ADVANCED PROCESS MODELLING FORUM 2017
London 25–26 April

Advanced process modelling for the food industry

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gPROMS

Two years ago…

- PSE & NIZO announced intention to collaborate together, combining strengths of process modelling, experience in & facilities for food research…

- …part of which to include the development of a food manufacturing model library within PSE's gPROMS FormulatedProducts
  - Product-process interaction key

…today

PSE, NIZO announce Centre of Excellence for Food Product & Process Modelling

Combination of food process modelling and experimentation accelerates innovation

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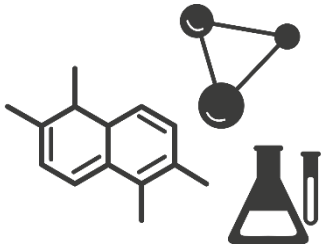
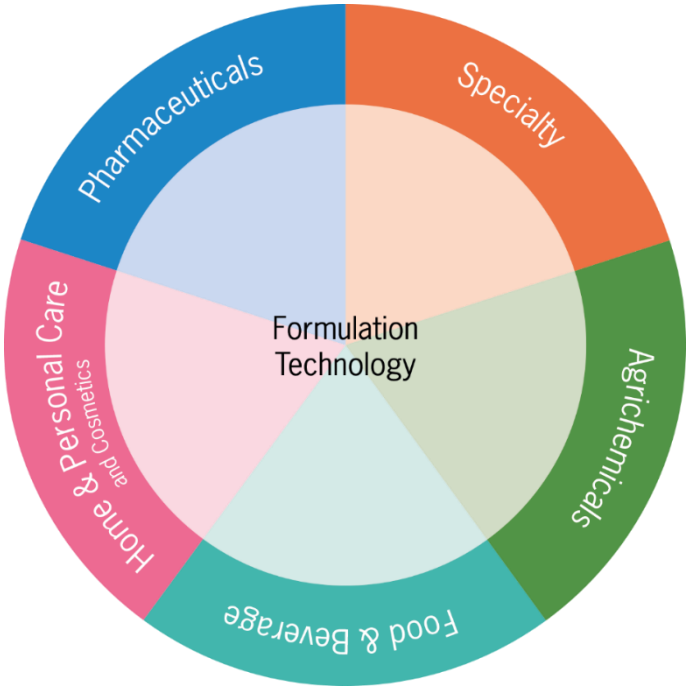
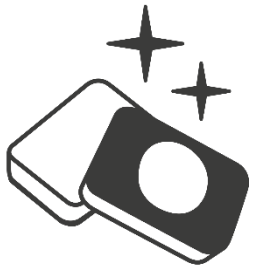
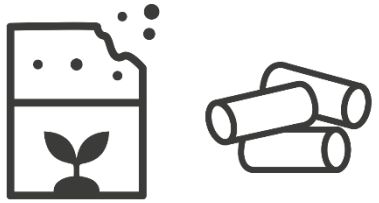
The integrated software and services solutions will result in better designed and operated processes with less variability, leading to better product quality, lower energy use and hence CO_2 footprint, and more flexibility when dealing with varying raw ingredients. Over and above the manufacturing benefits, the ability to combine models and experimental data to provide accurate prediction enables food & beverage organisations to explore the formulation and manufacturing decision space rapidly and effectively to accelerate design decisions.

Food in the Formulated Products world









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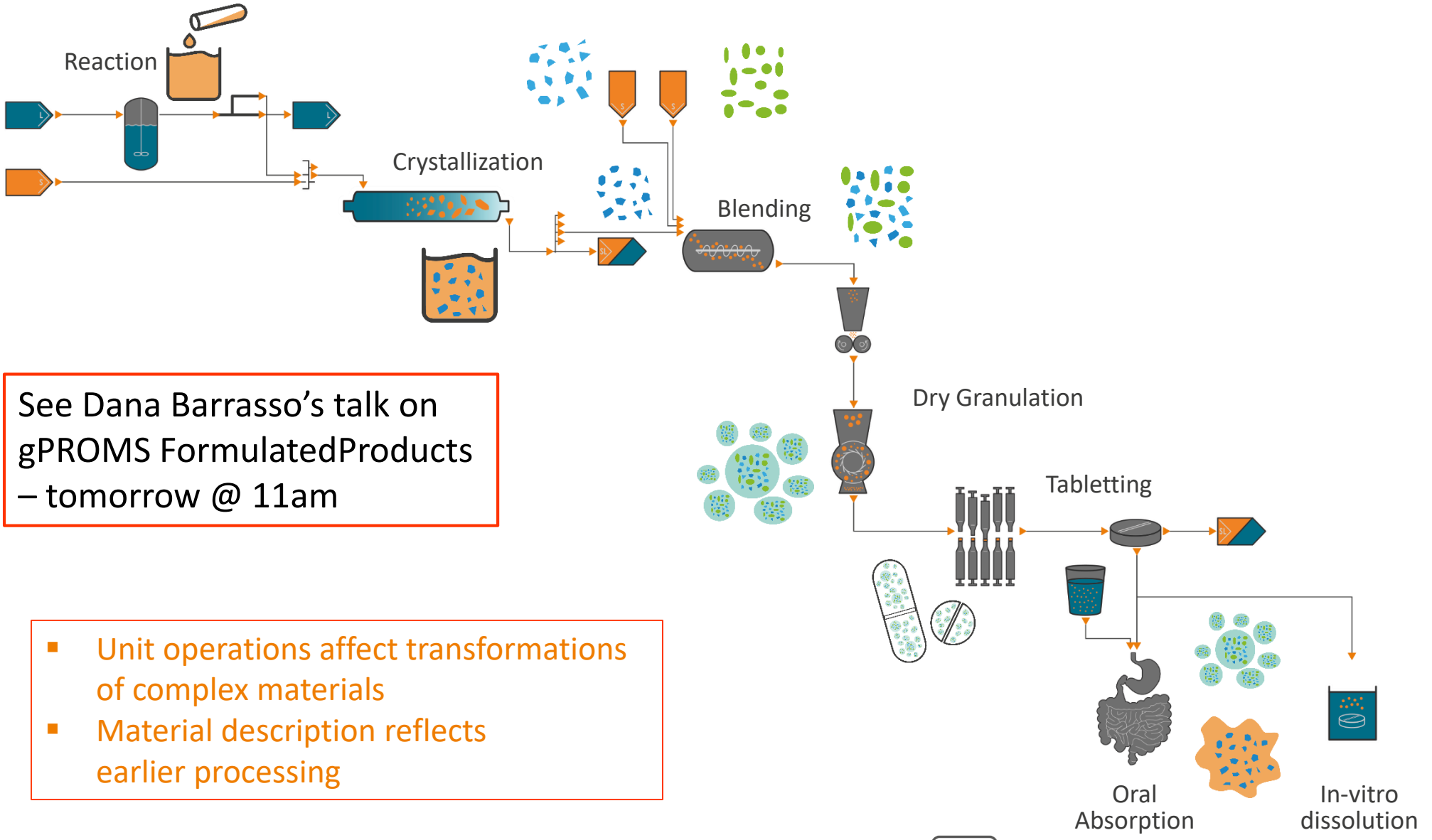
Tracking of material structure across the system



See Dana Barrasso's talk on gPROMS FormulatedProducts – tomorrow @ 11am

- Unit operations affect transformations of complex materials
- Material description reflects earlier processing

Database capabilities

- Flexible database structure compatible with
  - PSE provided databases
  - 3rd party databases
  - corporate databases, etc.

