preservation and storage (safe product)

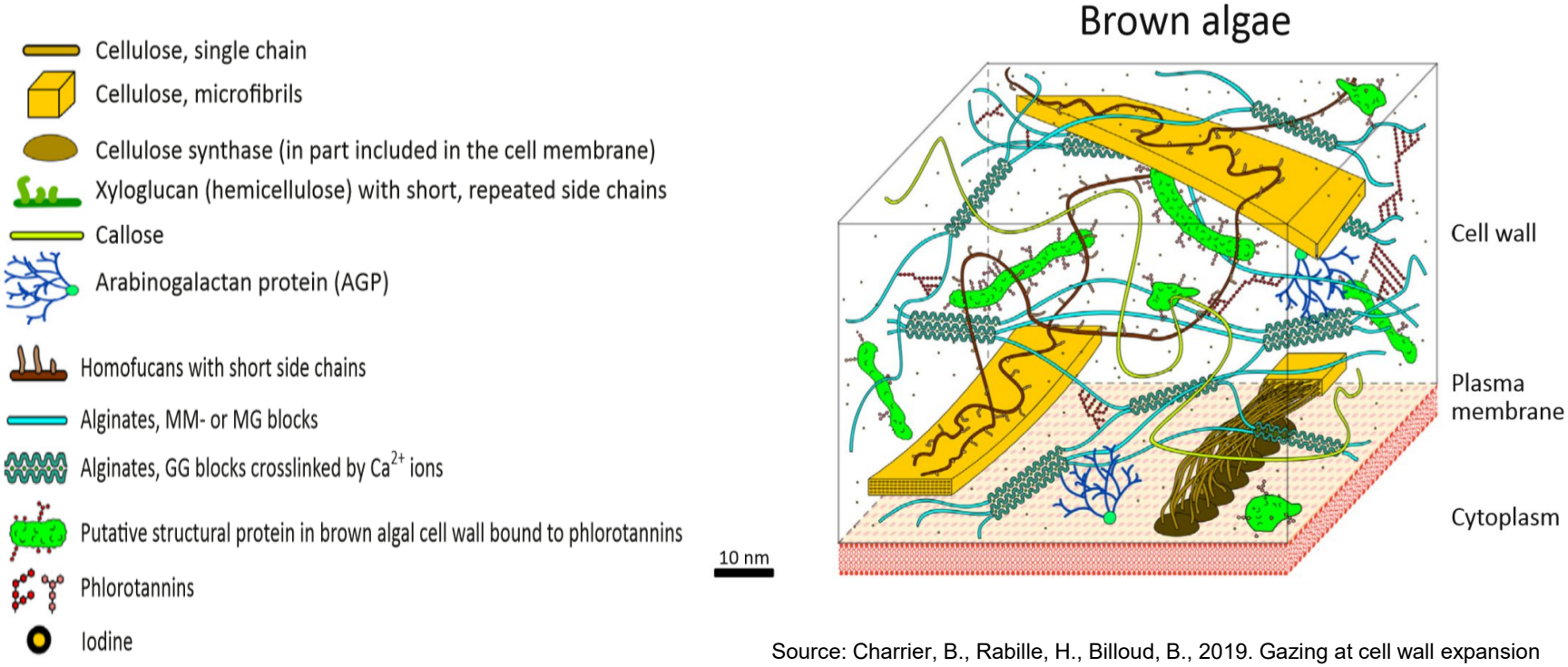
- Easy-to-handle product
- Reduced cost of transport
- Desired quality
  - Different attributes due to different treatments

Current processing situation in Scandinavia

- Very low technical solutions are found
- Air drying outside
- Air drying inside with a dehumidifier
- Air blast drying in chamber
- Freeze drying
- Frozen (shipping of a lot of water)

https://www.mundusmaris.org/index.php/it/nutrrimento/591-seaweed-it

Compounds in seaweed cell wall- brown seaweed



Source: Charrier, B., Rabille, H., Billoud, B., 2019. Gazing at cell wall expansion under a golden light. Trends Plant Sci. 24, 130–141.

Compounds inside the seaweed cell

Annual Review of Food Science and Technology

Source, Extraction, Characterization, and Applications of Novel Antioxidants from Seaweed

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Annu. Rev. Food Sci. Technol. 2019. 10:26.1–26.28

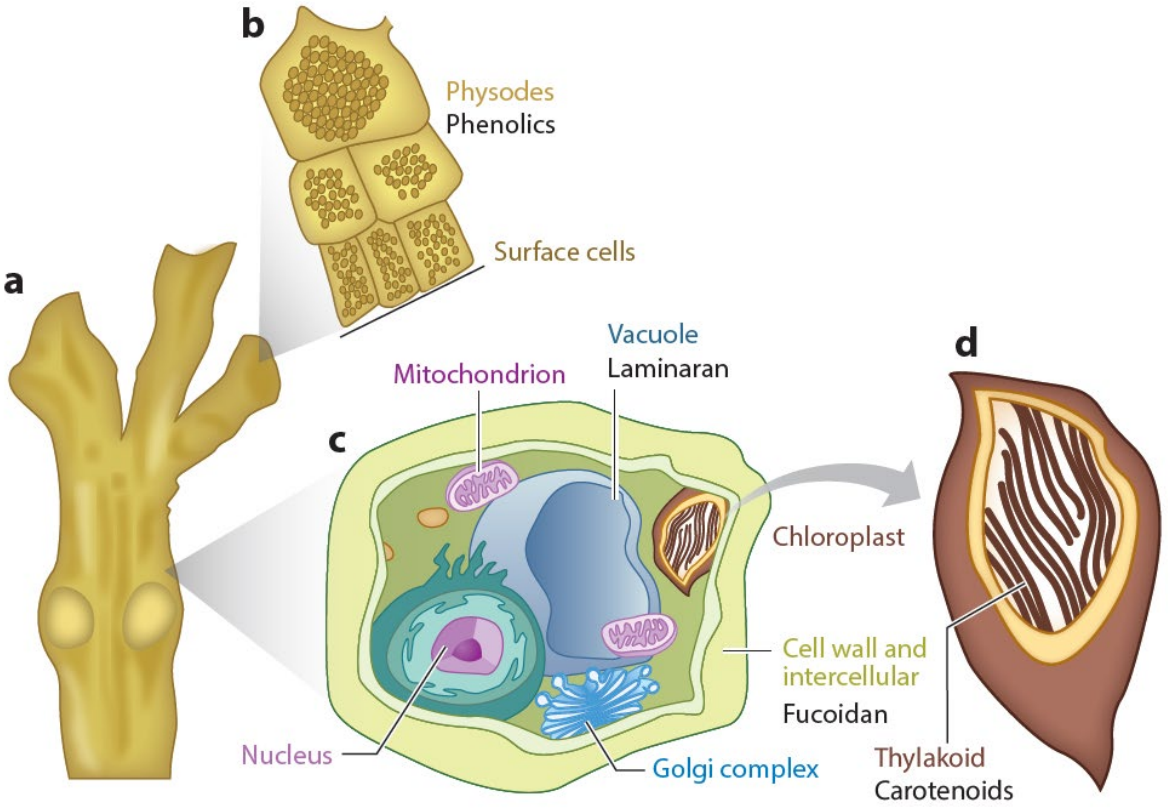


Figure 1

Example of a brown seaweed (*Fucus vesiculosus*). (*a*) Locations of the different antioxidant compounds: (*b*) phenolics and phlorotannins, located in the physodes in the surface cells (adapted from Baardseth 1958); (*c*) laminaran, located in vacuoles in the seaweed cell, and fucoidan, imbedded in the cell wall and intercellular spaces; and (*d*) carotenoids as the accessory pigment located in the membrane of the thylakoids also hosting chlorophyll *a*, which is responsible for algal photosynthesis.

