Senter for forskningsdrevet innovasjon
Norges forskningsråd

FOODS OF NORWAY

Biotechnological transformation of non-food biomasses and agri-food rest raw materials into novel high-quality feed ingredients

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a Centre for Research-based Innovation

Start-up:
1/9-2015

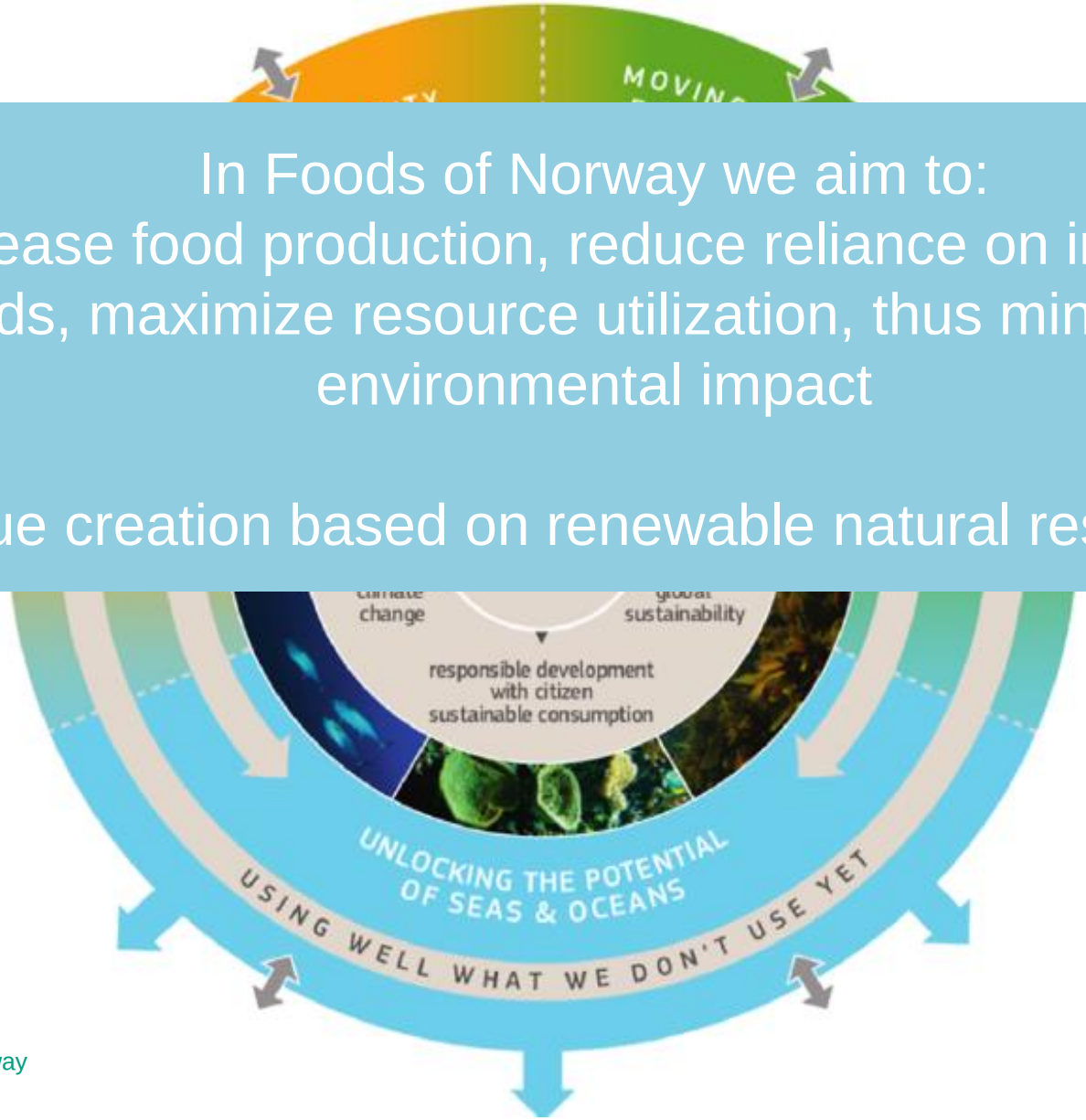
→ 2023

FOODS OF NORWAY

The Bioeconomy

In Foods of Norway we aim to:
increase food production, reduce reliance on imported feeds, maximize resource utilization, thus minimizing environmental impact

Value creation based on renewable natural resources



Foods of Norway – 6 integrated workpackages

1. Development of novel feeds and processing technology

Biomass: Trees, macroalgae, grass, animal and marine co-products
Process: Enzymatic processing, mechanical processing, fractionation technology, fermentation technology, biorefinery processes, feed technology

2 & 3. Impact of novel and improved feed ingredients on nutritional value, feed efficiency and animal health

Salmon
Dairy cows & growing cattle
Pigs & broiler chicken

4. Food quality assessment

Fish, pigs, chicken and cattle meat
Milk and milk products

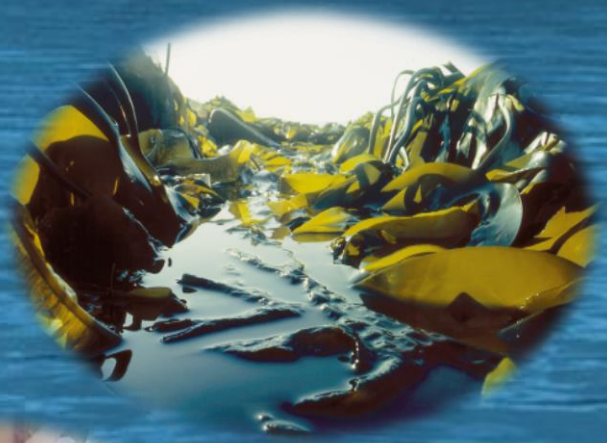
5. Genomics and genetics of feed efficiency, health and robustness

Identify biomarkers for high feed utilization from WP 2 & 3.
Selection of fish and farm animals with high feed efficiency.

6. Economic and environmental sustainability

Economical consequences
Environmental consequences (e.g. LCA)

