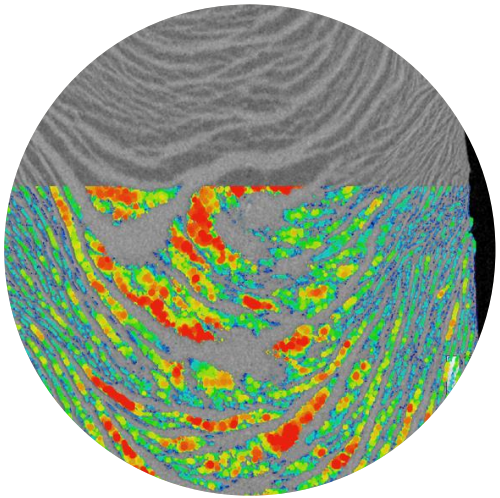
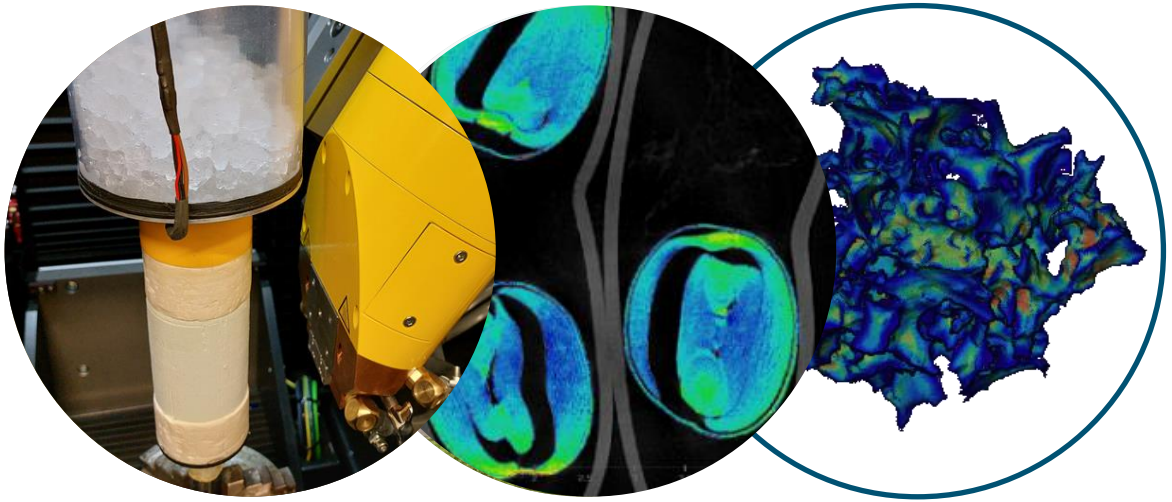
The microstructure of extruded meat replacers

XRT for food visualisation

Wednesday 11 September, Global X-Ray and CT Forum, Maaike Nieuwland





WAGENINGEN
UNIVERSITY & RESEARCH

Baker Hughes Confidential

The background to my XRT questions



Feeding the world sustainably



Healthy, qualitative food system



Towards a fossil free society



Closing the mineral & water loops



- AGRICULTURAL PRODUCE
- HARVESTING AND TRANSPORT
- PROCESSING AND STORAGE
- MANUFACTURING AND PACKAGING
- PRODUCT USE/ CONSUMPTION
- MATERIAL RECOVERY/RECYCLE
- WASTE / END OF LIFE MANAGEMENT

WAGENINGEN
UNIVERSITY & RESEARCH

Baker Hughes Confidential

Examples of technological and organisational solutions

1. A new generation of meat analogues
2. High-grade valorisation of beet pulp
3. Together against food waste
4. On the road to bio-asphalt









