FOODS OF NORWAY

Bioprocessing of seaweed to fish feed

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Foods of Norway
WP1: Development of novel feeds and processing technology

Production of single cell protein (SCP)

Wood

Seaweed

Enzymatic hydrolysis

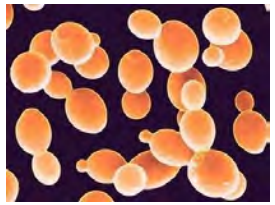
Enzymes

Hydrolysate

Fermentation

Yeast

Yeast broth
(Single cell protein)



Spray drying

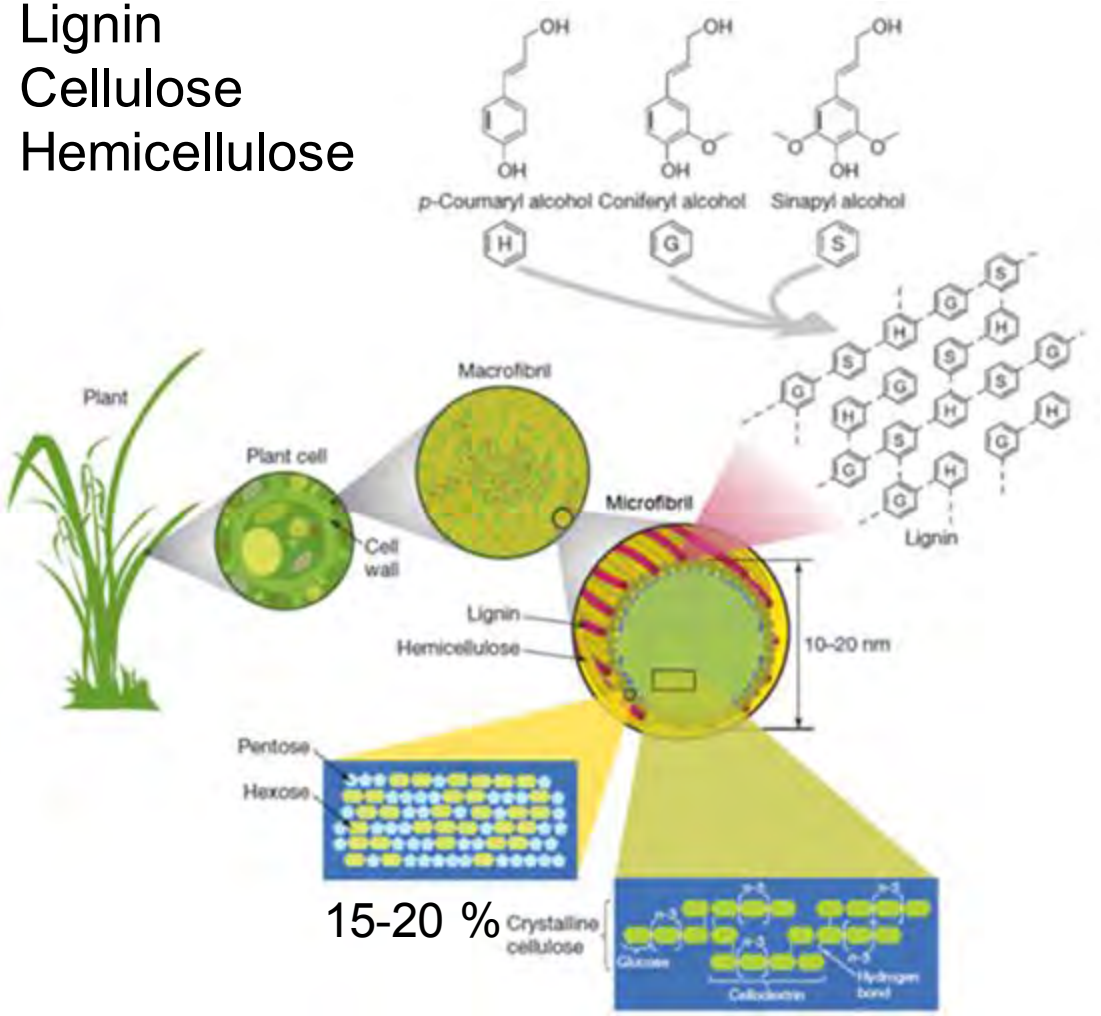