Aim

Show the recent research on effect of processing and preservation on compounds of seaweed

- What is it the consumer gets…

Rebecca L. Holdt, 2013

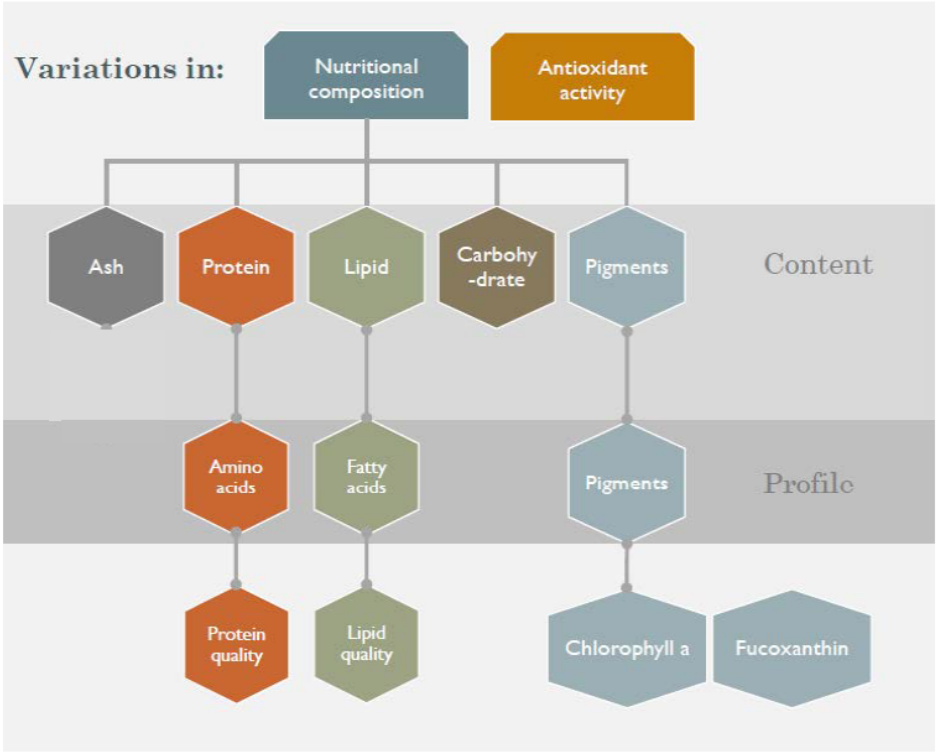
Gentle processing

AIM

To understand if a long, uncontrolled, low temperature drying of *Saccharina latissima* will degrade the valuable chemical compounds

HYPOTHESIS

There will be a loss of valuable compounds in dried *Saccharina latissima*



The Case Study Setup

Wild harvested Danish *Saccharina latissima* in March 2019

Dried vertically (V) or horizontally (H)

Closed, indoor drying facility

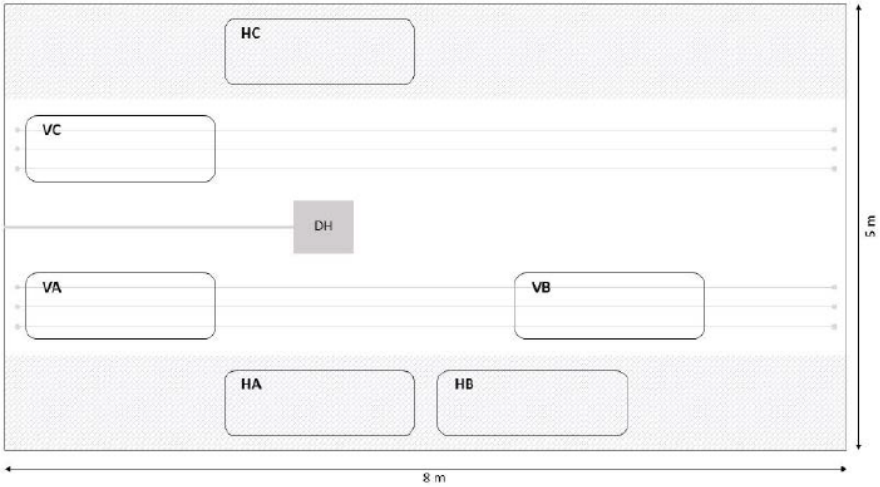
Sorption dehumidifier

Temperature uncontrolled (9.3 - 12 °C)

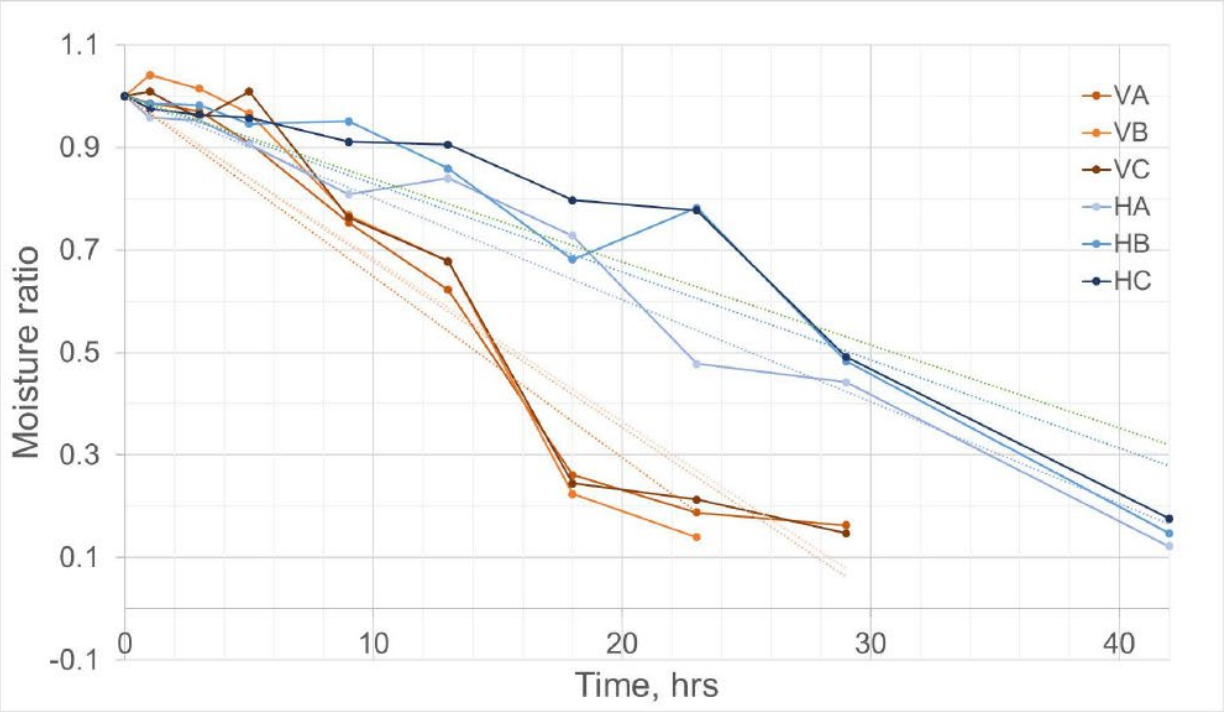
Relative humidity uncontrolled (32 - 78%)

Drying time V; 29 h and H; 42 h

Sampling every 0, 1, 3, 5, 9, 13, 18, 23, 29 and 42 h



What did the Case Study show?

