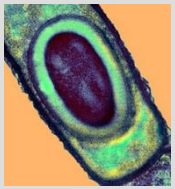
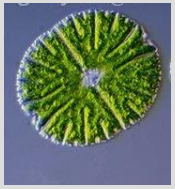
ETH zürich

Emerging bioprocessing concepts for healthy and sustainable foods

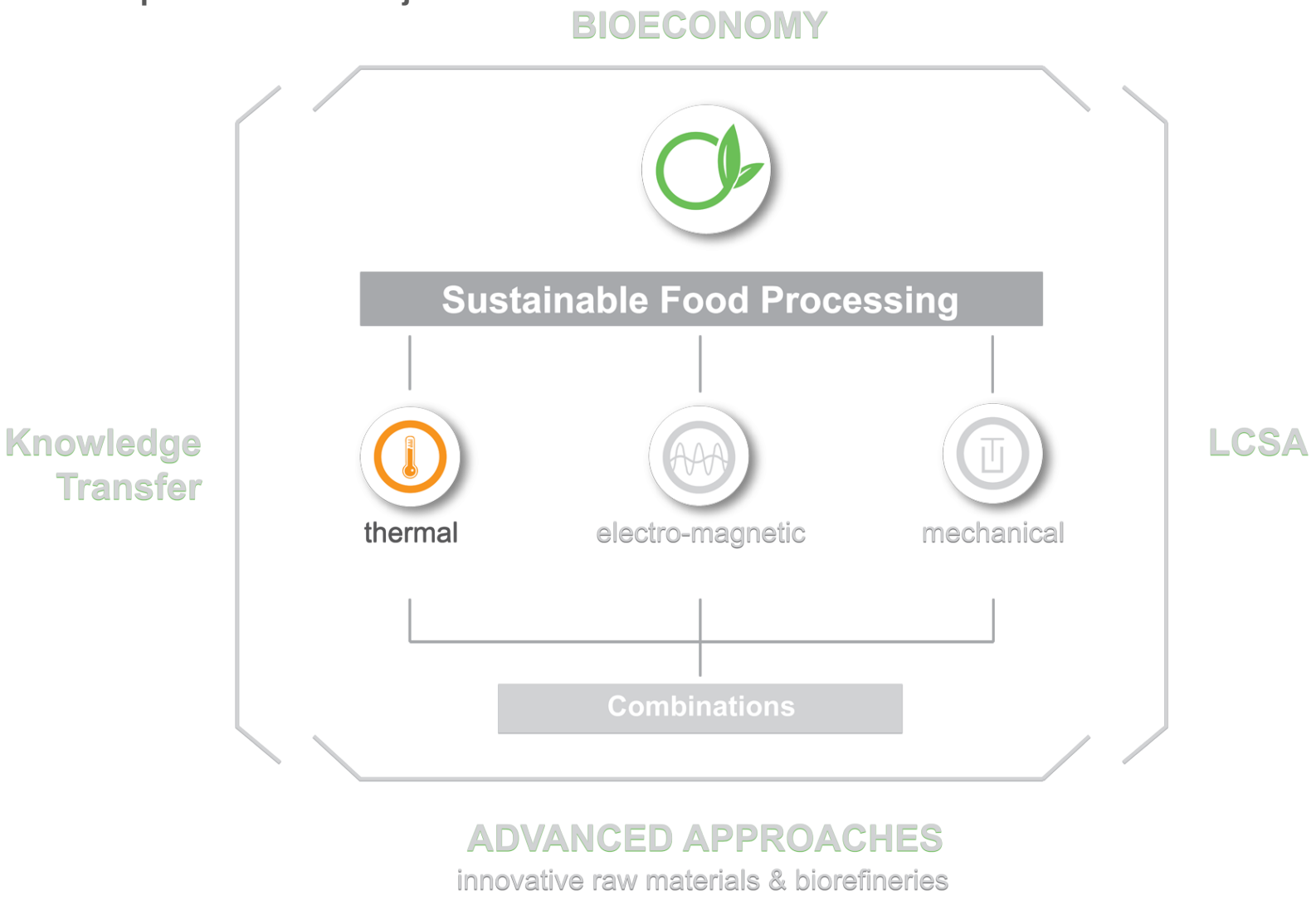
MELiSSA WORKSHOP- Science and Technologies on Regenerative Life-Support
08 June 2016, University of Lausanne

Prof. Dr.-Ing. Alexander Mathys
ETH Zurich

Focus areas of Sustainable Food Processing: Food Safety, Novel Proteins, LCSA

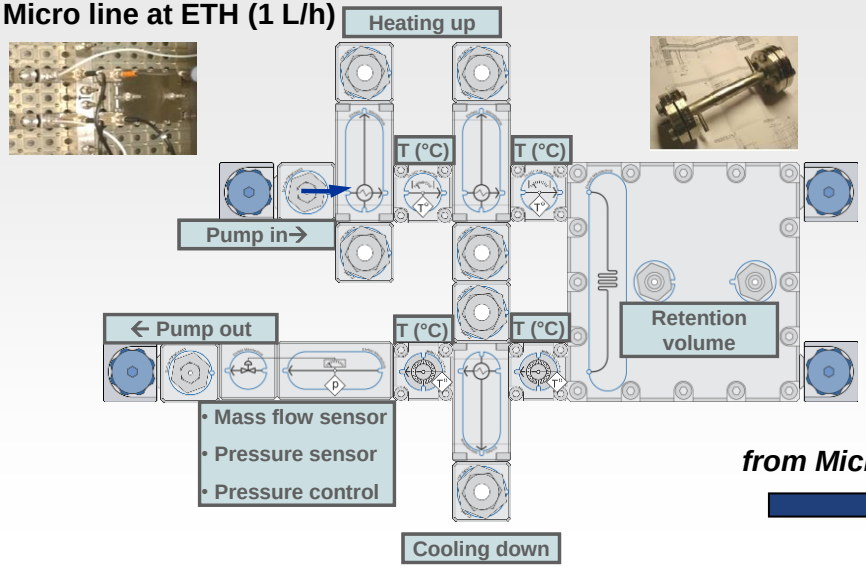
Focus 1	Sustainable Food Processing		Food Safety	• Bacterial spore control • Multi hurdle technologies
Focus 2			Novel Proteins	• Algae protein • Insect protein
Focus 3			Nutritional Life Cycle Assessment	• Aligned with focus 1 & 2 • Method development

Agenda of the presentation & objectives

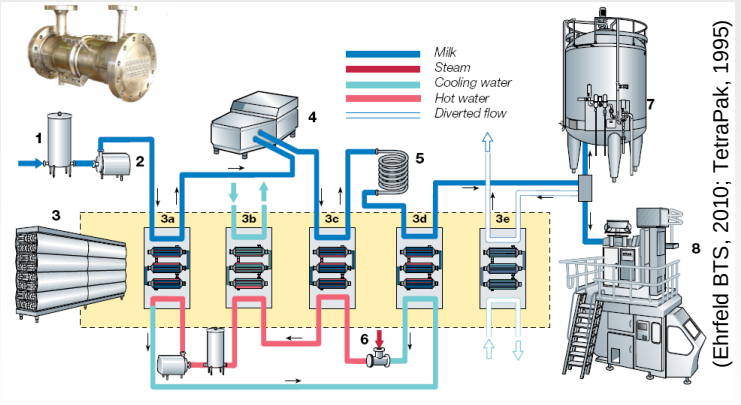


Up-scaling in thermal preservation via micro process engineering approaches

Micro line at ETH (1 L/h)



Industrial line (20'000 L/h)



(Ehrfeld BTS, 2010; TetraPak, 1995)

