Prof. Dr. Michael Beyrer

Professeur, Institut Technologies du Vivant, HES-SO Valais-Wallis

Design tools for sustainable meat substitutes: an overview of different manufacturing techniques

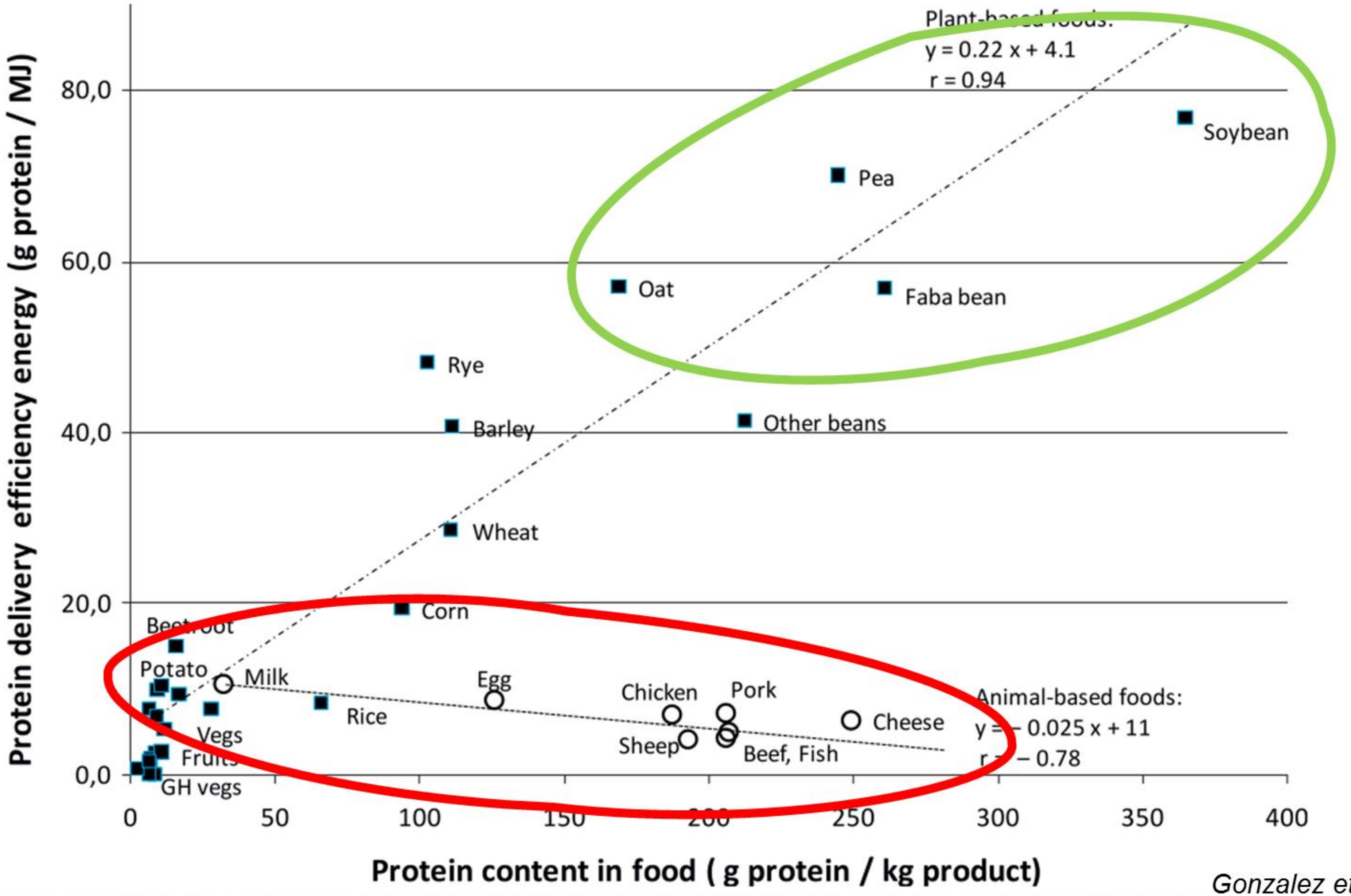
Design tools for sustainable meat substitutes: an overview of different manufacturing techniques