Converting non-edible biomass to feed

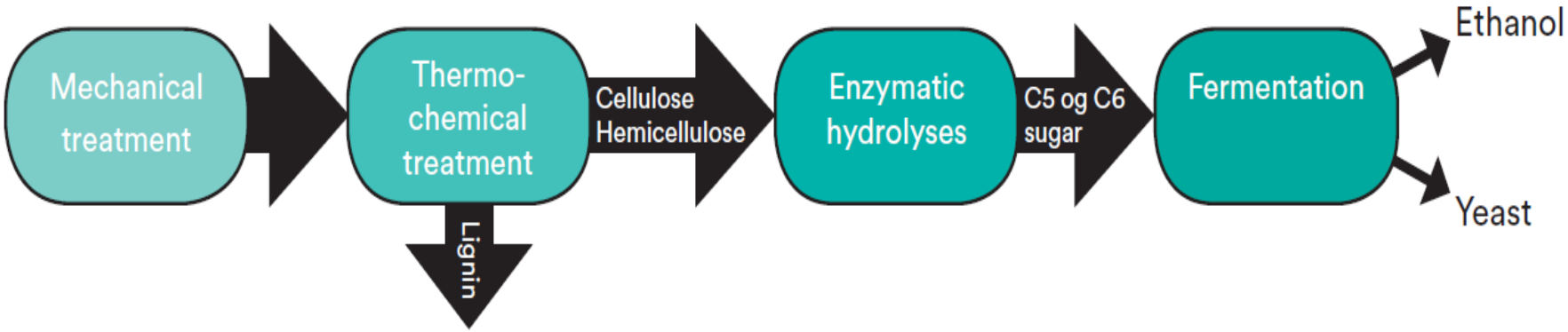


The Norwegian forest is a large national bioresource

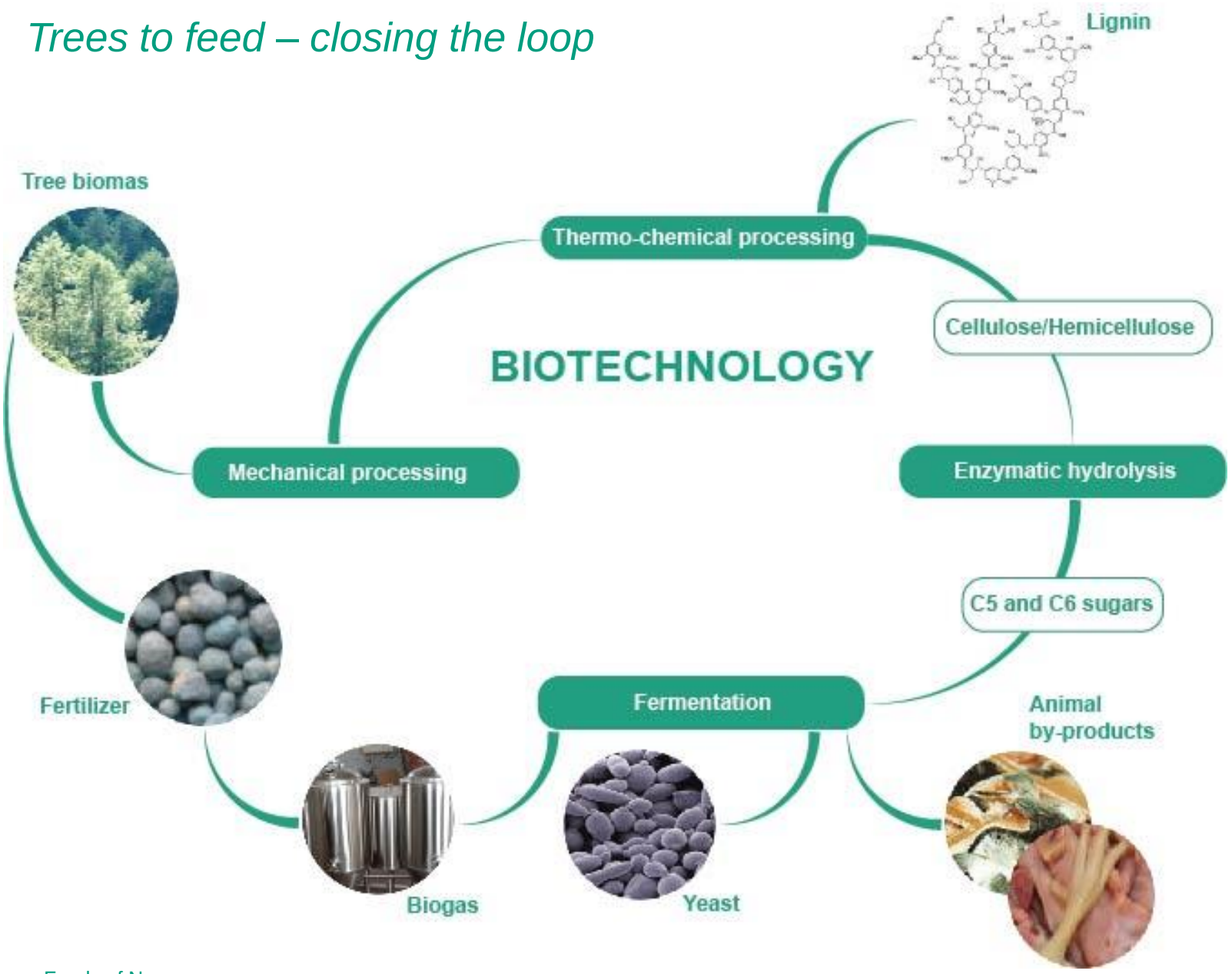
- ✓ ~ 43% of Norwegian land area
- ✓ Standing biomass: ~ 912 million m^3