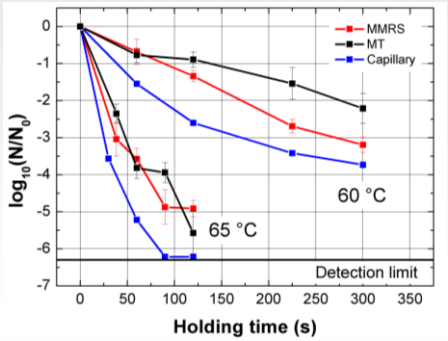
from Micro to Pilot and Industrial

Translation

Benefits

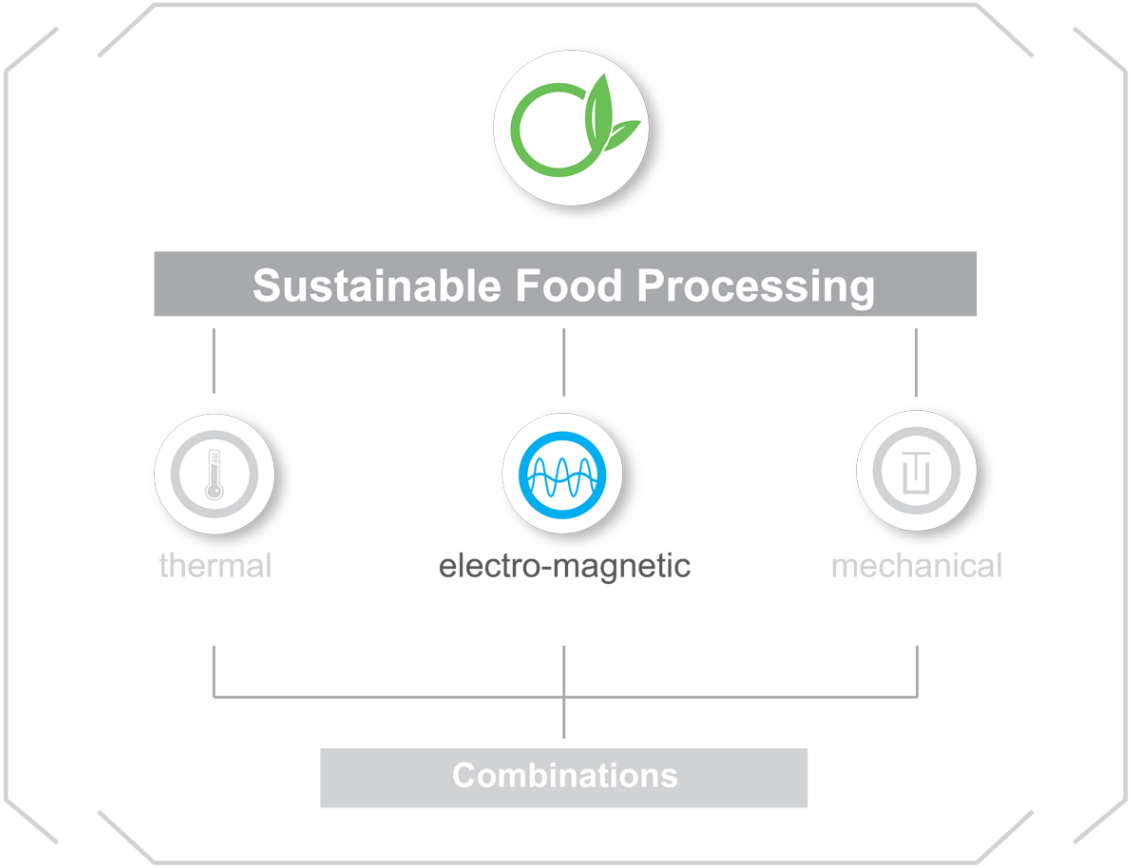
- Optimal lab-scale tool for thermal inactivation studies 60-160°C
- Multi-applicable micro process line for pasteurization or sterilization
- Continuous lab-scale equipment with standard connections for pilot scale modules → easier Up-scaling
- Less sample volume necessary
- Mobile and flexible

Pasteurization in micro and pilot scale-Different heat and mass transfers



(Mathys 2010; Georget, Sauvageat, Burbidge & Mathys 2013; Mathys 2016; Nestlé PTC Singen Support)

BIOECONOMY



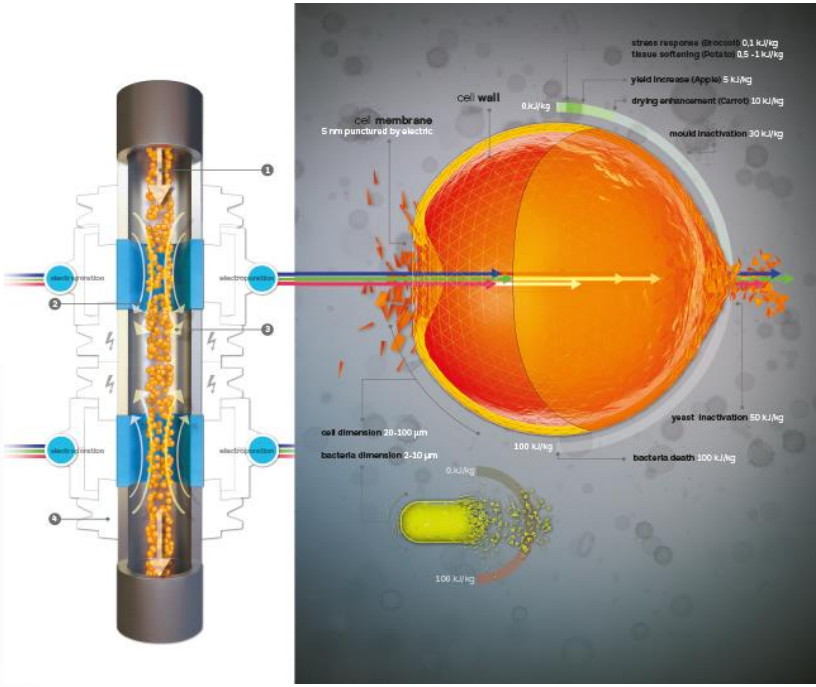
Knowledge Transfer

LCSA

ADVANCED APPROACHES

innovative raw materials & biorefineries

Electroporation- Pulsed electric field processing for multi product applications



Mathematical background

$$E = \frac{U}{d} \qquad W_{specific} = \frac{W_{pulse} \cdot f}{\dot{m}}$$

$$W_{pulse} = \int_0^t U(t) I(t) dt$$

(DIL, 2012; Elea mbH, 2014)

Pulsed electric field processing for healthy and high quality milk

	Treated raw milk		Untreated raw milk
Inactivation *E.coli*	5,8		0
[log N/N_0] *L.innocua*	5,8		0
pH value	6,9		6,9
Conductivity [mS/cm]	3,9		3,9
Color difference	0,74		
Lactoferrin concentration [mg/L]	64,1	**84%**	76,0
IgA concentration [µg/mL]	80,4	**58%**	136,3
IgG concentration [µg/mL]	703,5	**81%**	868,2
TGF-β1 concentration [ng/mL]	0,32	**84%**	0,38
TGF-β2 concentration [ng/mL]	38,9	**94%**	41,4
Shelf life [d]	>14		<4

Results of trials when treating the raw milk with 12 kV/cm and 244 kJ/kg; start temperature 30 °C, pulse duration 20 µs, colinear treatment chamber (diameter= 10 mm, torpedo), 2 bar counter pressure, no intermediate cooling

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Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 543 254 A1**

EUROPEAN PATENT APPLICATION

Date of publication:
09.01.2013 Bulletin 2013/02

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A23C 3/033 (2006.01) *A23L 3/32* (2006.01)

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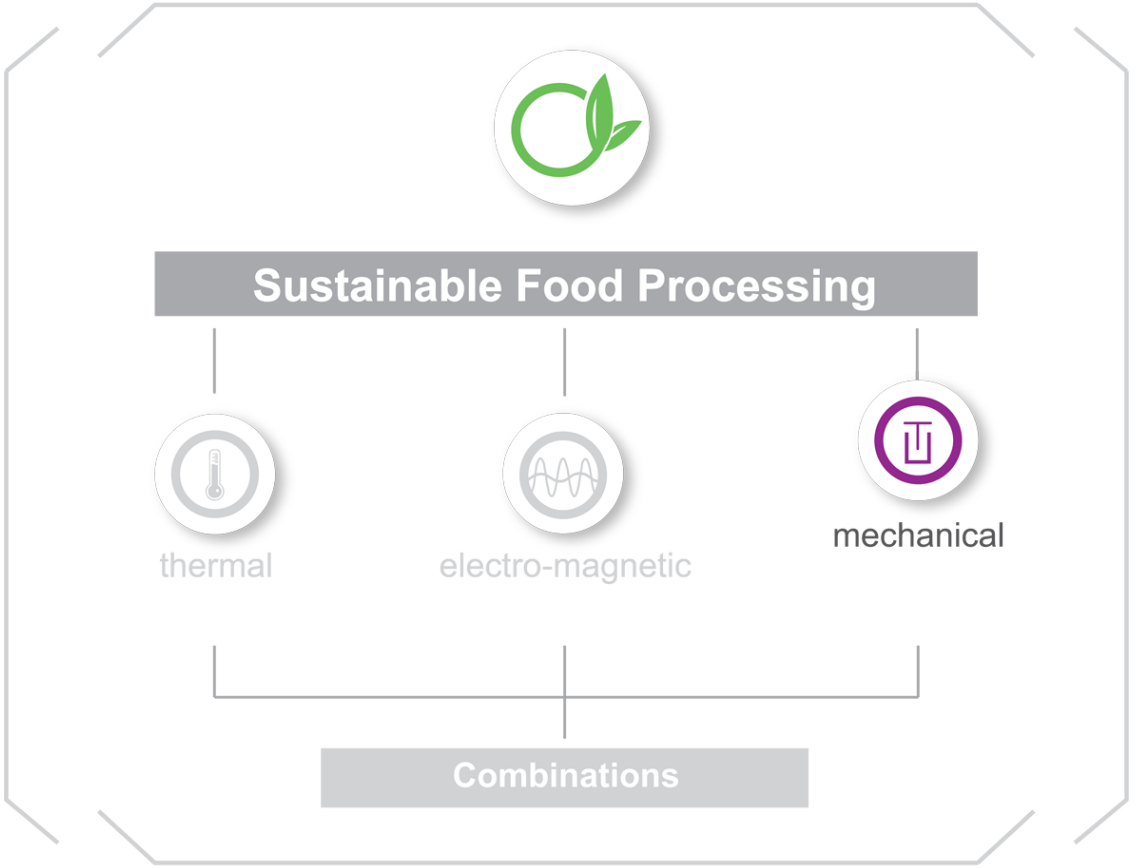
- **Toepfl, Stefan**
  49080 Osnabrueck (DE)