University of Applied Sciences

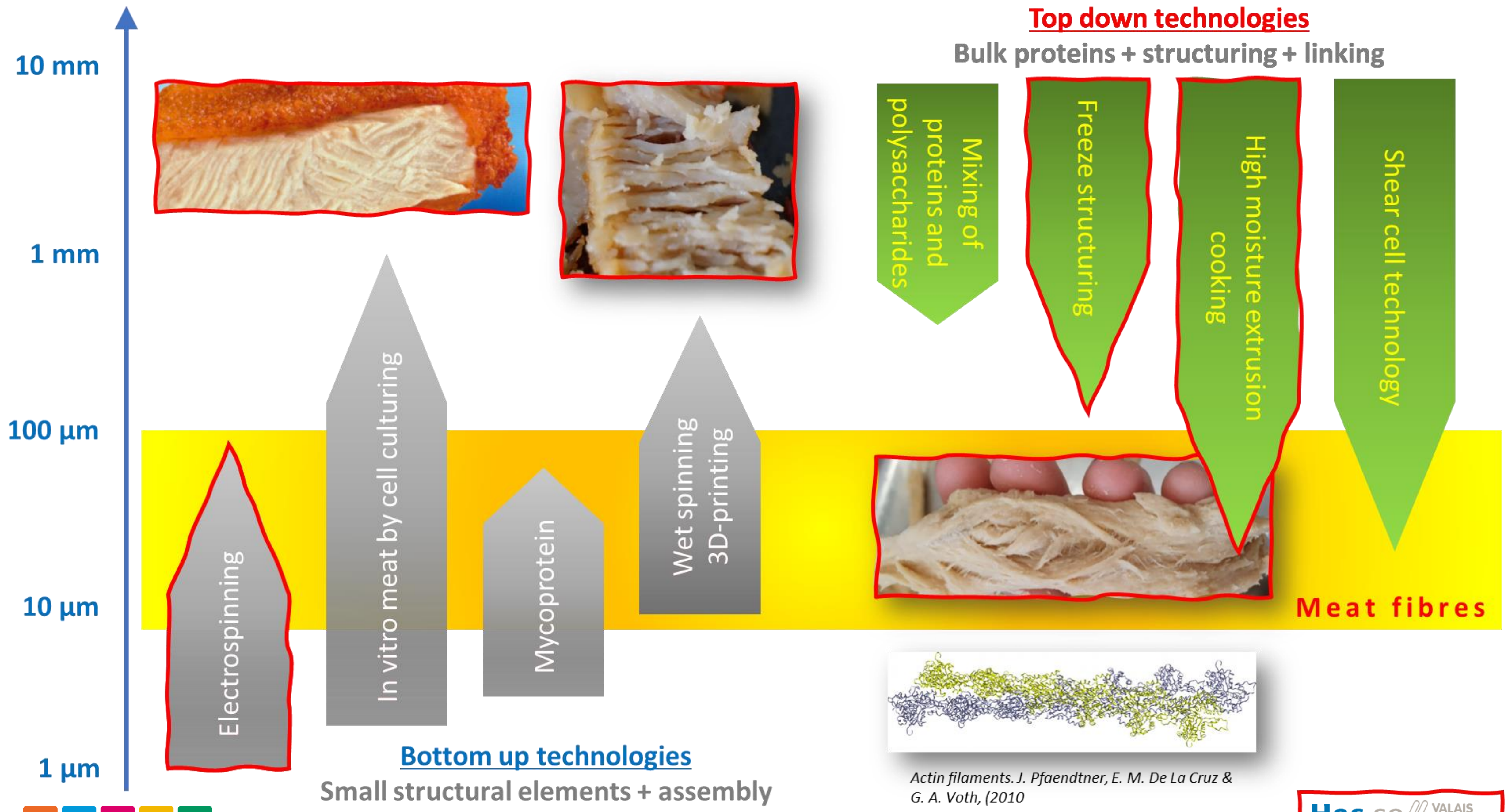
Western-Switzerland

School of Engineering - Sion

michael.beyrer@hevs.ch



Gonzalez et al., 2011



Actin filaments. J. Pfaendtner, E. M. De La Cruz & G. A. Voth, (2010

CRITICAL REVIEWS IN FOOD SCIENCE AND NUTRITION
https://doi.org/10.1080/10408398.2020.1864618

