Modelling moisture migration in crispy products on basis of X-ray Tomography (XRT)

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Background

Structure is next to composition the ruling characteristic of a food product. An essential quality attribute of products like crackers, bread crust, biscuits and snacks is crispiness. This quality is strongly related with the structure and water content. The rate of moisture migration, and the connected change in crispiness, also depends on details of the of the porous structure.
With XRT the detailed 3D structure can be captured as function of time, different recipes of processes [3]. By analysis of the structure and simulation of the transport processes, we understand the essential parameters that determine the structure and quality changes over time. And that is of great help to steer the quality and performance improvement of these food products.

Moisture migration model on basis of structure

In cooperation with Unilever and TI Food & Nutrition, Food & Biobased Research developed a structure based model that predicts the water migration and crispiness in porous food systems as a function of time [1,2].

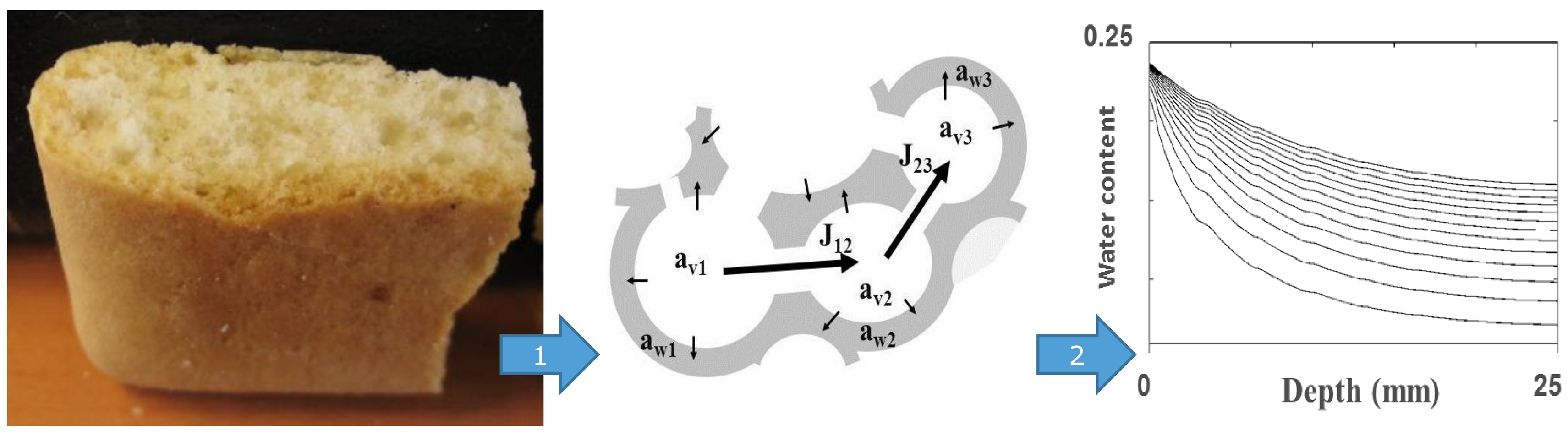

Figure 1. From the measured 3D structure*, the local vapour diffusion between individual cells and the local moisture absorption to the lamellae is characterised. For all cells together this constitutes of a large network upon which the water migration in the total product is simulated. Simulations closely match with SPI-NMR profile measurements of actual sorption experiments.