Materials

Dosage forms

Equipment

Physiology

- Significant increase in usability
  - single repository for validated data
  - less looking up of data
  - fewer transcription errors

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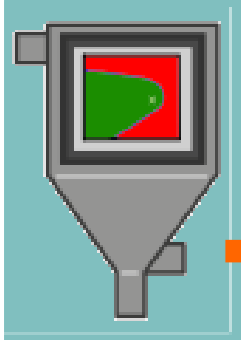
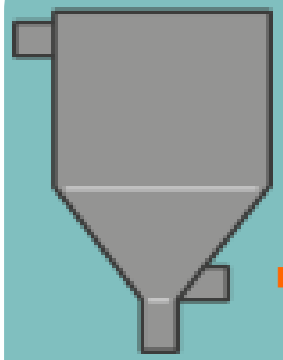
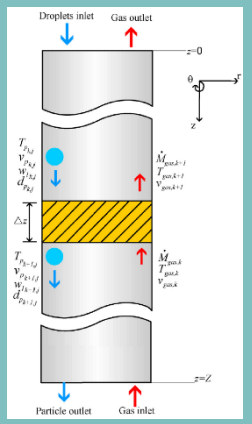
Hierarchy of model fidelity



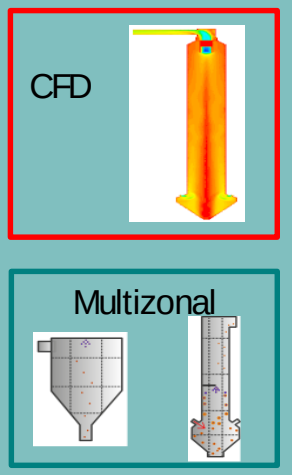
- Simple models
  - Mass & energy balance
  - Psychrometric principles
- Good for
  - Initial process design & capacity considerations



- Kinetic models
  - Population balance approach
  - Detailed description of kinetics
- Good for
  - Process design, scale-up, tech transfer, GSA, understanding…



- Detailed models
  - Spatial variations
  - Important if have a not-well mixed system
- Good for
  - Trouble shooting
  - Can be used for design etc. but time considerations



- CFD/ CFD-PBM models
  - Detailed hydrodynamics
  - Can be combined with other methods such as PBM
- Good for
  - Trouble shooting

M.Ali, *Numerical modelling of a counter-current spray drying tower*, PhD Thesis, University of Leeds (2014)

Model-based solutions for the food industry

- Partnership with NIZO – Centre of Excellence 
  - Leverage PSE's expertise in providing model-based solutions with NIZO's extensive experience in food research and product-process interactions
- Establish an industrial steering committee to guide development
  - First meeting APMF 2016 (last year)
- Develop a food manufacturing model library within gPROMS FormulatedProducts framework
  - Using current framework and knowledge

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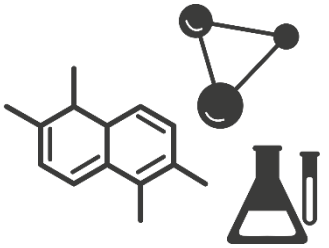

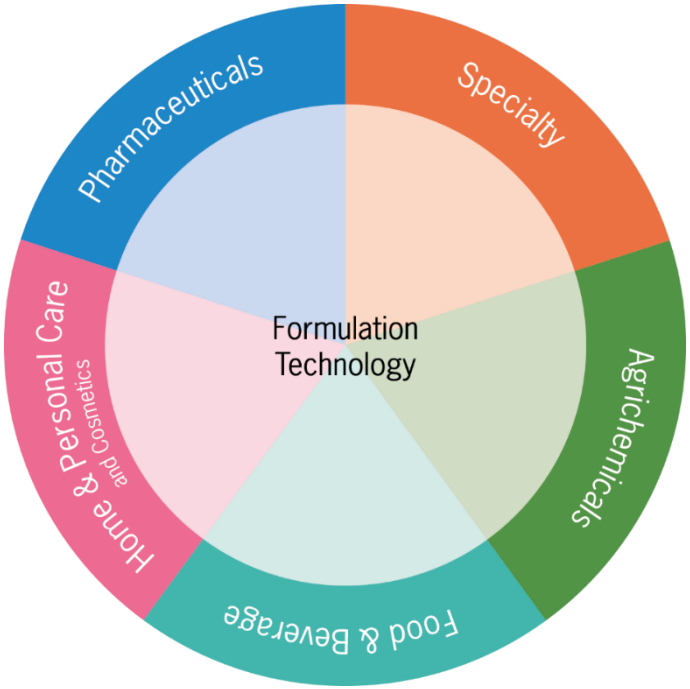

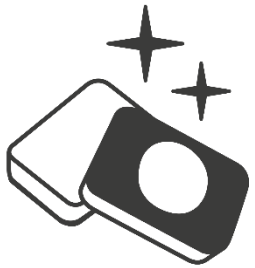

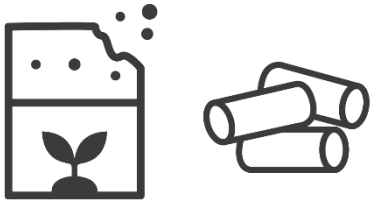

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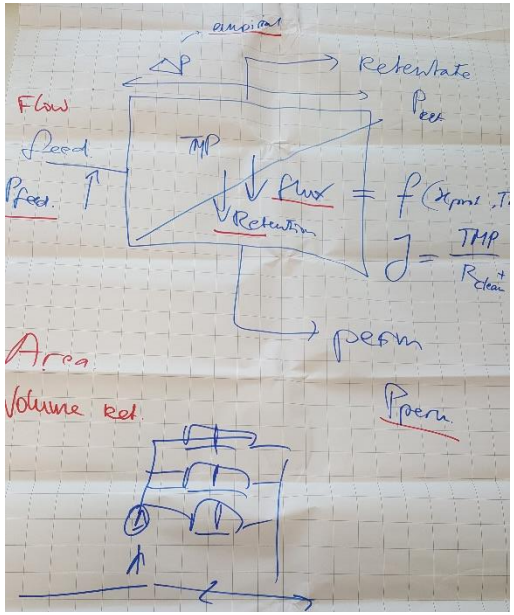
FrieslandCampina
nourishing by nature

