



Bio-based Economy: Essential for Climate Change Mitigation and for Improved use of the bioresources

The application of microbial bio-transformation systems for the food industry

Lene Lange

Professor, PhD & Dr.Scient.

Director and Founder, LLa-BioEconomy, *Research & Advisory*

Copenhagen, Denmark

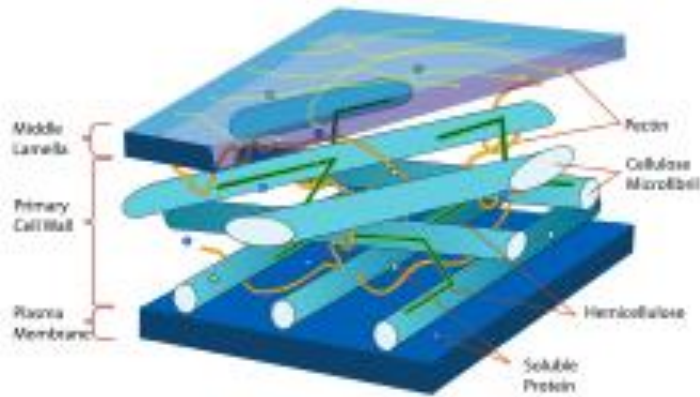
Len.Lange2@gmail.com; LenL@DTU.dk

Prebiotic food and feed ingredients: Biotransformation: improving gut-health by modifying microbiome with prebiotics



Small fractions of plant cell wall fibers (hemicellulose) can be used for improving gut-health in man and animal

- Prebiotic food and feed ingredients added for improved gut-health

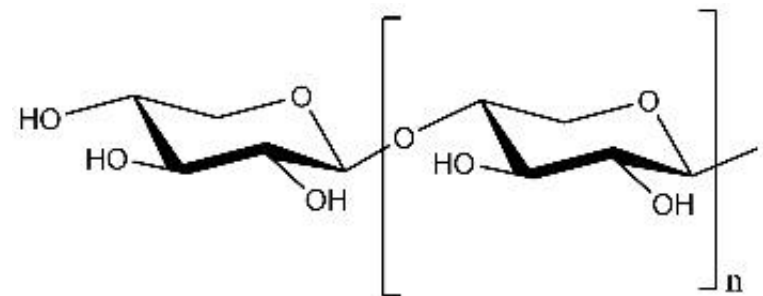


Prebiotics definition:

- Oligosaccharides are selectively feeding beneficial bacteria, e.g. [bifidobacteria](#) and [lactobacilli](#) within the digestive tract

Ex

- XOS: Xylo-OligoSaccharides, produced by enzyme treatment of Xylan fibers





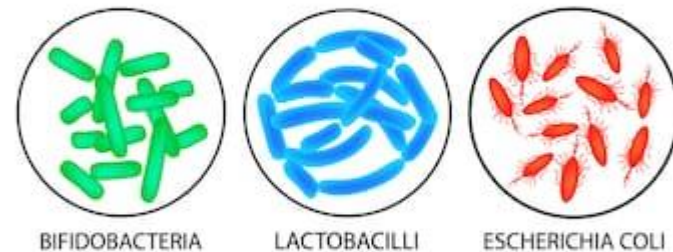
Biotransformation by living Bacteria: **Probiotics:** improving gut-health by enriching the microbiome



Diverse and Healthy gut microbiota

Definition: Probiotics are live microorganisms improving / restoring the gut microbiome

Good Bacterial Flora



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***Microbially fermented biomass**

Can provide both probiotics (living bacteria), and prebiotics (break-down products of fibers) plus anti-inflammatory compounds! (IBD; pigs)



Enzymatic biotransformation for developing new, locally produced proteins -Food & Feed

Plants (leaves and seeds), fungi insects, mussels and sea stars:

- Plant proteins from grass, clover etc, substituting for GMO Soy! SA!
- Plant proteins from seeds (legumes) and seed press pulp (oilseed, e.g. rape)
- Making new proteins, by growing fungi and/or insect larvae on plant residues
- Upgrade marine proteins! resources



New Research on Cow Rumen Microbiome Biotransformation



Reduction of methane from milk and meat production:

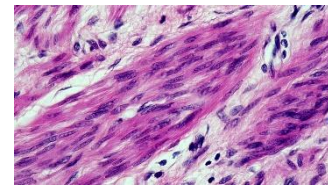
- Prebiotic, Probiotic and "Archaea-Inhibiting" feed additives
 - Stimulating digestive rumen fungi and rumen bacteria, inhibiting the methane producing Archaea
- Cattle Breeding for reduction of CH₄ emissions
 - Select for low methane and good digestive efficiency in new breeding
- Combining best results of "low-CH₄ cattle breeding" with most promising "CH₄ reducing feed-additive"

New Project:

@ Low Methane Dairy Project, (organizer Peter Lund, Aarhus University), funded by Danish Dairy Foundation.