Dried yeast

Feed ingredients

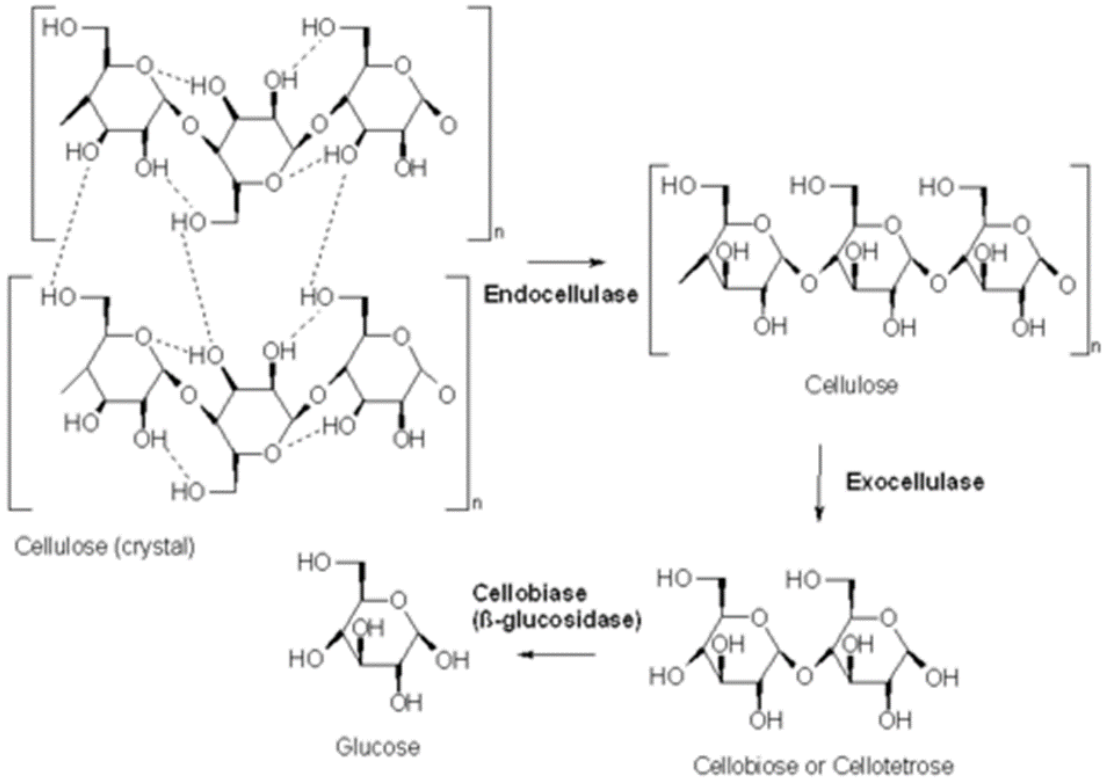
Feed trials

Lignocellulosic biomass

Lignin
Cellulose
Hemicellulose

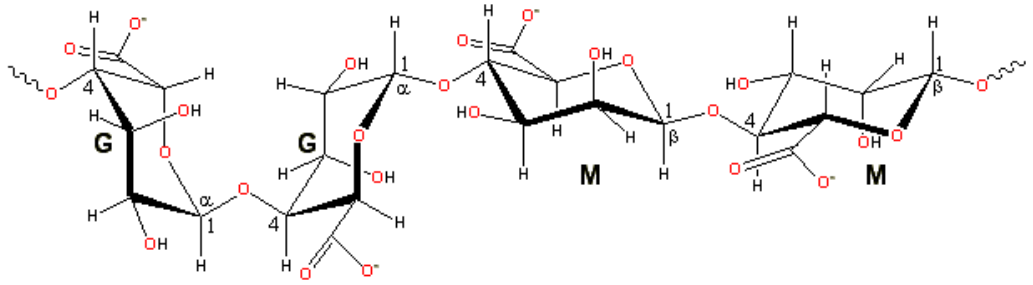


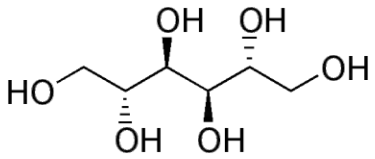
Cellulases

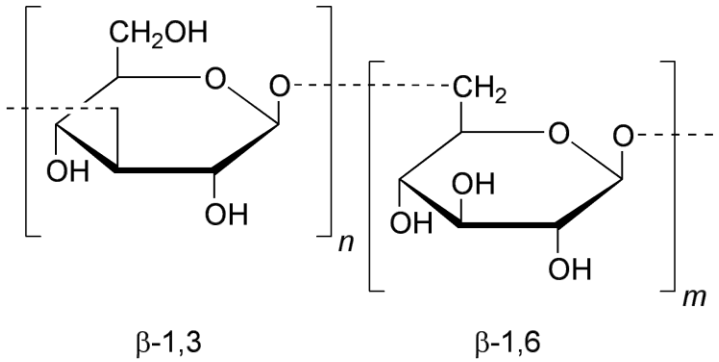


Brown seaweed composition

- 20 % DM
- Of DM:
- -30 % ash
- -10 % protein
- -25 % alginate
- -15 % mannitol
- -20 % laminarin