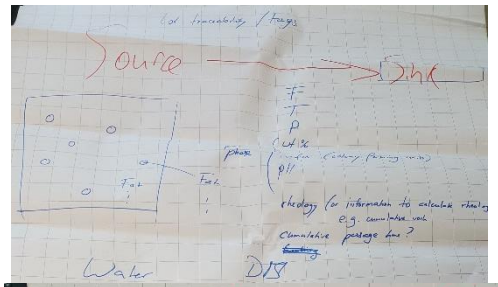
DANONE

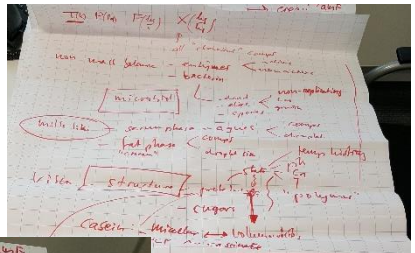
Nestlé

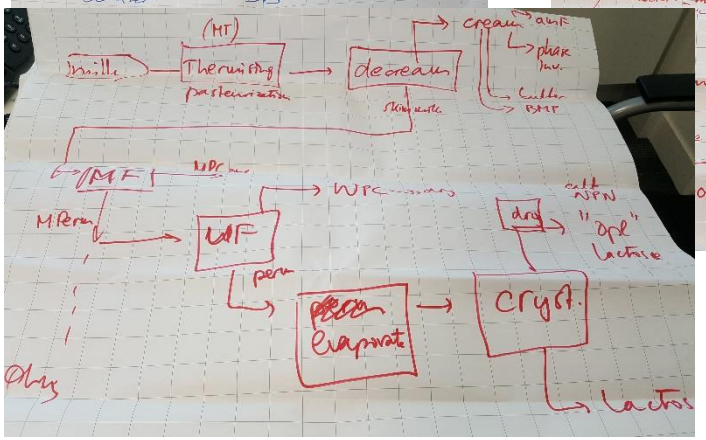
Food industry steering committee

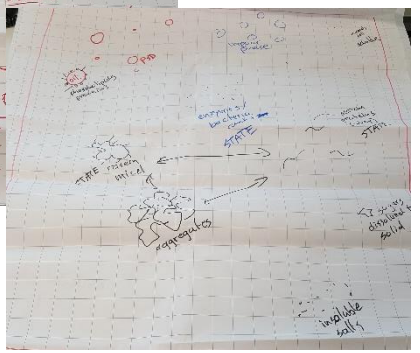
- Prioritise developments – which unit operations to develop first in food manufacturing model library?
- Requirements for physical properties, features, structure
- Regular face-to-face meetings





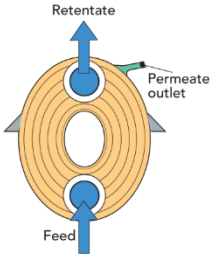


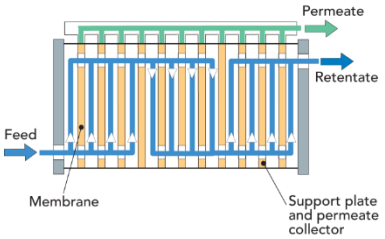




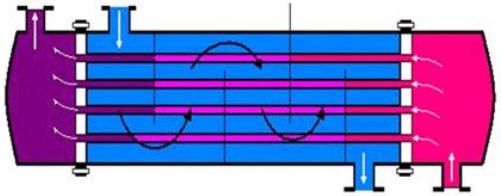
Prioritised models

- Membranes
  - Separation – calculate concentration build up in system

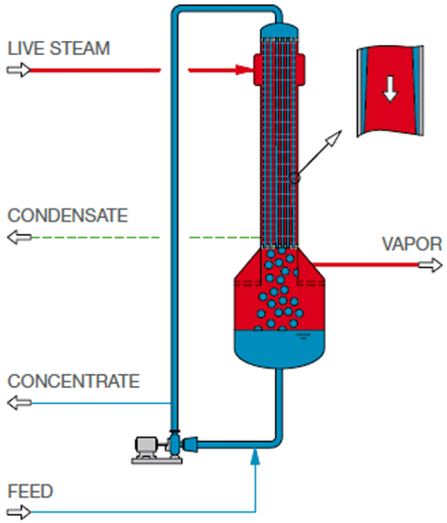




- Indirect heat treatment
  - Geometry: plate and tubular
    - Consider tubular first



- Falling film evaporators
  - MVR & TVR



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Preliminary scope and timelines for gFOOD developments

2017

gFP 1.0

First set of models for "gFOOD"

2018

Physical properties package

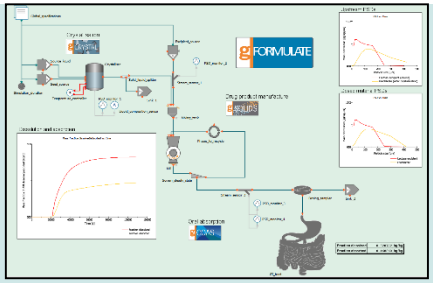
Data import tool

Global System Analysis

Faster, more robust model library

Enhanced parameter estimation

April 2017



Membrane

Spray-drying

Heat exchanger

Falling film evaporator

September 2017

Develop cases/ examples & material for training

Physical properties package development

TBD

TBD

TBD

December 2017

NIZO courses – Jan'18

APMF session: progress & applications

April 2018

gFP on-going library development

Fermentation

Centrifugation

Chromatography

Lyophilisation

Cheese

Product stability

Future models

...

Centre of Excellence for Food Product & Process Modelling

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FOR BETTER FOOD & HEALTH

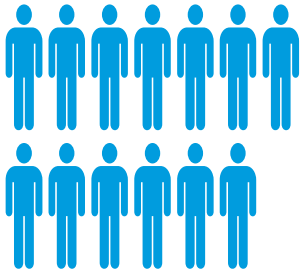
PSE / NIZO CoE food product & process modelling

INNOVATING TOGETHER

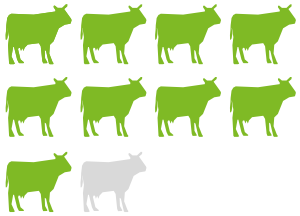
NIZO FOOD RESEARCH

INDEPENDENT, PRIVATE CONTRACT RESEARCH ORGANISATION

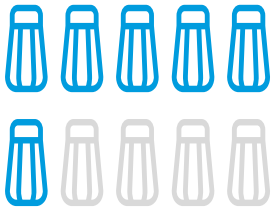
130 professionals at NIZO



9 of the **global top 10 Dairy Companies**



6 of the **global top 10 Ingredient companies**



The global **top 5 Infant & Clinical** companies

Number of publications on average per year **60**

17 General labs

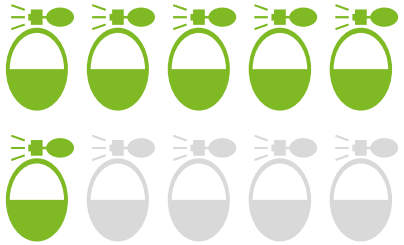
16 BSL-I labs*

4 BSL-II labs*

5 Food grade labs

6 of the **global top 10 Consumer goods companies**

6 of the **global top 10 Personal care companies**



Number of consortia on average **5-10 per year**

*also for GMOs

INNOVATING TOGETHER

NIZO FOR BETTER FOOD & HEALTH

NIZO FOOD RESEARCH

HISTORY

1948 — Founded by Dutch dairy companies

1960 — From control and optimization to innovation

1960-1970 — Development NIZO butter process; Development Leerdammer cheese; NIZO starter culture collection

1970 — Building of a dairy plant

1970-1980 — Casein models developed; First flavour analyses; Casomatic; Spray drying models developed

1990 — From pre-competitive to confidential research

1995-2000 — Ice-cream fat replacement; ETEC challenge model; Yield increase; Fermentation; CSK spin-off NIZO

