In-situ NMR highlights structural change during apple heating

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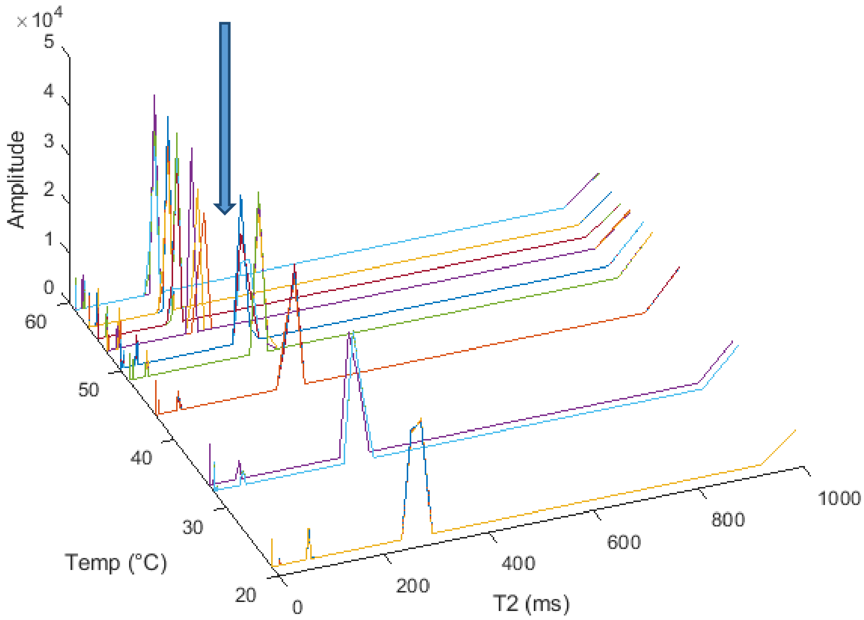
Introduction: Microstructure and texture evolution of foods during cooking is difficult to achieve, because conventional techniques cannot analyze the internal structure, while preserving its integrity. For this very often-processed product that is apple, it is essential to understand thermal degradations. To study such phenomena, we undertook in-situ quantitative NMR during the cooking process.

Methods: Five Golden Delicious apples were sampled in four 10 mm long and 5 mm diameter cylinders. Each of the twenty samples was sealed in parafilm. The thermal treatments were performed *in situ* in a 9.4 T Bruker Ascend 400WB instrument. A 5-mm diameter microimaging birdcage radiofrequency coil was used for both excitation and signal reception. A controlled hot air flow cooked the sample from 20 to 60°C in 70 min.
Non-spatially resolved (spectroscopy) T2 measurements were performed with a Carr-Purcell-Meiboom-Gill (CPMG) pulse sequence [1], with the interpulse delay τ of 125 microseconds. The repetition time was set to 5 seconds for a total acquisition duration of 2min30s.
Assuming that the T2 decay curve stands as a sum of weighted exponential decays describing the complexity of the internal structure of the sample:

$$S = \sum_{j=1}^{m} A_j e^{\left(-t_i / T_{2j}\right)} \qquad i=1, 2 \ldots.n$$

each decay curve was analyzed with an in-house Matlab® implementation of the non-negative least squares (NNLS) algorithm [2].

Results and discussion:
As an illustration, this figure shows T2 change with cooking temperature for one of our sample. A shift in T2 value of the main water fraction is between 50 and 53°C (arrow). This critical temperature is in accordance with mechanical properties changes measured on samples cooked at various temperature.



Conclusion: This study points out the feasibility of resolving multiexponential T2 decay, at high magnetic field, during apple sample cooking. It provides longitudinal information about structure change and water redistribution on a same sample during the whole process.

References: [1] Meiboom, S. and D. Gill, Rev. Sci. Instrum. (1958).
[2] Istratov, A. A. and O. F. Vyvenko, Rev. Sci. Instrum. (1999).