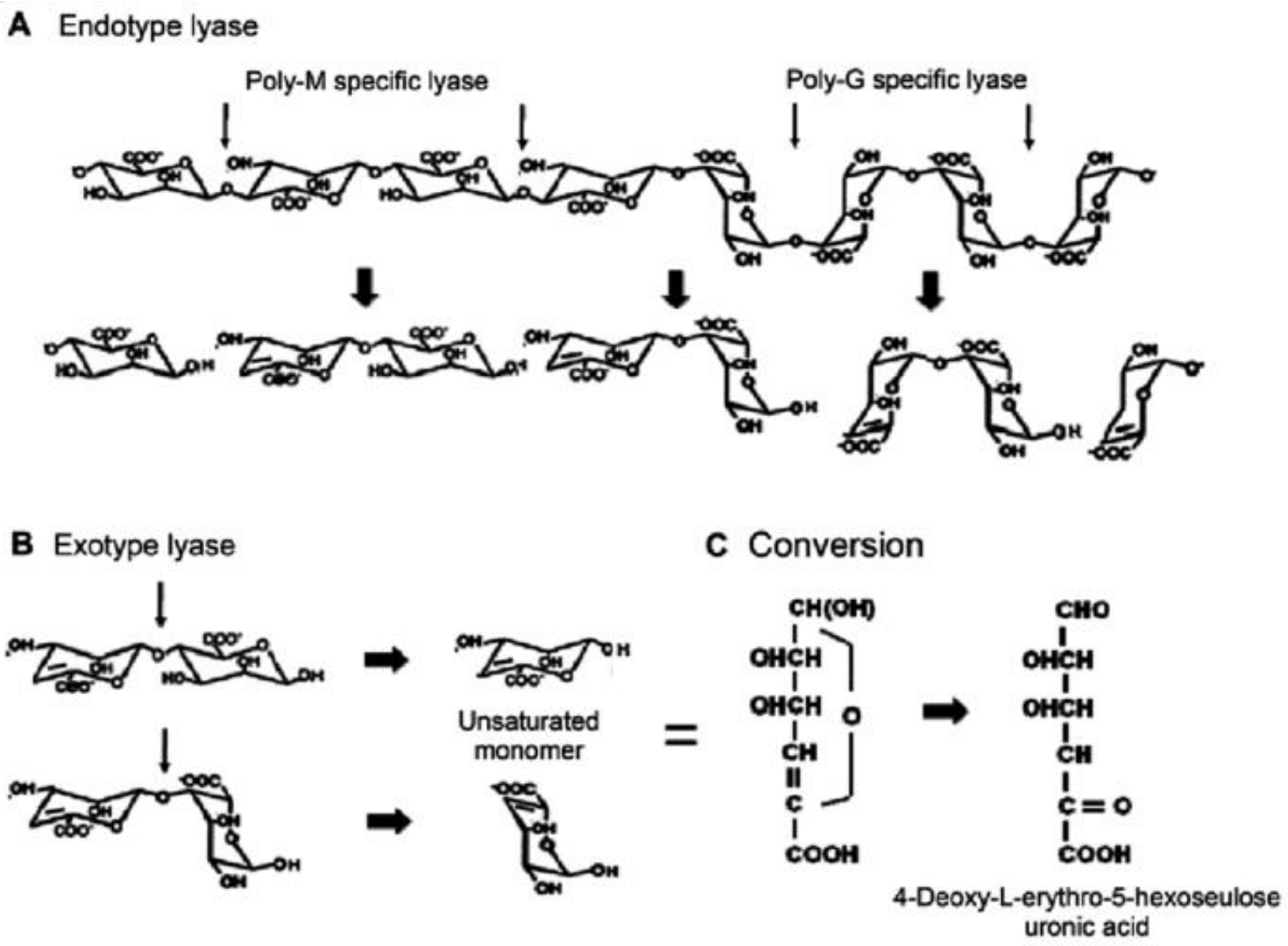






β-1,3 β-1,6

β(1→3)-glucan with β(1→6)-linkages (β(1→3):β(1→6) ratio of 3:1)



Solubilization
Reduce viscocity

Production of sugars

Seaweed nutrients and minerals

Large annual variation in sugar content

Less variation in nutrients and minerals

Fermentation medium, and fermentation conditions

Microbial biomass

Element	% Dry Weight
C	50
O	20
N	14
H	8
P	3
S	1
K	1
Na	1
Ca	0.5
Mg	0.5
Cl	0.5
Fe	0.2
others	0.3

Conditions

Temperature
pH
Mixing
Oxygen

Microbial biomass is produced under aerobic conditions

Enzymatic hydrolysis

Chopped seaweed

Enzymes

CellicCtec2
Alginate lyase

Seaweed slurry

Growth medium for yeast

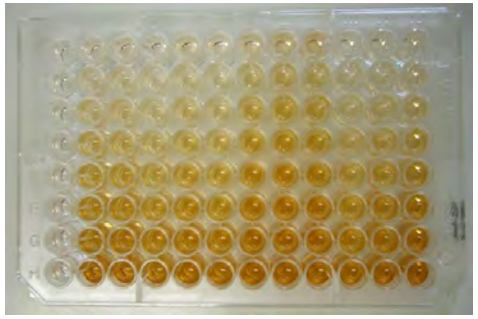
- **Medium composition:**
  - **Spruce hydrolysate from Borregaard Bali pilot plant**
  - **Hydrolyzed seaweed**