2003 — From dairy to food

2009 — Management Buy-out

2010 — Expansion microbiome expertise; Plant protein knowledge

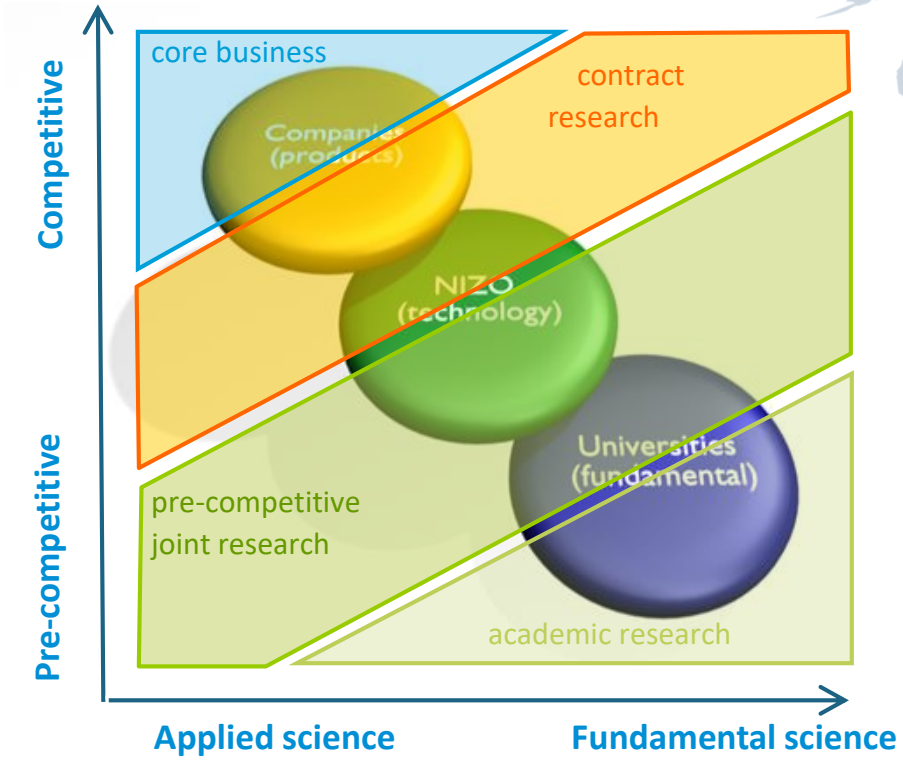
2015 — Full focus on contract research & fundamental research

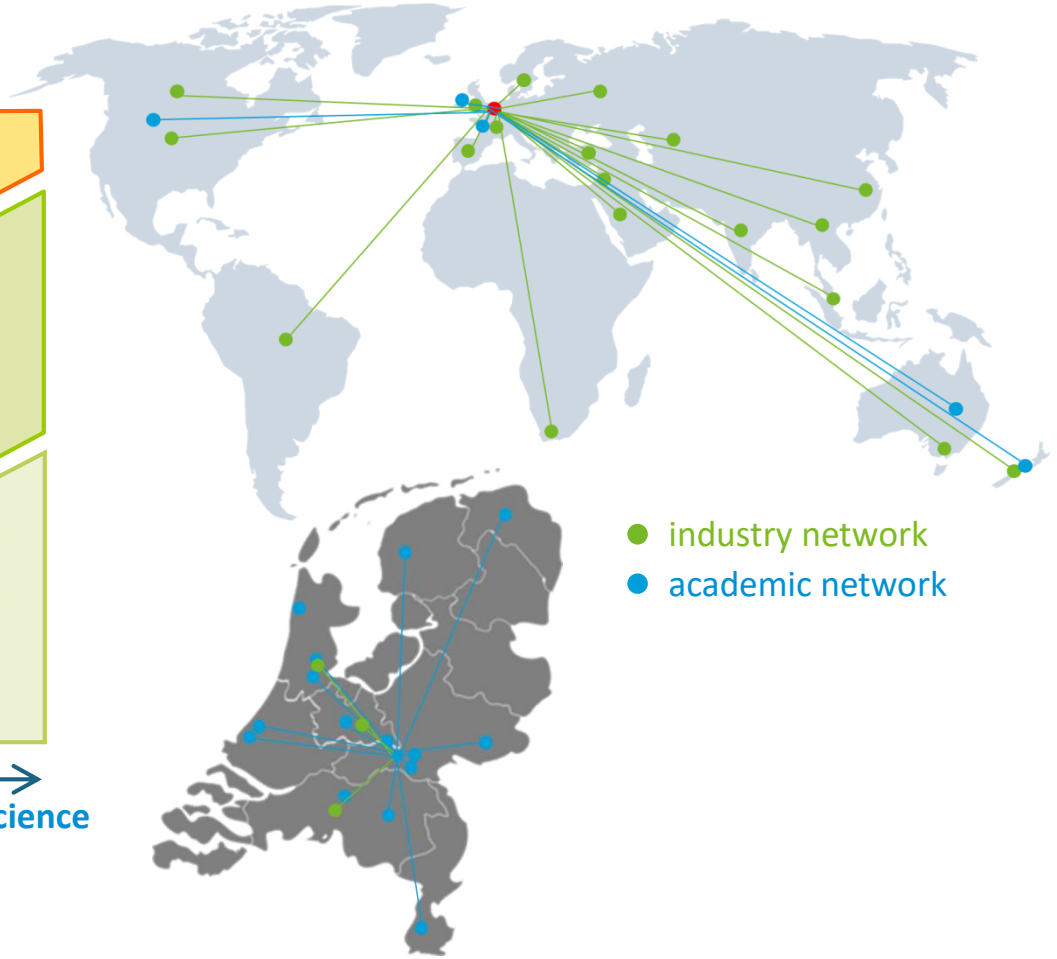
2016 — For better food & health

Gilde HEALTHCARE

NIZO FOOD RESEARCH

FROM SCIENCE TO SOLUTIONS





NIZO FOOD RESEARCH

FIELDS OF EXPERTISE

Bacteria

Nutrition & Health

Fermentation

Microbiomics

Processing

Efficient Upscaling

Proteins

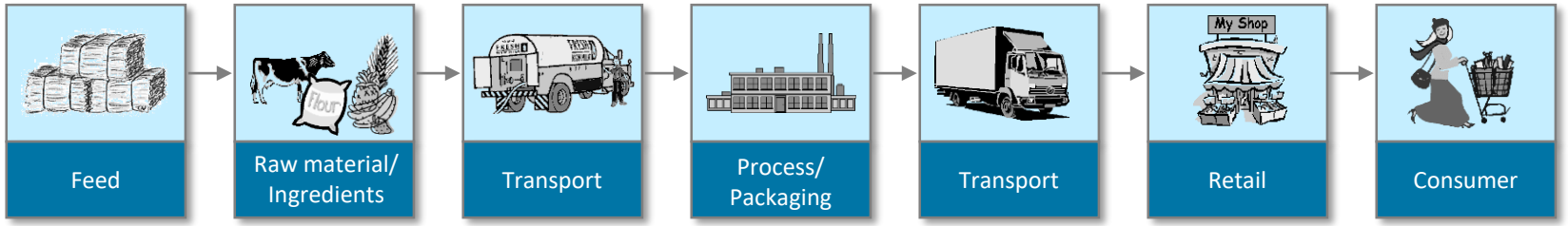
Dairy Technology

Protein Functionality

Flavour & Texture Interactions

Processing Efficiency

FOOD PRODUCT & PROCESS MODELLING @ NIZO



Farm management model

Process-product interaction models

Quantitative Microbial Risk Assessment (QMRA)