Baker Hughes Confidential

Examples of technological and organisational solutions

1. A new
   analog
2. High-g
   pulp
3. Together against food waste
4. On the road to bio-asphalt

High quality seeds to increase sustainability of crop production







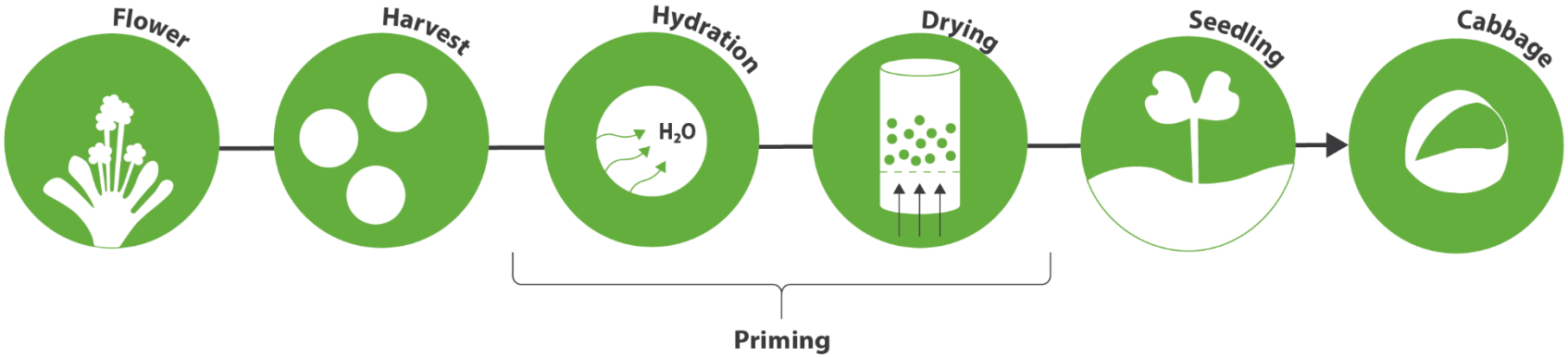
WAGENINGEN
UNIVERSITY & RESEARCH

Baker Hughes Confidential

Fluidised bed drying of high-quality seeds



Julia Veser



- Seed structure is essential for growing potential

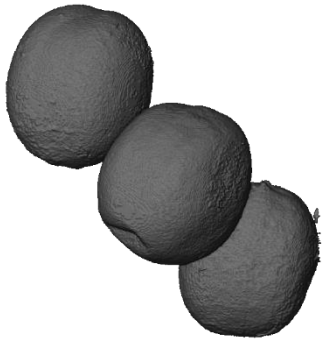
WAGENINGEN UNIVERSITY & RESEARCH

Website of the project

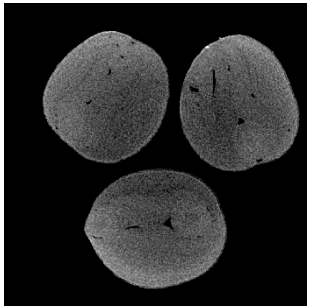
Baker Hughes Confidential

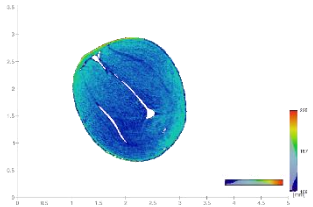
RIJK ZWAAN bejo

XRT of cabbage seeds



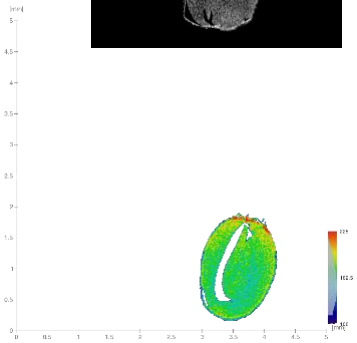
hydrated



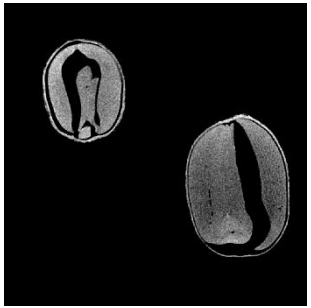


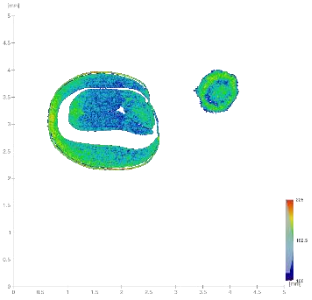
0.5 hr dried



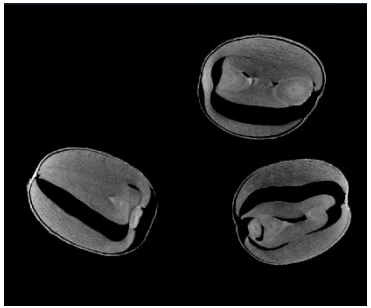


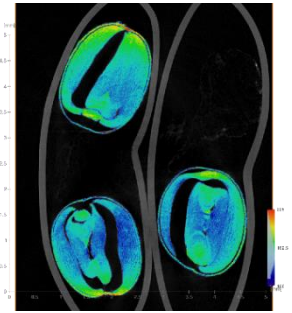
3 hr dried





24 hr dried





Examples of technological and organisational solutions

1. A new generation of meat analogues
2. High-grade valorisation of beet pulp
3. Together against food waste
4. On the road to bio-asphalt

Sustainable innovative frying processes







WAGENINGEN
UNIVERSITY & RESEARCH

Baker Hughes Confidential

French fry quality



Aleksandra Pawlik

- Can we improve the sustainability of industrial parfying?
- What are the relevant quality parameters?

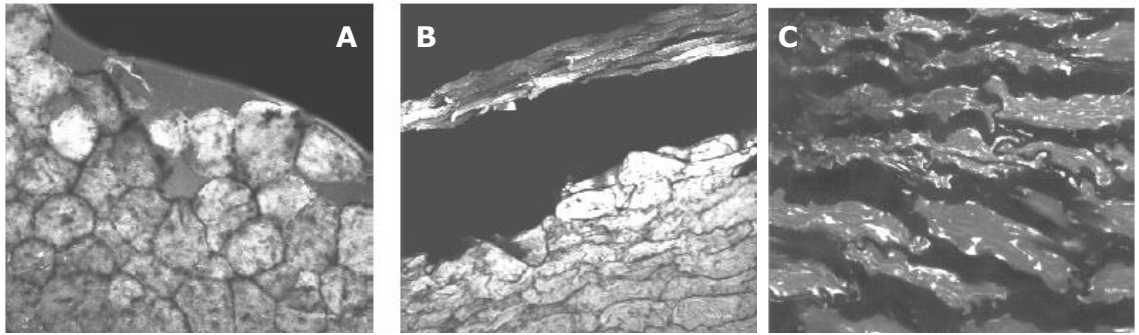
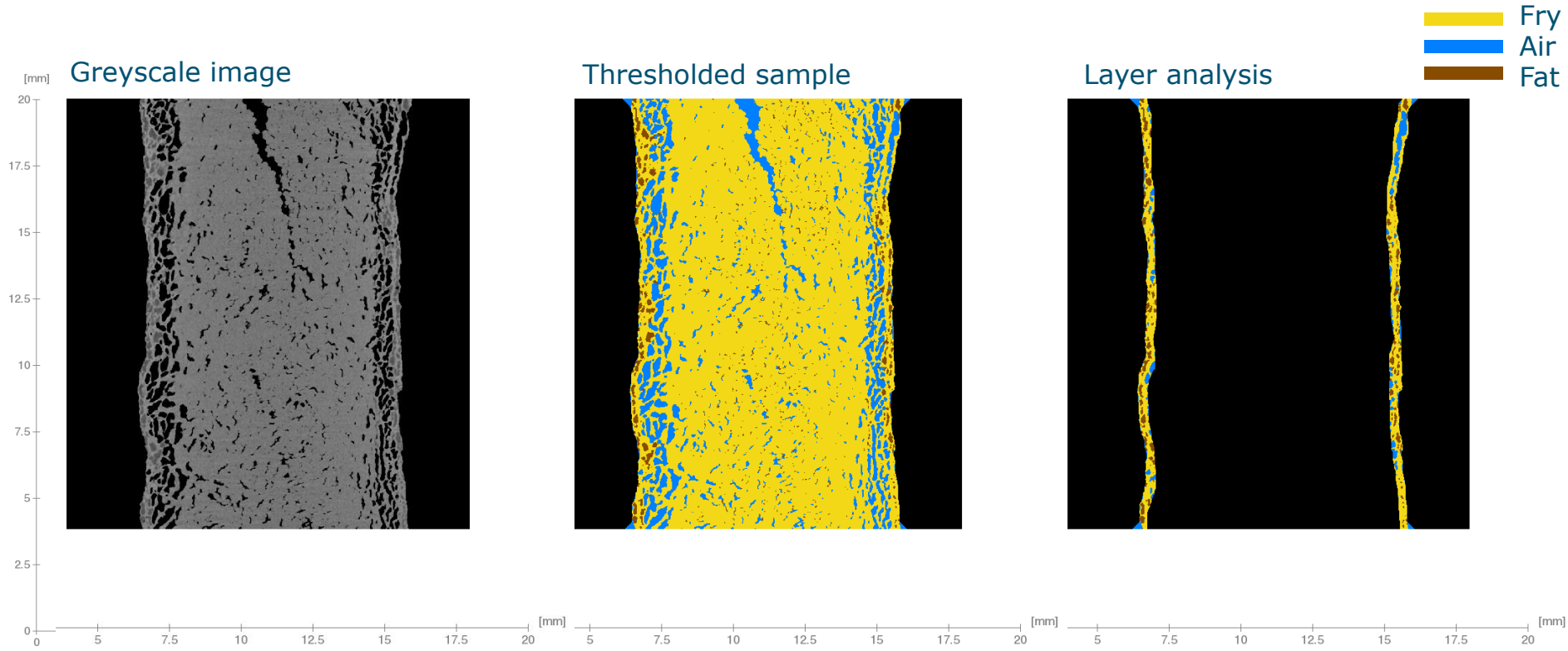


*Figure 2.6. CSLM imaging of a French fry after blanching (A, 100x enlarged), after a very intensive SHS treatment (B, 100x enlarged) and after par-frying in oil (C, 200x enlarged).