Taylor & Francis
Taylor & Francis Group

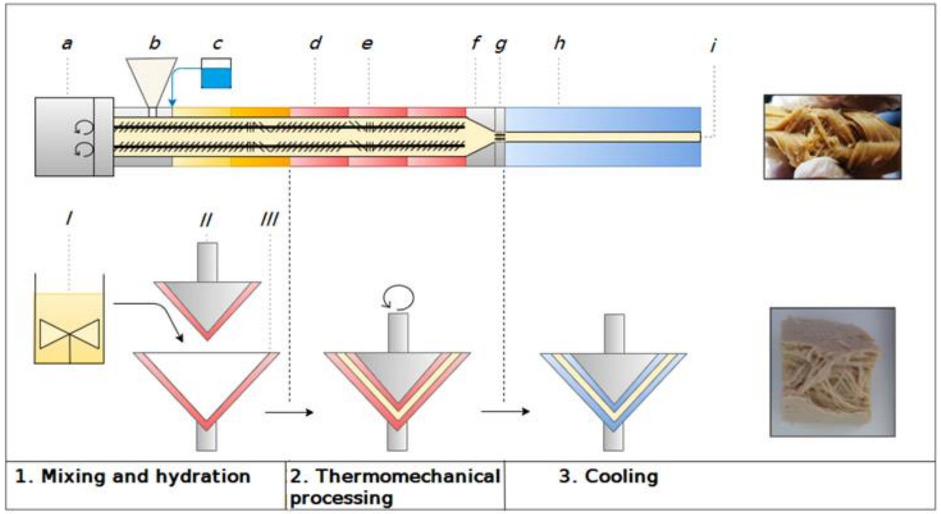
REVIEW

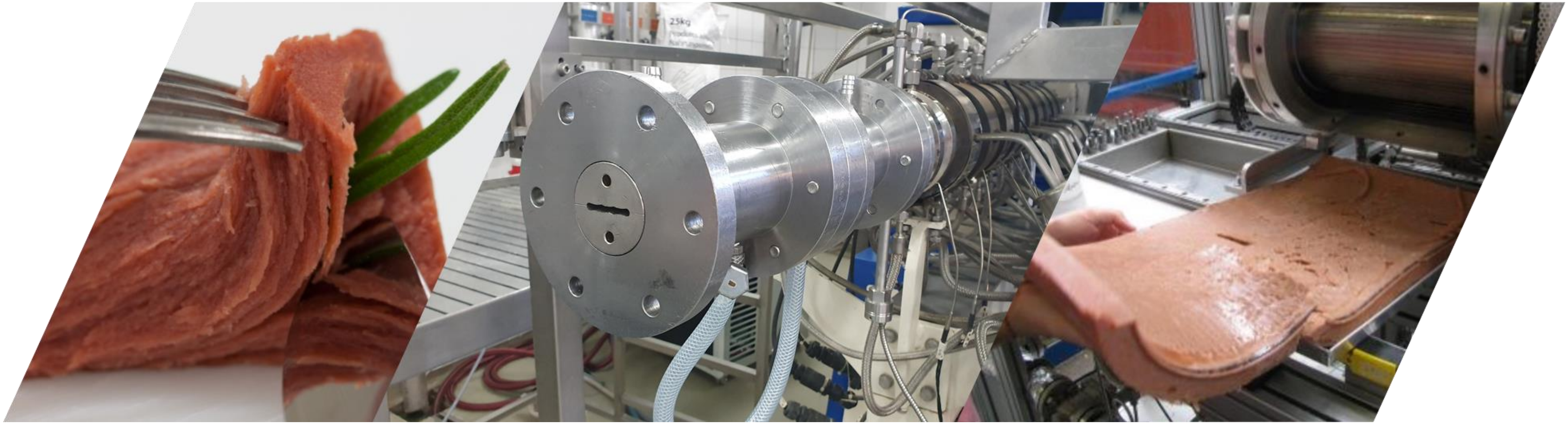
OPEN ACCESS Check for updates

Thermo-mechanical processing of plant proteins using shear cell and high-moisture extrusion cooking

Steven H. V. Cornet[a,b$], Silvia J. E. Snel[a,c#$], Floor K. G. Schreuders[a], Ruud G. M. van der Sman[a,b], Michael Beyrer[c#], and Atze Jan van der Goot[a]

