CHARACTERIZATION OF WATER STATE AND REPARTITION DURING DRYING PROCESS OF TOMATO WITH SINGLE SIDED NUCLEAR MAGNETIC RESONANCE

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Introduction

Drying is the most common form of food preservation and extends the food shelve-life, while allowing optimizations of packaging, storage and transportation (1). However, a better understanding of the physicochemical phenomena related to water loss remains necessary to adapt the drying process to the variability of the raw material in order to preserve the nutritional characteristics and the quality of processed products, while optimizing the energy consumption of the operation. Here, we aim to demonstrate the ability of single-sided nuclear magnetic resonance (NMR) for noninvasive in-situ monitoring of the evolution of water properties during tomato drying.

Materials

Two varieties of industrial tomatoes: H1311 and Terradou. The upper and lower parts of fruits were cut and only the outer pericarp was kept. Drying was performed in a oven (Froilabo-AP120®) at 45°C with controlled air flow. Fresh samples and three drying times, 4h, 7h and 16-18h (~ 40% water loss), were analyzed.

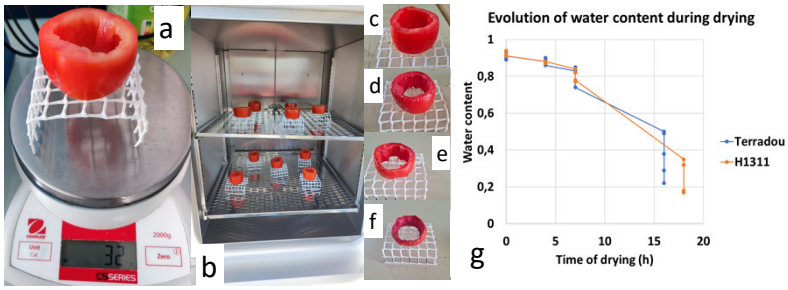

Figure 1 : Exemple of fresh prepared tomatoe samples (a, c) in the oven before drying (b) and after 4 hours (d) 7 hours (e) and 16 hours (f) of drying at 45°C. Plot of the evolution of tomato water content during drying (g).

Method

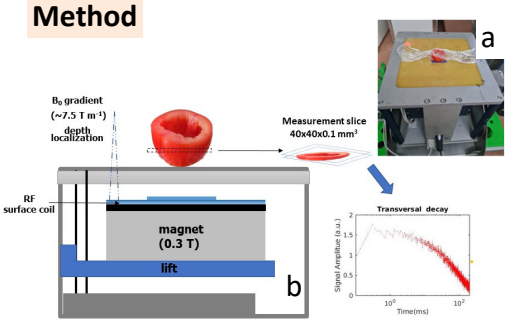

Figure 2 : (a) Tomato sample in plastic wrap on MOUSE® during experiment in climatic room. (b) Schematic representation of depth profiling experiment.

NMR experiments were performed at 10° C in a climatic room using a Profile NMR-MOUSE® PM25 (Magritek, Germany) with a ^{1}H resonance frequency of 13.23 MHz. A depth signal intensity (SI) was obtained by summing the 256 echoes acquired in the 100µm thick measurement slice (figure 2) using a CPMG pulse sequence with TE=100µs, TR=2s and 4 scans. Depth profile was then obtained by spanning the 16mm-height (80 depths and 200µm-step) of the sample thanks to the high precision lift. Transversal echo decays were also recorded at three specific depths (top, middle and bottom) for T2 measurements, with the following parameters: 2048 echoes, TE=100µs , TR=10s and 8 scans. Multiexponential analysis with NNLS algorithm was used to extract multicomponent T2 distribution.

Results and Discussion

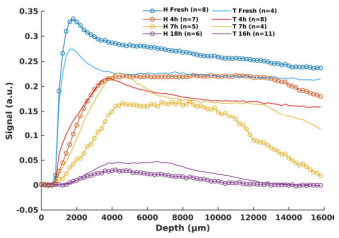

Figure 3 : Mean depth signal profiles in function of drying time of H1311 (circle) and Terradou (line) tomatoes.

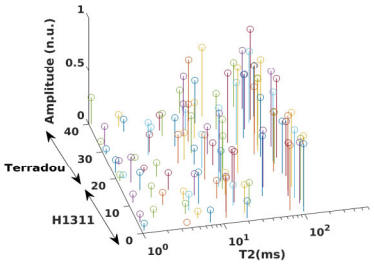

Figure 6 : T2 distribution of H1311 (1-20) and Terradou (21-40) samples after 7h of drying.

Both tomato cultivars displayed depth profiles whose shape can be related to dehydration (Figure 3). The decrease of the signal during drying occurred gradually from the extremities corresponding to the cut surfaces. The integrals of these profiles were linearly correlated with the water amount of each sample (Figure 4).

Both anatomical and water amount of tomatoes during drying are displayed in depth signal profiles

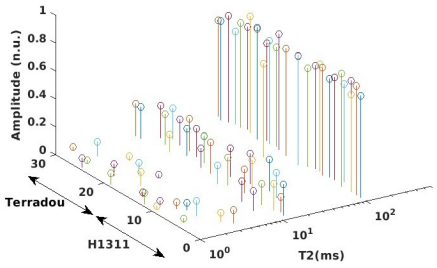

Figure 5 : T2 distribution of H1311 (1-15) and Terradou (16-30) fresh samples.

The common 3 (vacuolar, cytoplasmic and parietal) components distribution as the result of water compartmentation in fresh samples (Figure 5) (2) changed progressively to both a decrease and a great dispersion of T2 values by 7h (figure 6) of drying and to predominantly one short and unique T2 component after 16h of drying (figure 7).

These changes are attributed to both solute concentration (water loss) and physical changes (shrinkage and/or disruption) of cell membranes.

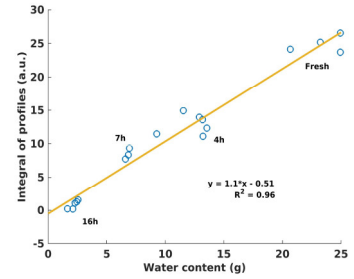

Figure 4 : H1311 integral of signal profile vs water content at each drying time.

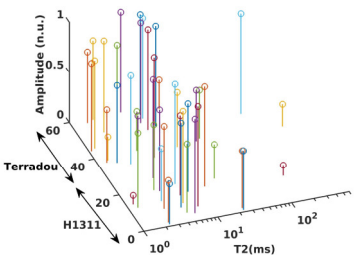

Figure 7 : T2 distribution of H1311 (1-30) and Terradou (31-60) samples after 16-18h of drying.
Note that only samples displaying a sufficient SN ratio (18 for Terradou and 16 for H1311) are presented.

Conclusions

This study demonstrates the capability of single-sided nuclear magnetic resonance (NMR) to monitor the state of water in tomato during drying. Changes in tomato morphology along with its water content are faithfully displayed in depth signal profiles, whereas multiexponential T2 analysis allow to follow-up the changes in water mobility and compartmentation related to physicochemical changes associated to drying process.

1. Nikita S. Bhatkar et al. Drying Technology, 39:11, 1720-1744, DOI: 10.1080/07373937.2021.1910832
2. Rodolphe Leforestier et al. MRC, 60:11, 637-650, DOI: 10.1002/mrc.5241

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