Analysis of XRT data

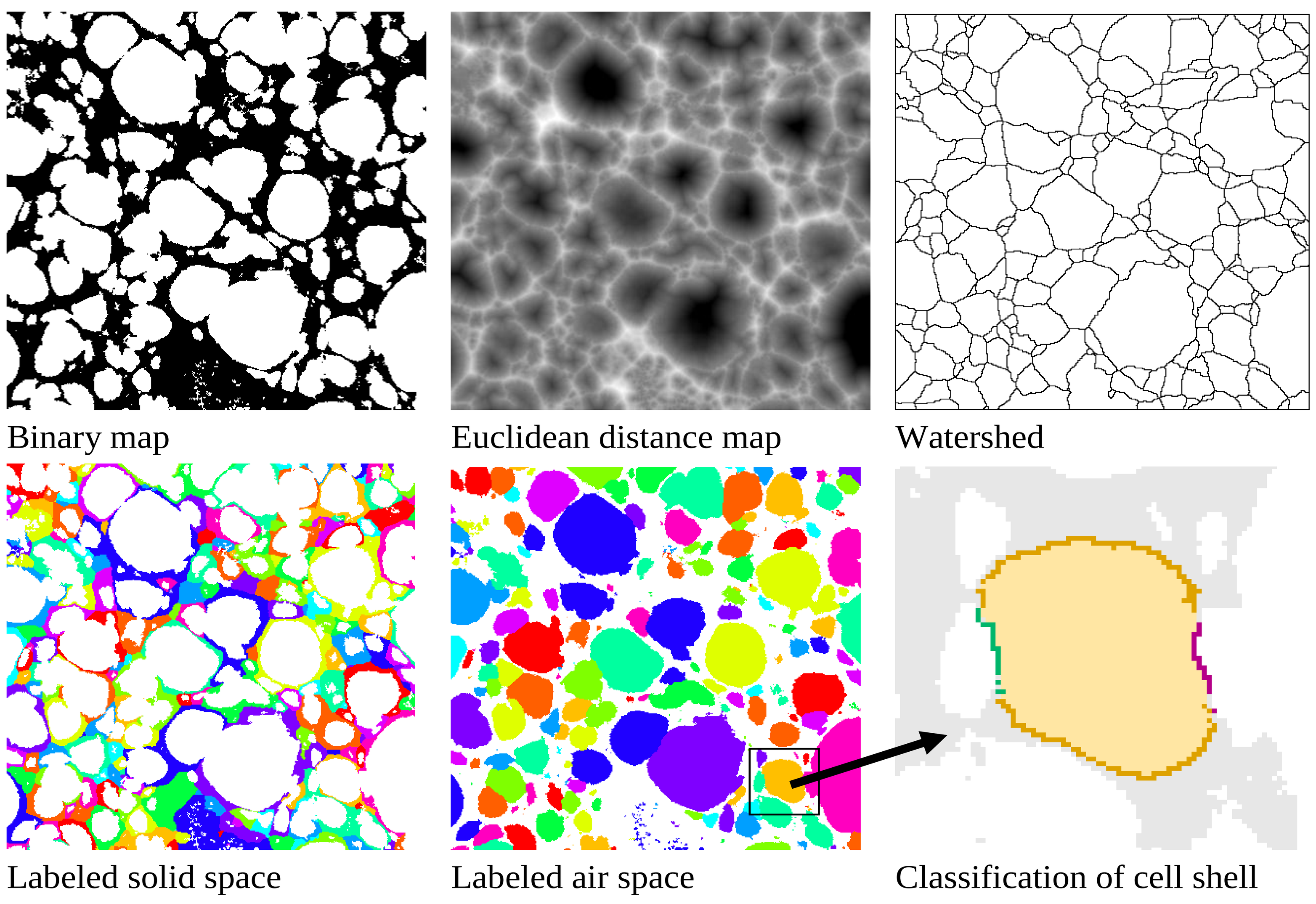

Figure 2. The 3D XRT data is classified as air and solid matter. The connected airspace is segmented with the watershed method. Then the sizes of the pore between the neighbouring cells and the solid surface area and thickness can be determined for each cell.

Results for fine and coarse cracker structure

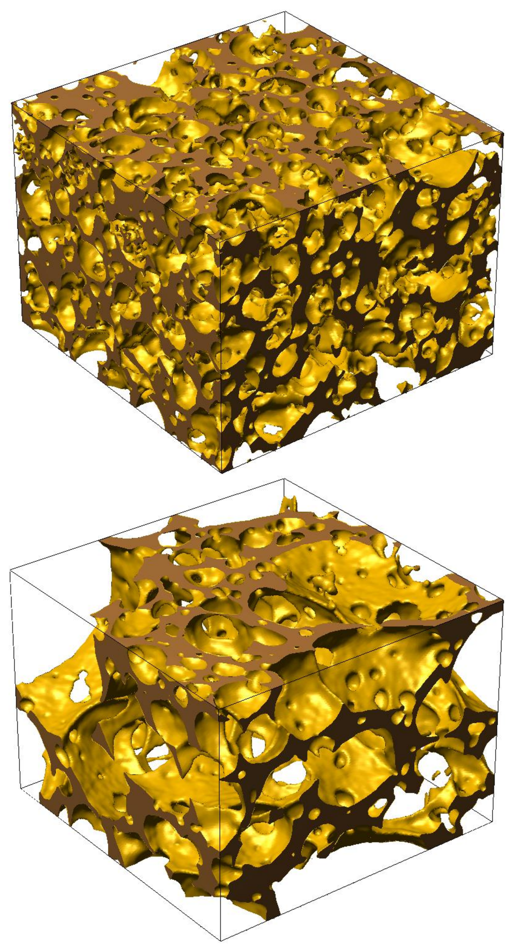

Figure 3: XRT of 3x3x3mm cracker samples with short and long proofing time.

