Processing of macroalgae for utilisation as a protein source in animal feed

PROMAC Final Conference

Inga Marie Aasen
SINTEF Industry

Background

- In order for the seaweed farming to grow to a significant industry, and fulfil all visions – a market for cultivated seaweed needs to be developed
- Options currently explored:
  - Food
  - Animal feed
  - Products based on functional or bioactive properties for feed, food, cosmetics etc
- Animal feed is not necessarily a 'low-hanging fruit'!
  - Low protein content, high salt content, indigestible carbohydrates….
    (for the brown algae currently cultivated)

Brown algae as protein source in feed

PROMAC

Example, salmon feed

- Current annual production volumes of salmon:
  - Norwegian production: 1.3 mill tonnes – growth to 5 mill tonnes envisoned
  - Global production of salmonids: ~3.5 mill. tonnes
- Brown macroalgae have a low protein content (5-15 % of dw)

Salmon production [1000 tonnes]	Feed demand[1)] [1000 tonnes]	SPC[2)] [1000 tonnes]	Seaweed demand[3)] [1000 t ww]
1 000	1 150	290	16 700
5 000	5 800	1 440	83 400

1): Feed factor 1.15

2): SPC = Soy protein concentrate, 25 % in the feed

3): 58 % protein in SPC, 10 % dw in seaweed, 10 % protein of seaweed dw

Brown algae as protein source in feed

Protein costs as a function of biomass costs, *exclusive* processing:

Biomass costs		Protein cost
[NOK/tonne ww]	[NOK/kg dw]*	[NOK/kg protein]*
5 000	50	500
250	2.50	25

*: 10 % dw, 10 % protein of dw

Fish meal: ~15 NOK/kg

Soy protein: 5-7 NOK/kg

→ Even with biomass costs in the same range as wild harvested *Laminaria hyperborea* (~250 NOK/ tonne ww), the protein costs will be far higher than for competing proteins.

An added-value of the seaweed as feed ingredient, or co-production of higher-value products, is required.

Brown algae a protein source for animal feed – Experimental approach

PROMAC

- Despite the limitations and challenges, more knowledge is needed:
  - … about the brown algal protein as a feed ingredient
  - … about how the biomass should be processed to allow application as feed ingredient

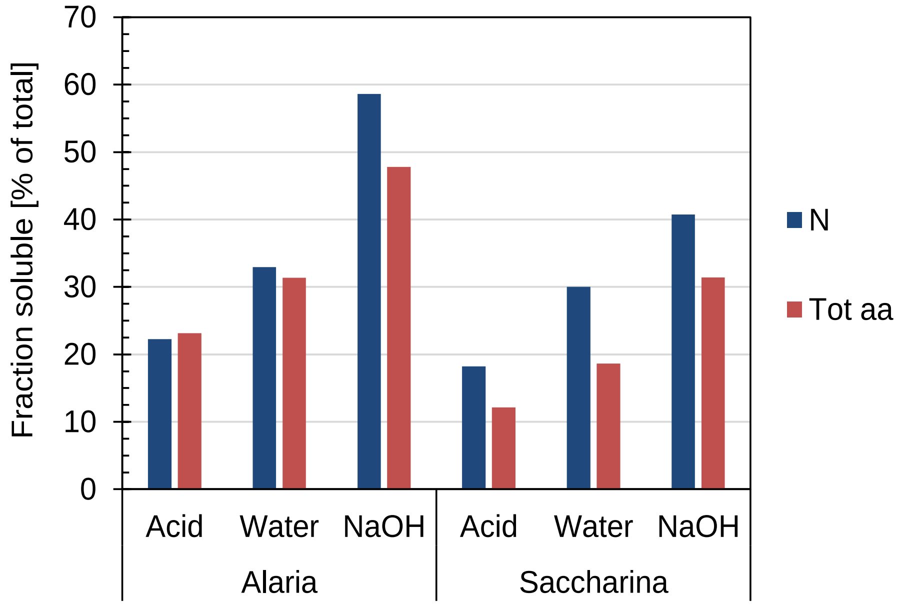
→ ***The aims of PROMAC***

Typical composition of Saccharina:

Dry weight [%]	Ash [% of dw]	Protein [% of dw]	
		Total aa	Total N
~10	40-45	~10	2-2.2

Protein solubility and extraction yields

Laboratory scale tests

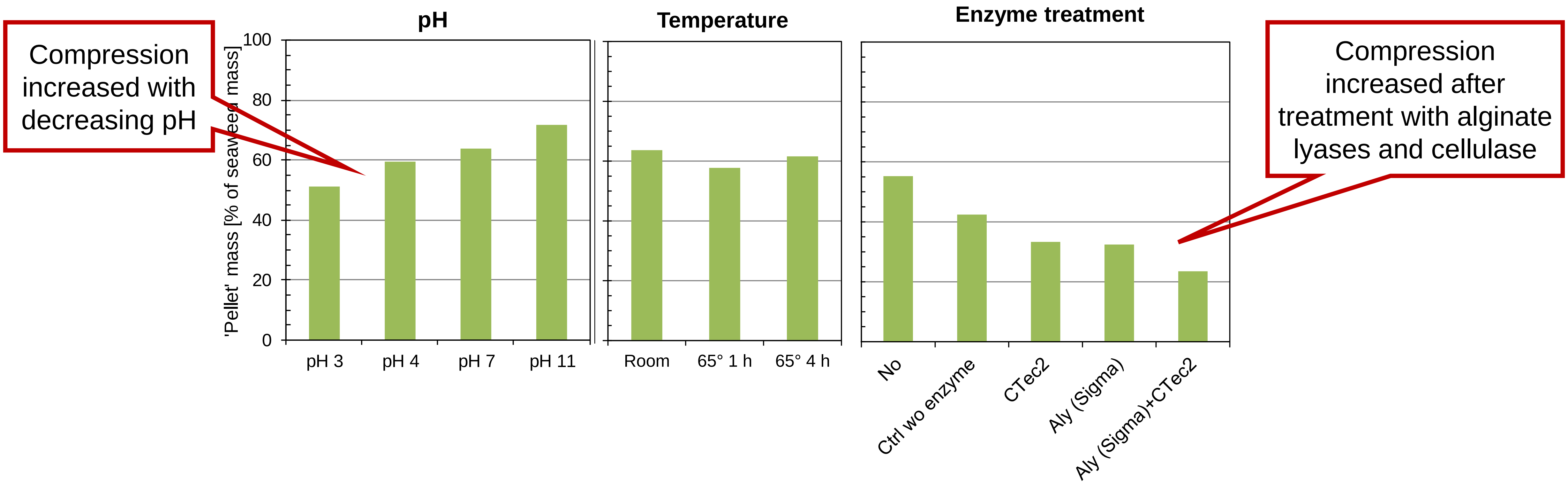


Solubility

- A low fraction of the protein in the brown algae is soluble
- Increasing solubility with increasing pH, but high pH also solubilise alginate resulting in high viscosity
- The high viscosity implies that high dilutions will be required for an efficient solid/liquid separation
- Water use should be minimised

Protein solubility and extraction yields

"Compression" of the biomass as a function of pH, temperature and after enzyme treatment