* Van Loon, PhD thesis, 2005

French fry quality – porosity analysis



Examples of technological and organisational solutions

1. A new generation of meat analogues
2. High-grade valorisation of beet pulp
3. **Together against food waste**
4. On the road to bio-asphalt









Baker Hughes Confidential

Breading



Martijn Noort

- Bread crumbs should be crispy
  - Thin lamella
  - High porosity
- How does formulation and processing influence the structure?

Public private partnership: Development and implementation of the total use principle of bivalves

WAGENINGEN UNIVERSITY & RESEARCH

Topsector Agri& Food

ROULLIER

Nomad Foods

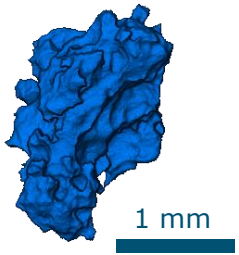
aker Hughes

HENDRIX GENETICS

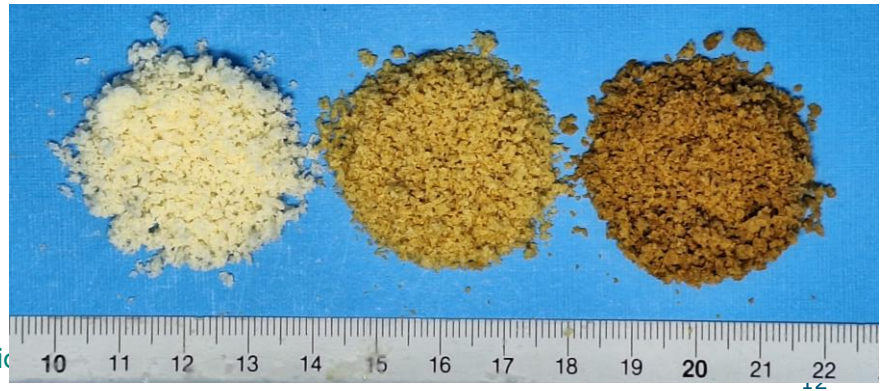
LENGER SEAFOODS The Taste of Excellence

emonta Natuurlijk Goed

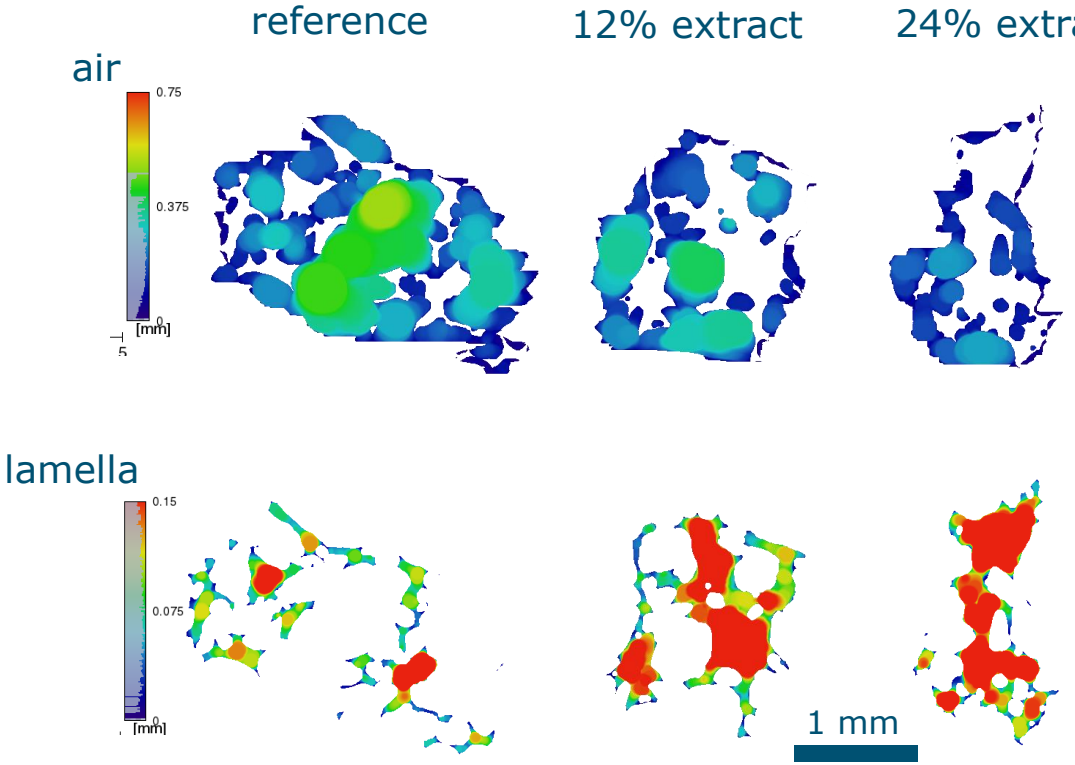
Bread crumbs with added protein extract

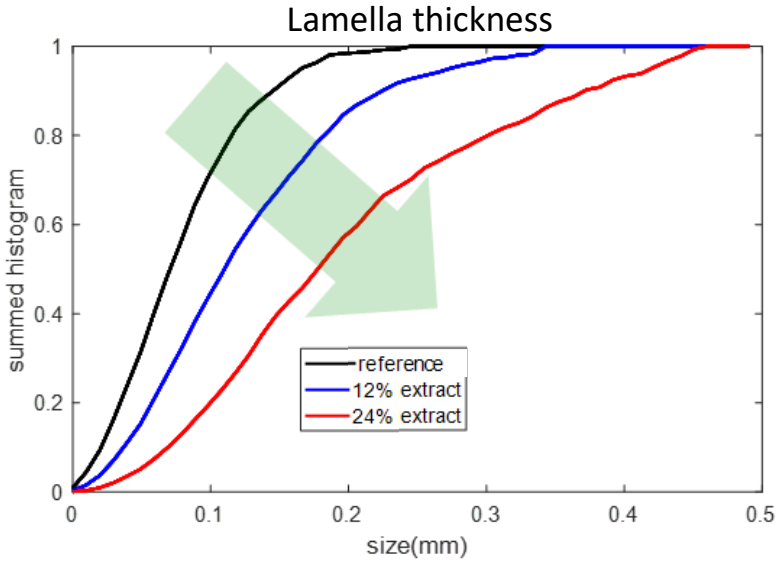






Bread crumbs with added protein extract





Baker Hughes Confidential

Examples of technological and organisational solutions

1. **A new generation of meat analogues**
2. High-grade valorisation of beet pulp
3. Together against food waste
4. On the road to bio-asphalt