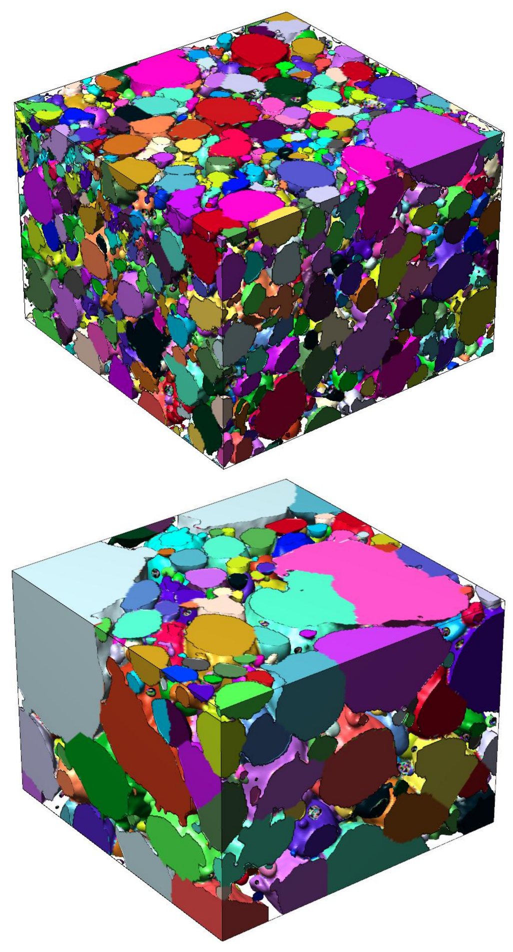

Figure 4: Result of airspace segmentation to individual cells.

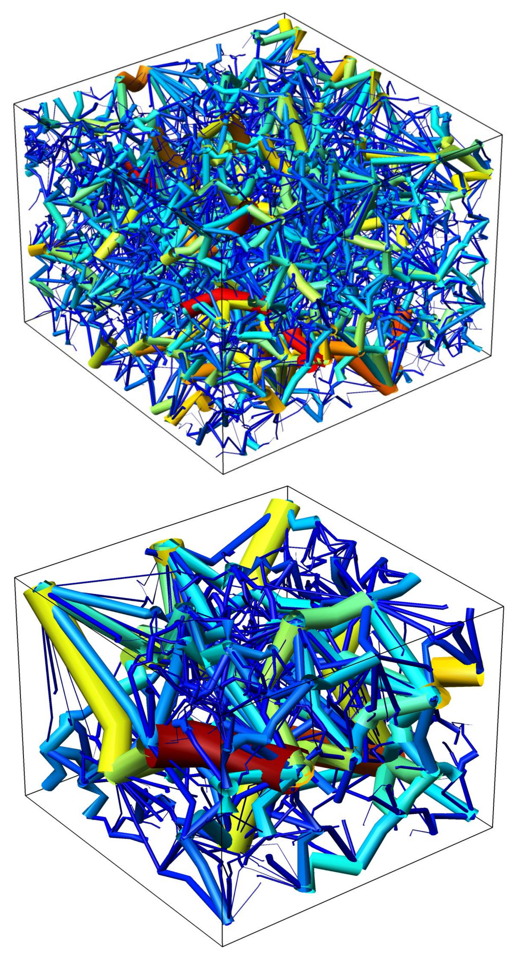

Figure 5: Network of gas diffusion connections through the pores.

