Modelling of pore development during drying of viscoelastic food materials

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In Literature, there is poor understanding why food materials get porous during drying [1] and we aim to provide a mechanistic explanation for the pore development, based on a multiphysics model, describing a) heat/mass transfer during drying, b) drying-driven mechanical stress development of the food material, and c) viscoelastic relaxation.
We target both cellular food materials and homogeneous foods.
We assume that food matrix behaves as a hydrogel. Pre-existing pores (as intercellular spaces) are assumed to be very small, spherical, gas-filled bubbles exchanging water vapour with the matrix. We also study the impact of an elastic skin on the drying process.
The problem is described by a set of coupled PDE equations, which are solved within a finite element code [2]. The model shows that during drying, the food matrix shrinks, but also tensile stresses are generated – which lead to enlargement of pores, and thus to increase of porosity. This effect is enhanced when an elastic skin is present. It can also explain the effect of case hardening on pore development, leading to the development of a stiff elastic skin if the material gets near the glass transition.

Similar phenomena happen during drying of maltodextrin solutions with high molecular weight. Their rheology has been fully characterized recently [3], showing viscoelastic behaviour. It is observed that pore formation happens during drying if an elastic skin is formed via gelation during drying [4-5]. This example allows us to extend the model to viscoelastic materials.

The multiphysics model is very novel to the field of food engineering, and presents large potential such as describing food structure development in osmotic drying, freeze-drying or vacuum drying, or other food structuring methods involving intensive heating like frying, baking, microwave heating, extrusion.

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