(Mathys, Töpfl, Siemer, Favre, Benyacoup & Hansen, 2013)

BIOECONOMY



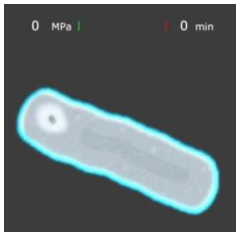
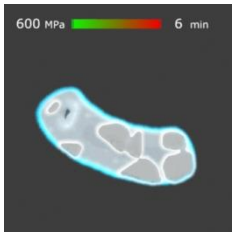
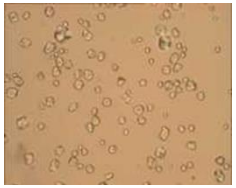
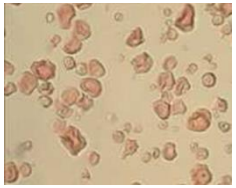
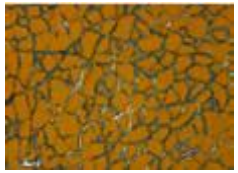
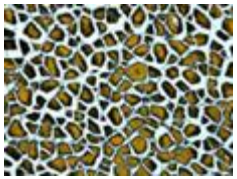
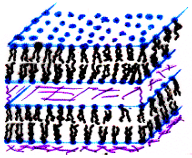
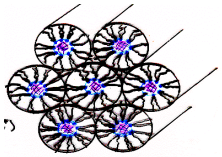
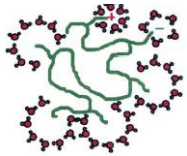
Knowledge Transfer

LCSA

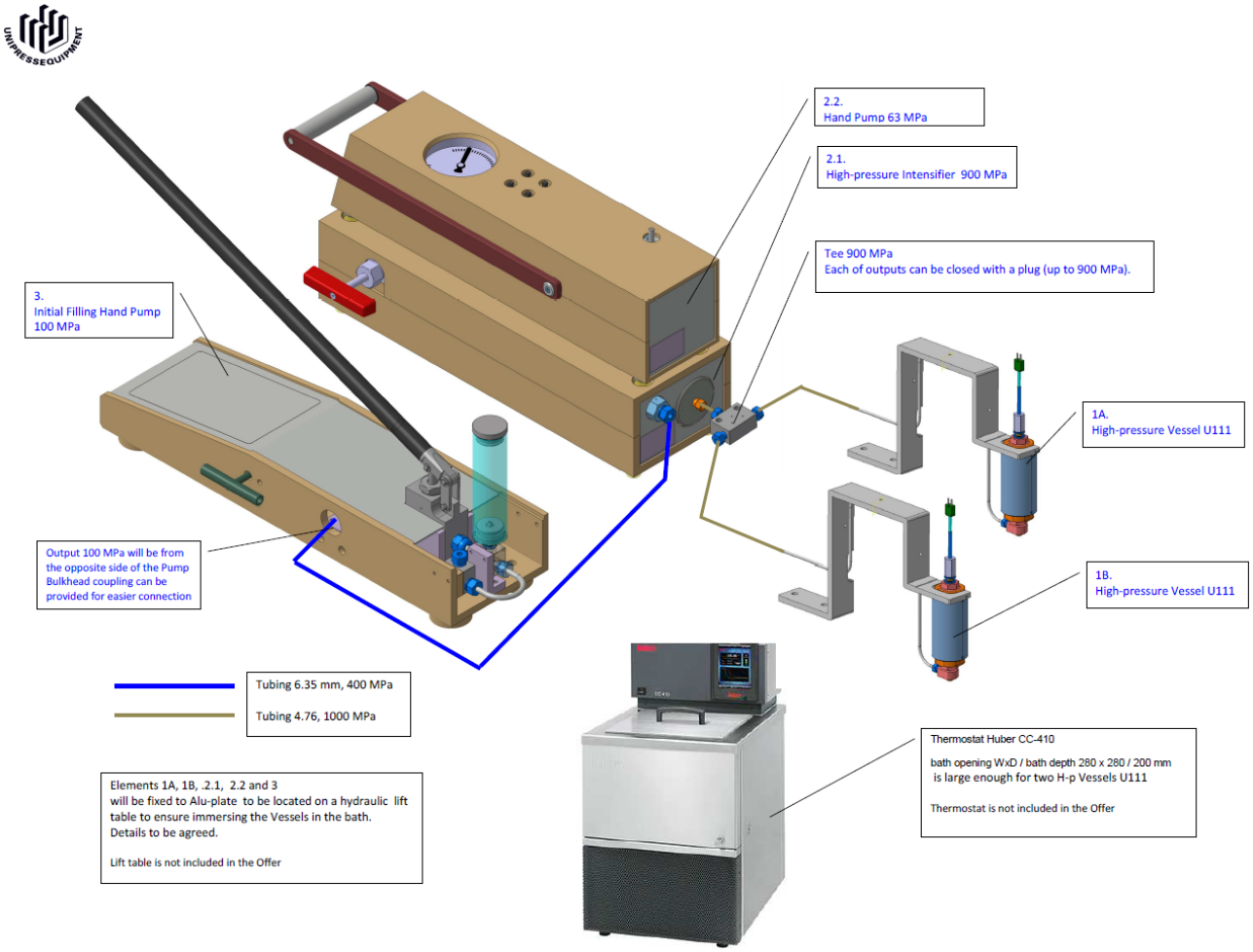
ADVANCED APPROACHES

innovative raw materials & biorefineries

Ultra high pressure up to 1000 MPa - effects on biomaterials

microbes		Inactivation	
starch		Swelling	
tissue		Disintegration	
lipids		Transition	
proteins		Unfolding	

New mobile high pressure research unit up to 900 MPa at ETH Zurich



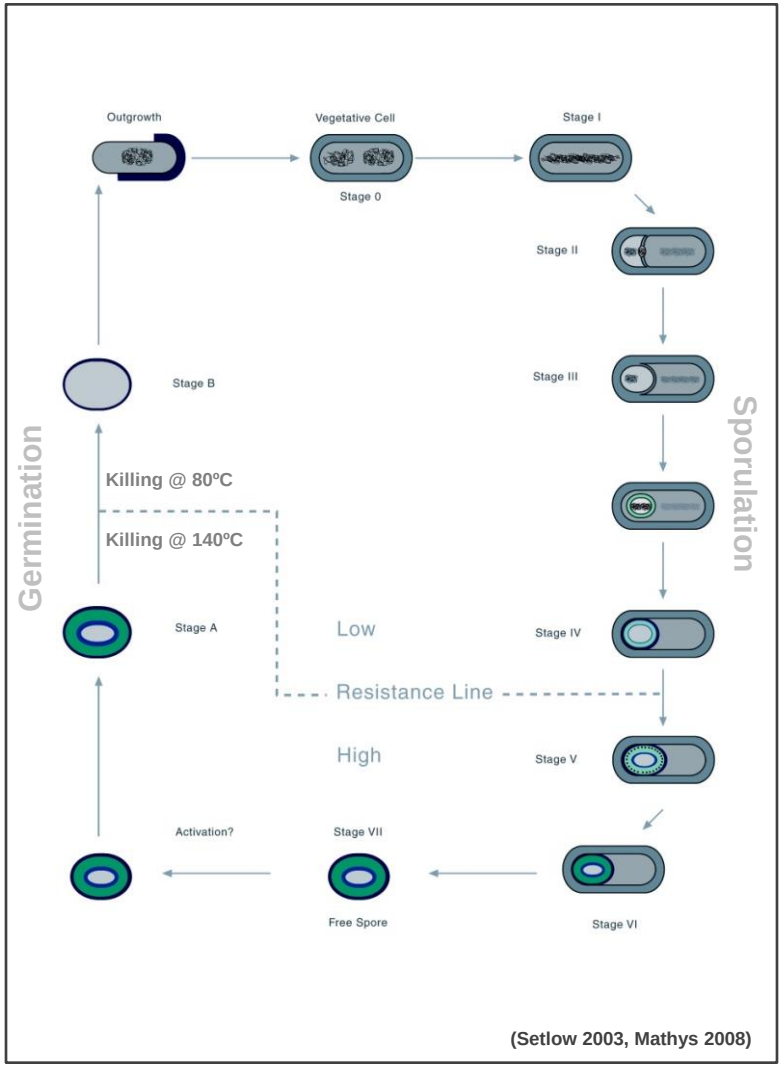
New high pressure unit at ETH:

- **Double HPP vessels, a 6 ml**
- **Complete T profile without injecting in sample**
- **Pressure range 0-9000 bar**
- **Temperature -40°C-150°C**
- **Mobile system (fits in a car)**

(Unit modification by Prof. Mathys, ETH Zurich 2016)

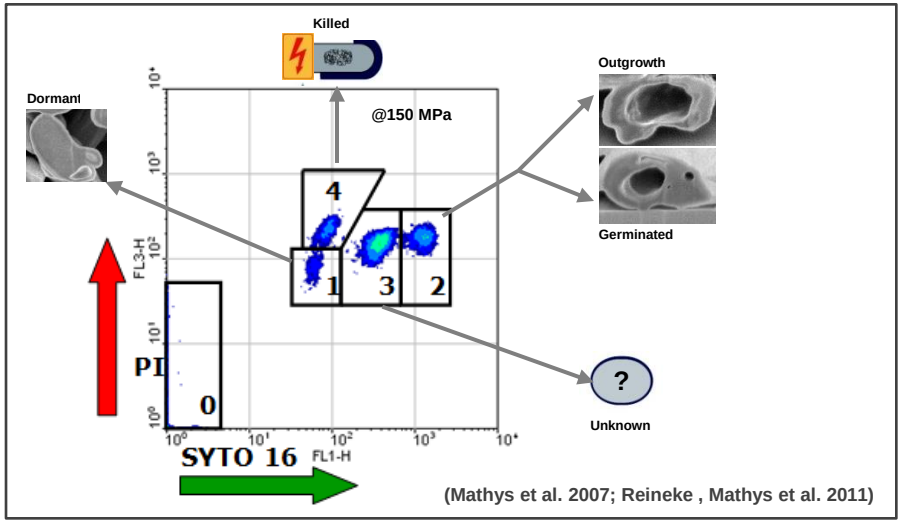
Bacterial spore life cycle- Mechanistic research based on flow cytometry, FIB-SEM and modelling

Spore germination as key step for innovative preservation



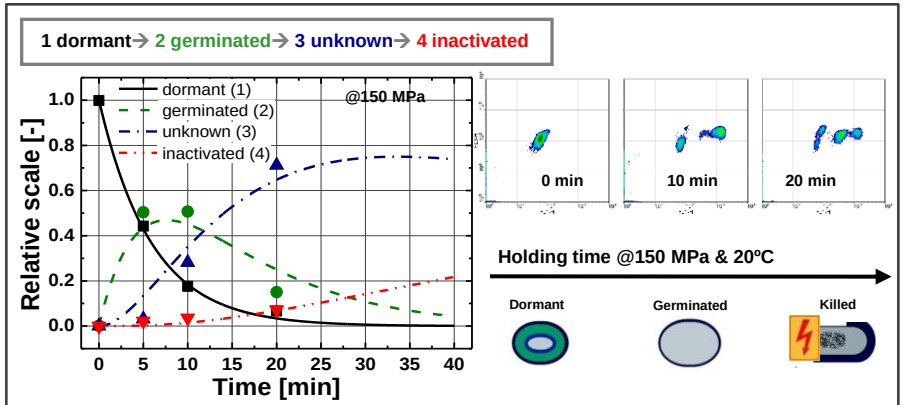
(Setlow 2003, Mathys 2008)

Germination analysis performed by flow cytometry & FIB-SEM imaging



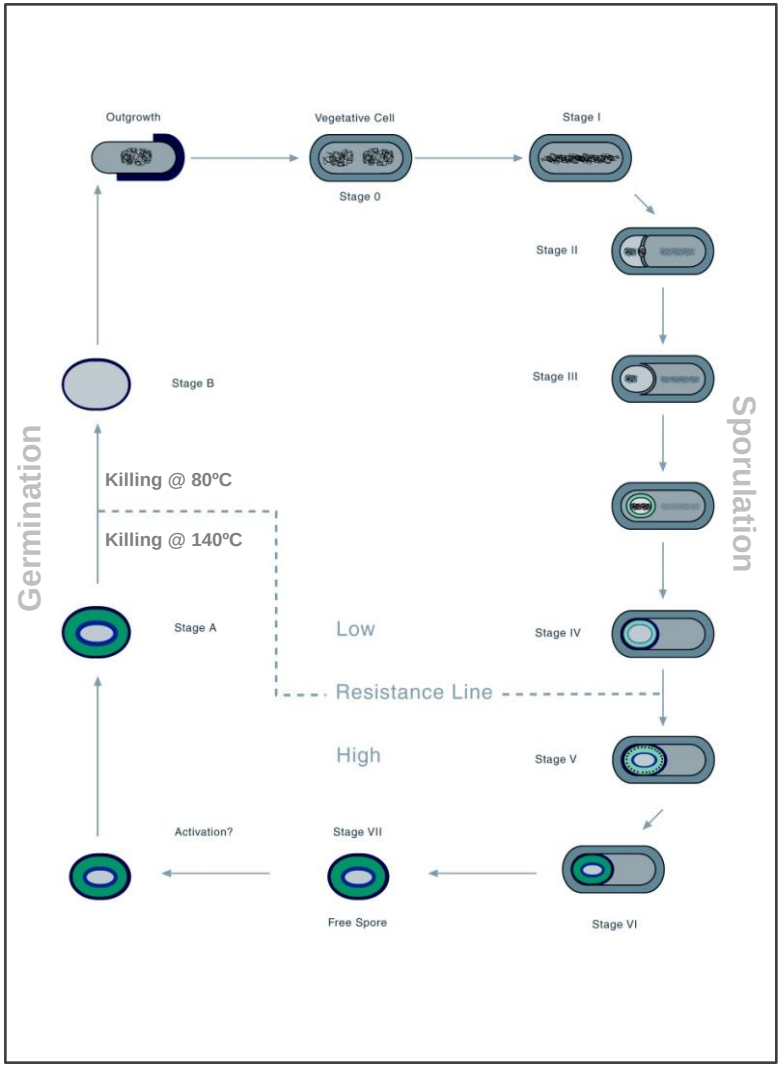
(Mathys et al. 2007; Reineke , Mathys et al. 2011)

Dynamic spore germination during alternative pressure preservation



(Mathys 2008; Mathys 2010; Mathys 2016)