[a]Food Process Engineering, Agrotechnology and Food Sciences Group, Wageningen University & Research, Wageningen, The Netherlands; [b]Food and Biobased Research, Wageningen University & Research, Wageningen, The Netherlands; [c]Food Process Engineering, School of Engineering, Sion, The Netherlands



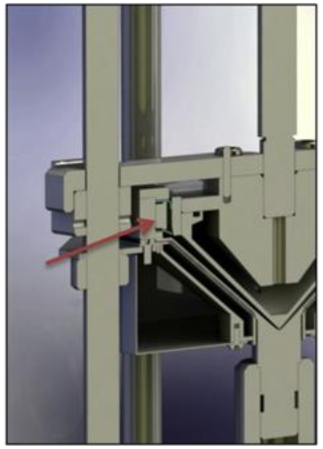


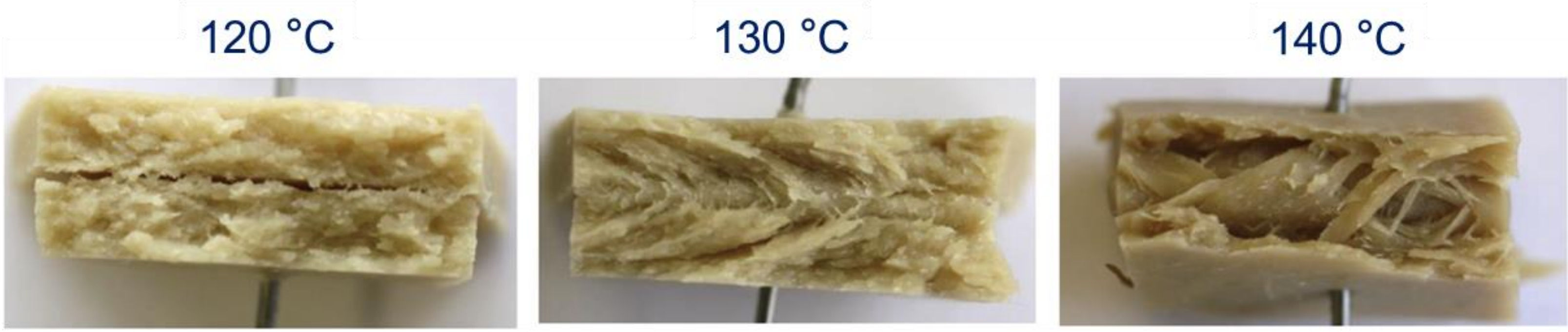
swissuniversities
Hes·so VALAIS WALLIS School of Engineering

Thermo-mechanical fixation of the protein network in a Couette cell – no shear at final cooling

Influence of increasing shear rate on the layer formation in a **pea protein isolate melt** (Snel and Beyrer; unpublished)

Shear-induced structuring as a tool to make anisotropic materials using **soy protein concentrate**. Grabowska et al. 2016, Journal of Food Engineering 188, 77-86