@ DTU & Lla-BioEcon are responsible for the microbiome studies, searching for signature patterns in microbiome composition and function, using the new peptide-based functional annotation, "CUPP" (Barrett & Lange, 2019)

Alternative production systems for more sustainable meat and milk proteins



New technology for large scale production of milk and meat proteins:

- Grown *in vitro* in fermentation tanks
- Using state of the art technology platform, developed for industrial biotech production of microbial (fungal and bacterial) enzyme proteins. Bulk scale; low cost!
- Estimated to be competitive to: Cultured meat, produced by *in vitro* cultivation of animal cells; and to animal based production?





Background: R&D, Experimental & Upper Management; in both Public & Private Sector

- 20 years Private Industry R&D : Novo, Novo Nordisk and Novozymes
 - Novozymes Position: Research Director in Molecular Biotechnology
- Last 12 years, Danish Universities: Full Professorships at University of Copenhagen, Aalborg University and Technical University of Denmark (KU/KVL, AAU & DTU). Research Director AAU; Campus Director AAU Cph
- Early career: 8 years, Danida, Ministry of Foreign Affairs; Seed pathology; Research collaboration –Africa, Asia & South America

International positions

- Board Chair for CIMMYT, CGIAR (International Wheat and Maize Research Institute; HQ in Mexico; with a Global Mandate)
- Program Chair, IRRI, CGIAR (International Rice Research Institute ; HQ in Manilla; with a Global Mandate)

***All through public & private career: Leading own research groups!**

LLa-BioEcon a new Start up company: "BioEconomy, Research & Advisory"



Research Activities

Consortium partner (SME, Research) to National, Nordic, EU and International research projects within Bioeconomy.

Field: Enzyme discovery, molecular biotechnology, enzyme process design & valorization of residues, biomass & industrial side-streams

Advisory Roles, selected activities

- Vice Chair, Scientific Committee for BioBased Industries Program, Advisory to the EU Commission
- Member, Nordic Bioeconomy Panel & Danish Bioeconomy Panel
- Advisory committee Bioeconomy, Icelandic NCM Chairmanship
- Member, World Wildlife Foundation, Scientific Committee
- Bioeconomy advisory to EFFAT, focus: "Bio-based" job-potential
- Microbiome Support CSA, EU Commission advisory on Microbiome
- Future Farming, Green Think-Tank, "Food & Agriculture, Denmark"

Strengthening food & agriculture business by using New Biotransformation systems



Improved commercial viability of food and feed biotransformation

- Producing additional products by biorefining: Valorizing also crop residues, industrial side streams and biowastes
- Biofertilizer, to substitute inorganic fertilizers for reduced Nitrous Oxide
- New Value chains from Biogas (feedstock e.g. grass): Biogas separated in CO₂ and CH₄; using CH₄ for growing bacterial single cell proteins (U-loop fermentation; EU approved).OR: using CH₄ as basis for production of jetfuel and
- Enzymatic conversion:Recalcitrant Chicken Feather to protein-rich feed
- Producing new types of textile fibers, substituting for cotton & fossils
- Coppice trees => wood paste => yeast-cream = protein-rich food & feed