Photo: Skog 22

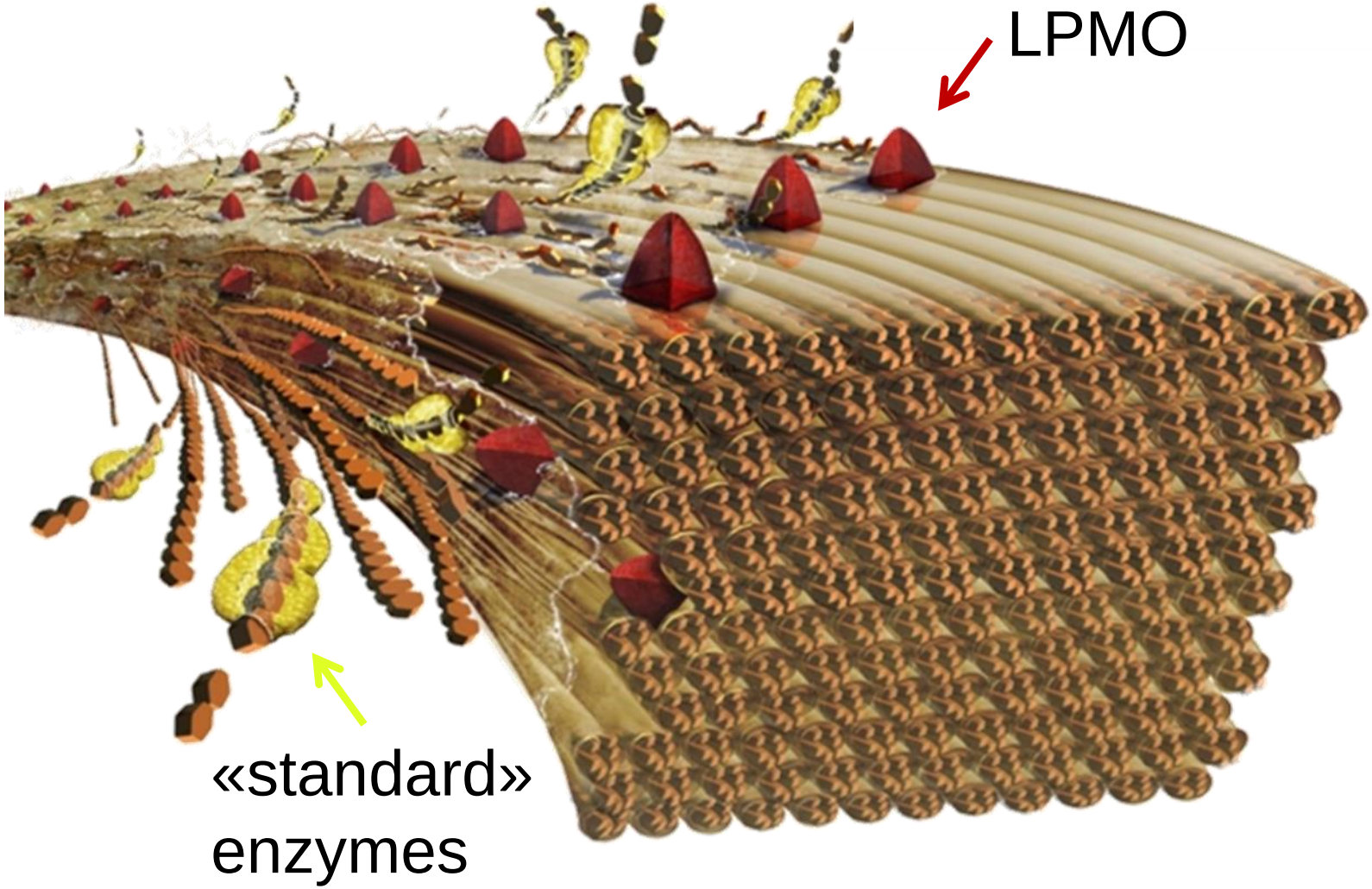
Value chain from tree to feed



Trees to feed – closing the loop



Novel enzymes is needed!
Lytic Polysaccharide Monooxygenases

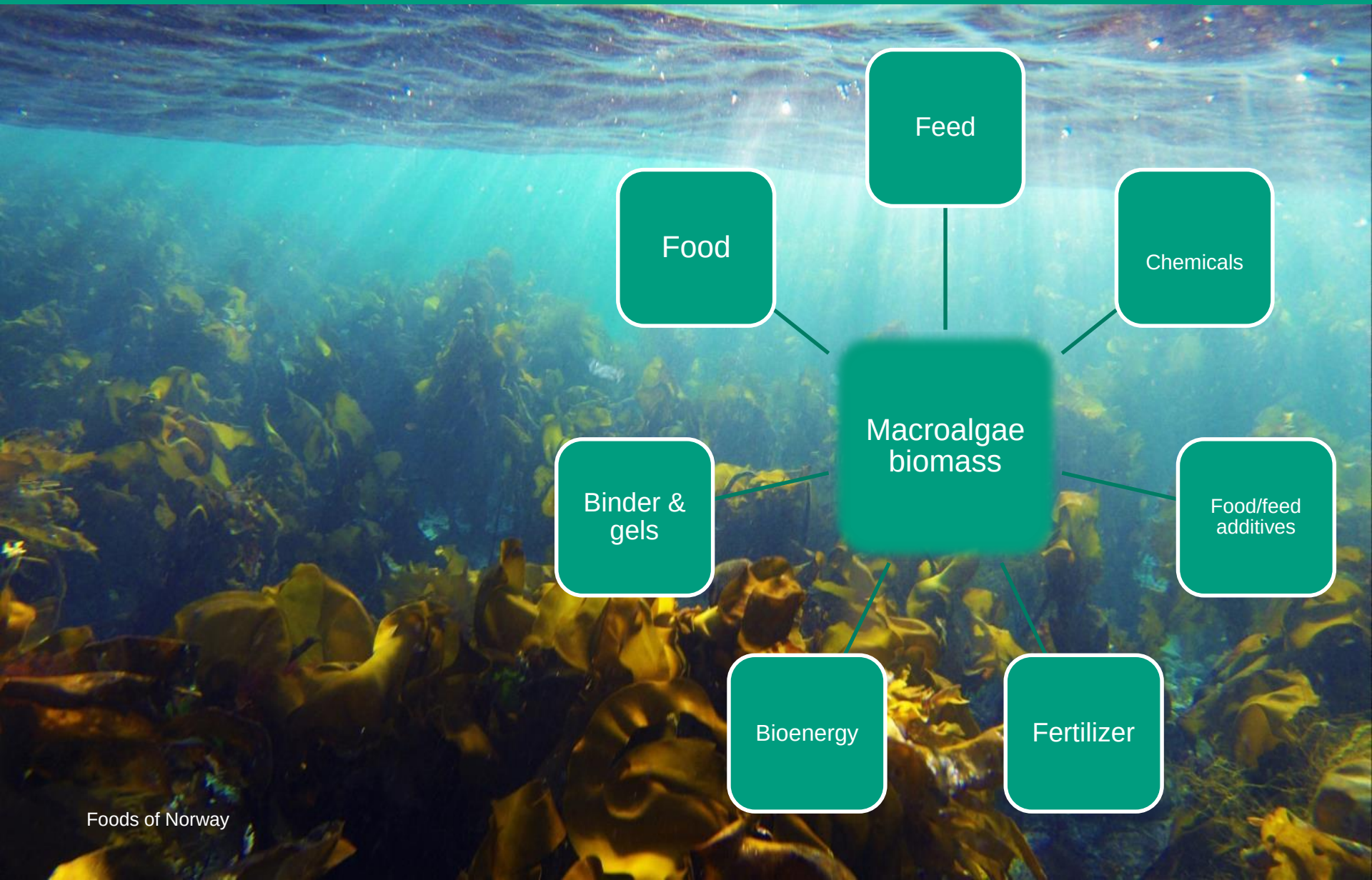


Kilde: Vincent Eijsink, IKBM

Marine macroalgae as a feed resource

Foods of Norway

Macroalgae - applications



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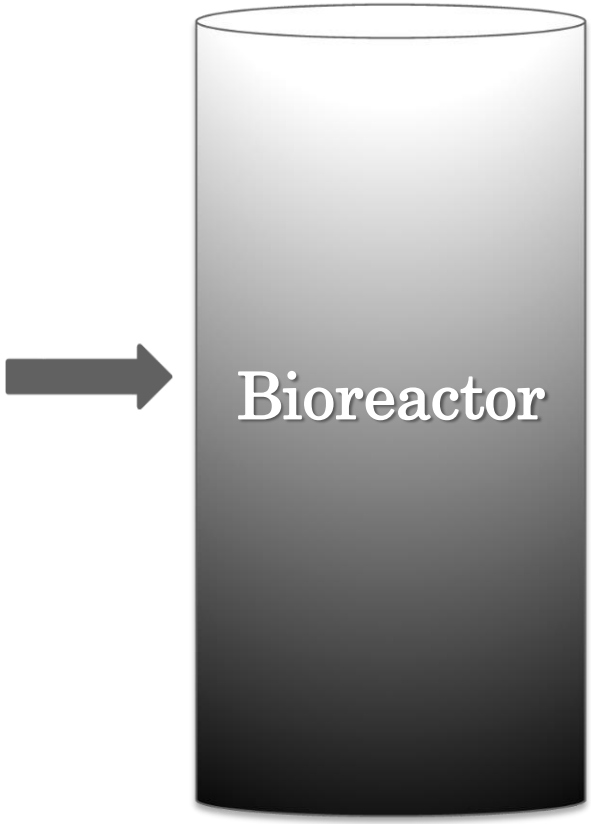
Biorefining macroalgae