Baker Hughes Confidential

The ingredients of meat analogues[1]



Thiemo van Esbroeck

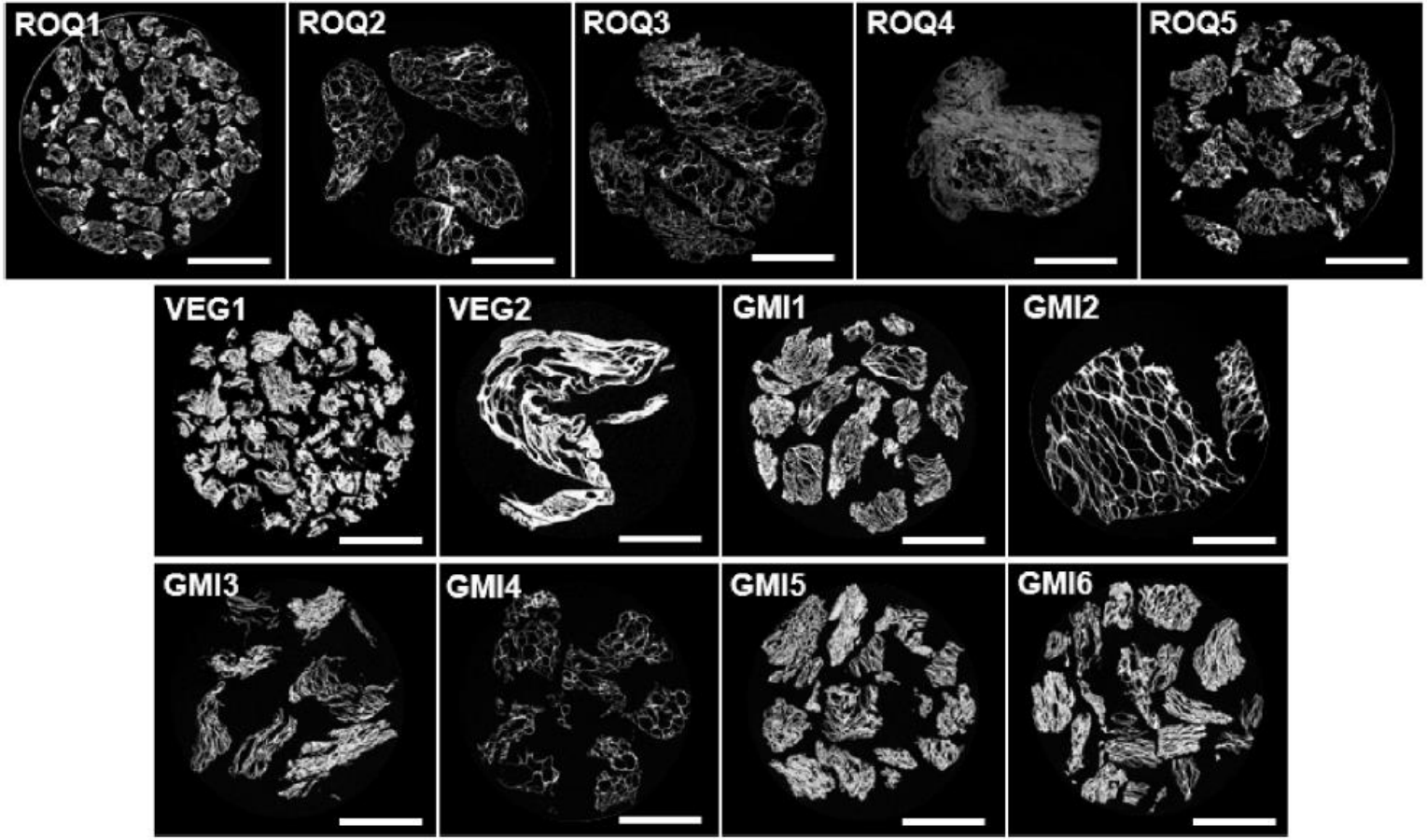
[1]Van Esbroeck et al, 2024

- Texturized Vegetable Protein (TVP) is often used in meat analogues
- The type of TVP influences the quality of the meat analogue
  - Size
  - Water holding
  - …

