Next Generation Food Ingredients for Better Health and Sustainability

FEDIOL

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Food Process Engineering Laboratory

- New principles and systems for preparing (structured) foods
- Scientific - Understanding the behaviour of complex (food) systems
- Societal - principles for processes and chains that are significantly more sustainable, combine excellent taste with better nutrition
- Educate young academics with high awareness of sustainability, quality and health, and a drive for true innovation

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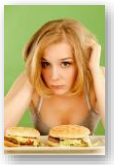
6 technical & support staff, 8 scientific staff
~35 PhD students, 4 postdocs; 50 – 70 BSc / MSc thesis students

Challenges for the 21st century

- Health
- Consumer trust
- Sustainability

Balance in diet to combat non-communicable diseases



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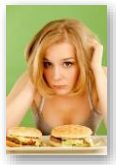
Challenges for the 21st century

- Health
- Consumer trust
- Sustainability

How can we win back the trust of the consumer?



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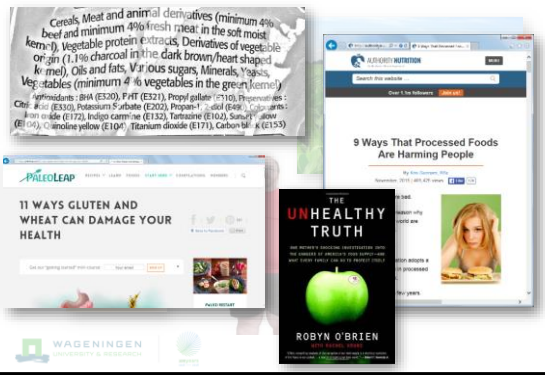
Challenges for the 21st century



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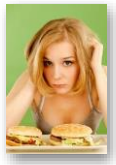
Challenges for the 21st century

- Health
- Consumer trust
- Sustainability

How can we keep up with increased demands?



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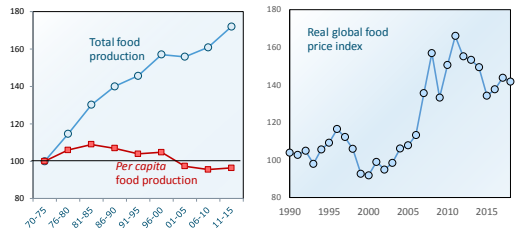
Global Food Production



Global grain production, Int. Food Policy Research Inst, US Bureau of the Census, CIA
FAO Food Price Index 2018

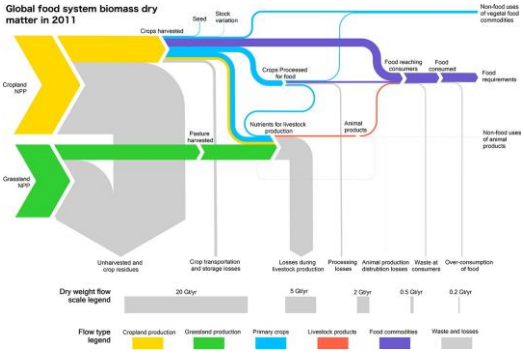
Towards complete use

First generation
Isolation of primary product, Rest streams discarded

Second generation: cleaner
Isolation of primary product, rest streams digested or low-quality use

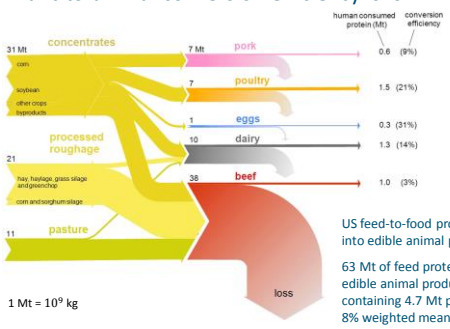
Third generation: total use
Towards complete, high-quality use of raw material

Global food system biomass dry matter in 2011



P. Alexander et al., Agricultural systems 153 (2017): 190-200

Plant-to-animal conversion efficiency is low



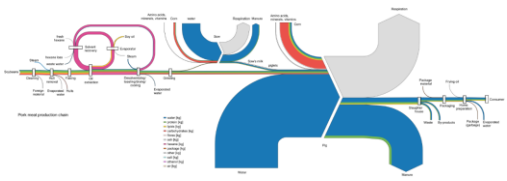
1 Mt = 10^9 kg

US feed-to-food protein flux into edible animal products.