Brown algae



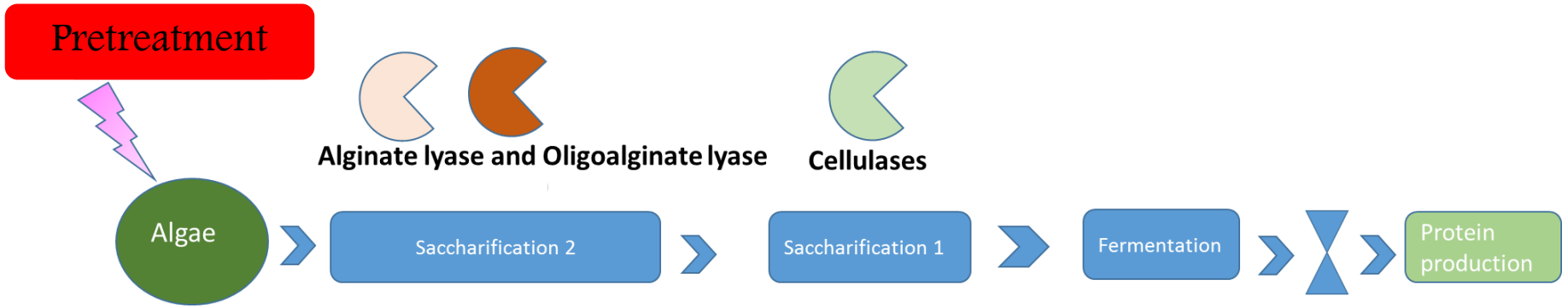
Fish feed

BIOFEED; Havbruk / BioTek 2021

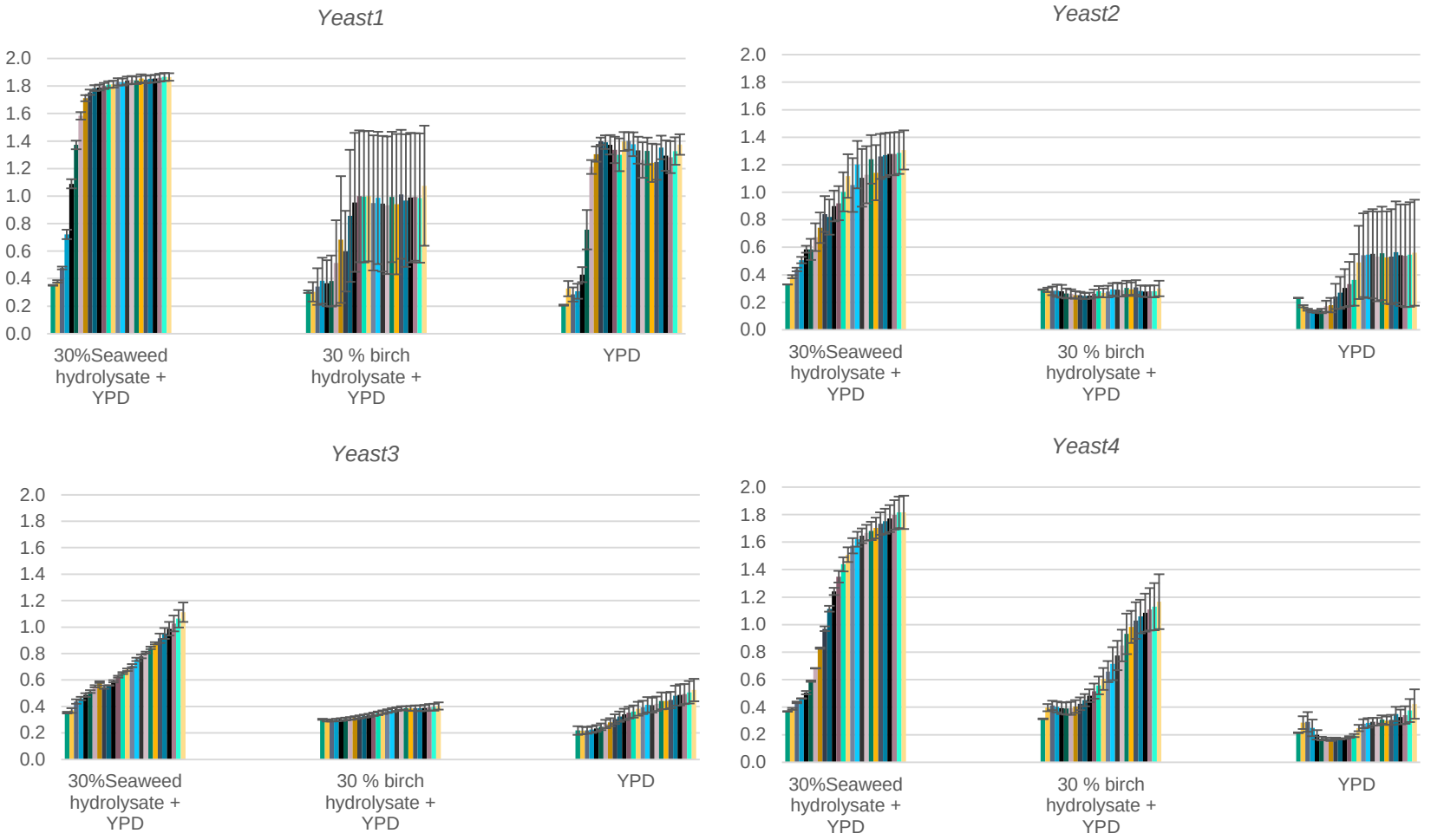
Conversion of kelp to sugar

Require taylor-made enzymes

- Laminarinase, mannanase, alginate lyase, cellulase, lipase & protease

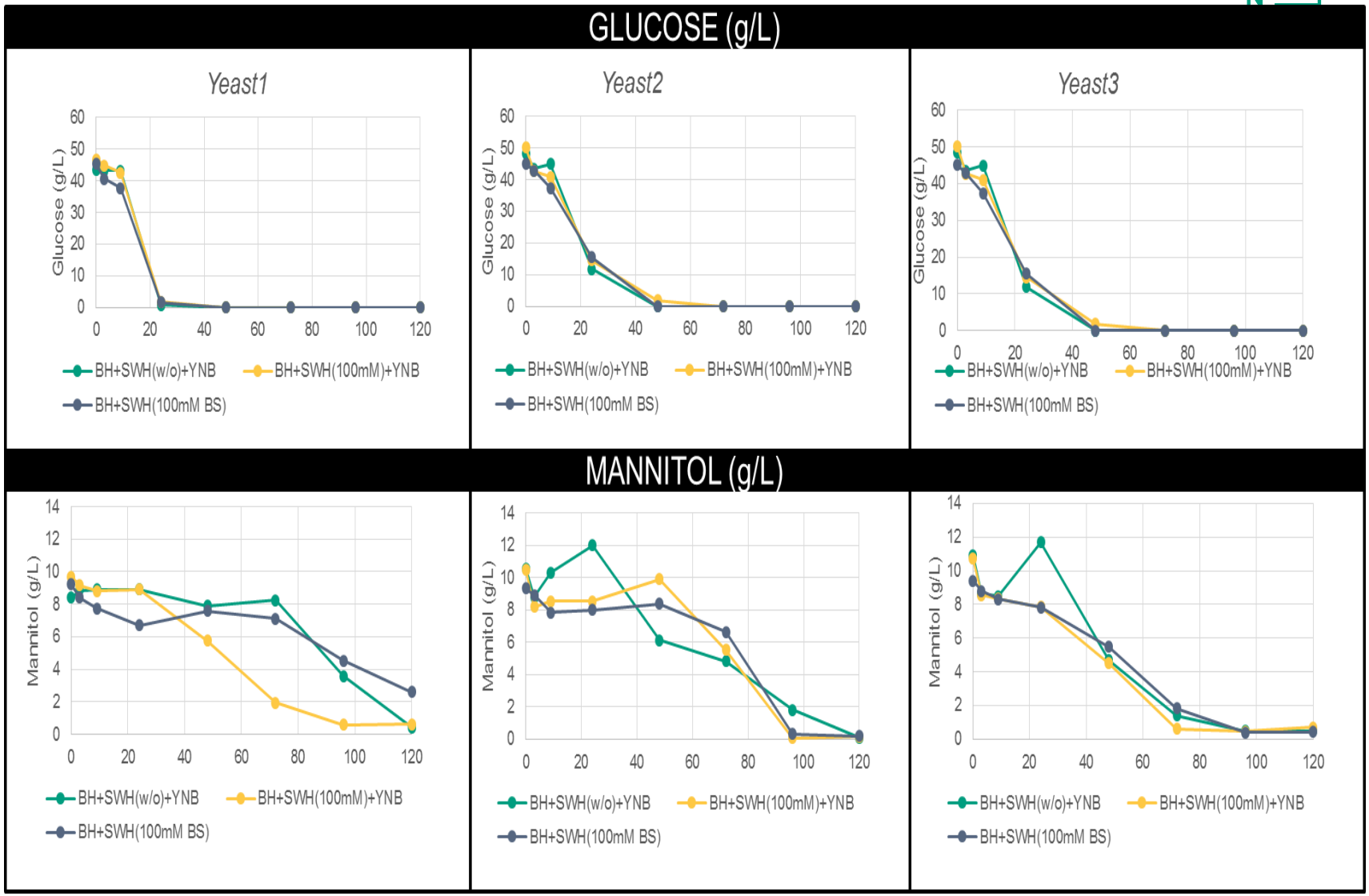