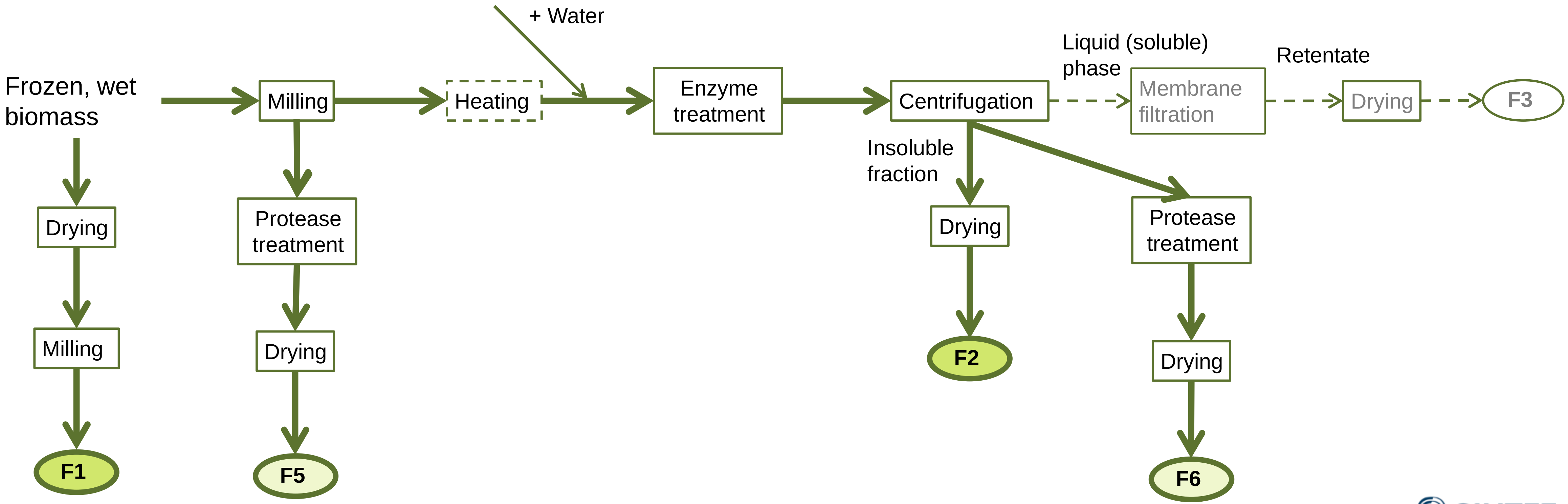
- Maximum extraction yields of N from *Saccharina* were ~40 %, while the maximum yield of 'real' protein (total amino acids) was ~25 %

Production of protein-enriched fractions for animal feeding

- Due to the low yields, the selected strategy for pilot-scale production was to remove undesired components to increase the protein fraction in the remaining part
  - *Most important: Salts (> 40 % of dw in cultivated Saccharina)*
- This is the same strategy as normally applied for plant proteins

Production of protein-enriched fractions for animal feeding

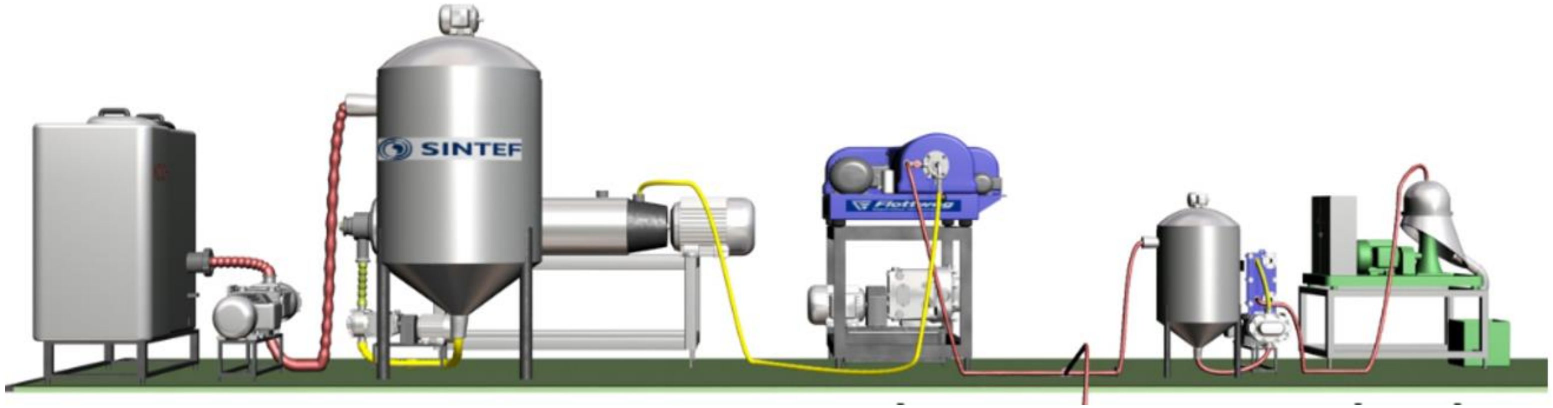
- *S. latissima* and *P. palmata*, ~200 kg ww of each, was processed in 2016 and *S. latissima* (750 kg ww) was processed in 2017