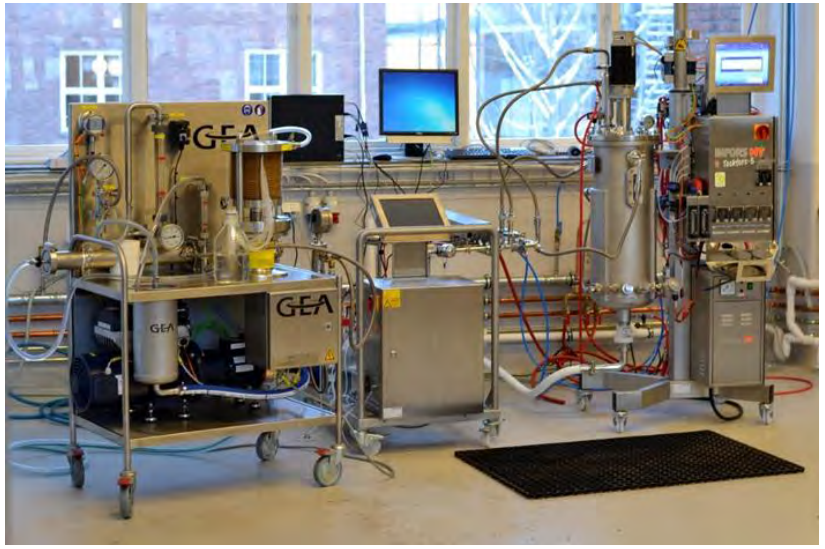
Mainly glucose

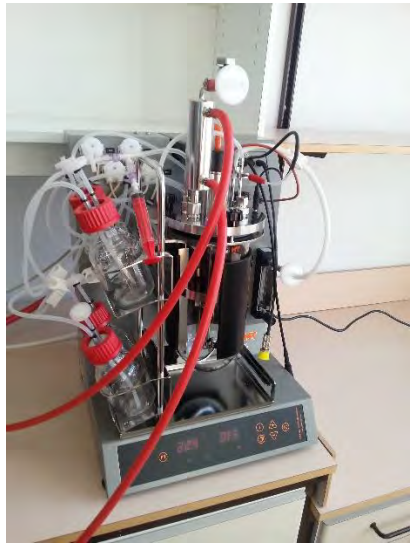
+

Glucose, mannitol, minerals, nitrogen