Screening of yeast



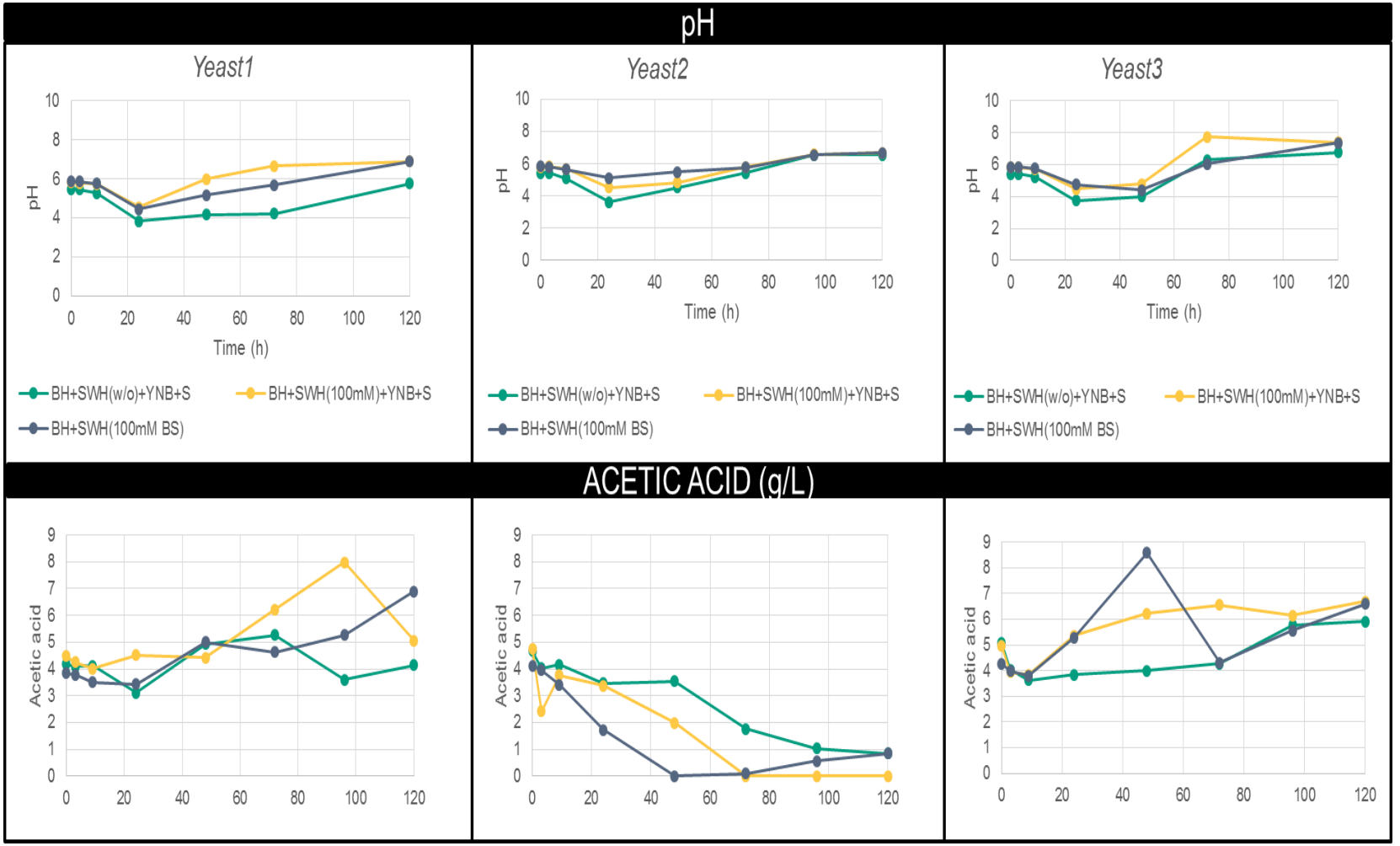
Source: Sharma et al. unpublished

Use of different substrates



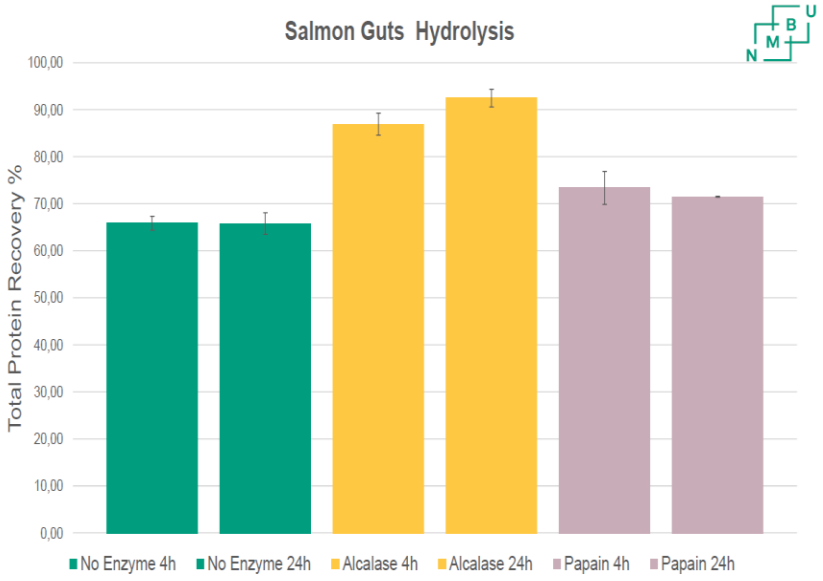
Source: Sharma et al. unpublished

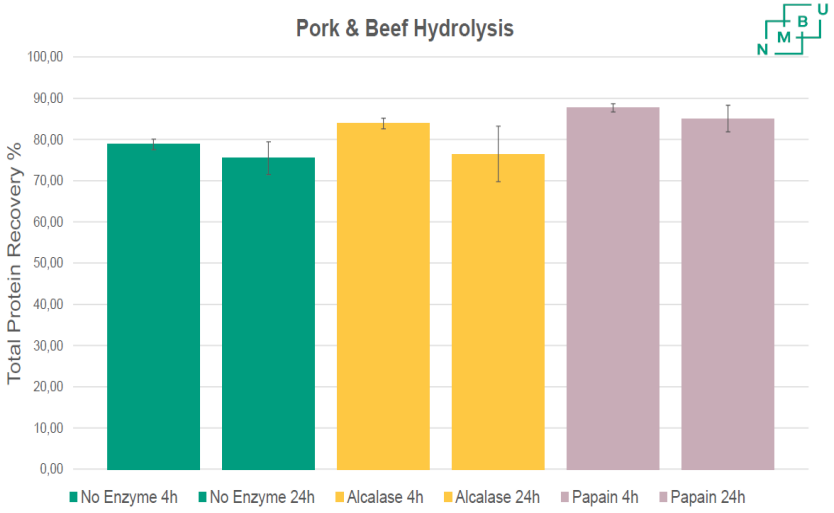
Fermentation products – inhibitors? Continuous, batch vs fed-batch?