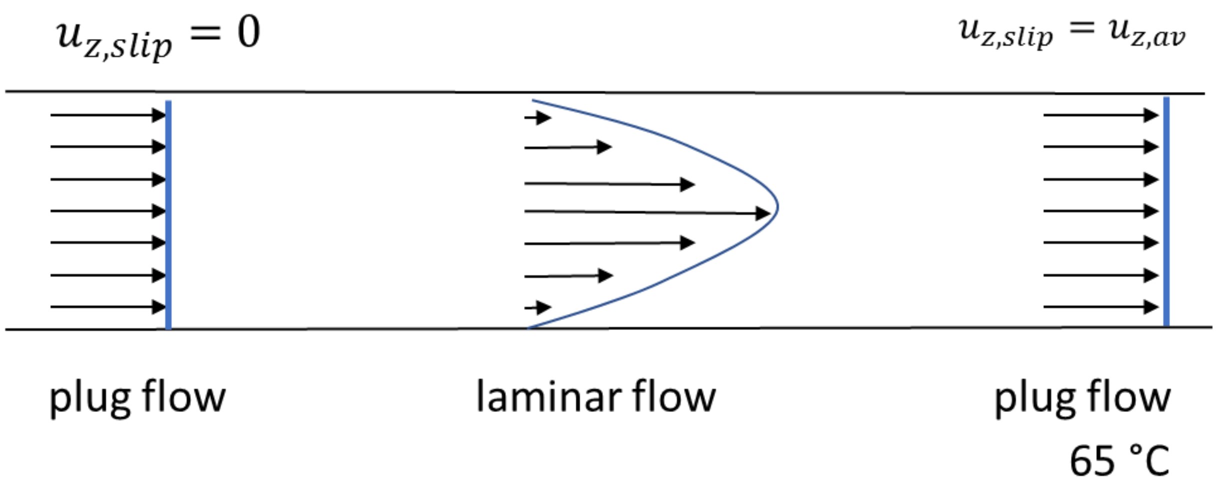


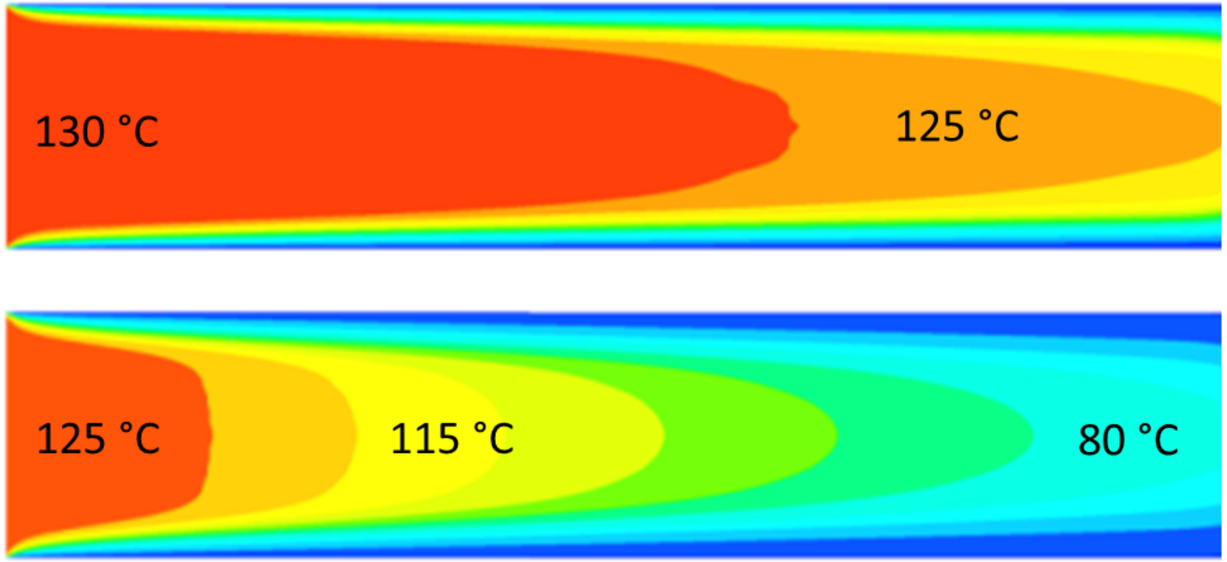


Other processing conditions: 45% SPC, 30 rpm, 15 min

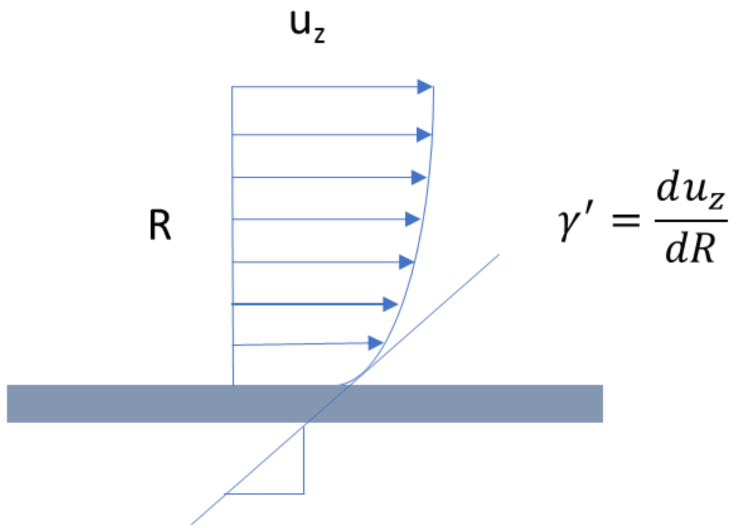
The viscosity gradient results in fibre formation (Cheftel et al., 1992)

u – profile in a cooling die (schematic)





Mooney analysis and correction of a slip at the wall. See also: D. Forte, 2016, The design of food extrusion dies.)