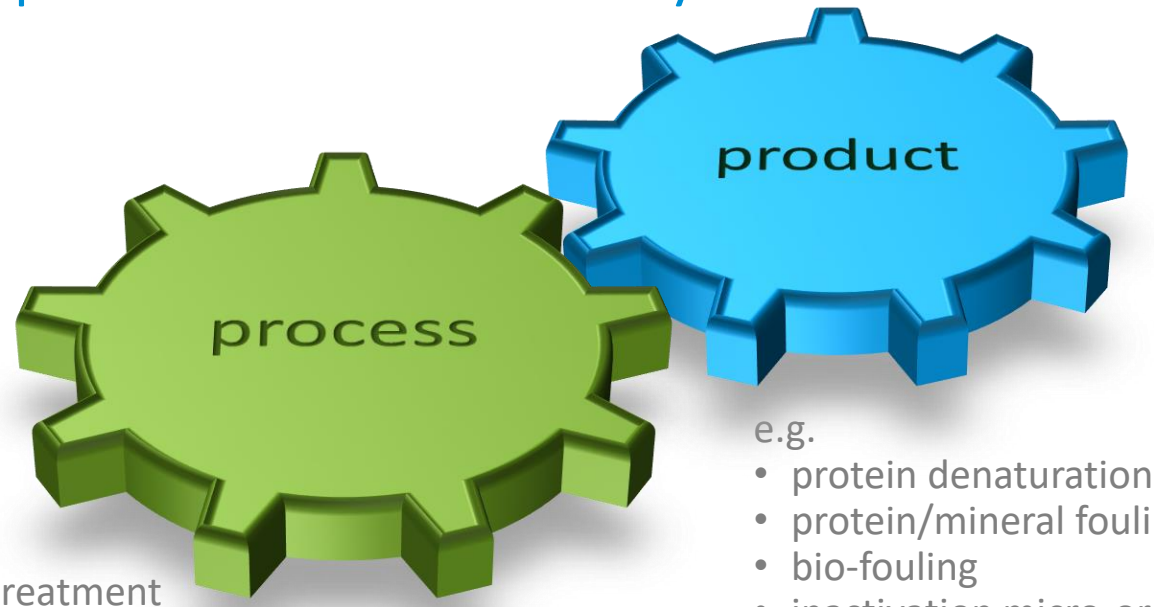
Bio-IT

GI tract model

Sensory / Thelometry

MODELLING - APPROACH

(mechanistic) understanding and quantification of process-product interactions is key

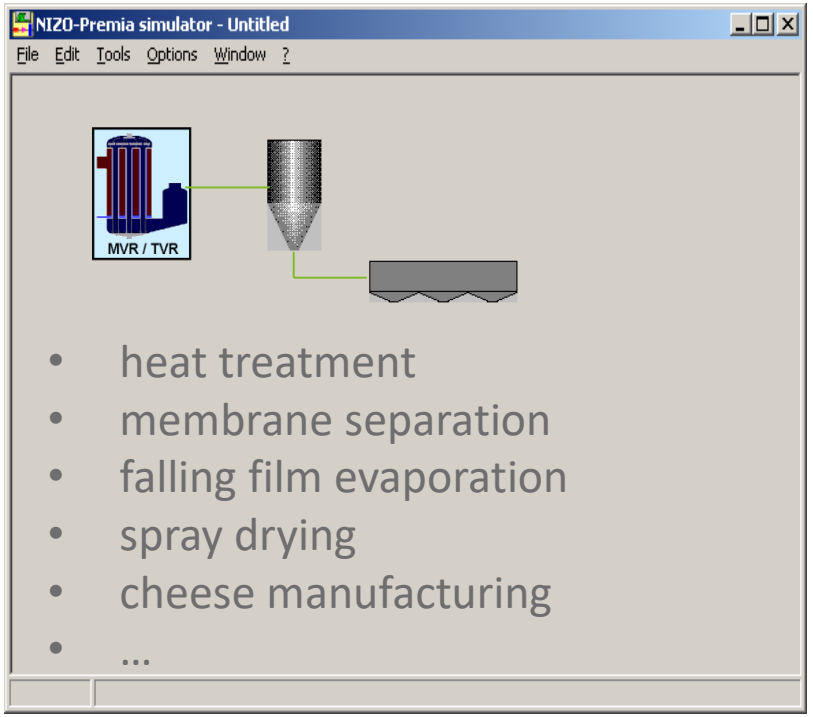


e.g.
- heat treatment
- spray drying
- falling film evaporation
- membrane separation
- …

e.g.
- protein denaturation
- protein/mineral fouling
- bio-fouling
- inactivation micro-organisms
- …

NIZO PREMIA

- PREMIA: PREdictive Models for Industrial Applications
- A user-friendly tool for modelling process-product combinations
  - practical user interfaces for each model
  - models can be linked and combined
- Designed for use in practice
  - built in graphical tools, optimisation tools, calibration etc.



Premia will migrate to gPROMS / gFOOD

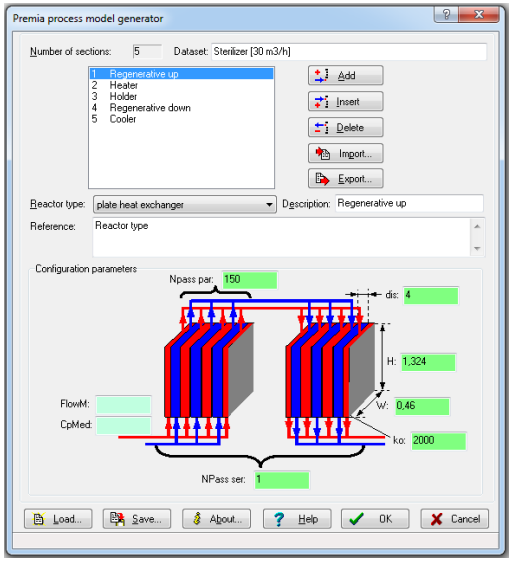
NIZO PREMIA MODELS

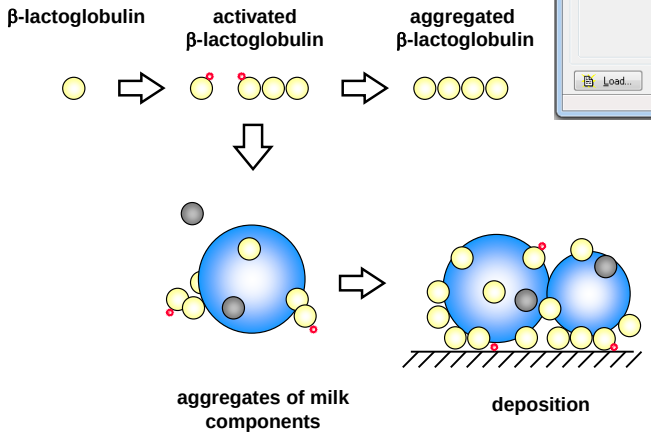
HEAT TREATMENT

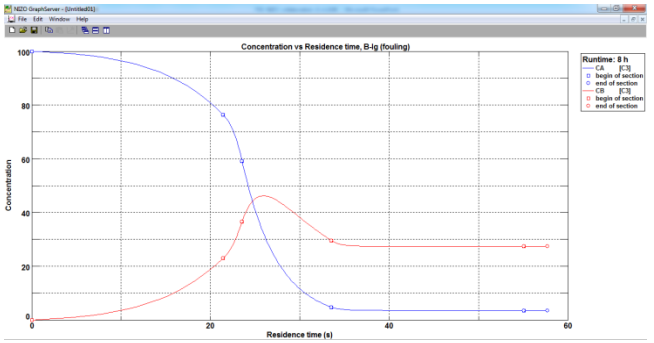
- CSTR
- isothermal tube
- tube heat exchanger
- plate heat exchanger
- flash reactor
- steam injector
- steam infuser
- …