Source: Sharma et al. unpublished

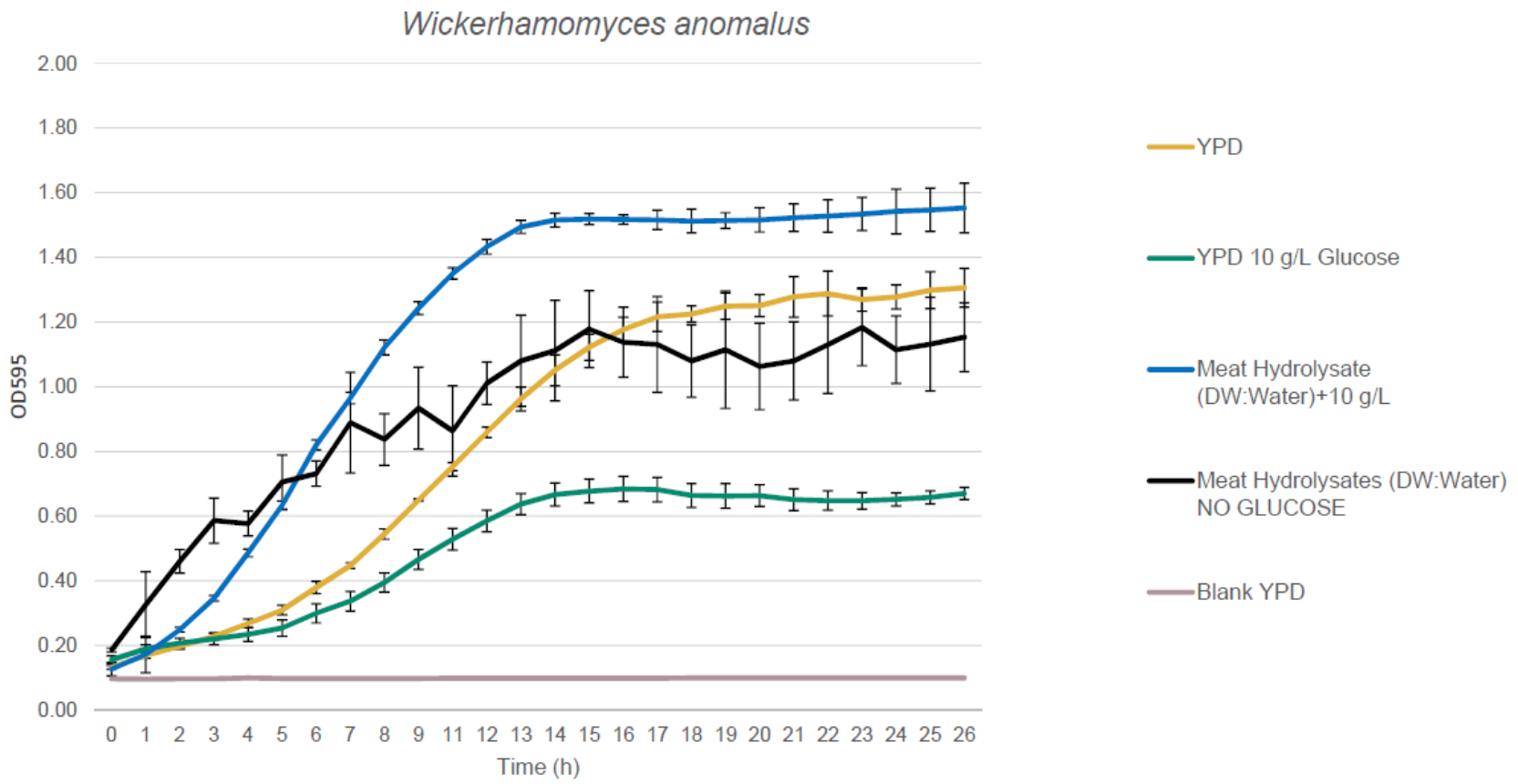
Hydrolysates – nutrients for yeast medium – N, P….





Source: Lapena Gomez et al. unpublished

Nutrient sources for yeast fermentation



Source: Lapena Gomez et al. unpublished

Woody/ Algal Biomass

Enzymatic hydrolysis

Hydrolysate

Fermentation

Yeast broth

(Single cell protein)