Green Grass* Biorefinery,

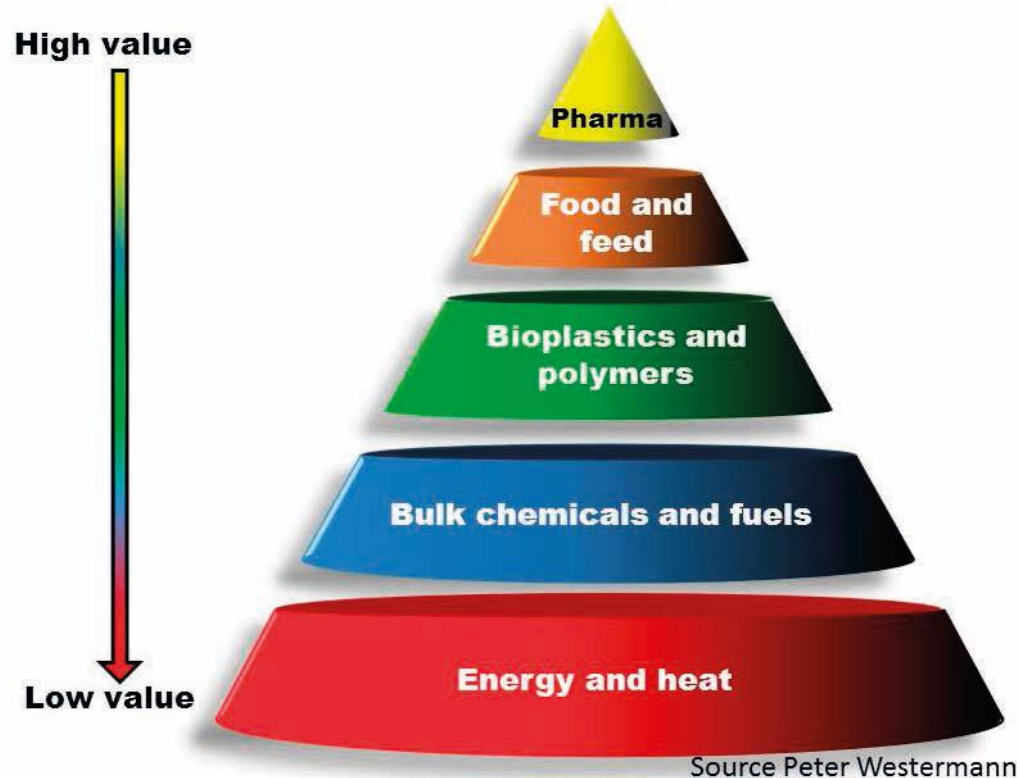
-many higher value products!



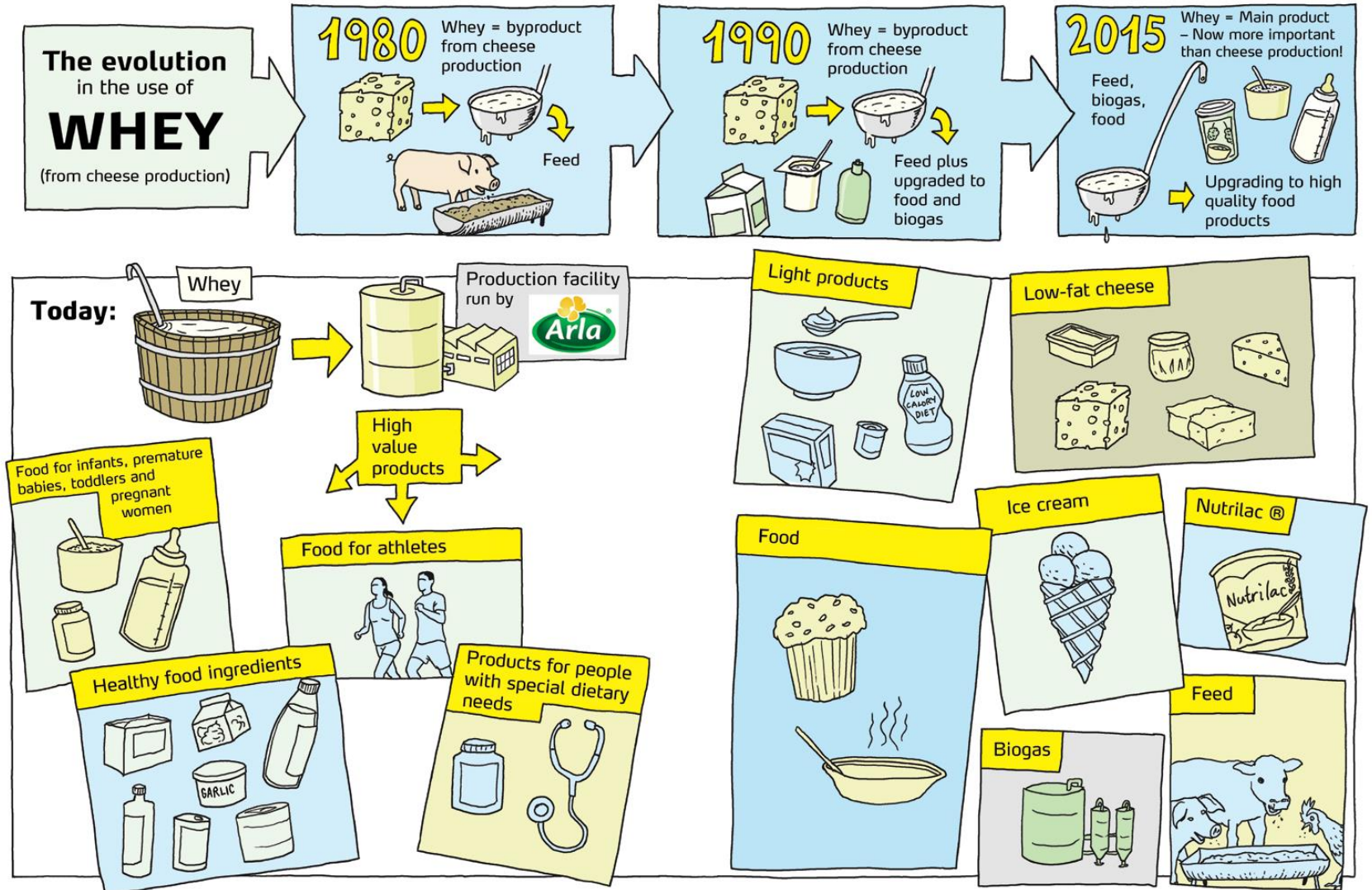
- **Protein rich animal feed (and food?)**
 - Feed protein recovered from screw-press-juice by precipitation &
 - Additional protein by enzyme treatment of pulp; substitute for Soy-protein!
- **Prebiotic feed ingredients from hemicellulose of the pulp**
 - For pigs, chicken and fish. Gut-health promoting => less use of antibiotics!
- **Fibers from pulp, used as fibers for new types of textiles?**
 - Reducing need for more acreage (water and pesticide) for cotton; enzymes!
- **Bio-Fertilizer, optimized circulation of nutrients back to the soil**
 - NPK: dosable, N-low emission & N-slow-releasing; conv. & organic farming
- **Biogas => CO₂ & Bio-Methane as basis for jetfuel, bunker oil & feed**
 - First step towards Negative Emission Technologies, NET, using CO₂ & CH₄!