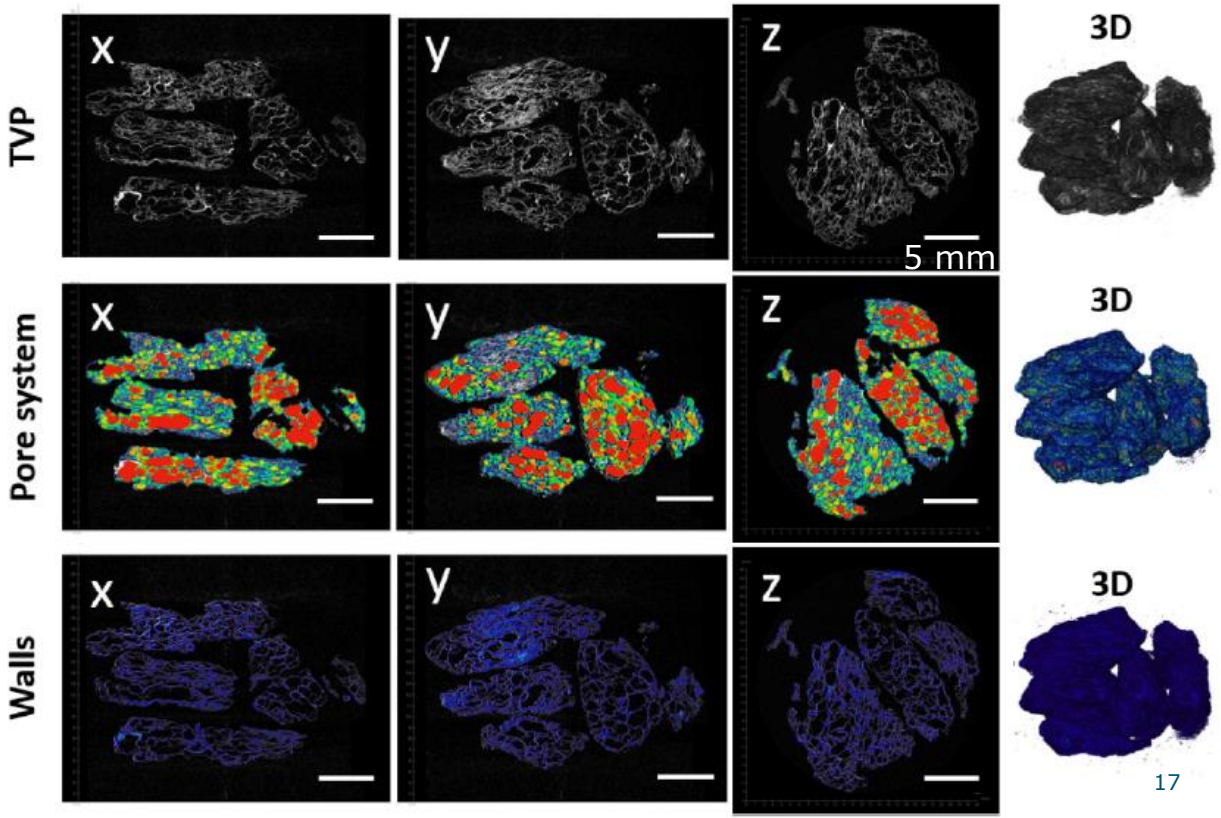


- How is microstructure connected to quality?

TVPs in the XRT



TVPs in the XRT



WAGENINGEN
UNIVERSITY & RESEARCH

Examples of technological and organisational solutions

1. **A new generation of meat analogues**
2. High-grade valorisation of beet pulp
3. Together against food waste
4. On the road to bio-asphalt









Baker Hughes Confidential

XRT for visualizing frozen meat replacers[2]



Walter Heijnis

- Extrusion is often used to make (ingredients for) meat replacers

[2]Nieuwland et al, 2023

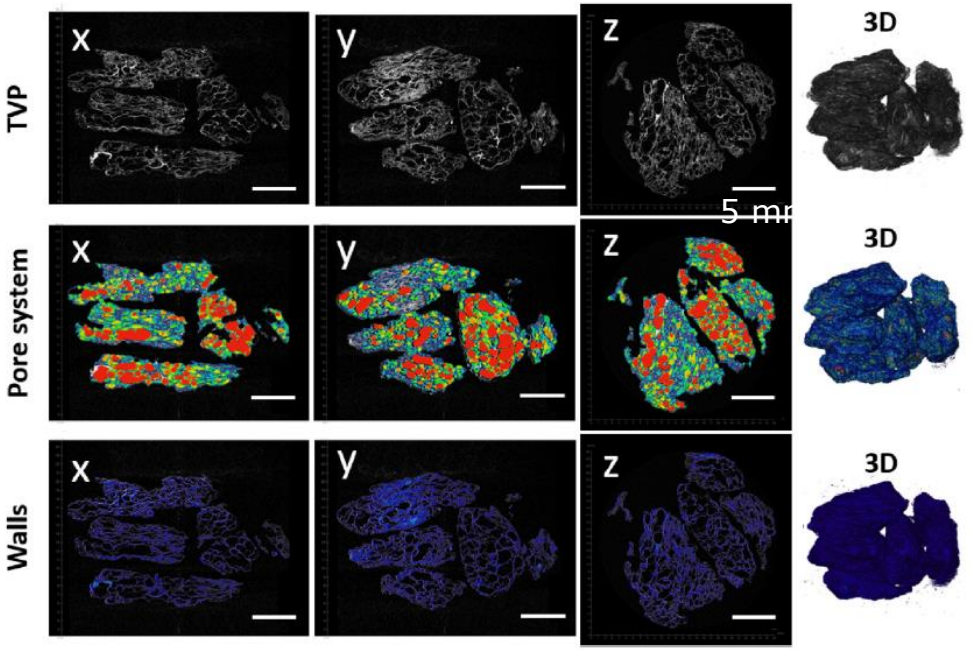
XRT for visualizing frozen meat replacers[2]



Walter Heijnis

[2]Nieuwland et al, 2023

- Extrusion is often used to make (ingredients for) meat replacers



Baker Hu

WAGENINGEN
UNIVERSITY & RESEARCH

XRT for visualizing frozen meat replacers

- Extrusion is often used to make (ingredients for) meat replacers
- Either low moisture extrusion or high moisture extrusion
- Structure important for quality