Bacterial spore germination and inactivation

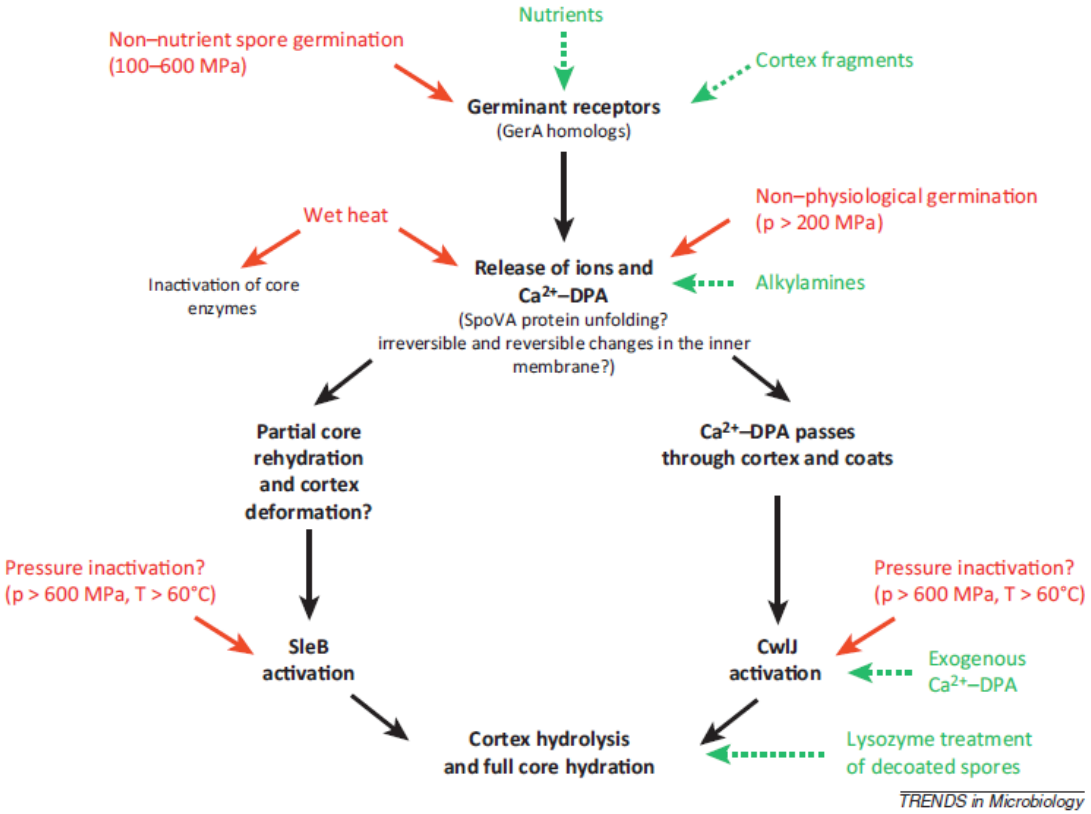


Review
Trends in Microbiology June 2013, Vol. 21, No. 6
Cell PRESS

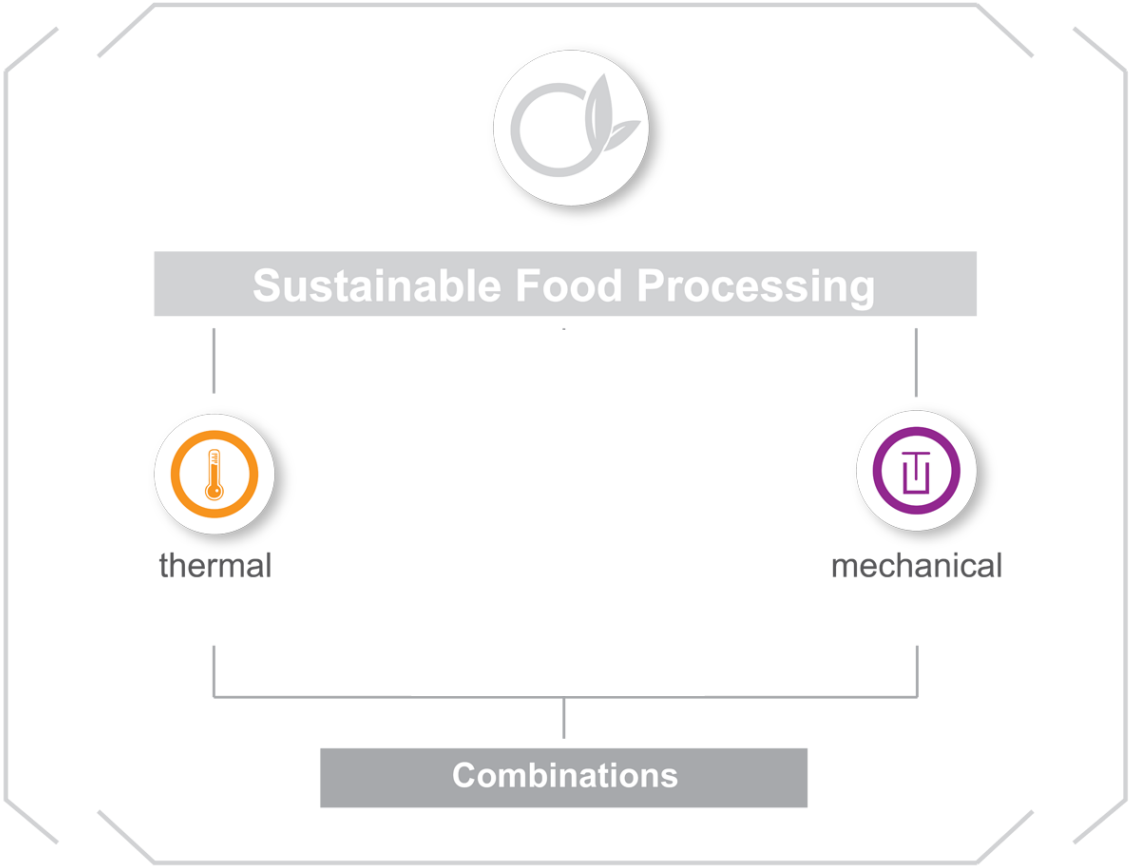
Mechanisms of endospore inactivation under high pressure

Kai Reineke[1,2], Alexander Mathys[3], Volker Heinz[3], and Dietrich Knorr[1]

[1] Department of Food Biotechnology and Food Process Engineering, Technische Universitaet Berlin, Berlin, Germany
[2] Quality and Safety of Food and Feed, Leibniz Institute for Agricultural Engineering (ATB), Potsdam, Germany
[3] German Institute of Food Technologies, Quakenbrück, Germany



BIOECONOMY



Knowledge Transfer

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ADVANCED APPROACHES

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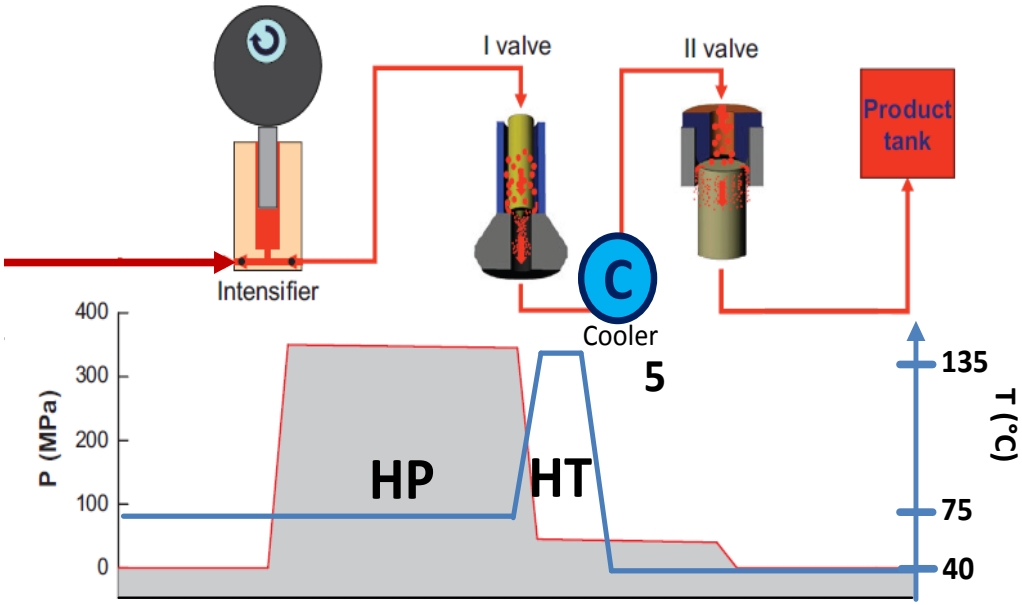
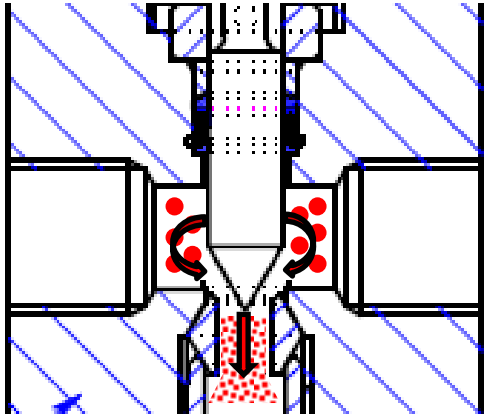
Physical technique combinations- Conversion and stabilization in time with minimal foot print
Continuous ultra high pressure homogenization UHPH up to 380 MPa and ultra high temperatures



(Adapted from Donsì, F., Ferrari, G. & Maresca, P., (2009). High-pressure homogenization for food sanitization.) Stansted, Modell FPG 11300:350



Processed medium

Flow direction

Drawings from Stansted Fluid Power Ltd. Essex, UK (2005)

Can we benefit from the combination of high pressure (HP), high temperatures (HT), shear forces and cavitation to disintegrate the product and inactivate bacterial spores in one step via a continuous process?