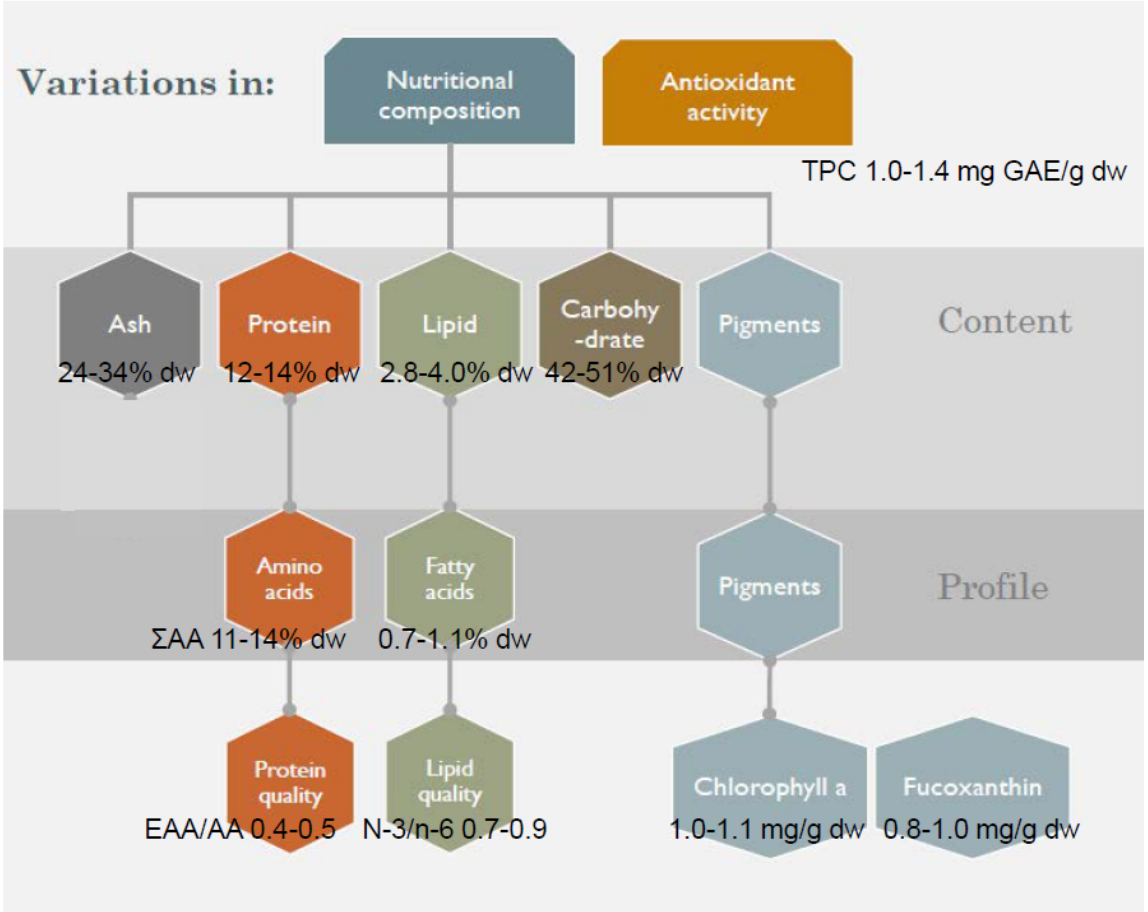


VA	-0.0323
VB	-0.0317
VC	-0.0352
V	**-0.0331 ± 0.0015**
HA	-0.0162
HB	-0.0171
HC	-0.0199
H	**-0.0177 ± 0.0016**

Vertical hanging is almost **twice as fast** compared to horizontally

What did the Case Study show?

No significant loss of any of the analysed compounds were found during drying for neither of the methods (vertical vs. horizontal)



Range of the content of compounds from both drying methods

Conclusion on gentle drying

None of the chemical compounds analyzed were lost when drying with uncontrolled parameters (9.3-12 ºC and 32-78% humidity) with a sorption dehumidifier neither for the vertically or horizontally hanging sugar kelp.

Vertical drying is almost twice as fast as horizontal drying, and therefore it is recommended that the company dries their sugar kelp by the vertical method, as this will be both faster and more economically sustainable.

Seaweed processing- heat and fermentation

Praveen Kumar Sappati, Ingrid Undeland, Jens J Sloth, Balu Nayak, Susan Holdt

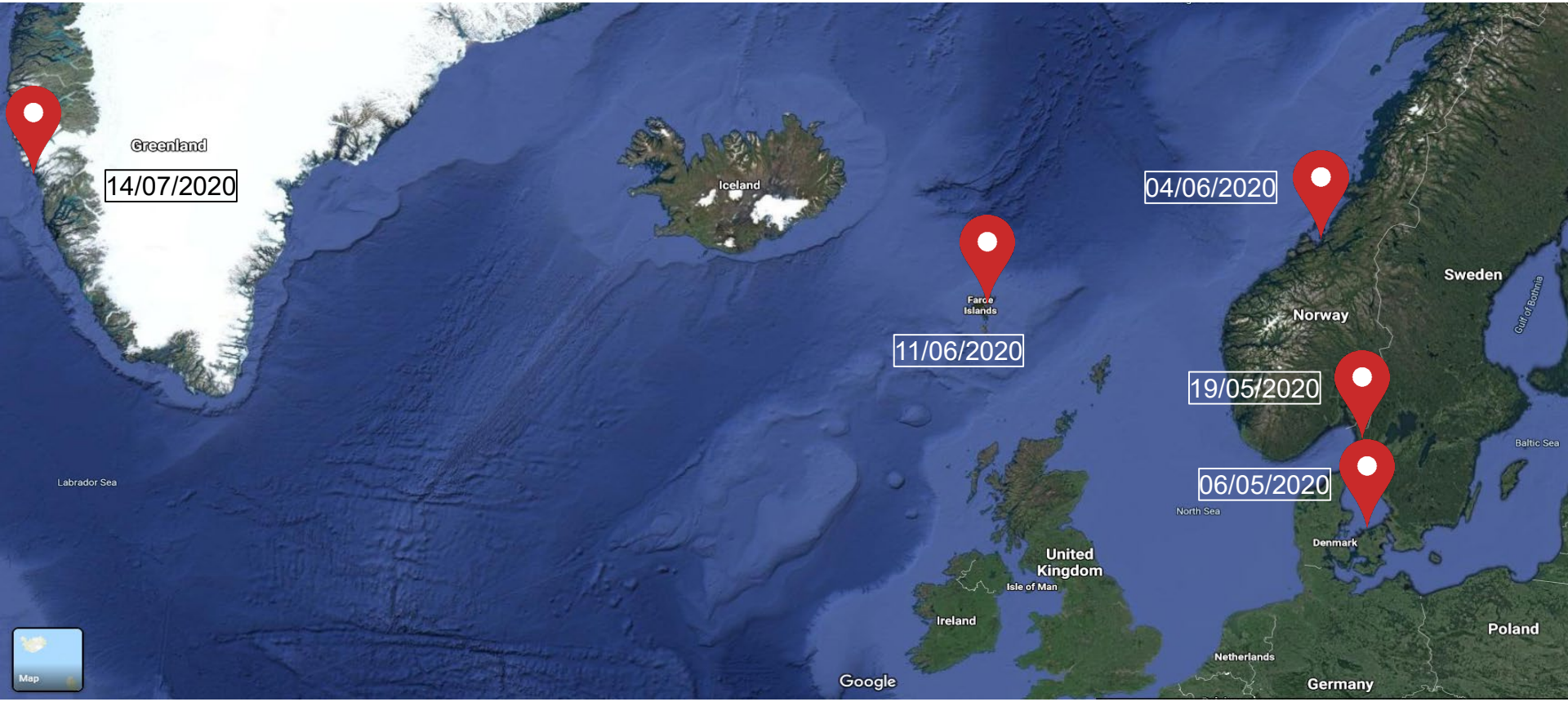
Project supported by Ekhagastiftelsen

SEAWEED-BIO-ASSESS

Seaweed, a superfood for a growing population- improving the bioavailability of healthy ingredients