Spray drying

Dried yeast

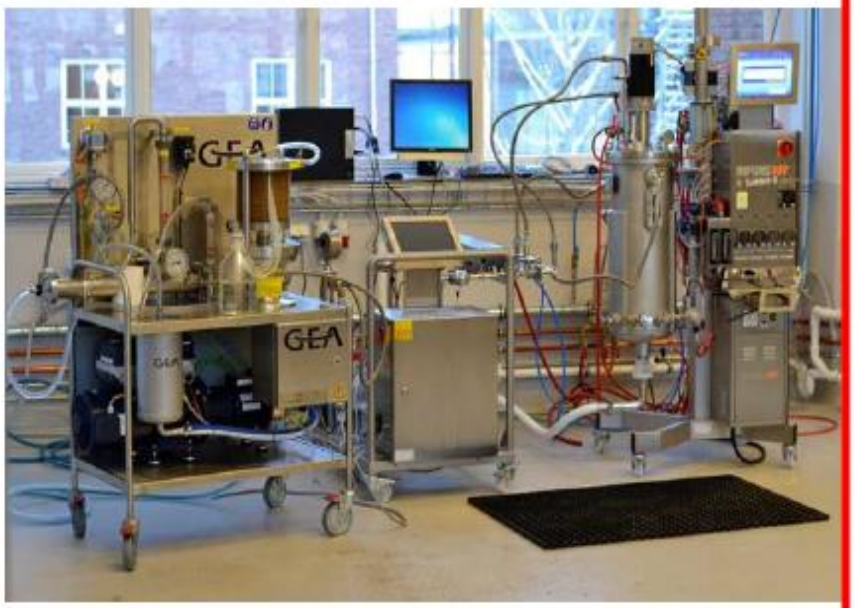
Enzymes

Yeast

Meat/fish hydrolysates

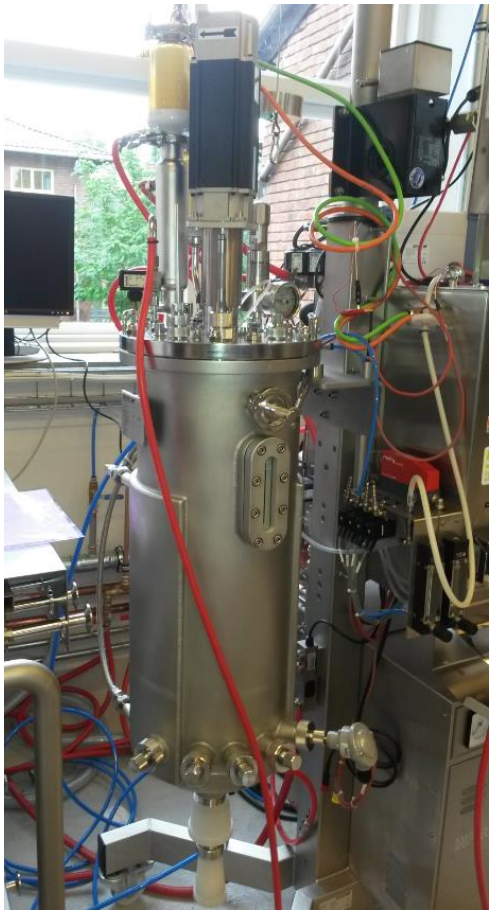
Feed trials

Ingredients for fish feed


GEA
GEA

Biorefinery laboratorium, NMBU

30-l fermentor

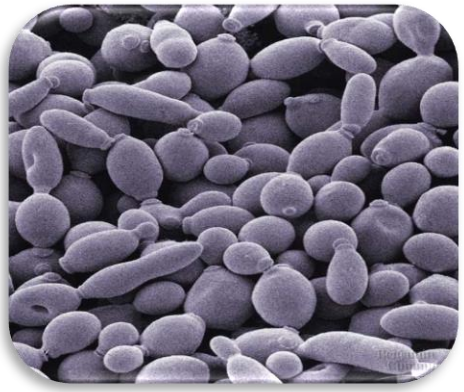


Hydrolysis/incubations

Nano- Ultra-filtration

Borregaard AS and other industrial partners
Large-scale biorefinery/processing plants

Yeast produced from wood – a high-value feed resource



Yeast:

- ~ 50-60% crude protein
  - 6-10% nucleic acids
- Favorable amino acid composition
- 2-10% lipids

- High-lipid species
- GRAS species

Source: Øverland et al.,2013, Aquaculture 402–403, 1–7

In vivo exp. - «Ås gård»

New fish Laboratory at NMBU

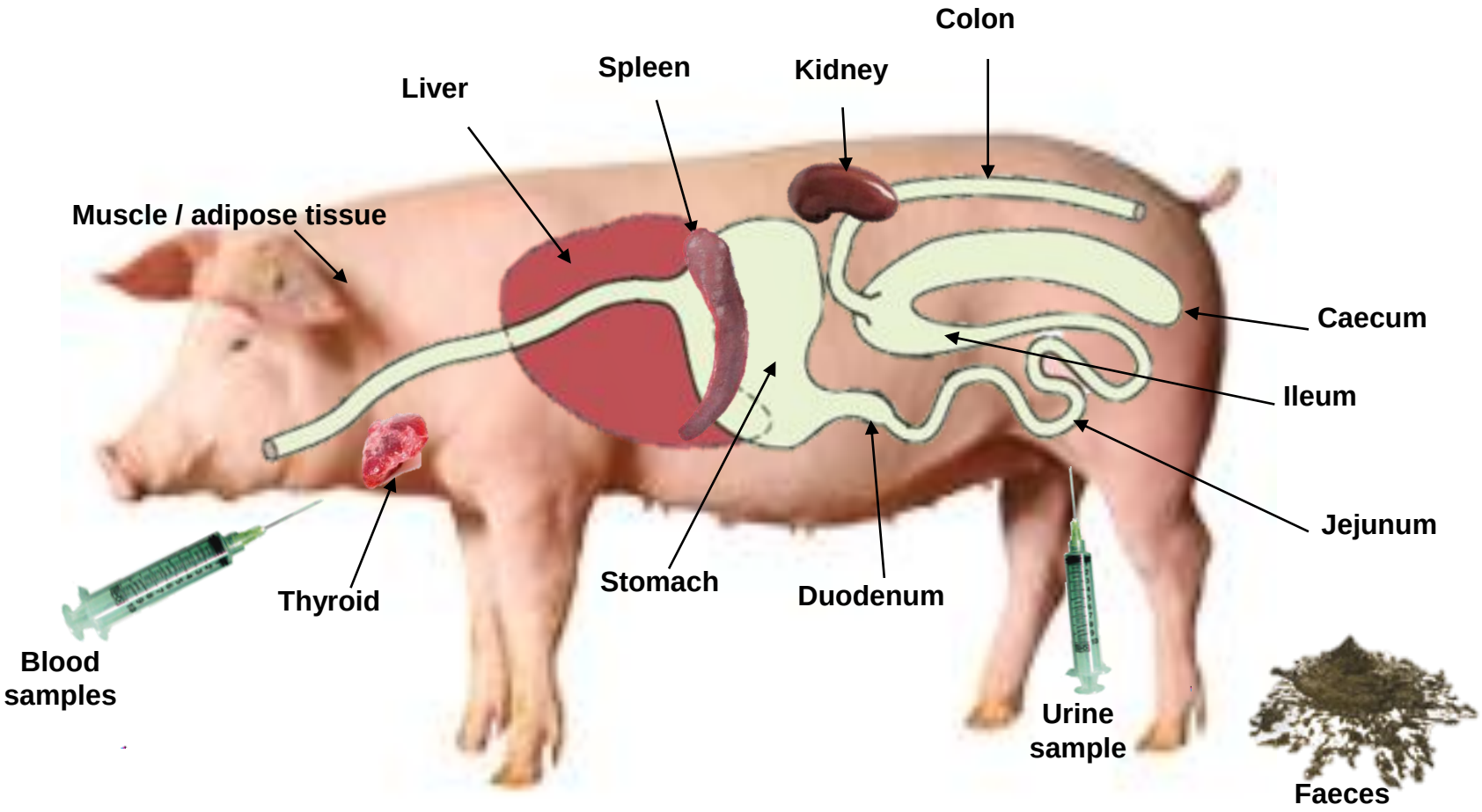
Foto: NMBU; Janne Brodin

Ongoing research with yeast to salmon

- Small and large-scale experiments
- Effect on growth performance, health and product quality