SINTEF

Palmaria and *Saccharina* production

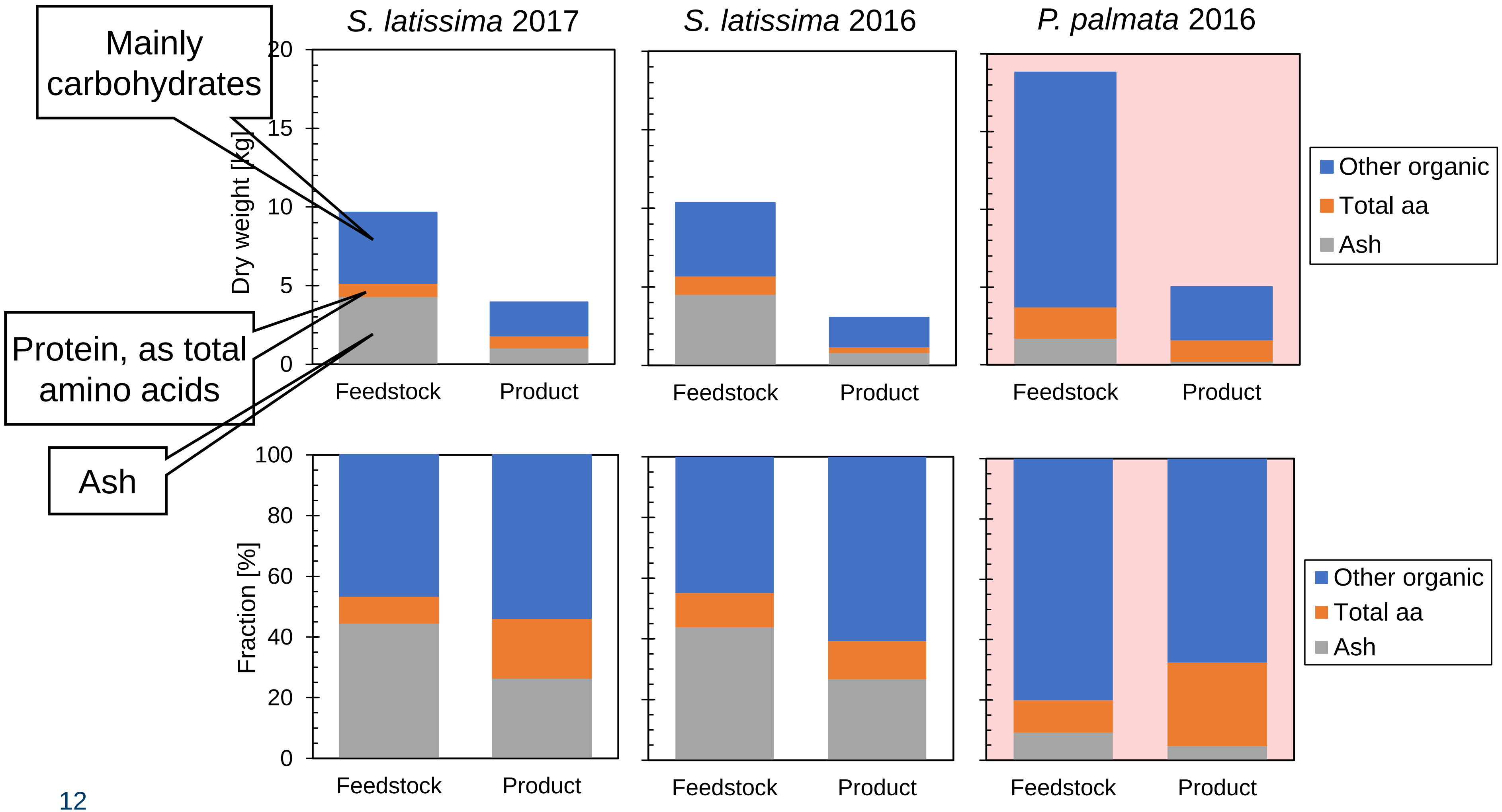
- SINTEF Ocean's mobile pilot plant



Mincer → Heat exchanger → Hydrolysis tank → Tricanter → Polishing centrifuge

Pilot scale productions in 2016 and 2017

Pilot production - Composition of the products



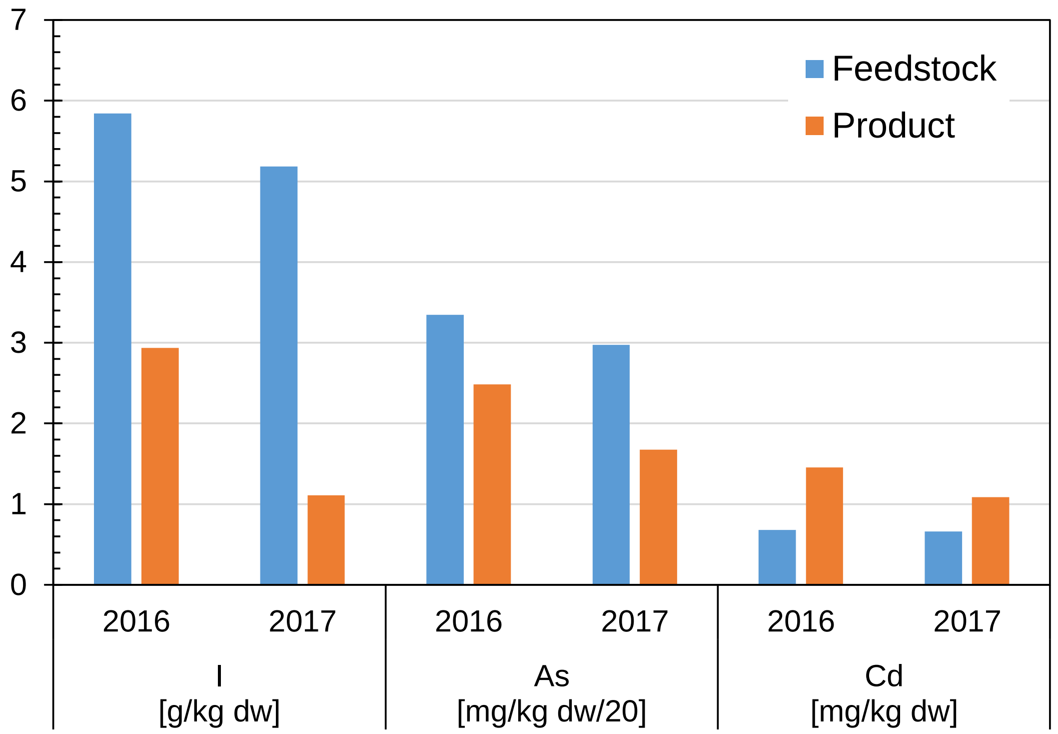
***Saccharina*, iodine:**

2016
Feedstock: 5.8 g/kg
Product: 2.9 g/kg

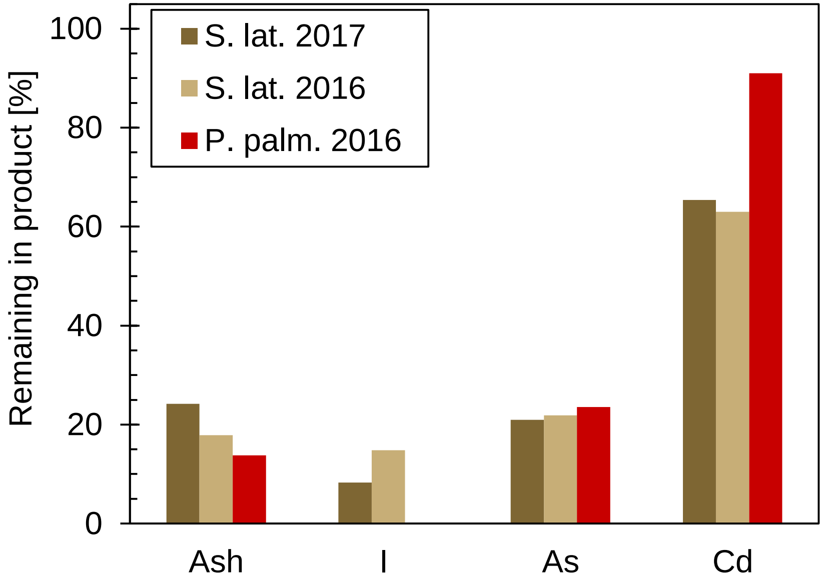
2017
Feedstock: ~5.9 g/kg
Product: 1.1 g/kg

Iodine and heavy metals

Concentrations in feedstocks and products



Remaining amounts in the product



- Arsenic was reduced in the same ratio as total minerals (ash)
- Iodine was reduced more than ash
- Cadmium accumulated

Protein and amino acids

PROMAC

- 80-90 % of the N in the raw materials are amino acid N (protein + free)