Praveen Sappati , Impact Umaine, 2019

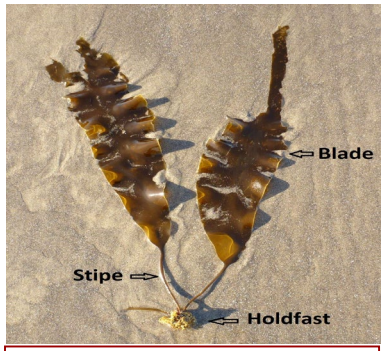
Harvesting Locations



Processing

Sun Drying

Hot Air Drying
(40, 70 C)



Fresh Sugar Kelp

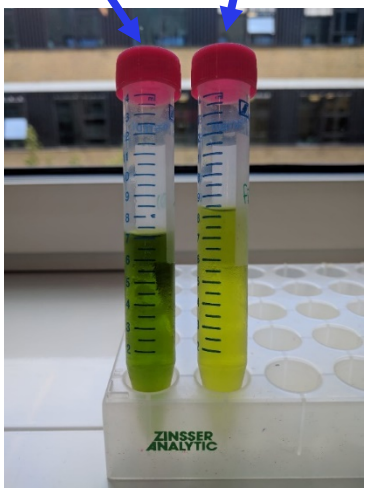
Freeze Drying

80 C Blanching
(20, 120 s)

Fermentation
(Wild, NT, S22, S207)

Processing Results (Pigments)

Norway Sweden



Pigment Extract

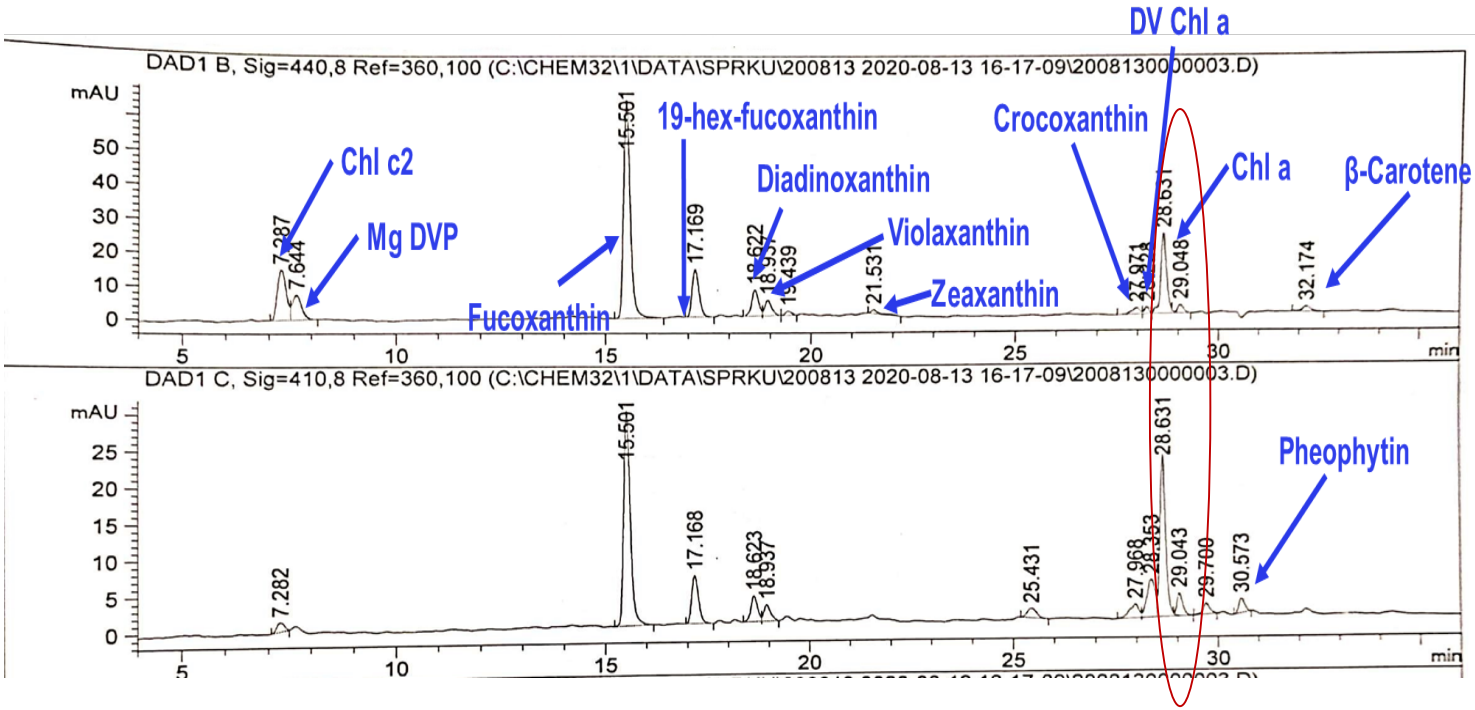


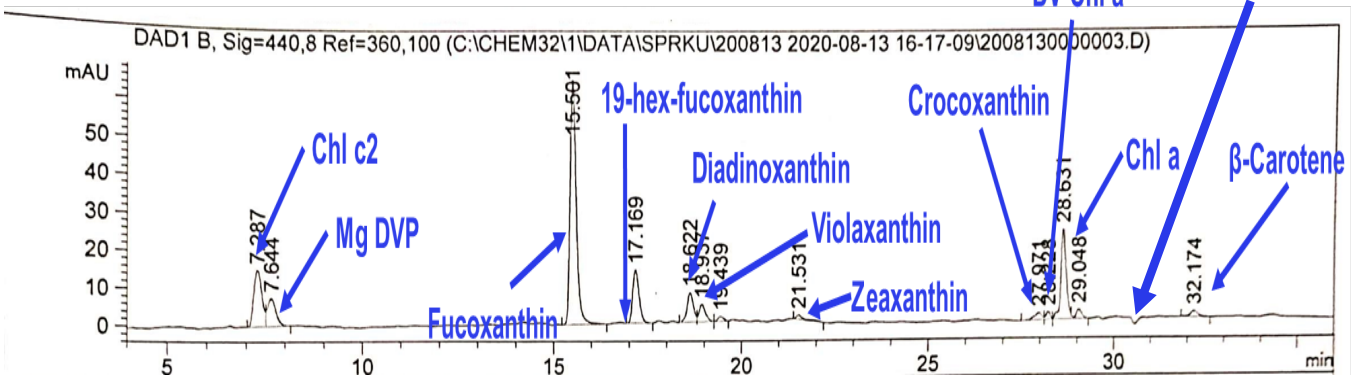
Fig 1. HPLC analysis of freeze dried sugar kelp