and phosphorus

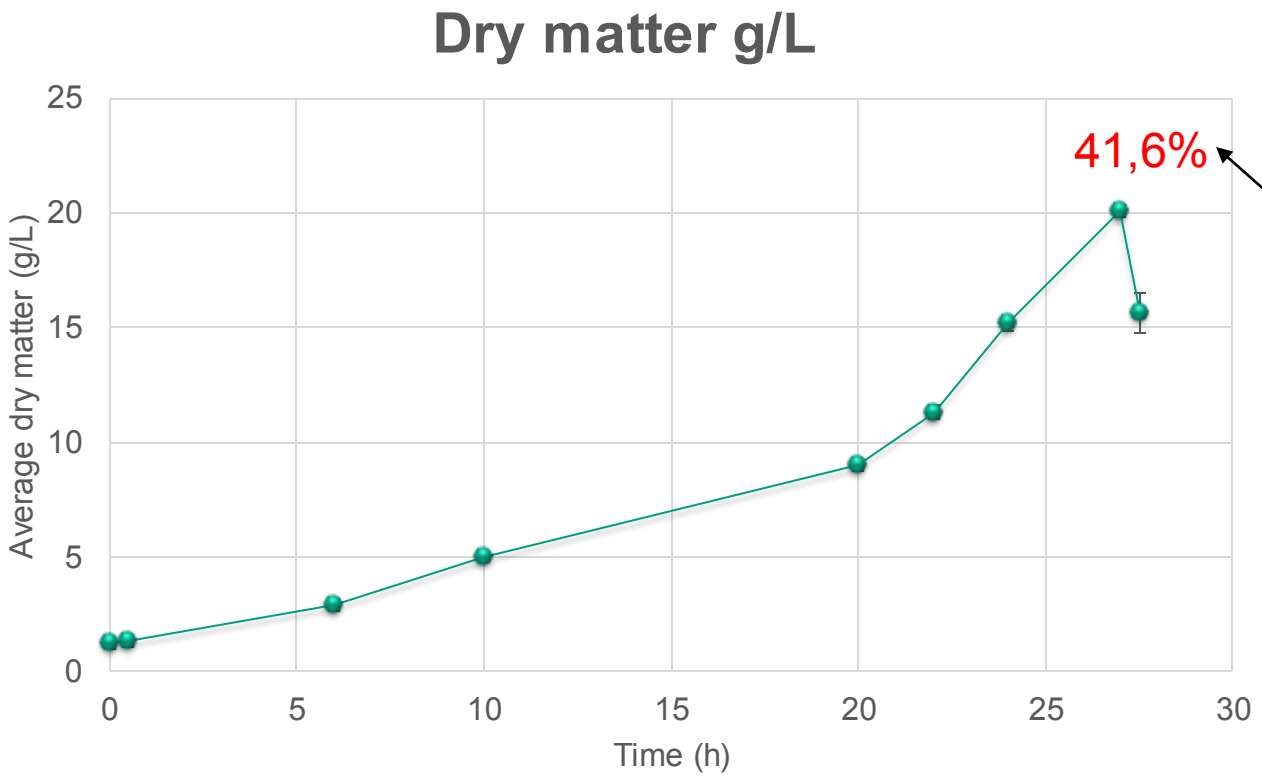
SCP fermentation: screening and scale up