- Free amino acids constitute ~10 % of the total amino acids in the raw materials. Alanine is the dominating free amino acid
- In the products, 90-100 % of the N were amino acids
- In lab-scale tests, 70-90 % of the <u>free</u> amino acids were 'lost' to the liquid phase, depending on conditions (temp., pH, +/- enzymes etc), can assume 60-80 % in pilot-scale
- In general: the protein-'loss' will be the soluble protein, ie. the product will have a higher fraction insoluble protein

Conclusions and future

- For utilisation of brown algae as an animal feed ingredient, salts and iodine can be reduced by a simple processing, which will allow higher inclusion levels in the feed
- The process can be a part of a biorefinery where water-soluble compounds are isolated from the liquid phase, and alginate is extracted from the solid phase, which also will increase the protein content of the product
- Available quantities and costs exclude use of seaweed as the main protein source in feed, at least on a short term

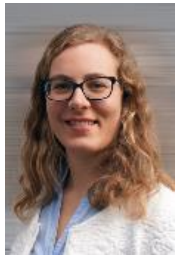
➔ *Need to document properties and benefits of the seaweed components compared to similar, and cheaper, compounds from other biomasses*

➔ *Need to develop separation processes that integrate production of multiple components in a seaweed biorefinery*

Partners and people contributing to the results

- SINTEF Materials and Chemistry
  - Ingrid Sandbakken
  - Inga Marie Aasen
- SINTEF Ocean
  - Raza Slizyte
  - Erlend Indergård
  - Jorunn Skjermo
  - … and others
- NTNU
  - Master students with Turid Rustad as supervisor
- NIBIO
  - Michael Roleda
- MATIS
  - Rosa Jonsdottir and others
- CEVA
  - Helene Mairfang


Inga Marie


Ingrid


Turid


Rasa


Jorunn


Erlend


Michael


Rosa


Helene