63 Mt of feed protein yield edible animal products containing 4.7 Mt protein, an 8% weighted mean protein conversion efficiency

A Shepon et al., 2016, Environ, Res. Lett, 11 105002

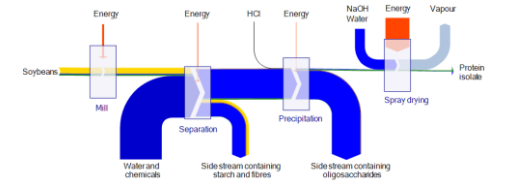
Pork production chain



Losses in the chain from crop to product are 70 – 90% of all resources produced

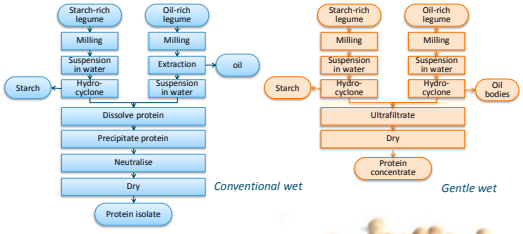
M. Rodriguez Illera et al., Wageningen University, 2017

Plant protein extraction

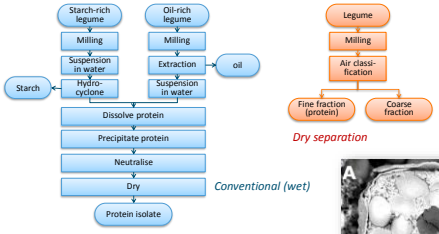


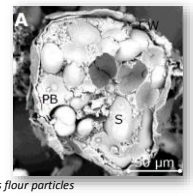
P.J.M. Pelgrom, PhD thesis, 2015; J.A.M. Berghout, PhD thesis, 2015

A new approach: *mild* processing



A new approach: *dry* fractionation





Structure of peas and its flour particles

Schutyser, M. A. I., et al. *Trends in Food Sci Techn* 45.2 (2015): 327-335.

Truly native proteins; proteosomes

- Intact protein bodies containing intact proteins
  - From lumen of endoplasmatic reticulum
  - Insoluble aggregates surrounded by membrane (and membrane proteins)
  - Protein content ~ 75 *wt%*
- Can be suspended in water to high concentrations
- Disintegrate upon heating → gelation
- Seem to be relatively digestible

Dry separated

Conventional isolate

Mildly fractionated protein: excellent emulsifier

Fractionation by concentrated suspension in water

Freeze-thaw stability

d_{32} (μm)	Before freezing	After thawing
Commercial isolate	0.94	36.18
Functional fraction	1.01	0.96

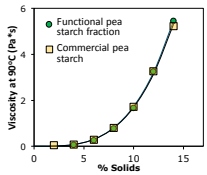
d_{32} (μm)	pH 6.5	pH 3.5
Commercial isolate	0.78	39.21
Functional fraction	1.45	3.98

pH stability

M. Geerts *et al.*, PhD thesis, 2018;
Innov Food Sci Emerging Techn 41 (2017): 251-258

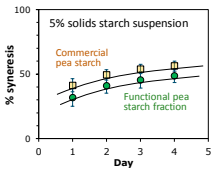
Functional starch intermediate

- Very similar thickening properties as conventional starch
- Lower syneresis (possibly less retrogradation)
- 32% fibre



Commercial pea starch solution

Functional pea starch solution



M. Geerts *et al.*, PhD thesis, 2018
M. Geerts *et al.*, J Cereal Sci 75 (2017): 116-123

Next Gen Food Processing for Health and Sustainability

Functional starch fractions
Same thickening, less syneresis
32% fibre, lower glycaemic index
More complete use of raw materials

Functional protein fractions
Freeze-thaw stability, foam stability
Protein digestibility, liquid up to 40%
Superior ingredient for meat analogues

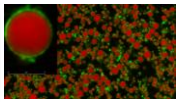
Functional oil/fat fractions
Chemical and physical stability
No additives (oil bodies + water)
satiety (ileal break effect)

Clean processing at lowest possible footprint

Efficient use of raw materials

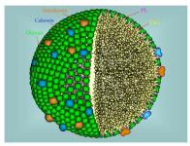
Better nutritional functionality
Less or no additives

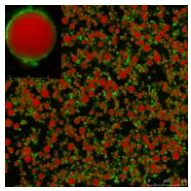
More fibre, micronutrients, minerals
Bioavailability of micronutrients
Satiety, glycaemic index



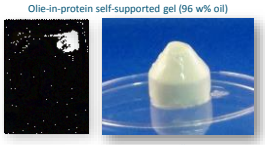
Functional oil intermediate (oleosomes)

- Aqueous extraction: no solvents, environmentally benign, cost effective
- No stabilisers/emulsifiers necessary
- Very stable product (physical, oxidation)
- Regulates satiety
- Lowers risk on CVD