Yeast 30 L fed-batch fermentation



Protein content

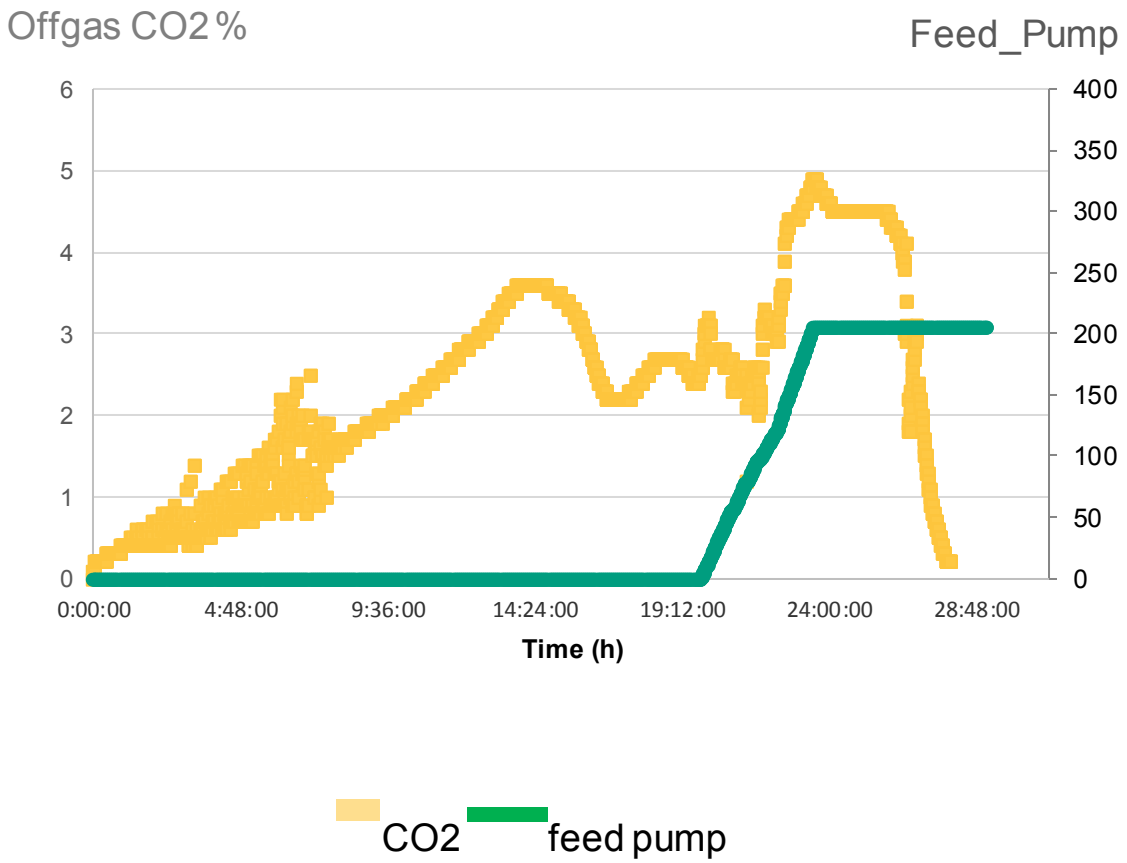
Medium:
-Seaweeed hydrolysate
-Spruce hydrolysate