Predicts:

- inactivation micro-organisms
- protein denaturation
- inactivation enzymes
- protein/mineral fouling
- bio-fouling
- …

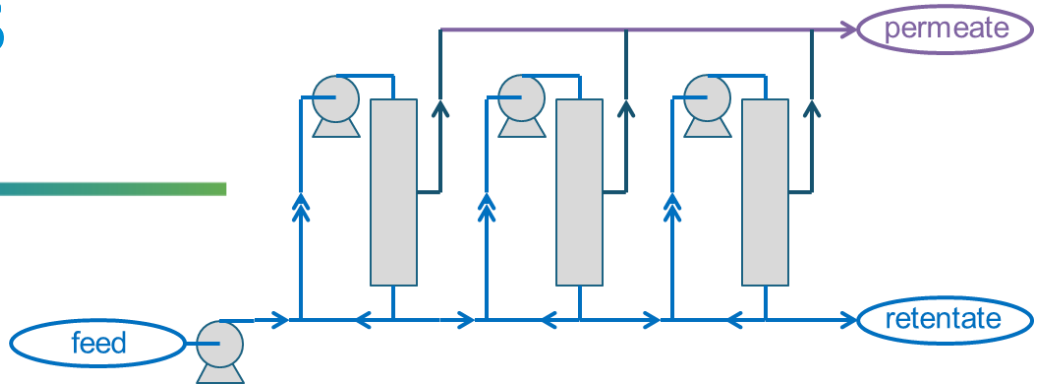






NIZO PREMIA MODELS

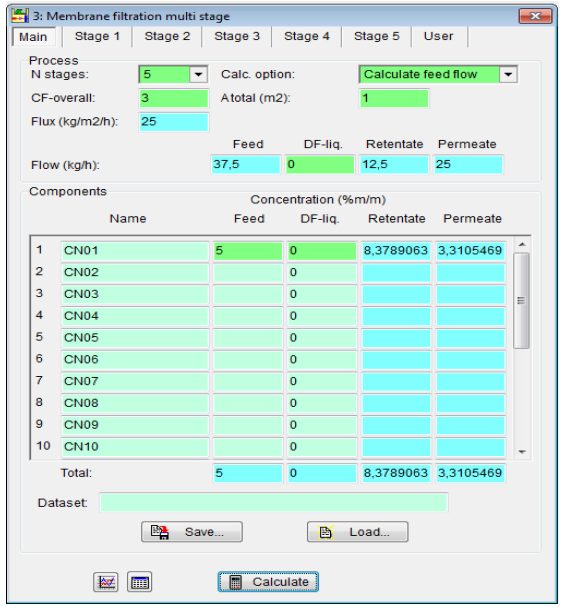
MEMBRANE SEPARATION



- multi-stage membrane systems
- multi-component products

predicts

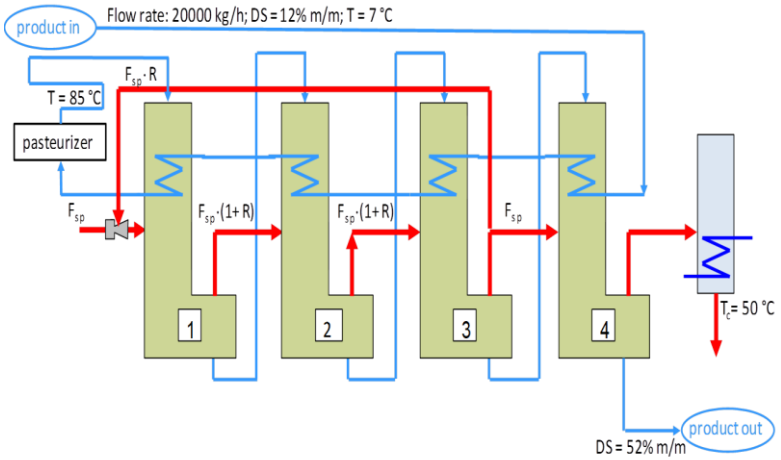
- component concentrations in permeate and retentate
- required membrane characteristics
- optimal configuration

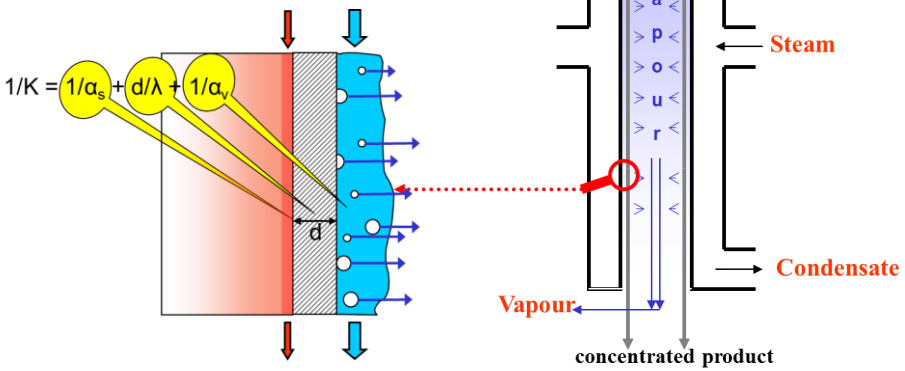


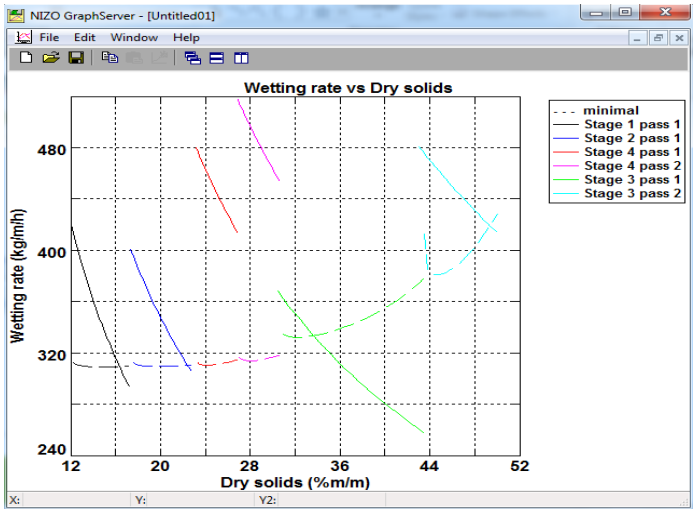
NIZO PREMIA MODELS

FALLING FILM EVAPORATION

- (minimum) wetting rates
- product temperature
- product viscosity
- vapour flows, pressure drops
- heat transfer coefficients
- energy consumption
- runtime
- …