Biomass Conversion Value Pyramide



A modern Dairy is a Biorefinery, Case: "Arla"



The many types of Biomass Conversion

* = *Potential for New Protein*



- The **Yellow** Biomass conversion (straw, corn stover, wood)*
- The **Green** Biomass conversion (green grass & biorefinery crops)*
- The **Blue** Biomass conversion (fish residues & sea-weeds)*
- The **Red** Biomass conversion (slaughterhouse waste)*
- The **Grey** Biomass conversion (Industrial side-streams)*
- The **Brown** Biomass conversion (sludge & household waste)
- The **Purple** approach: **CCU!** (GHG: methane to feed)*



The **Yellow** Biorefinery -straw, stover, wood

Wood processing waste = Many Value Chains

From Cellulose

- Sugar platform for biochemicals, biomaterials and biofuels

From Hemicellulose

- Gut-Health promoting cell wall oligoes with *prebiotic* effect for animal feed and food ingredients

From Lignin

- A broad spectrum of bio-materials, -binders & -chemicals



Soldier

Green biorefinery, with grass as feedstock:



Change in Agricultural practice:

- shifting from cereal to growing grass
- lowering the run off of nutrients
- producing more food & feed per hectar

Many new, higher value products!

- **Protein rich animal feed**
 - Soluble feed protein recovered by precipitation
 - Additional protein extracted by protease treatment of pulp (Rubisco protein; 40% more for Food (Dotsenko & Lange 2016))
- **Prebiotic feed** ingredients from hemicellulose
 - For pigs, chicken and fish; and man! (Dotsenko & Lange 2017)
- **Minerals** used as fertilizer: circulated back to the soil!