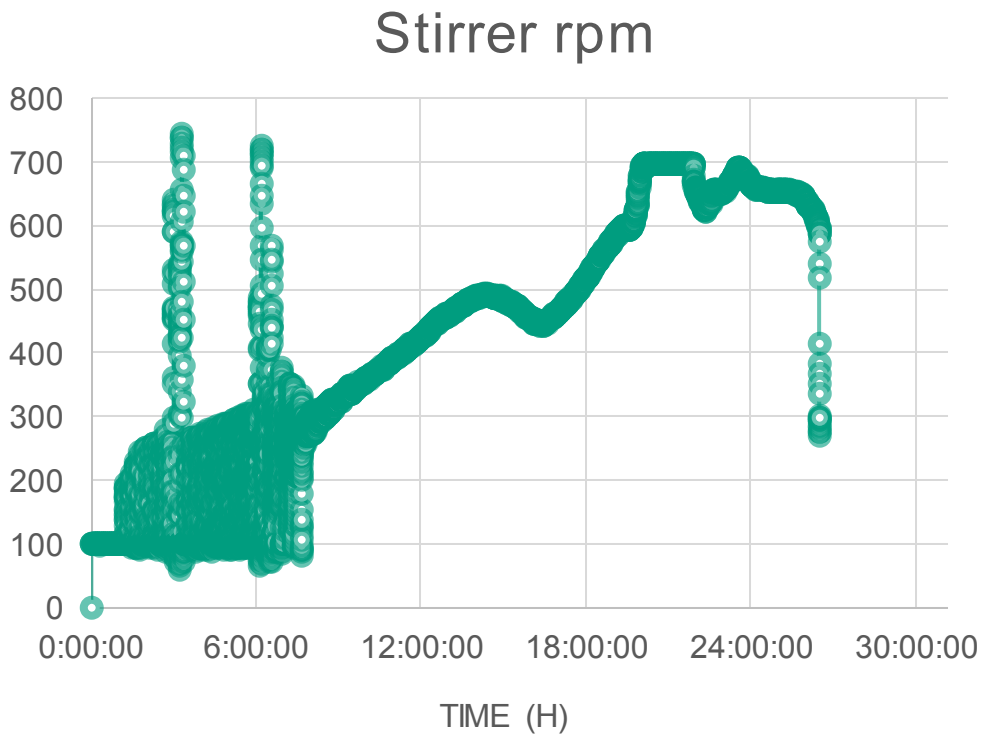
$$C_6H_{12}O_6 + 0.48\ NH_3 + 3\ O_2 \rightarrow 0.48\ C_6H_{10}O_3N + 3.12\ CO_2 + 4.32\ H_2O$$

(38 %)

Online monitoring of process

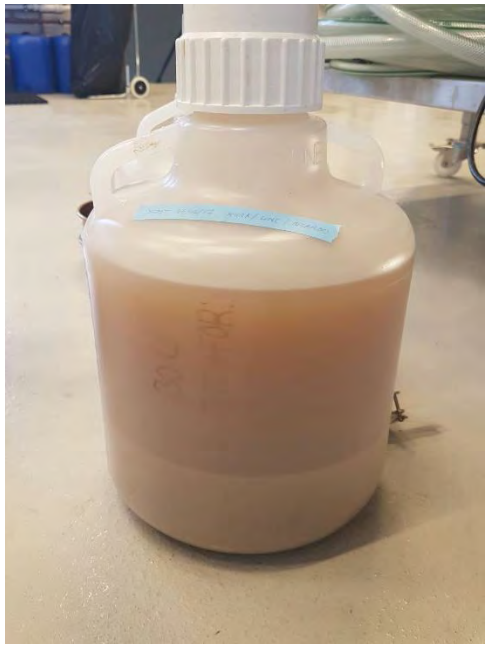
Dissolved oxygen (DO) set point 20%





Sugar consumption

Down stream processing: Separation and spray drying



Washed fermentation broth

2 kg

Feed

Future research

-Monomeric sugars from alginate (exo lyase)

-Cloning and expressing new alginate lyases

-Design seaweed enzyme coctail

-Yeast strains that can utilise uronic acids

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