(Georget, Miller, Callanan, Heinz and Mathys, 2014)

Research Topic

Microbial decontamination by novel technologies - Analytic approaches and mechanistic insights

Submission closed.

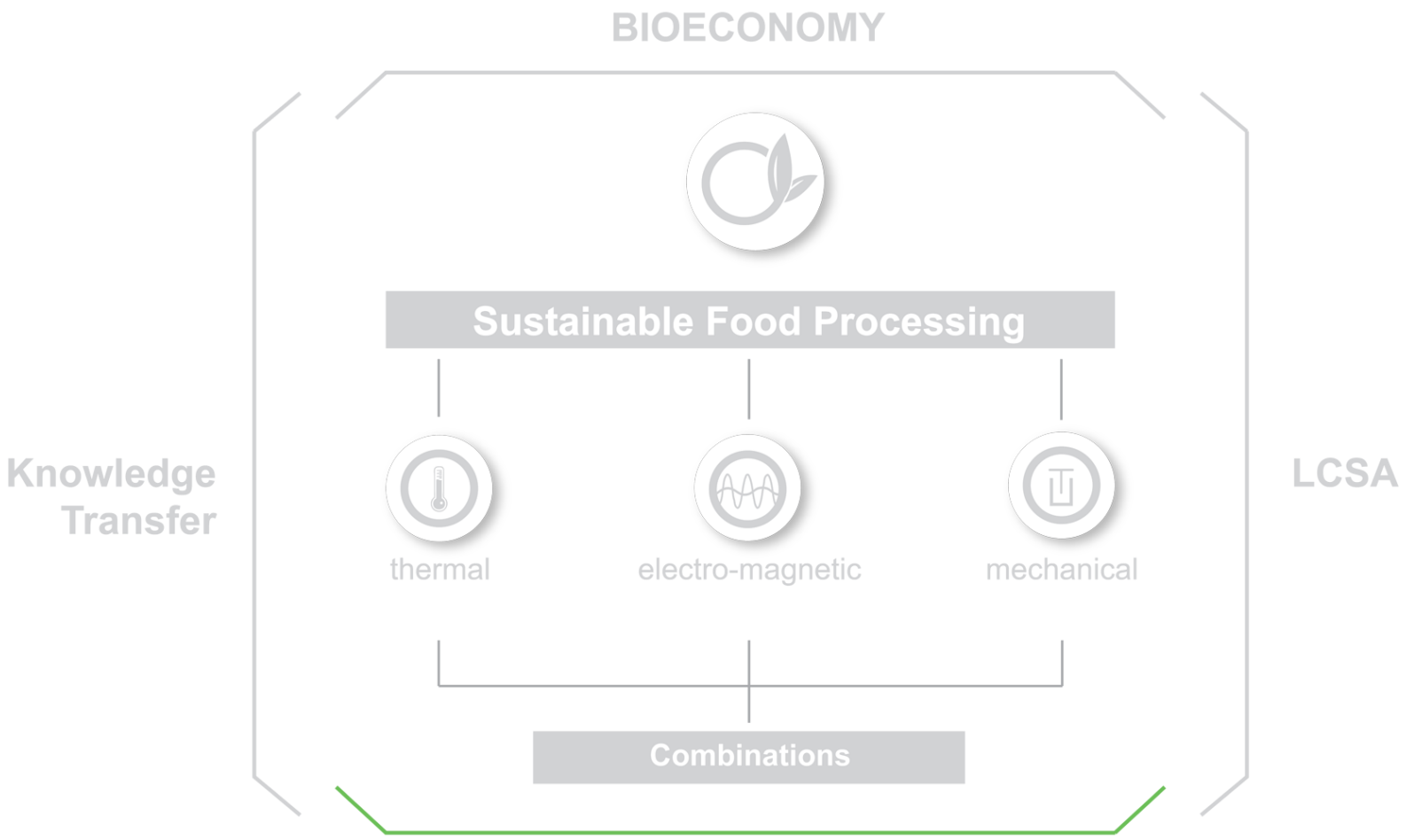
Overview | 10 Articles | 44 Authors | Impact | Comments

Topic Editors

Henry Jaeger Following
University of Natural Resources and Life Sciences (BOKU)
Vienna
Austria
2,474 views **15** publications

Alexander Mathys
ETH Zurich
Zürich, Switzerland
5,367 views **37** publications

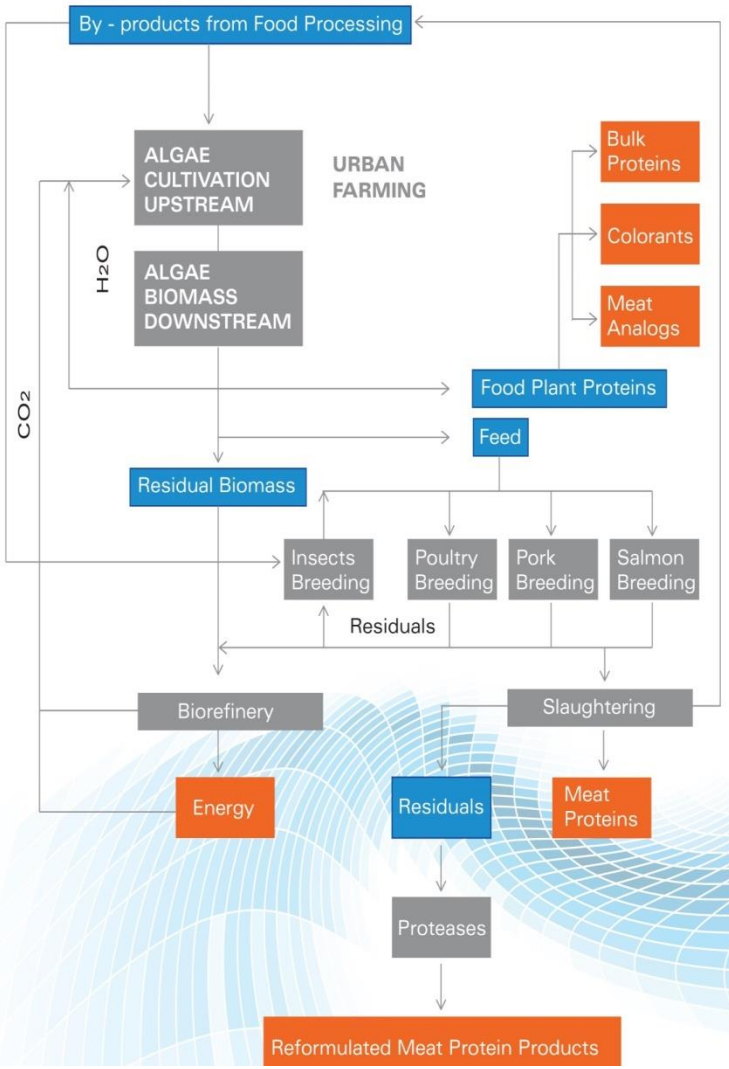
Kai Reineke Following
GNT Europa GmbH
Germany
6,108 views **31** publications