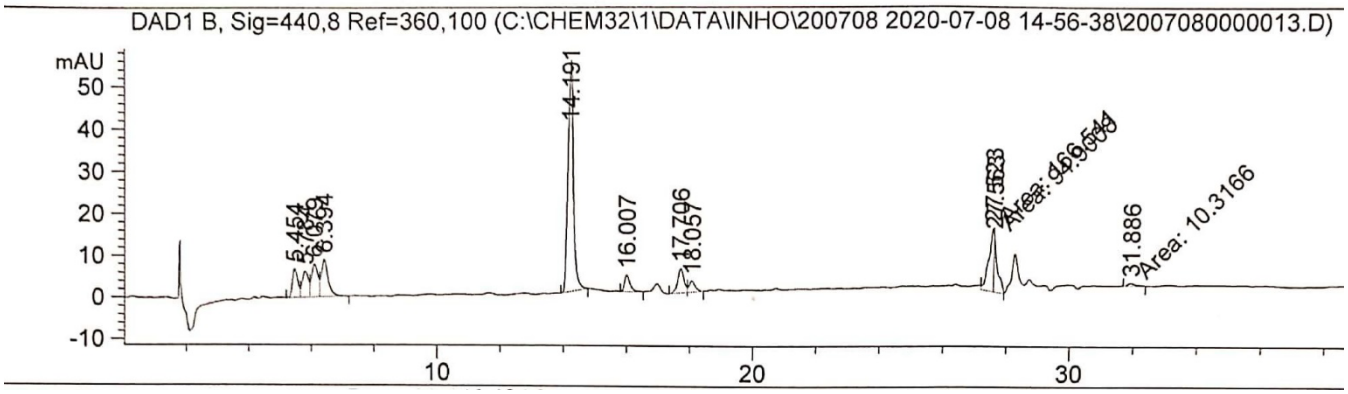
Different countries- pigmentation- Norway more green- higher in chl a

Processing Results (Pigments)

Freeze Drying

Sun Drying



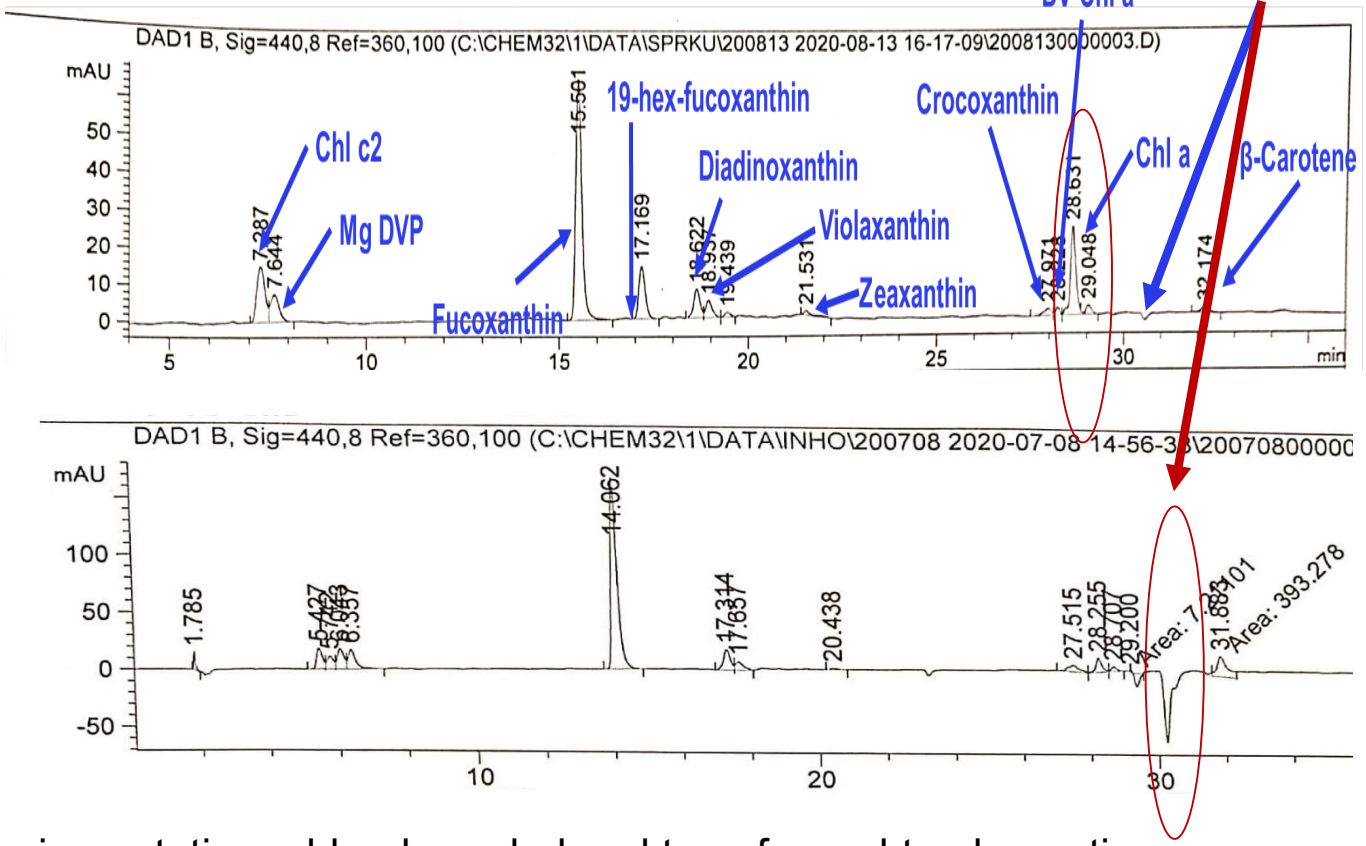


Sun drying- pigmentation- overall less concentration of pigments

Processing Results (Pigments)

Freeze Drying

Hot Air Drying
(70 C)

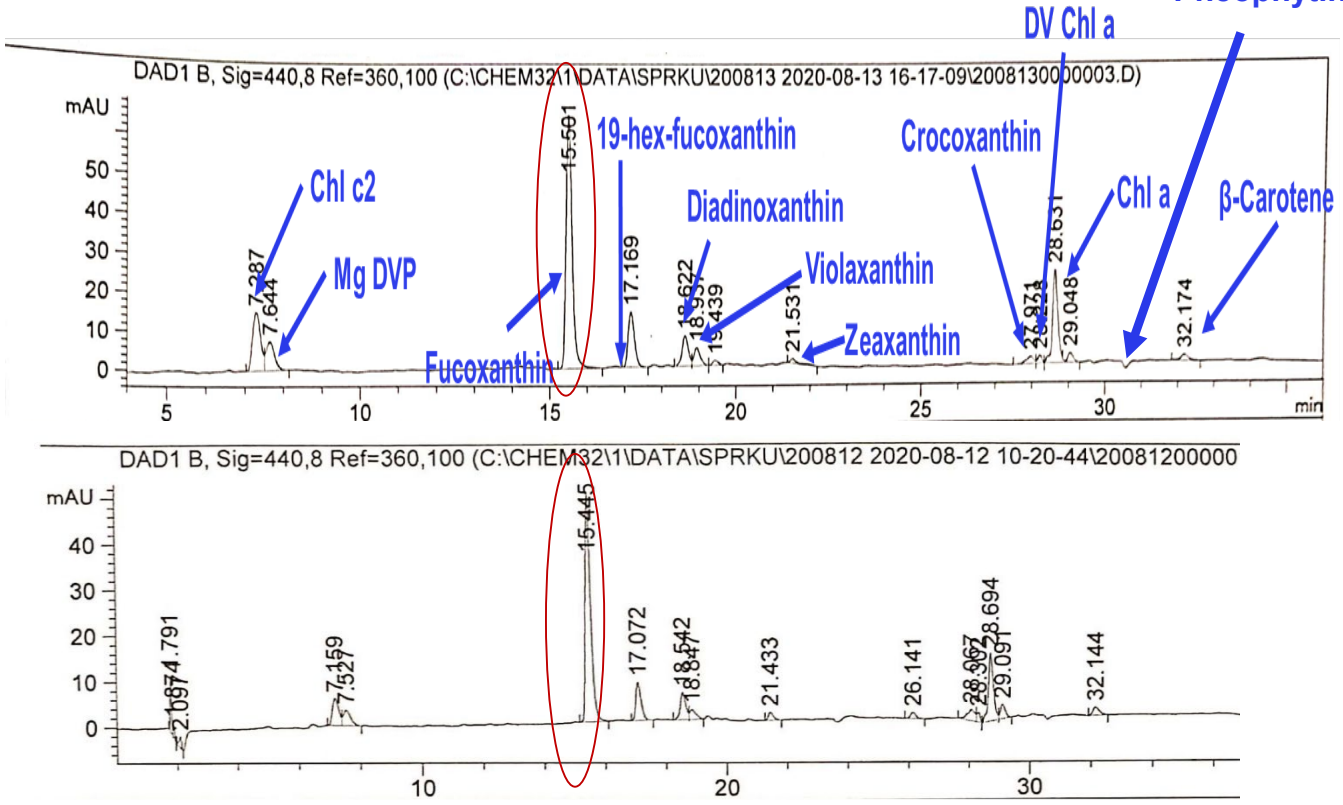


Hot air drying- pigmentation- chl a degraded and transformed to pheopytin

Processing Results (Pigments)