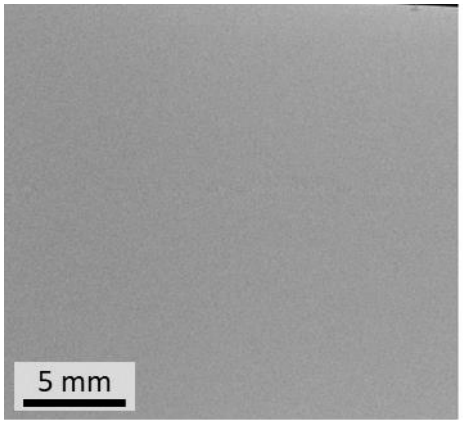
Low moisture extruded



High moisture extruded

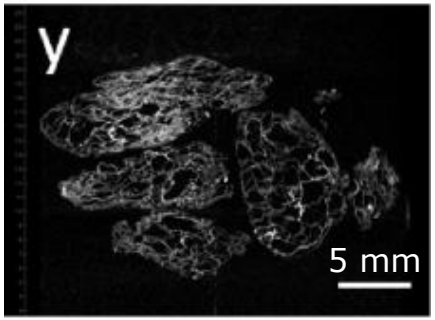
WAGENINGEN
UNIVERSITY & RESEARCH

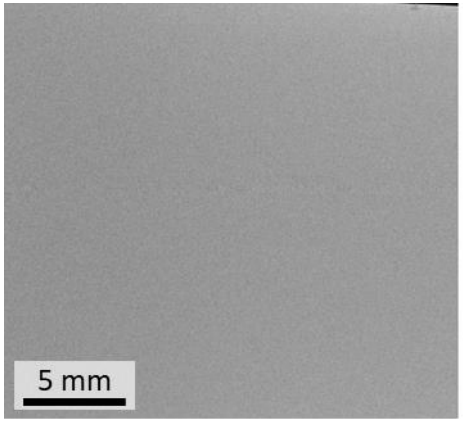
XRT for analysing structure



Baker Hughes Confidential

XRT for analysing structure



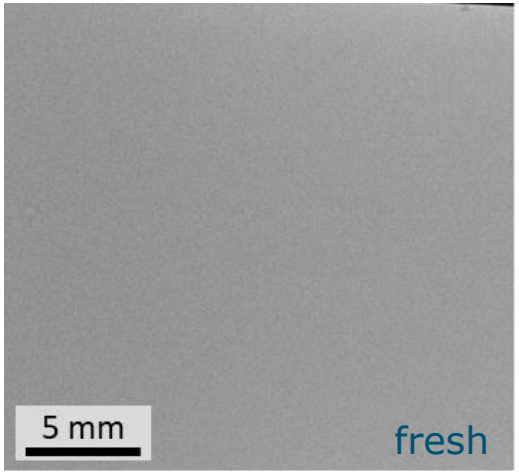


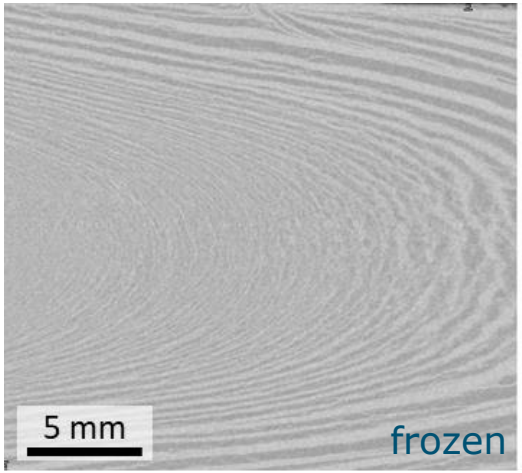
Baker Hughes Confidential

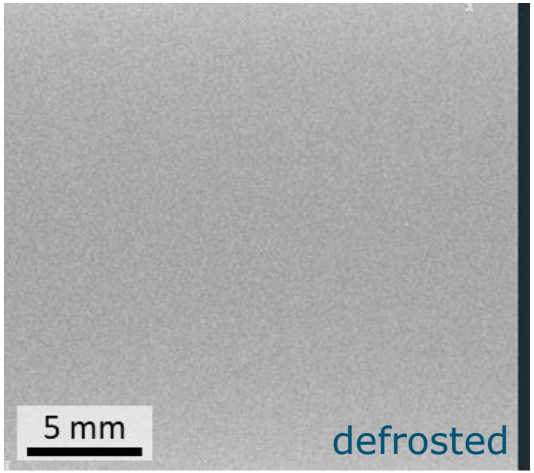
XRT for analysing structure



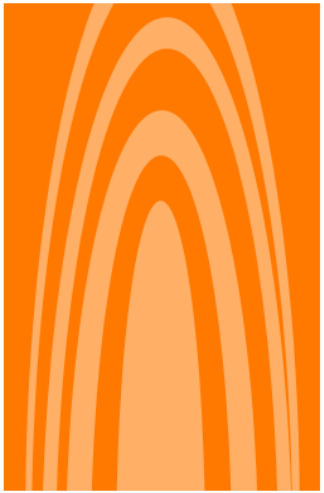


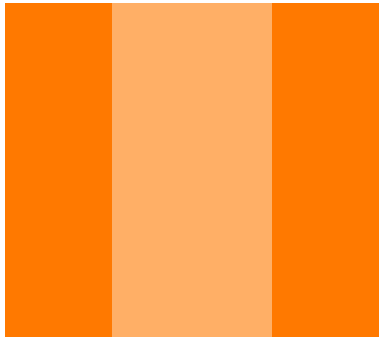






The effect of freezing



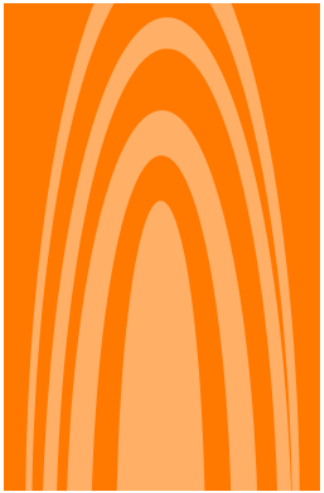