Photo: J. Brodin, New fish laboratory at NMBU, Ås-campus

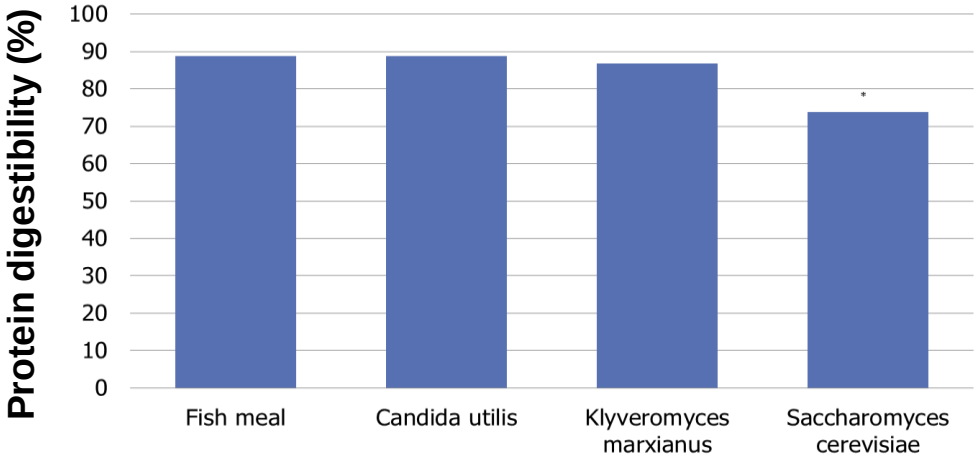
Feeding trials - sampling

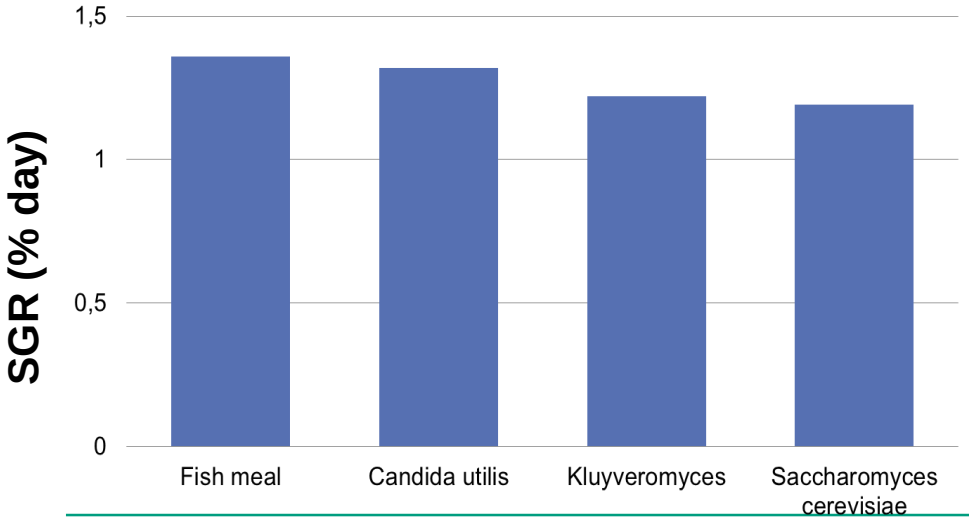


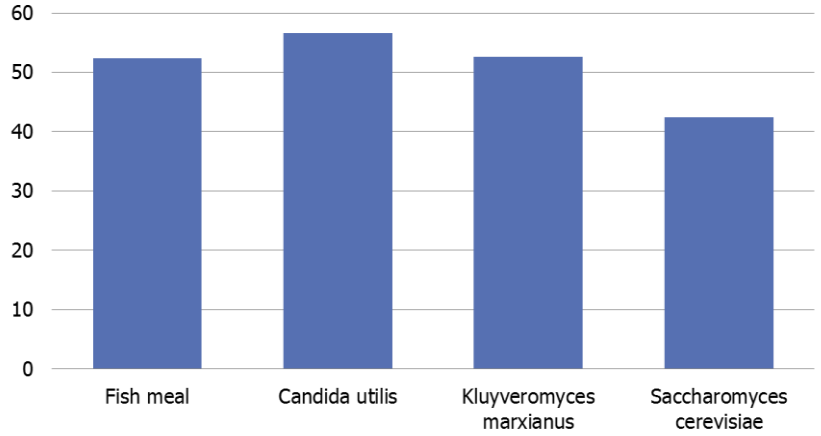
Sampling

Sampling of 20 pigs = long workingday for 18-20 people

CP digestibility, growth rate and N retention in salmon fed 30% YEAST



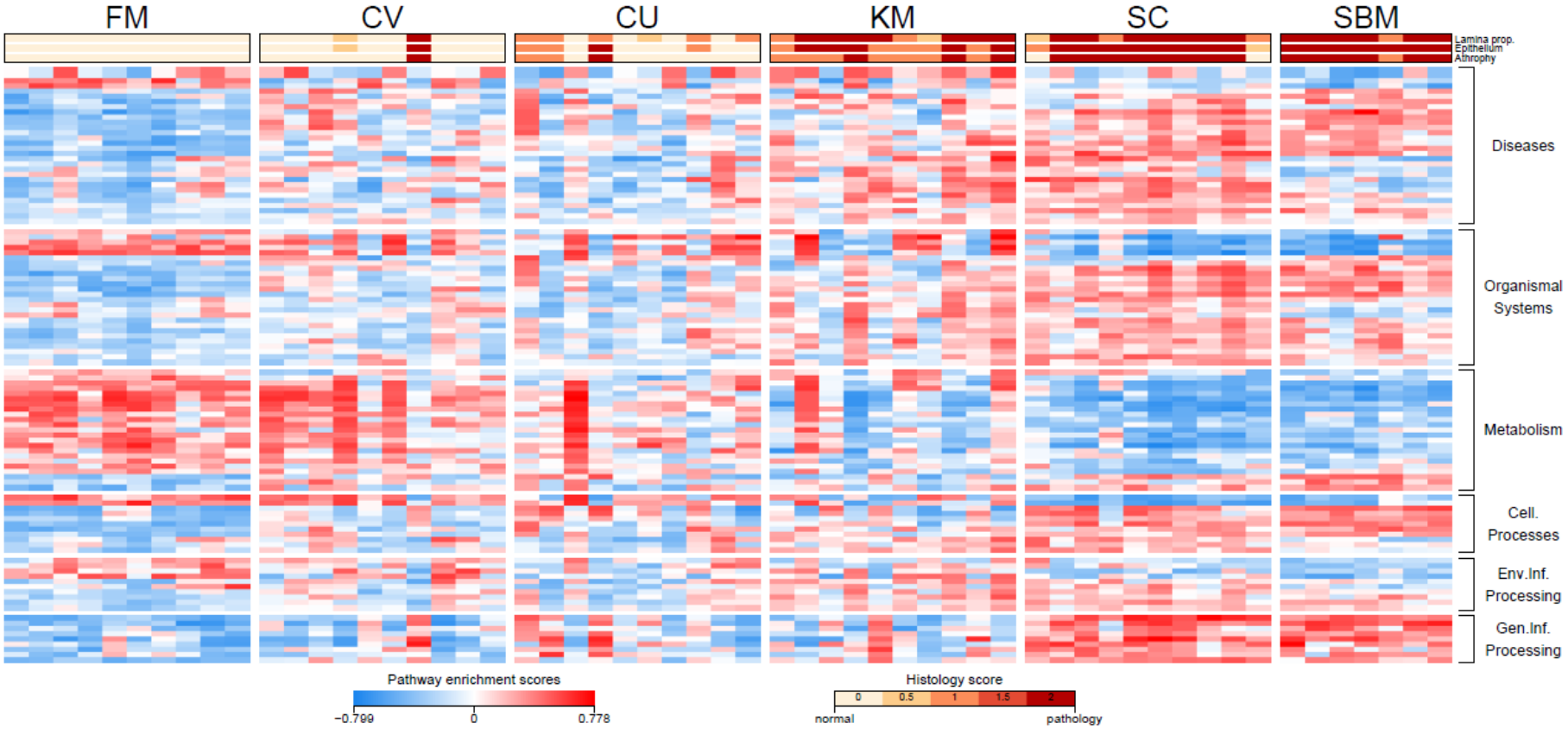




Protein retention, %

Source: Øverland et al., 2013, Aquaculture

Specific yeast strains can improve gut health in salmonoids



Differently expressed genes - Heat map - KEGG

Source: Grammes et al., 2013, PlosOne, 8-12, 1-13

Conclusion

Renewable biomasses from both sea and land

↓

High-quality feedstuffs by biotechnology/biorefinery

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Foundation for sustainable production of high-quality seafood, meat & milk

Photo: Norsk sjømatsråd

Thank you for your attention!