Freeze Drying

80 C Blanching (20 s)



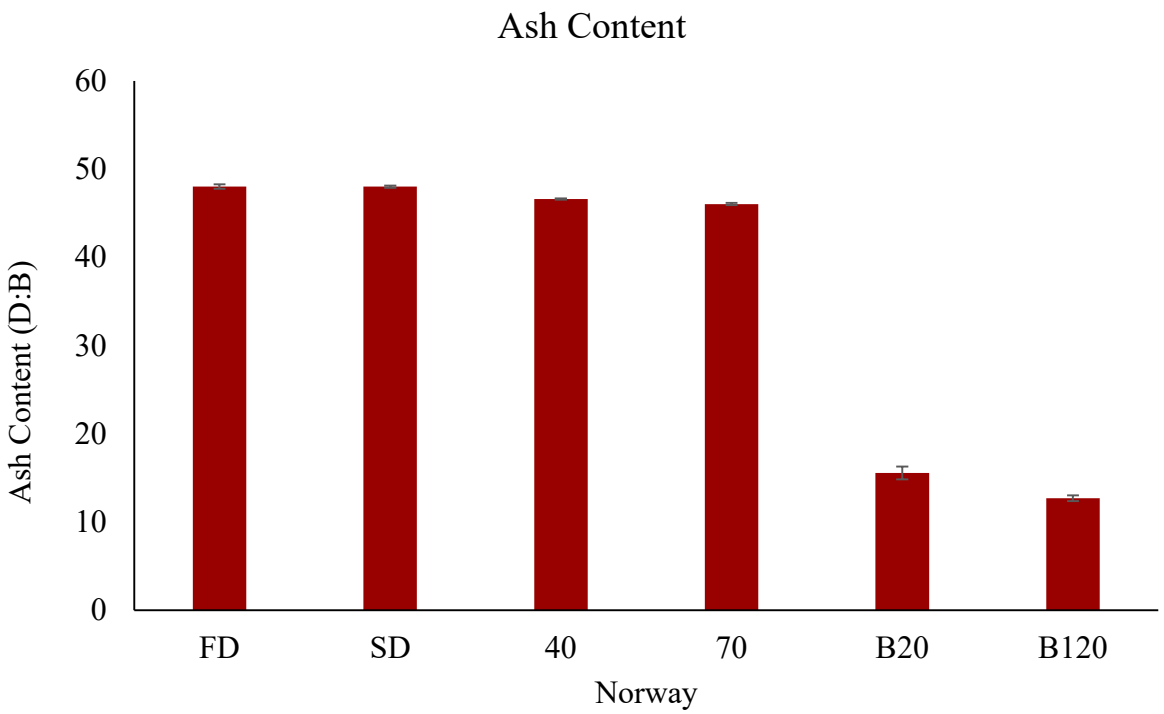
Blanching-pigmentation- still fucoxanthin present although seaweed turnes green -due to ratio between the brown (fucoxanthin) and the green (chl a) color

Processing Results (Ash)

Freeze Dried (FD)

Blanched 20 Sec (B20)

Ash Content



Conclusion on processing

- Differences in composition of seaweed from different countries
- Sun drying decreases the concentration of pigment
- High temperature processing increases the pheophytin, due to degradation of chlorophyll.
- Fucoxanthin is still present despite the blanching
- Wash out of minerals in the blanching

Ongoing analyses:

- Iodine
- Trace elements
- Phenols
- Sugars
- Protein and aminoacids
- Lipids
- Process water (blanching and fermentation)
- Digestion model and bioaccessibility

What is the shelf-life of *Saccharina latissima* stored at 2 °C and can pre-processing prolong it?

Cecilie W. Nielsen*, Jonas S. Sørensen, Katharina J. Kreissig, Grethe Hyldig, Lisbeth T. Hansen and Susan L. Holdt

Aim of study: Investigate the shelf-life of sugar kelp

Hypothesis:

1. Washing in seawater will have a longer shelf life compared to washed in fresh water

2. Blanching will prolong the shelf life

What is shelf-life?

Definition:

Food spoilage may be defined as a process of change which renders a product undesirable or unacceptable for consumption

Food products can deteriorate in several ways:

- Microbial spoilage
- Chemical deterioration
- Loss of quality

P. Subramaniam, *The Stability and Shelf Life of Food*, 2016

Experimental design

Seaweed from Dansk Tang

Treatment

Control/harvest seaweed

NaCl

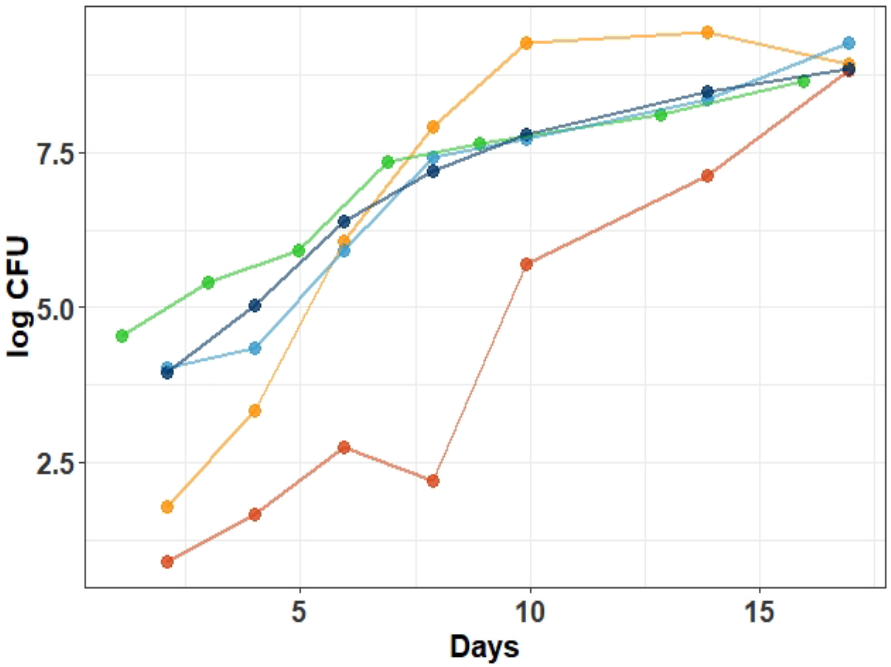
Potable water/tapped water

Washed or blanched

Storage temperature:	2 ºC
Storage time:	16 days
Replicates:	3

Total coliforming units (CFU) on marine agar

SELECTED RESULTS



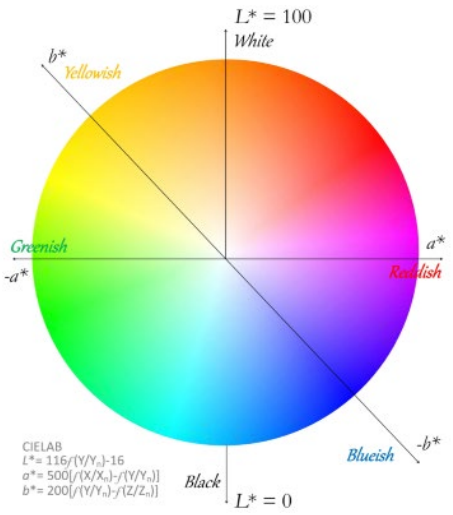
- Harvest seaweed — pH = 6.3, NaCl = 1.2%
- Washed seawater — pH = 6.3, NaCl = 1.2%
- Washed potable water — pH = 6.3, NaCl = 1.2%
- Blanched seawater — pH = 7.6, NaCl = 2.3%
- Blanched potable water — pH = 8.6, NaCl = <0.2%