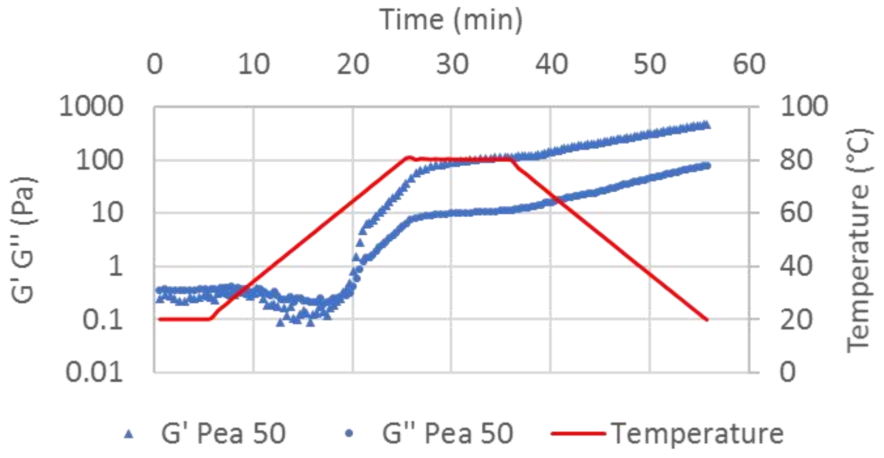
$$\gamma'_{slip-corrected} \equiv \frac{4u_{z,av}}{R} - \frac{4u_{z,slip}}{R}$$

Temperature profile of a PPI melt in a recangular cooling die.

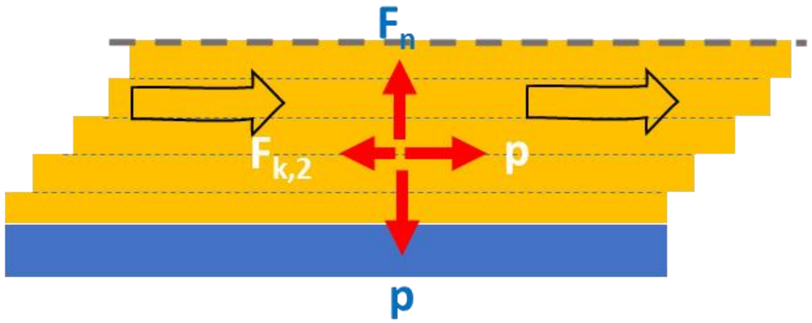
The throughput is a factor 4 different for the two examples

(Decaix, Kerche, & Beyrer, unpublished)

Sol-gel transition of pea protein and the effect of layer formation



(Rodriguez, Snel, & Beyrer, unpublished)



- $F_{k,1} > G'_{LVE}$
- $F_{k,2} = \mu_{k,2} \times p_{static}$

Factors influencing the sol-gel transition and final elasticity modulus G':
Water content (exceed the content of bound water); time-temperature profile of heating-cooling, salt content; pH

- G'_{LVE} - Elastic modulus of the gel (cohesion, for the LVE)
- $F_{k,1}$ - Force of kinetic friction between the metallic surface and the protein melt (adhesion)
- $F_{k,2}$ - Force of kinetic friction between layers of the viscoelastic solid
- $\mu_{k,2}$ - coefficient of kinetic friction between layers of the viscoelastic solid


- Vegetables
- Rice
- Fibres or textured vegan protein (TVP)
- Binder (potato flakes)
- Water
- Spices
- …