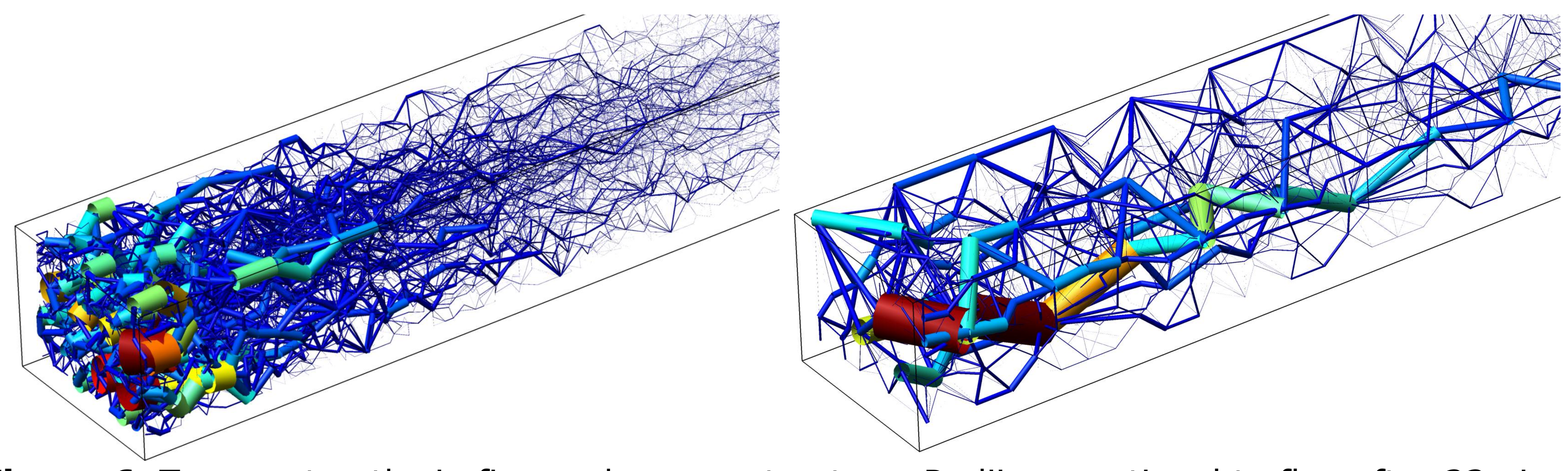

Figure 6. Transport paths in fine and coarse structure. Radii proportional to flux after 22min.

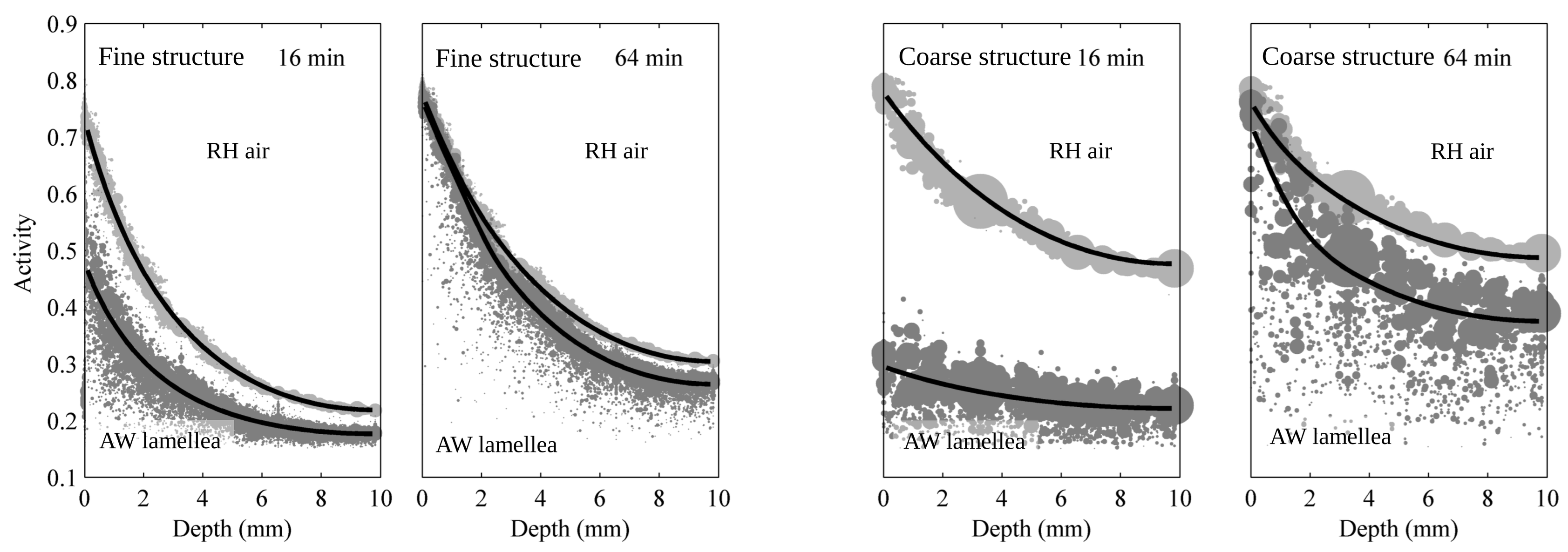

Figure 7. The development of air humidity and absorbed water activity profile over the depth. Situation after one quarter and after one hour, for the fine and coarse cracker structure.

Conclusions

Changes in crispiness as a result of moisture migration can be predicted on basis of the actual structure. For crackers it was found that the coarse structure has a fast transport via a few very open connections. A fine cracker however, absorbs more readily moisture at the surface as a result of the thinner lamellae.
Thanks to the insight in structure, its effect on transport processes and the related changes in quality attributes, we can better steer the development of bakery product and snacks.

References

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2. Esveld, D.C. et al. J. Food Eng. 109, 301-320 (2012)
3. Meinders M.B.J. & Esveld D.C., VMT March Nr 07, (2013)
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