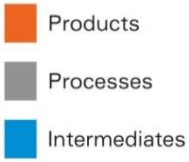


ADVANCED APPROACHES

innovative raw materials & biorefineries

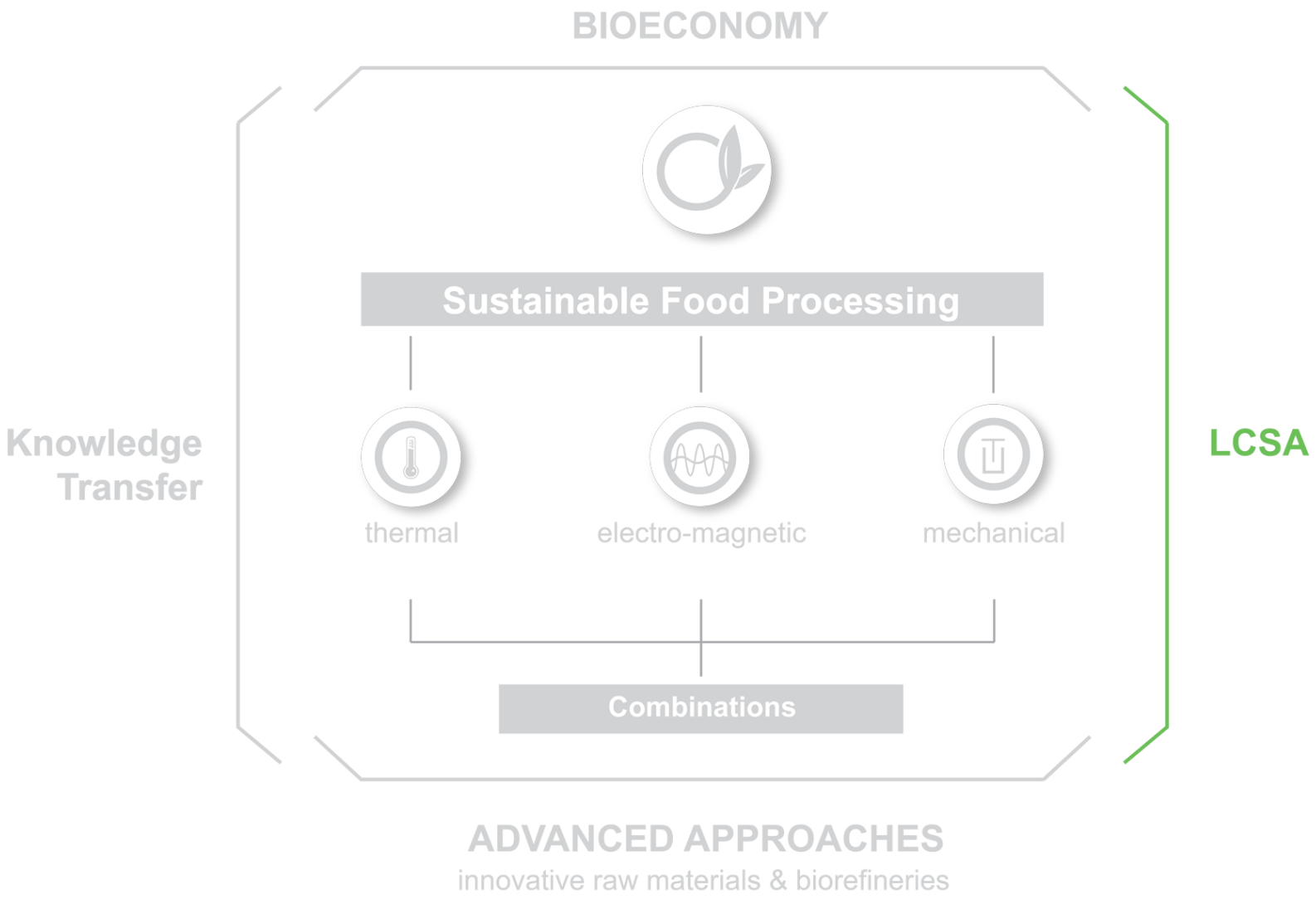
An integrated biorefinery approach by using algae and insects





NOVELPROTEINS

(Mathys, Smetana & Mathys, 2014)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Sustainable Food Processing
thermal
electro-magnetic
mechanical
Combinations
Knowledge Transfer
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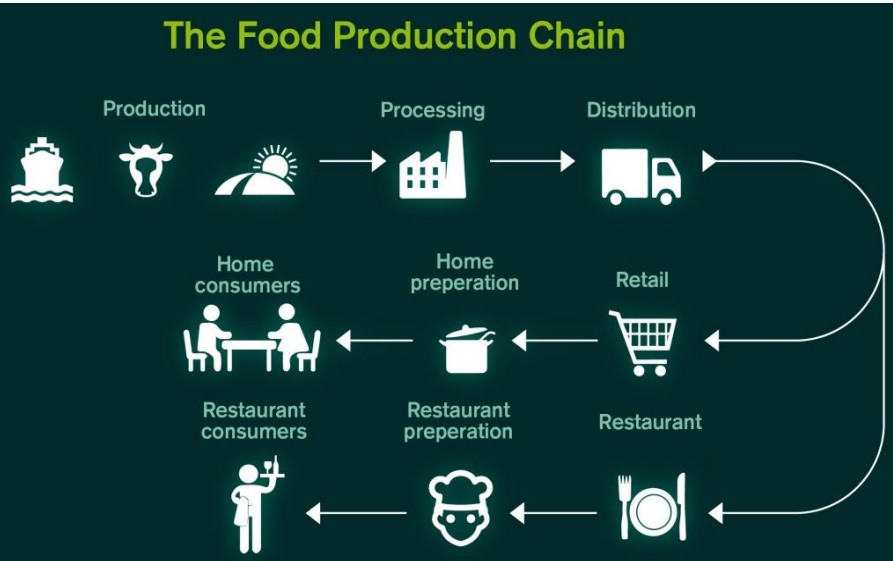
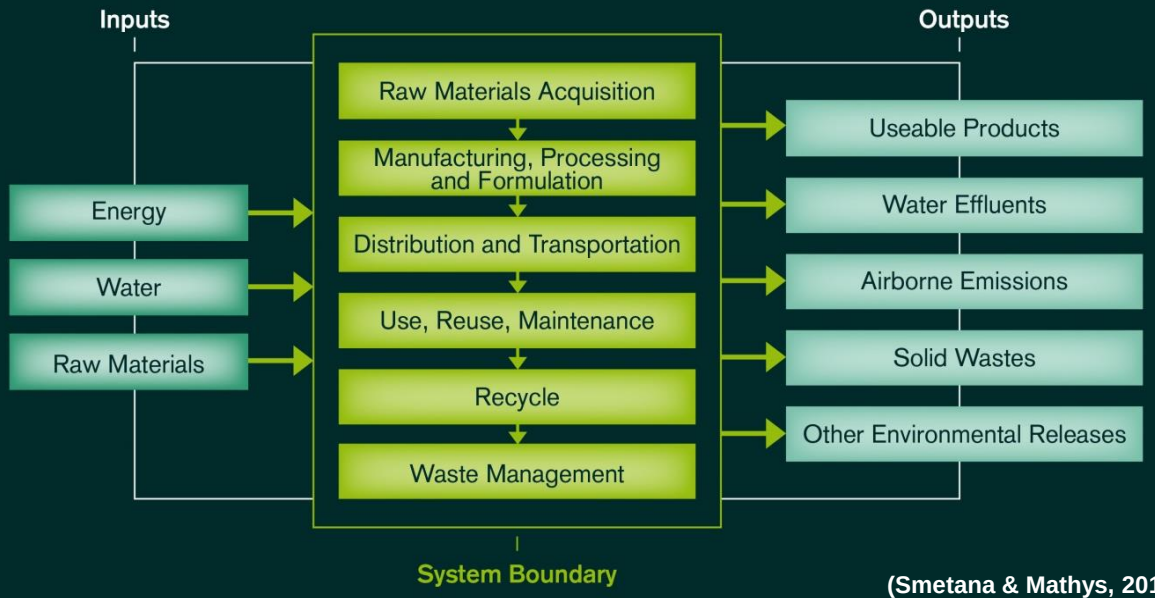
Life Cycle Sustainability Assessment LCSA

LCSA = LCA + LCC + SLCA

LCSA = Life Cycle Sustainability Assessment
LCA = Life Cycle Assessment
LCC = LCA-type Life Cycle Costing
SLCA = Social Life Cycle Assessment

The selection of social criteria and their quantification is one of the many challenges and **there is currently no uniform usage of a standardized set of indicators.**

