Probing water migration and molecular mobility during the ageing of bread

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The wide spatial variations in water contents of freshly baked baguettes give the product its special eating quality with a brittle glassy crust and a soft rubbery crumb. During storage at a constant relative humidity of 55% (selected as representative of typical atmospheric relative humidity), the overall water content and its relative distribution across the bread change. In this study water migration as a function of storage time in commercial French baguettes was monitored gravimetrically and through its impact on molecular dynamics using low field NMR relaxometry.

The results of the water content analyses revealed that the average water content of whole baguettes decreased from ~30 % (wet weight basis) down to ~14% after 168 hours of storage at ambient temperature and 55% RH. The water content of the "crust" part, defined as the outer 1/3 of the baguettes (by weight) were only 17% and did not decrease substantially during the same storage period. This implied that the gain of water of this drier outer layer by the water migration from the crumb (43%) is balanced by the loss of water from the crust to the surrounding atmosphere.
As expected, the variations in water content in the different regions of the baguettes were mirrored by variations in molecular mobility as probed using the low field NMR (T_2). Of particular importance in this context was the deconvolution of the relative contribution of this decrease in mobility as a result of (i) the decrease in water content and (ii) the re-ordering and subsequent crystallisation of the starch component, i.e. starch retrogradation (probed by Differential Scanning Calorimetry). Carefully designed control experiments where retrograded bread crumb was re-equilibrated to a range of water contents clearly indicated that the decrease in mobility was more influenced by water loss than starch retrogradation.