Photos: GEA Technology

Mixing

Cutting

Forming

Frying

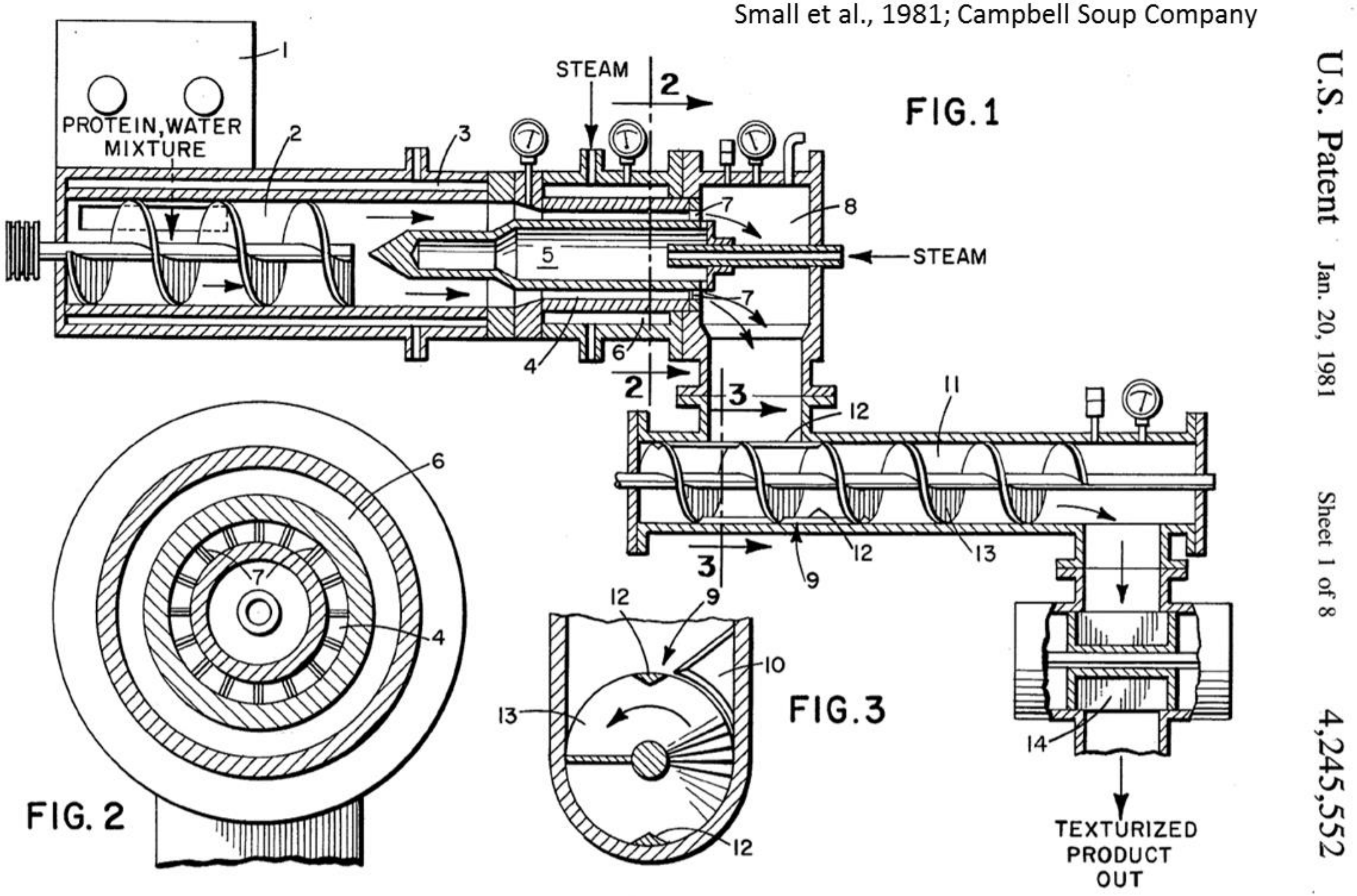
Freezing

- Rehydrated textured vegan protein (TVP)
- Methylcellulose-Oil-Emulsion
- Coconut butter
- Spices, colorants, flavours, …

Textured vegetable protein - TVP

Meat analogue or meat extender

Small et al., 1981; Campbell Soup Company



- Archer Daniels Midland, invented in the 1960s, TVP = trademark
- 1971 TVP approved for school lunch programs
- Typically high soy protein from pomace of oil pressing, including extraction with hexane
- Often used to replace ground meat: Bolognese, chili sin carne, tacos, burgers, …
- Moisture content in the barrel around 20 to 25%
- Extrusion at 150 – 200 °C and direct expansion; shape: chunks, grains, nuggets

Technologies of meat analogue manufacturing are multifold, like the layer or fiber formation principles based on plant proteins. A better understanding of the thermo-mechanical transition of plant protein is fundamental for developing advanced equipment. Our approach considers both raw material properties and engineering.

Prof. Dr.-Ing. Michael Beyrer

Head of the research group
Food and Natural Products

michael.beyrer@hevs.ch

Hes·so Valais Wallis
School of Engineering