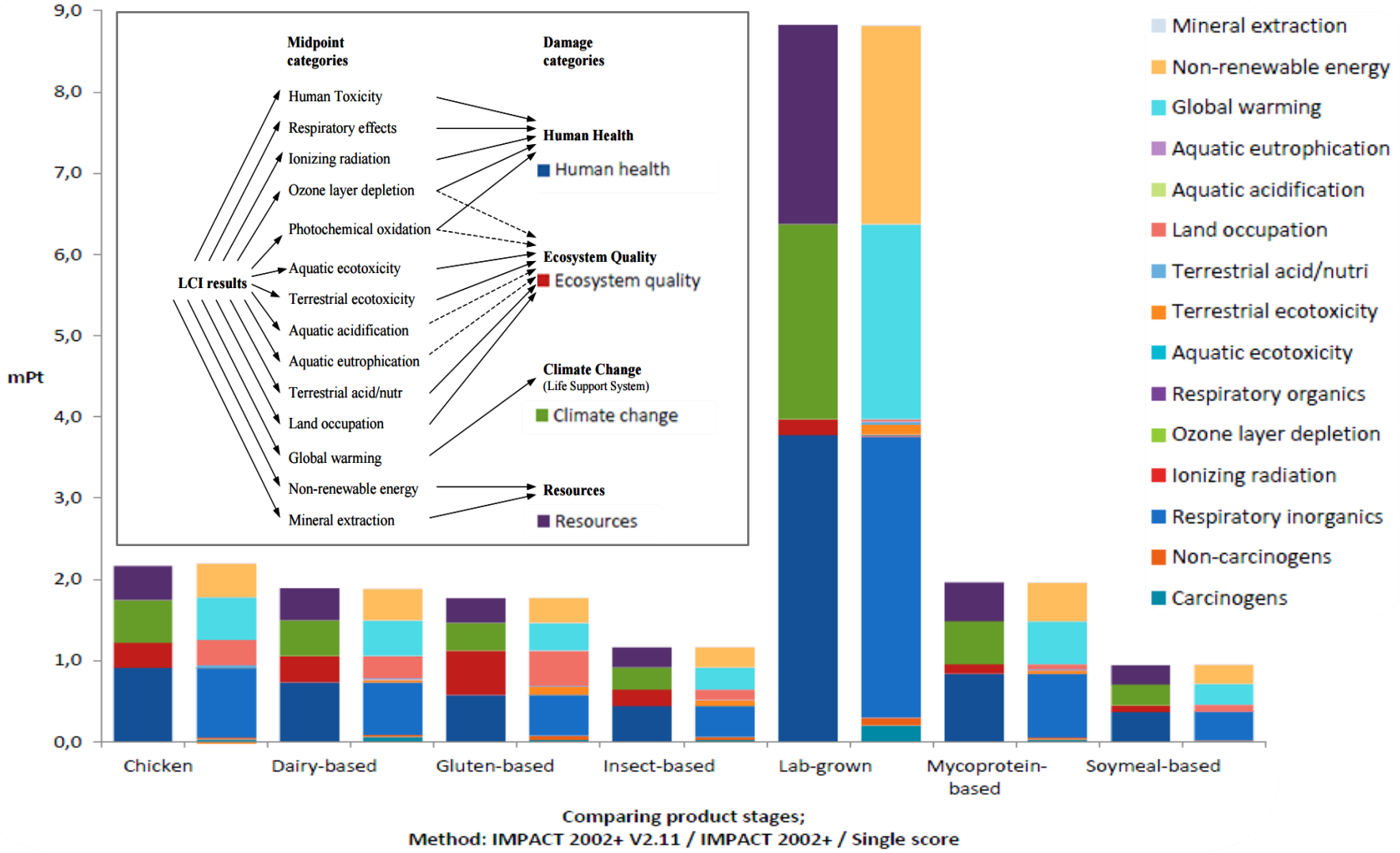




(Smetana & Mathys, 2013)

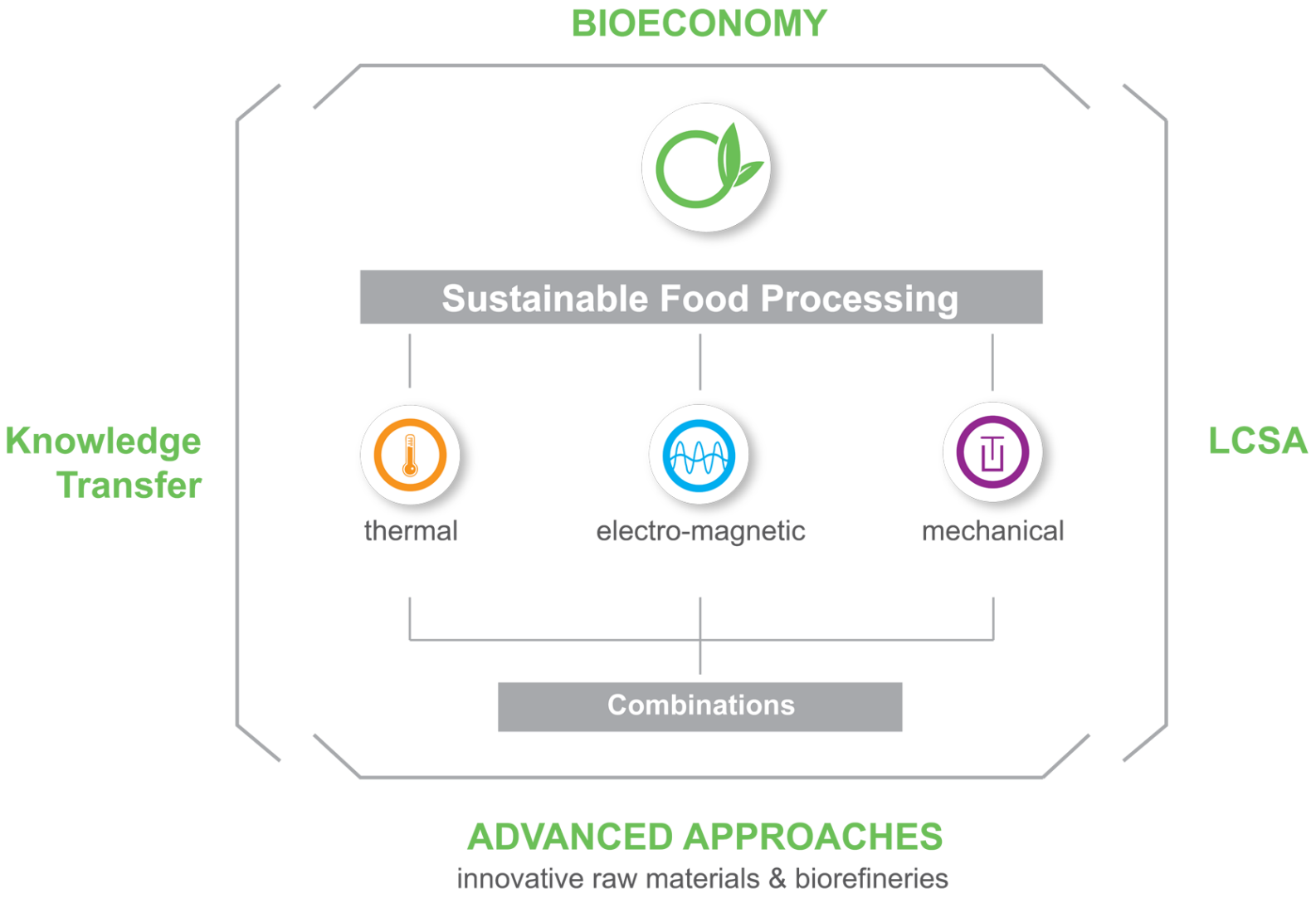
SOURCE: Finkbeiner, M., Schau, E. M., Lehmann, A., & Traverso, M. (2010). Towards Life Cycle Sustainability Assessment. Sustainability, 2(10), 3309–3322. doi:10.3390/su2103309

LCA of meat and meat substitutes, 1 kg of ready to eat product, from cradle to plate



(Smetana, Mathys, Knoch and Heinz, 2015)

Conclusion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Keyword or person

Departments

Sustainable Food Processing

About us | Research | Education | Publications

ETH Zurich → D-HEST → IFNH → Sustainable Food Processing →

Inner structure of germinating spores

Focused ion beam sectioning of bacterial spores for better understanding of inactivation and sterilization

Read more →

The Sustainable Food Processing group focuses on a system oriented approach in food production via the consideration of the total value chain including emerging needs in society and their environmental, economic and social impact. Sustainable Food Processing is part of the global bioeconomy.

Read more →

Welcome to Sustainable Food Processing ETHZ

The **Sustainable Food Processing** group focuses on a **system oriented approach in food production** via the consideration of the total value chain including emerging needs in society and their environmental, economic and social impact. **Sustainable Food Processing** is part of the global bioeconomy. Life cycle sustainability assessment LCSA as guidance tool is the foundation of our emerging food process development. Selected mechanical, biotechnological, thermal and non-thermal techniques to realize several objectives such as i) biomass and (ii) energy use efficiency, (iii) significant waste reduction along the food value chain and (iv) healthy and high quality food production are evaluated. Innovative raw materials from algae and insects are utilized within urban farming and processing concepts to enable new ways of sustainable food supply.

Contact

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Sustainable Food Processing
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Department for Health Sciences and Technology (D-HEST →)
ETH Zurich
Schmelzbergstrasse 9
CH-8092 Zürich, Switzerland

People

Group Head →
Secretariat →
Ph.D. Students →
Open Positions →

Research

Structural analysis of spores →
Bacterial spore mechanisms →
Advanced Flow Cytometry →
Micro Process Engineering →
Life Cycle Assessment →

Education

List of Lectures and Courses → provided by SFP

Publications

Awards →

alexander.mathys@hest.ethz.ch
www.sfp.ethz.ch

Open Positions:

- **PostDoc on Advanced Life Cycle Assessment combined Food Process Development**
- **Ph.D. Student on Nutritional combined Life Cycle Assessment**

Acknowledgement:

- **ETH Sustainable Food Processing & Food Process Engineering Teams**
- **Buhler AG & Migros Industry Support**