NIZO PREMIA MODELS

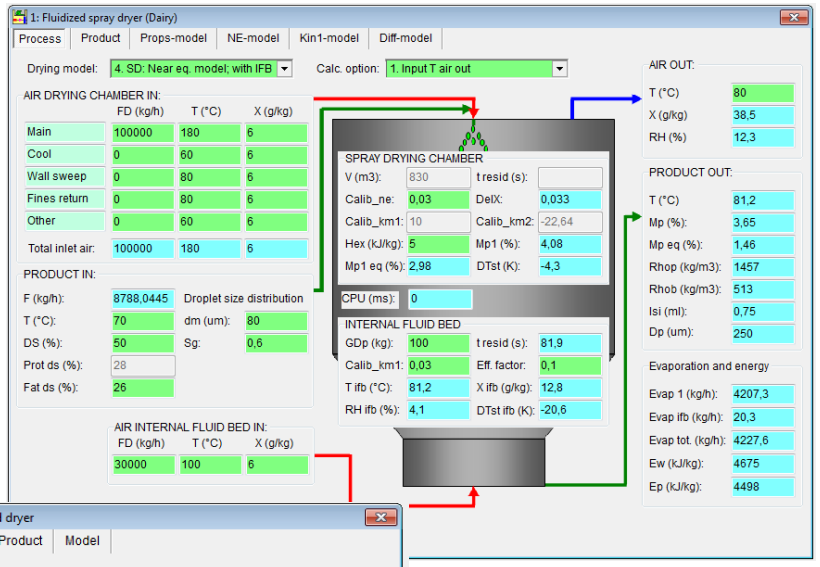
SPRAY DRYING

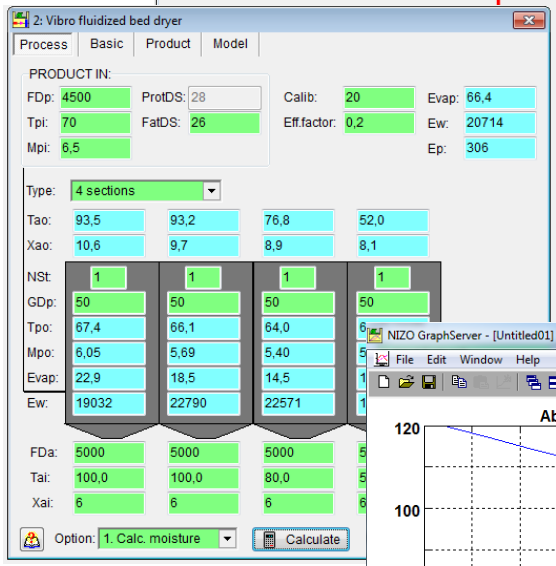
- spray dryer
- SFB
- VFB

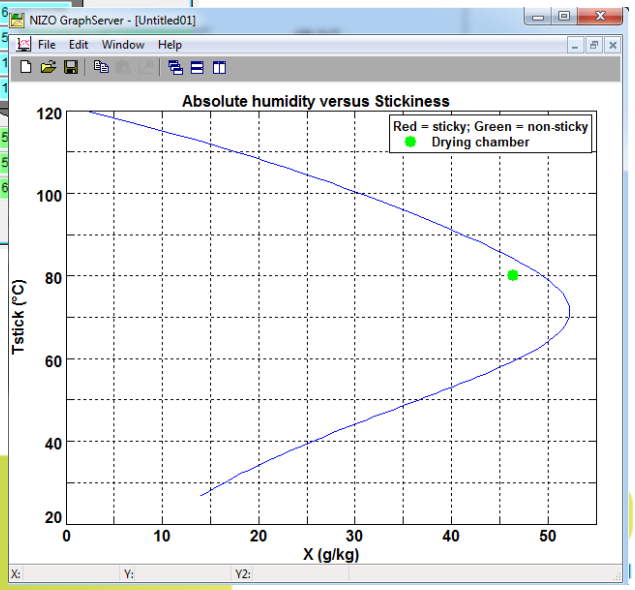
- predicts
  - powder moisture
  - stickiness/fouling
  - isi[1,2]
  - bulk density[1]
  - inactivation enzymes[2]
  - probiotic viability [2]
  - agglomeration[2]

[1] empirical data (product/dryer specific)

[2] using single droplet drying model and/or CFD (not part of Premia)



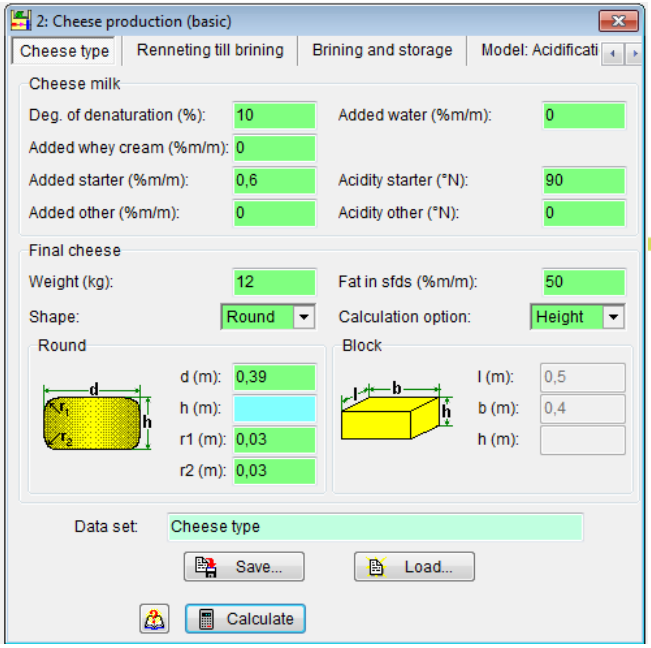


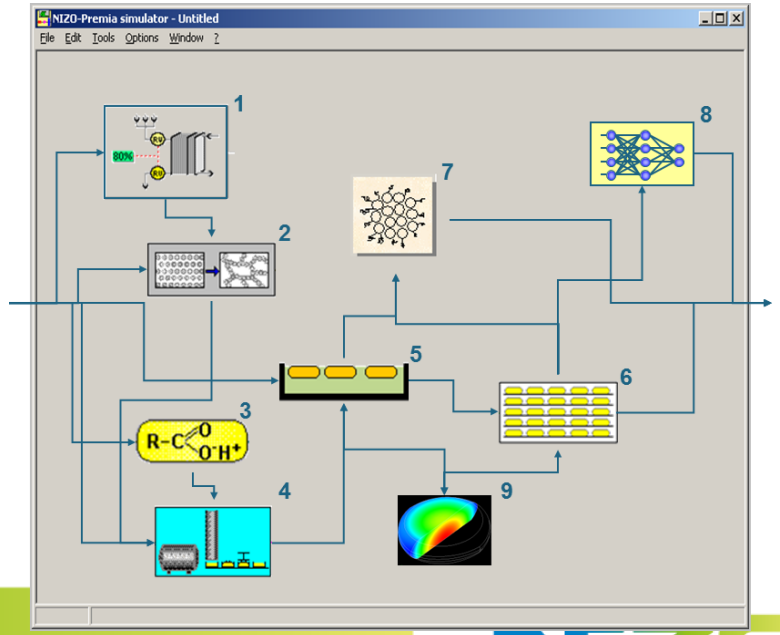


NIZO PREMIA MODELS

CHEESE

- standardisation
- thermisation
- pasteurisation
- renneting
- acidification
- curd preparation
- brining
- storage
- cheese yield
- protein breakdown
- taste (neural networks)