Key findings

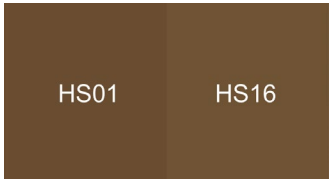
- Harvest and washed are following the same trend
- 2 log reduction when blanching
- Blanched seawater has a rapid growth, above 7.5 log CFU/g after 7 days
- Blanched potable water remained low untill day 10, whereafter a rapid increase occured

CIELAB colour

SELECTED RESULTS



Harvest seaweed

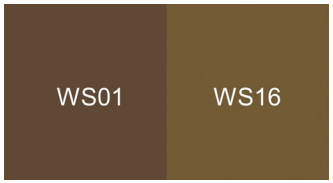


No significant changes

Washed seaweed

Higher lightness (L*)

Decrease in green (−) to red (+) (a*)

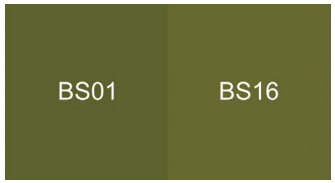


Higher lightness (L*)

Slight decrease in green (−) to red (+) (a*)

Blanched seaweed

No significant changes



No significant changes

Blanching makes biomass greener

Washed- some decrease in green over storage

Blanched- no change in colour over storage

Sensorial properties

SELECTED RESULTS

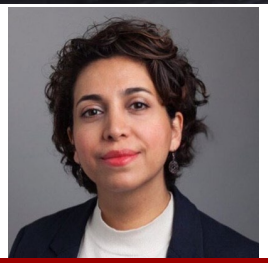
Tendency	Attribute		Key findings
 **Falling** intensity of attribute over time	• Sweet • Fresh sea • Rubber	• Fresh acid • Cooked peas • Umami	• For all attributes, the half-time is ~7 days • Blanched are initially more intense for cooked peas and umami
 **Similar** intensity of attribute over time	• Resilient • Leather • Silky		• Blanched are less resilient than washed and harvest
 **Increasing** intensity of attribute over time	• Transparent • Slimy • Acetic acid	• Sour • Old flower water • Sulfur	• Increases are in general from day 9 • For slimy is a rapid increased for washed in fresh and blanched in seawater

Wrap-up and conclusion

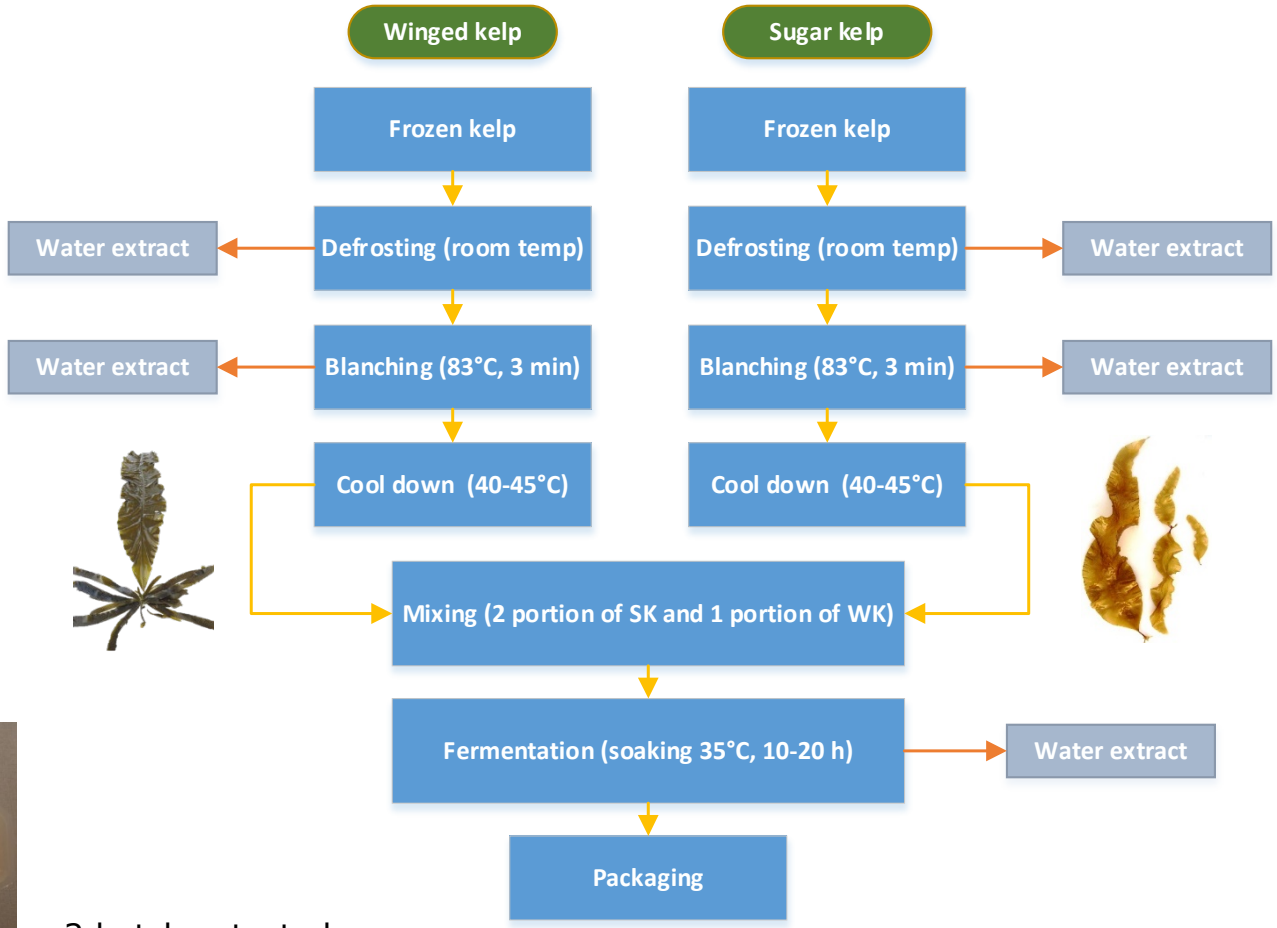
Aim of study:	Investigate the shelf-life of sugar kelp	›	Results indicate shelf-life of 7 – 9 days
Hypothesis 1:	Washing in seawater will have a longer shelf life compared to washed in fresh water	›	No – there are no difference in initial results
Hypothesis 2:	Blanching will prolong the shelf life	›	Initial results suggest blanching in potable water could prolong shelf-life
Next steps	Analyse several parameters, with the following as main categories:		• Valuable chemical compounds • Microbiota • Texture • Drip loss