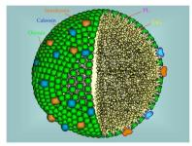


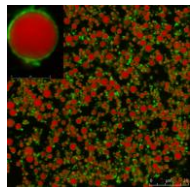
Olie-in-protein self-supported gel (96 w% oil)



C. Nikiforidis *et al.*, 2015; J. Romero Guzmán *et al*, 2016

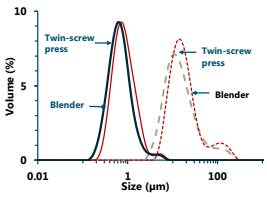
Oil body extraction





C. Nikiforidis *et al.*, 2015; J. Romero Guzmán *et al*, 2016

Larger-scale production of oil bodies



1:1
Solids to solvent

- Oil bodies can be extracted in 1:1 solid liquid ratio with yield up to 90%
- Oil bodies recovered with twin-screw press have similar characteristics than those recovered with a kitchen blender

Functional oil intermediates

- May be produced in the dry state through cryo-milling
  - Subsequent dry separation (air classification or electrostatic)
- May be produced through gentle wet extraction
  - 1:1 aqueous extraction achieved on lab scale
  - Processing is more environmentally benign and potentially simpler
- Fits well in clean label solutions
  - Very stable emulsions with superior techno- and nutritional functionality; no stabilisers and emulsifiers necessary
  - Added functionality translates into larger value
  - Products need to be tuned towards application: added value and added expertise

Conventional oilseed processing

Extraction process

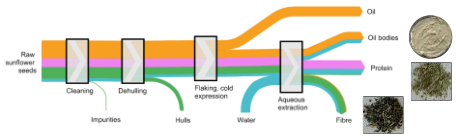
- Very high extraction yields
- Use of organic solvents – compromises consumer trust
- Proteins become denatured, reduced solubility and functionality
- Meal mostly used as cattle feed

Meal

- Press cake has 45% protein, 3.5 % phenols
- *Undenatured* proteins have excellent emulsifying and foaming properties
- Low in allergenic factors and ANFs
- Phenols are natural antioxidants

Data for Sankey diagram for sunflower seeds, from AOCS Lipid Library

Towards mild oil processing: better value creation



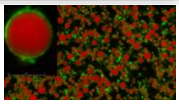
- Cold pressing avoids protein denaturation (but has reduced yield)
- Subsequent aqueous extraction can have high yield
  - Oil bodies: new range of food products
  - Protein fraction: better functionality than pure proteins due to phenols
    Excellent emulsifiers/foamers, chemically stable emulsions
    Excellent nutritional properties
  - Fibre fraction: to be explored

Data from D. Karefyllakis and J. Romero Guzman, Wageningen University, 2018

Next generation oilseed processing

Simpler processing but more tuning towards application required: more knowledge-intensive processing
- Mild aqueous processing: less steps, no solvents, much less water
- Dry processing: no water, even oil in (natural) powder form possible

Traditional and next generation processing can be combined, while eliminating solvent based extractions
- High-quality, cold-pressed oil
- Oil bodies suitable for clean-label products
- High-quality protein and phenolics



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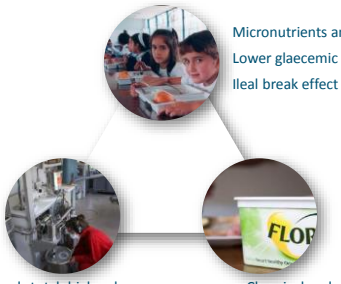
Next Gen Food Processing for Health and Sustainability



Micronutrients and fibre
Lower glaecemic index
Ileal break effect on satiety

Less waste, towards total, high-value use
Much less water and energy, no chemicals
Well suited for local processing

Chemical and physical stability
Simpler formulation, clean label
Better taste of structured products

The Sustainable Food Initiative

DANONE, COSUN, Cargill, Unilever, Avebe, Corbion, NWO, TU/e, dutch biorefinery cluster, HEINEKEN, Ministerie van Economische Zaken, provincie Gelderland, DSM, symrise, KraftHeinz, TNO innovation for life, ppm oost, Universiteit Utrecht, ISPT, WAGENINGEN UNIVERSITY & RESEARCH, TiFN, NIZO FOR BETTER FOOD & HEALTH, FrieslandCampina

Sustainable Food Initiative

... more partners in negotiation

Thanks to everyone of the Wageningen Food Process Engineering Research Group and all academic and industrial partners

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And especially Juliana Romero Guzman, Costas Nikiforidis, Albert van der Padt, Dimitri Karefyllakis, Jochem Jonkman, Jacqueline Berghout, Pascalle Pelgrom, Marlies Geerts, Qinhui Xing, Maarten Schutyser, Atze Jan van der Goot and many others

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