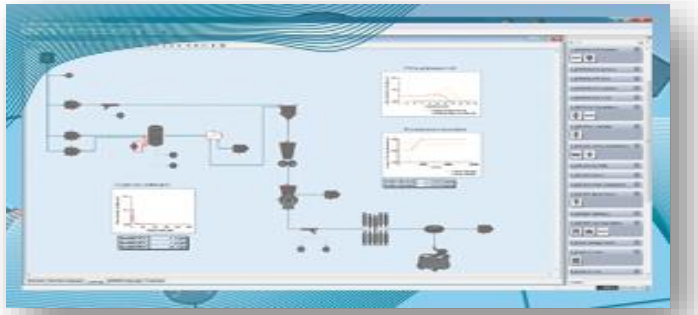




PSE/NIZO COLLABORATION

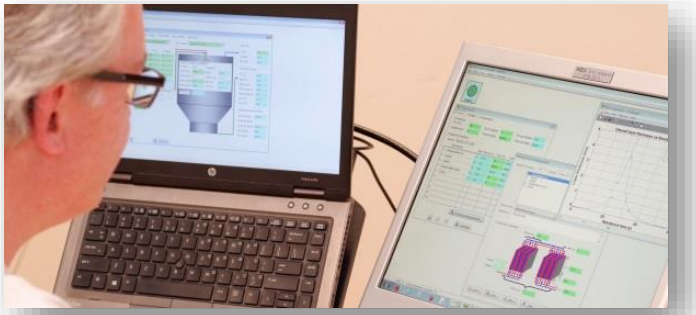
CoE food product & process modelling

Mechanistic process modelling



gPROMS platform

Food process-product modelling

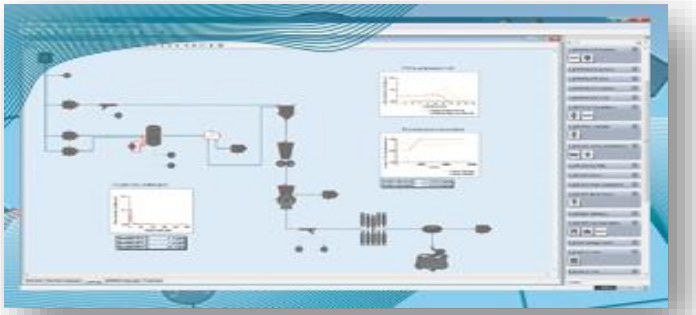


process-product models

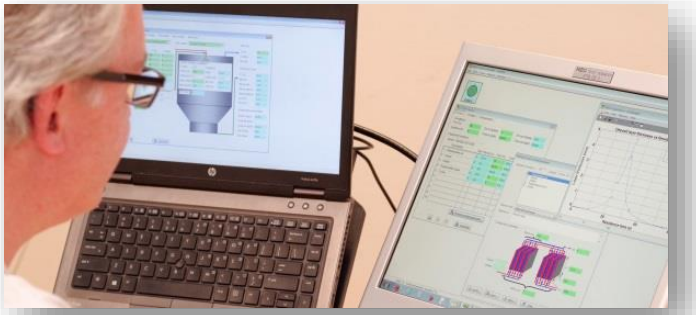
PSE/NIZO COLLABORATION

CoE food product & process modelling

Mechanistic process modelling



Food process-product modelling



Experimentation service

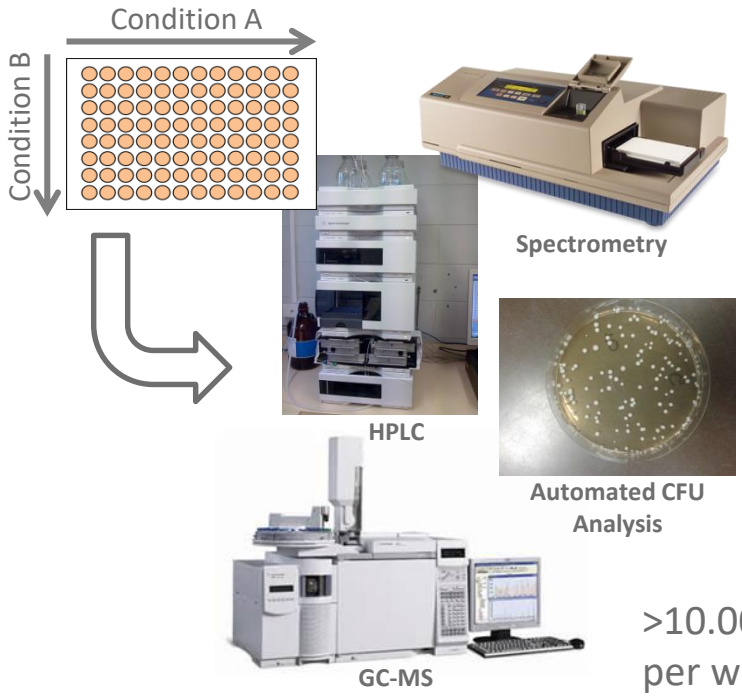
Processing Centre

EXPERIMENTATION SERVICE

State-of-the art laboratory facilities

- Analyses tools
  - physical
  - chemical
  - microbial
  - sensorial
- HTS & micro-systems
  - heat treatment
  - fermentation
  - spray drying
  - …

Fermentation / HTS



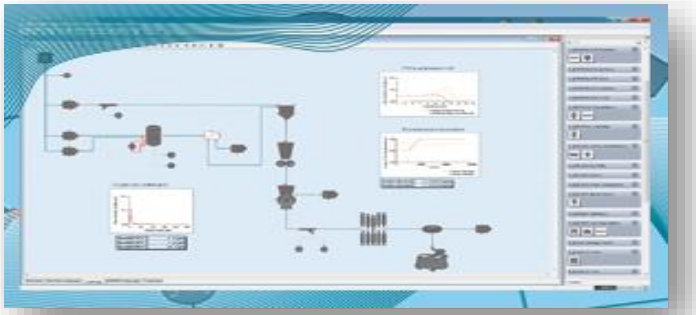
- Sugars
- Acids
- Proteolytic Hydrolysis
- Flavor Molecules
- CFU's
- Corrected OD (automated dilution in time)
- Enzymatic activity
- Protein expression
- Oligosaccharide formation

>10.000 fermentations per week

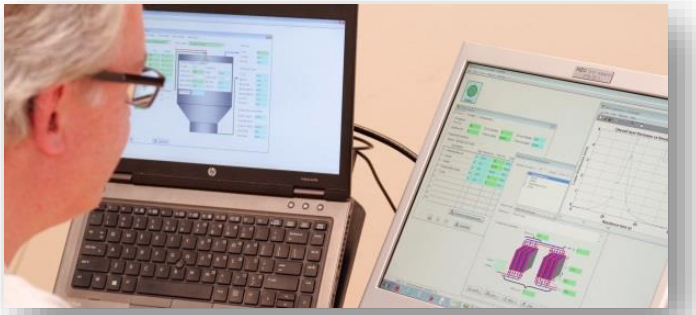
PSE/NIZO COLLABORATION

CoE food product & process modelling

Mechanistic process modelling



Food process-product modelling



Experimentation service

Processing Centre

NIZO PROCESSING CENTRE

- Food-grade semi-industrial scale pilot plant
  - Research
  - Up-scaling
  - Toll manufacturing
- Processing options
  - Heat treatment
  - Membrane separation
  - Fermentation / hydrolysis
  - Evaporation
  - Drying
  - Cheese production
  - …

Cheese production