X-ray tomography visualisation of phase separation in plant-based meat analogues, relating the microstructure to juiciness

INDUSTRIAL DEVLOPMENT PROJECTS

THE INDUSTRIAL CHALLENGE

Meat analogues are central for the protein shift towards plant-based products. To enhance juiciness in meat analogues, oleogels could be a way to incorporate healthy fats that have higher thermal stability. Challenges AAK faces are related to characterisation of the oleogels in the matrix; how they affect the microstructure, how they are retained during cooking, and how the protein fiber formation is influenced.

WHY USING A LARGE SCALE FACILITY

Microscopy often uses thin sections that are prone to drying, and following a system during heating is difficult. Tomography provides a 3D view of sample structure. Neutron- and synchrotron facilities can provide fast acquisition of 3D micro-tomography images with high resolution. This enables fast transitions to be followed with respect to time or temperature through, so called, 4D tomography. X-ray micro-tomography give a structural understanding in 3D, but it can be difficult to gain contrast in soft matter with high water content. Neutron micro-tomography was considered as an alternative since the water location is visualised, providing an inverse image to the X-ray tomography. To confirm the microstructure from the lab analysis with chemical information with respect to fat and protein location, soft X-ray spectro-microscopy at large scale facility can provide resolution that is difficult to achieve at lab scale.

HOW THE WORK WAS DONE

Meat analogues with different fats in the form of oleogels were prepared, their structures determined and compared at µm scale using two lab-based X-ray tomographs, a Zeiss Versa XRM 520 and an Exciscope Polaris. Initial neutron imaging tests were conducted at the ICON beamline of the Swiss Spallation Neutron Source, SINQ, by beam line scientist Anders Kaestner, but the resolution was too limited to yield further results. Instead, X-ray spectro-microscopy was tested at the SoftiMAX beamline of MAX IV, with the aid of Jörg Schwenke. Finally, X-ray micro-tomography during a simulated cooking step was conducted by continuously acquiring images in-situ during heating at the ForMAX beamline of MAX IV, supported by beamline scientist Eleni Myrto Asimakopoulou (see Figure 1).

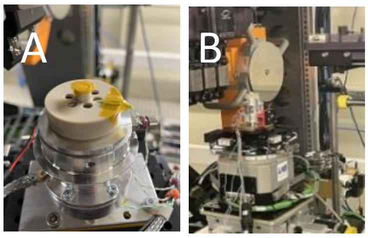

Figure 1. The sample environment designed by LU A : with a sample. B: at the ForMAX beam line

THE RESULTS AND EXPECTED IMPACT

The 4D analysis method using ForMAX allowed the evolution of the microstructure of the meat analogues to be followed during heating. The field of view was 950 x 650 µm and a specific volume was tracked during the heating. The shrinkage or expansion of the specific volume was seen to be affected by the inclusion of oleogels (see Figure 2).

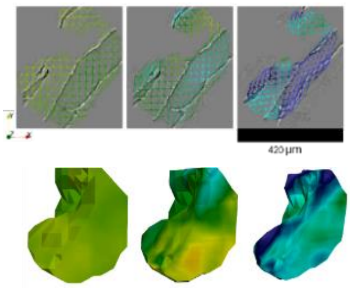

Figure 2. Shrinkage (blue) and expansion (orange) of a pore during heating of a meat analogue. Green denotes the initial size. Scalebar = 420 µm

The different components could however not be differentiated using X-ray spectro-microscopy at the pre-selected energies. In the future another energy level will be used.

"Oleogels are a promising technology to support both sustainability and healthier food formulations by enabling lower saturated fat solutions. The advanced visualization techniques used in this project provide unique insights into structural changes during heating"/Rayo Hernandez Sanchez

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