Iodine- different processing steps of fermented seaweed salad - by Nordisk Tang

- Azadeh Bahmani, Susan L. Holdt Jens J. Sloth and Max Hansen



Fermented seaweed salad - production process

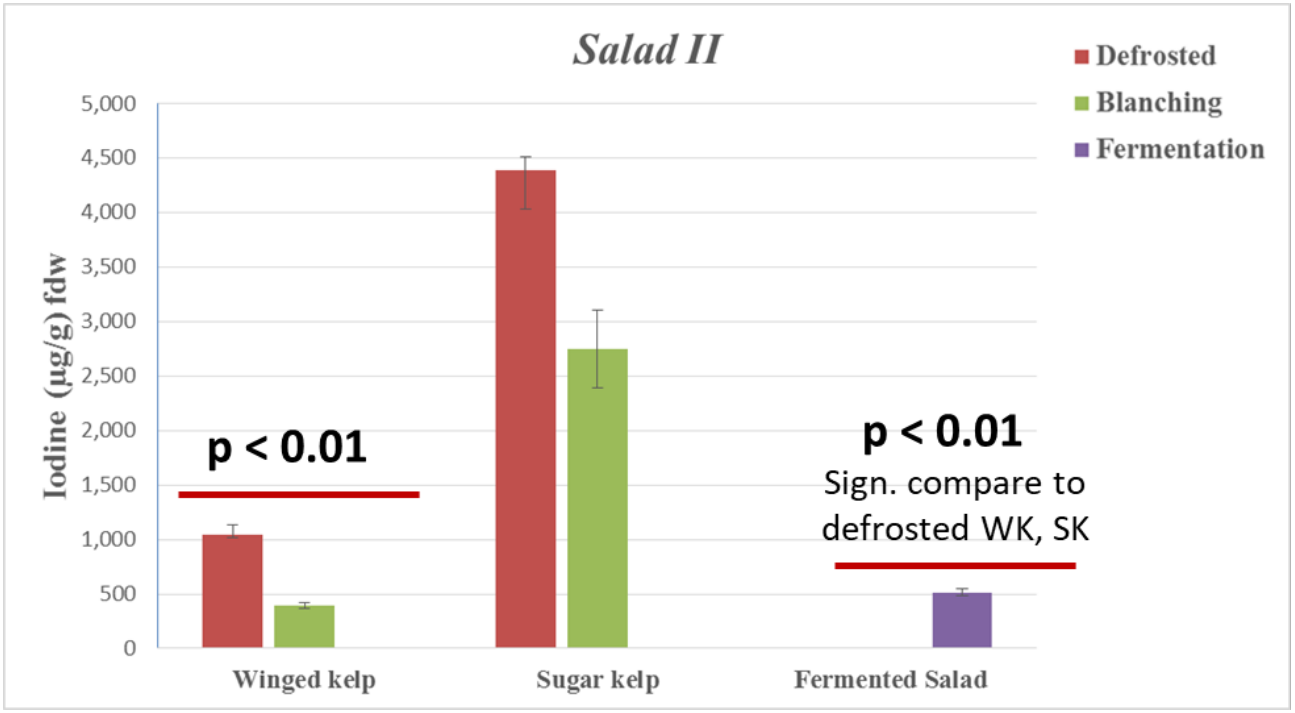


2 batches tested

(not all steps of both batches)

Solids

- IODINE reduction in every process
- Sugarkelp more iodine
- Final salad below recommended threshold values

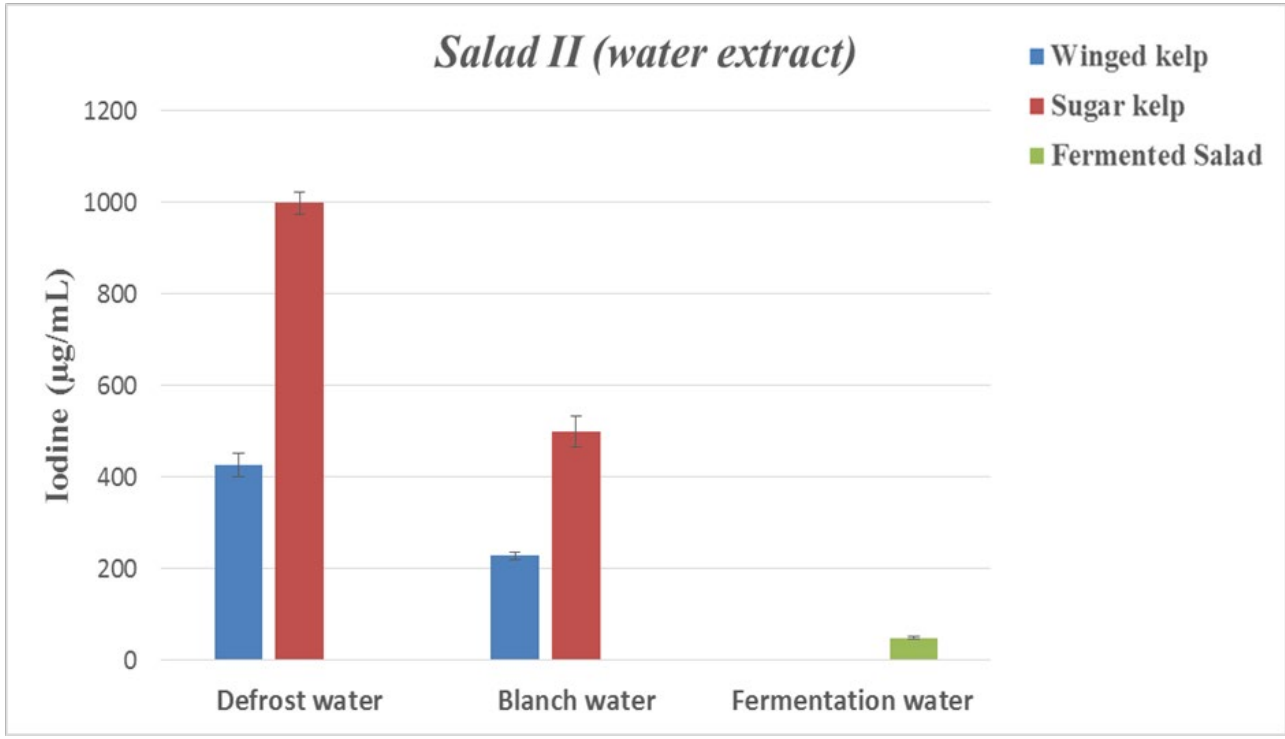


Solids

- IODINE reduction in every process
- Sugarkelp more iodine
- Final salad below recommended threshold values

Liquids

- IODINE reduction in every process
- Liquids below recommended threshold values (<2,000 ppm)
- Lowering to pH 3.8 (and fermentation) seems interesting



Conclusions on seaweed salad

- All process steps decreased the iodine conc significantly (solid and liquid)
  - Blanching, fermentation
- Fermented seaweed salad did have conc of iodine below threshold values

Results not shown here…..

- But not only about conc but also quantity of intake
- Low to moderate intake of seaweed salad not a concern (if >age 4)
- Large variation of iodine within batches of seaweed salad
  - And species with sugarkelp higher concentration
- Rather one large ”kick” of iodine one day, than moderate over a period

Overall conclusion

- Gentle processing (around 10 degrees) are not affecting compounds
- Processing (heat, blanching, fermentation) are affecting the compounds
  - loosing or transforming compounds
  - utilize to reduce un-wanted compounds
- Fresh seaweed shelf life is 7-9 days
- Further processing may take place in the kitchen of the consumer
- More knowlegde is needed- not done yet for the overall picture

Ongoing research

- Vitamins
- Storage
  - Compounds
  - Microbial communities
- Processing effect on biomass
  - Still analyses are being performed
- Bio-accessability
  - Good and the bad compounds
- Iodine
  - Speciation (what type of iodine)
  - Compromise of compounds

Thank you – suho@food.dtu.dk