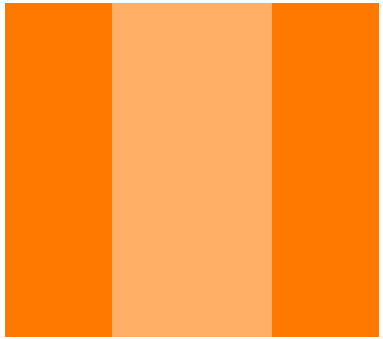
Higher concentration protein

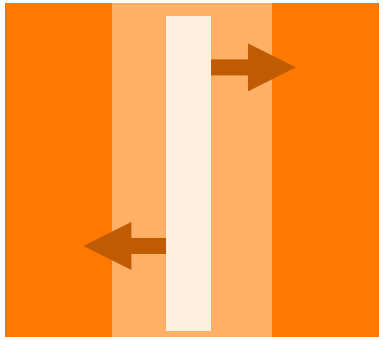
Lower concentration protein

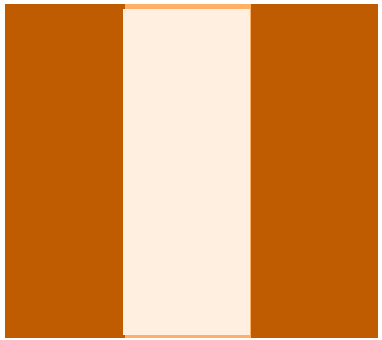
Baker Hughes Confidential

The effect of freezing









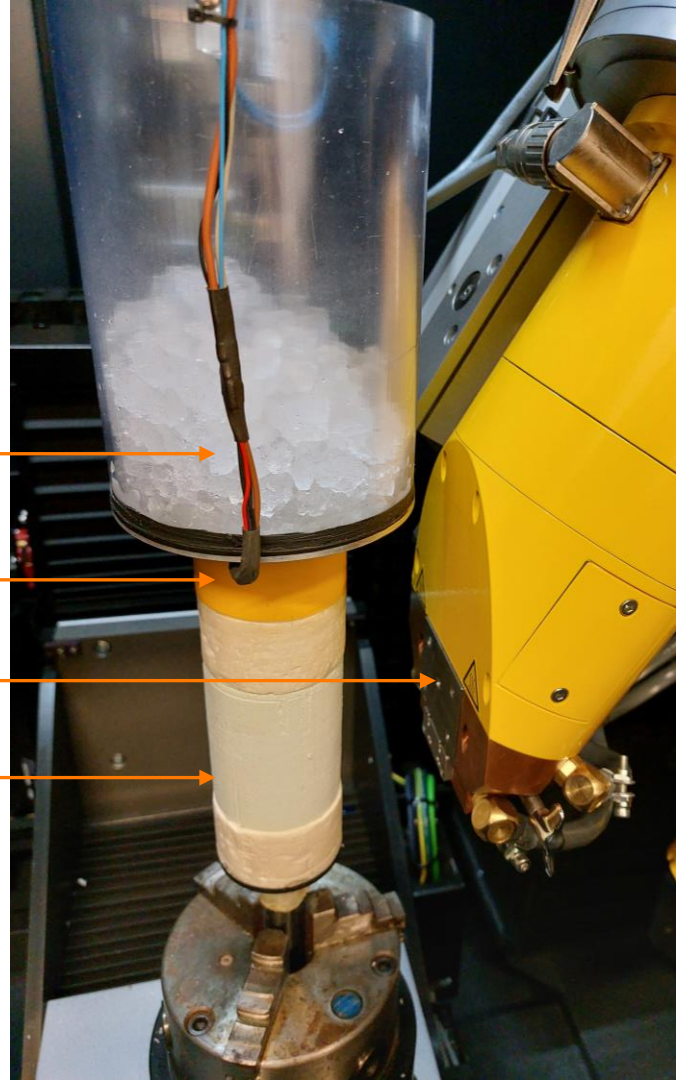
Highest concentration protein

Higher concentration protein

Lower concentration protein

Ice (very low concentration protein)

Frozen sample measurements



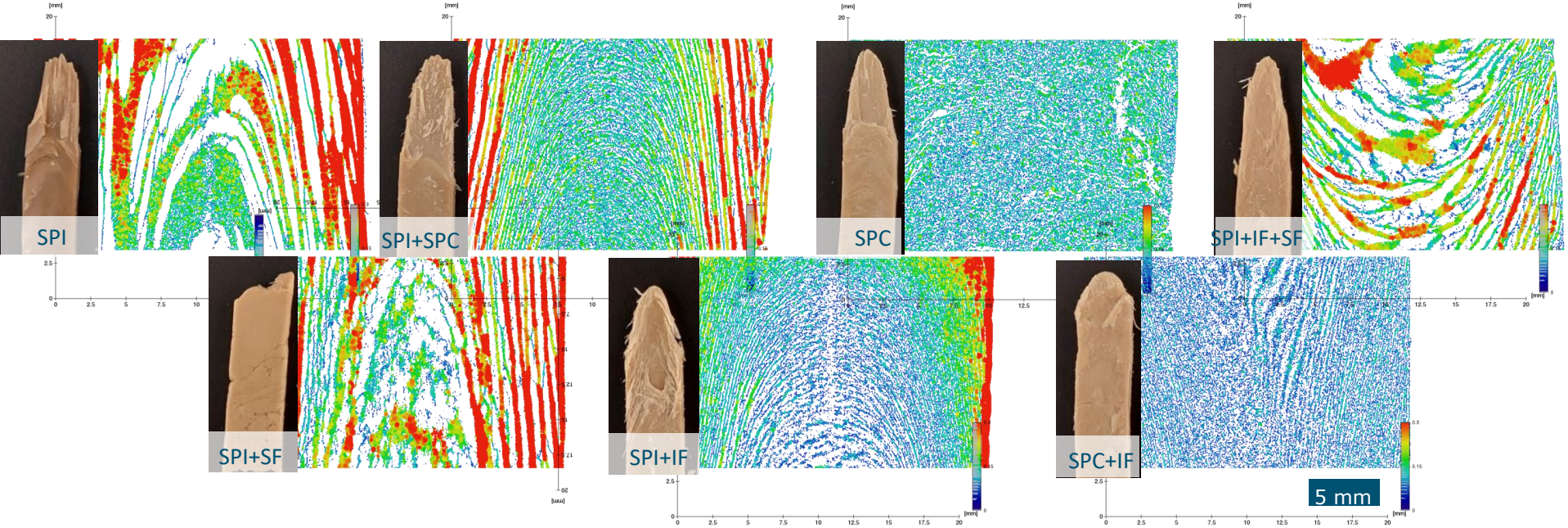
Baker Hughes Confidential

Visualisation structural differences



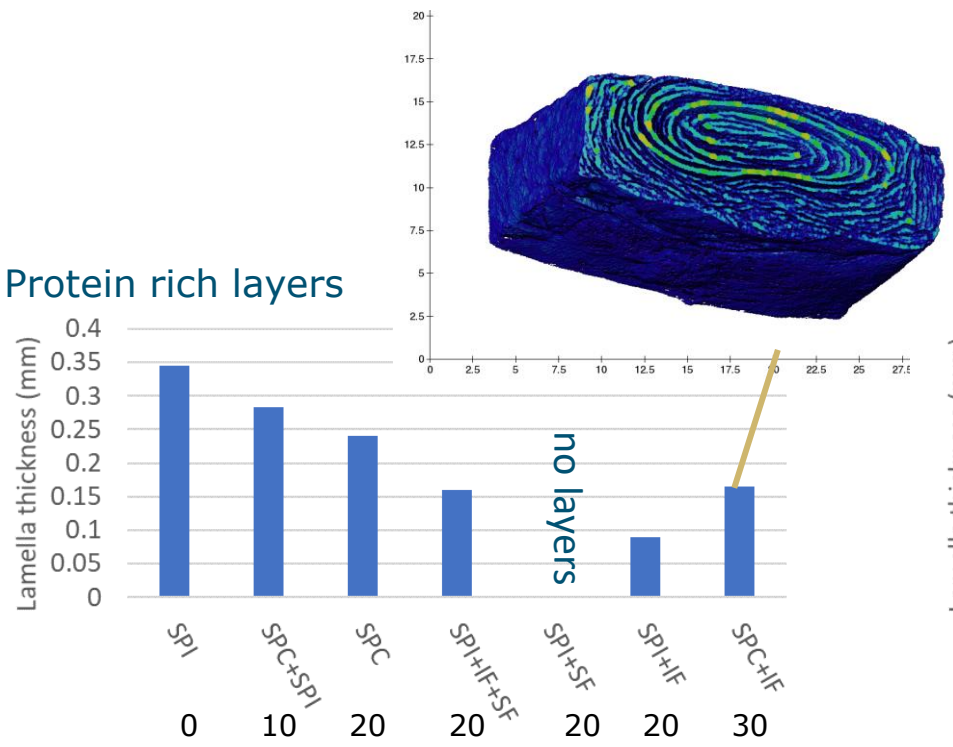
Quantification of structural differences