Blue Biorefinery: upgrade of marine biomass

- Seaweeds



- Fish, discard and innards



- Fish cut-offs



- Mussels as a new biomass

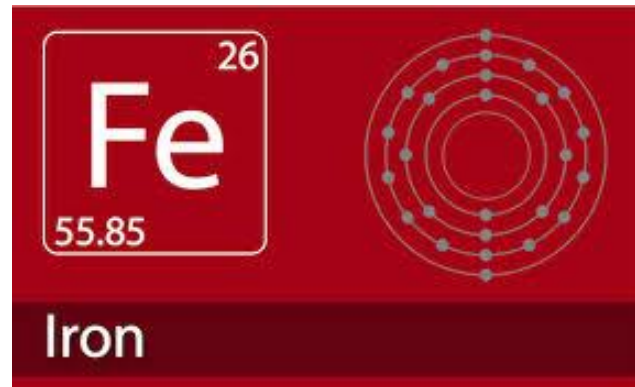
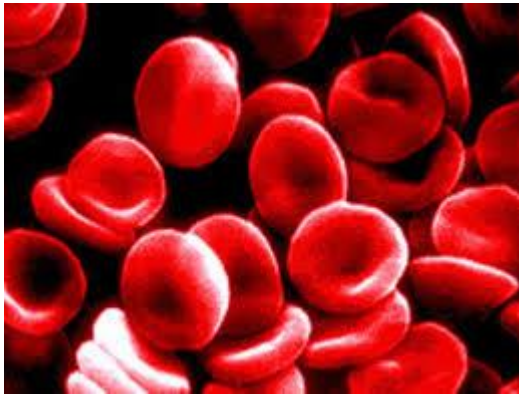


- Invertebrates (e.g. sea cucumber)

A modern slaughterhouse is a Biorefinery :

-a new resource with potentials for upgrade to higher value products

- Blood-based, Iron-rich food supplement and drugs
- Protein-dense products for elderly and convalescence





The soon 10 billion people!

Reduce non-food use of land, water & pesticides. Save it for food and feed!

Reduce acreage of land used for Textile production

Circularity in textile sector a necessity! Message:

Develop new technology: For cleaning and recycling of fibers and molecules to new textiles. Combine with alternative local fibers

EU directives can create markets for new products

-Fishery by-catch compulsory to land; cannot be dumped

-Sorting of textiles compulsory => massive amounts available for up-grade

Blue Bioeconomy, production without land-use

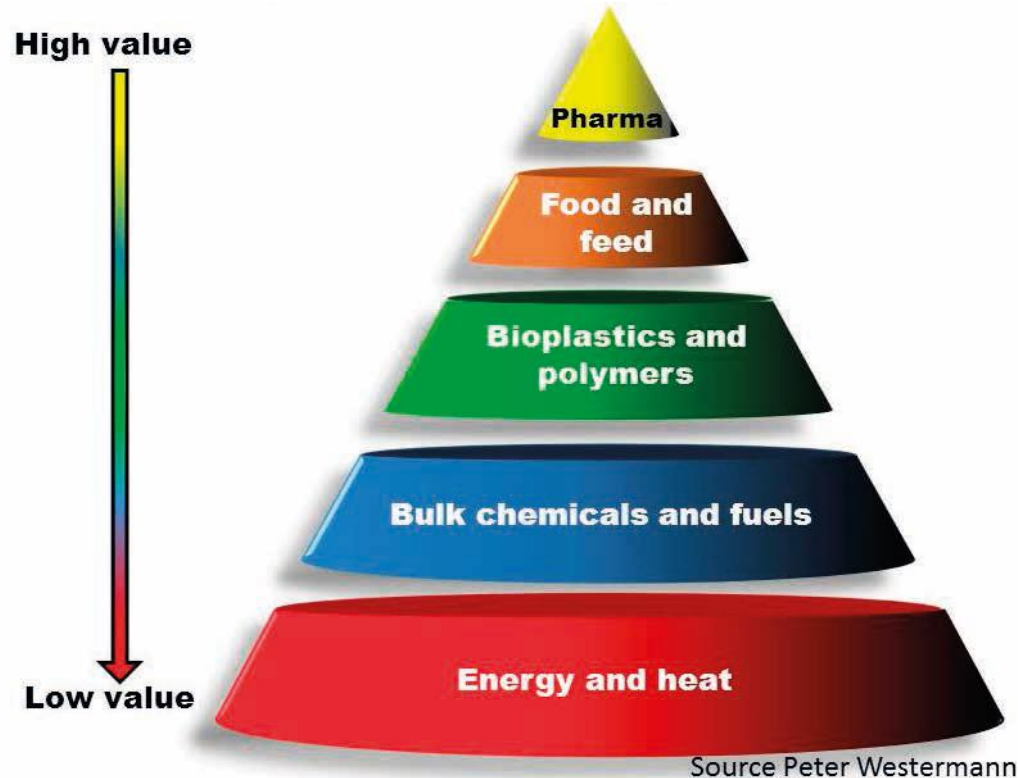
Producing food, feed, skin care and pharma from seaweeds, sea cucumber, fish innards and cut-offs. Ireland opportunity!

Extensive Pasture systems to be challenged globally?



Key Message:

Improved use of bio-resources is an essential part of Global Climate Change, Strategy and Actions; and a short cut for improved business



Thanks for Listening, lene

lene.lange2@gmail.com; lenl@dtu.dk