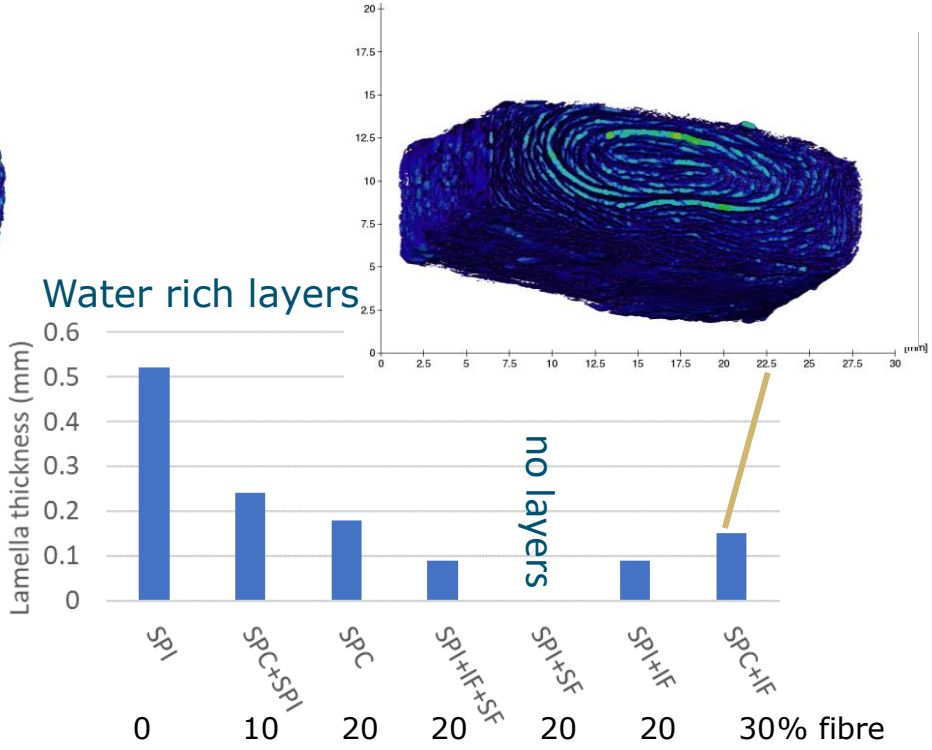
- Thickness maps of protein dense layers



Baker Hughes Confidential

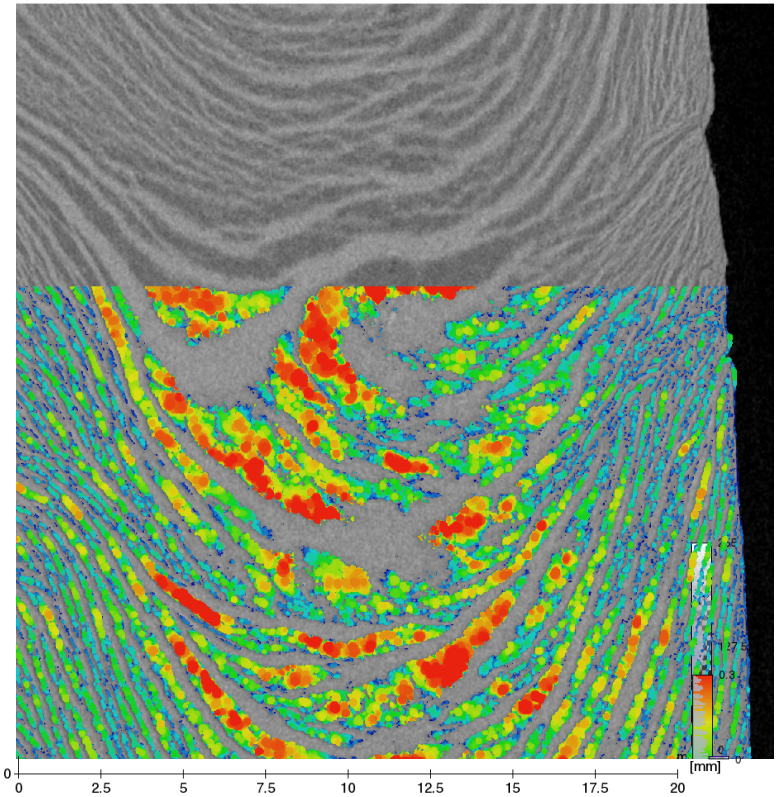
Quantification of structural differences (2)





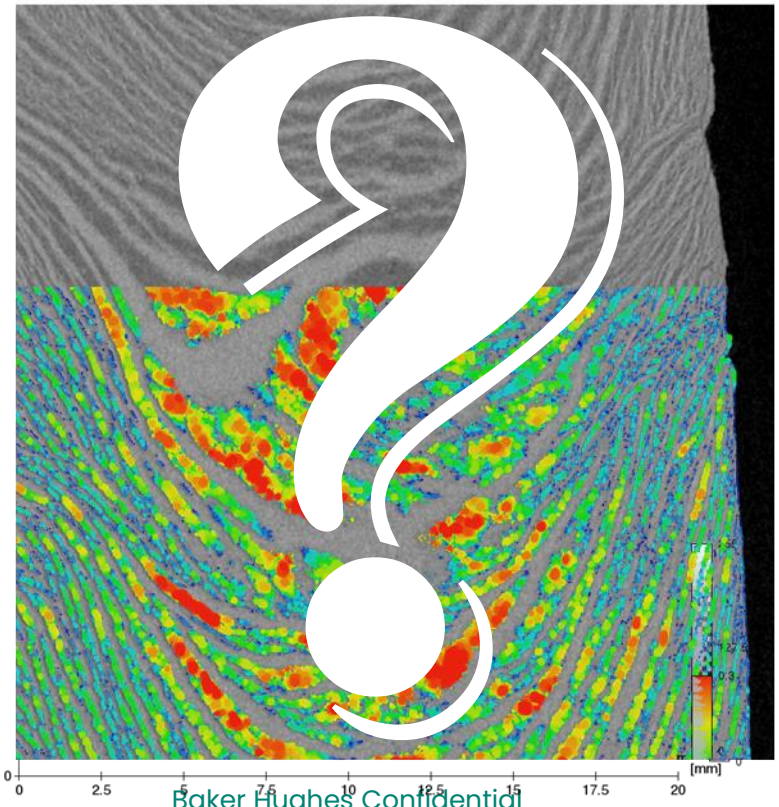
Conclusions

- XRT can be used to investigate a rich variety of food products
- Freezing can assist in enhancing density differences
- Extruded products can be visualized in frozen state
- There is more to microstructure of extruded products than composition (i.e. amount of fibre)



Baker Hughes Confidential

Questions?



Baker Hughes Confidential

WAGENINGEN
UNIVERSITY & RESEARCH

Thank you for your attention!

Questions

Maaike.Nieuwland@wur.nl

