TD-NMR Analysis of the Structure and Composition of Soft Candy Confectionery During Processing

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Introduction

- Soft candy confectionery, specifically gummies, are a globally beloved treat with complex production (Smith et al., 2021).
- Ensuring consistent quality is paramount to customer satisfaction.
- The intricate relationship between the structure, composition, and processing parameters of these confections greatly influences their final properties such as texture and moisture content (Brown et al., 2020).
- Understanding and monitoring these changes in real-time during production is thus essential for optimal quality control.
- We present a custom-built, portable MR probe based on a Halbach array to non-destructively investigate the structure and composition of soft candy confectionery during various stages of processing.
- This approach enables characterization of key properties such as viscosity, moisture content, and brix value, thus facilitating efficient and consistent production.
- The insights obtained will significantly enhance quality control and production in the confectionery industry.

Materials and Methods

Magnetic Resonance Setup

- Custom-built Halbach array is used with with the Magritek KEA2 spectrometer shown in Figure 1.
- The spacing was optimized using finite element simulations (FEMM, femm.info) and comprises 16 NdFeB magnets.
- The magnetic field in the homogeneous region is 0.188T
- Samples are measured with Carr-Purcell-Meiboom-Gill (CPMG) to improve signal to noise ratio.
- Biexponential fitting and NNLS are used on the echo train.

Figure 1. Magnetic Resonance Setup: KEA2 console on left, probe on right

General Experimental Procedure

- Gelatin Solution: 8g powdered gelatin mixed in 16g of hot water (80–90 °C).
- Sugar Mixture: 20g corn syrup and 40g of sucrose were heated in 20ml water until the temperature reached 95-98 °C.
- Combining Solutions: Gelatin and sugar solutions were combined, stirred and heated to desired brix value.
- Molding and Aging: The mixture was poured into cornstarch molds and kept at room temperature for 24 hours.
- Cooking time and molding time are varied to observe effect of brix value and solidification period on TD-NMR.

Results and Disscussion

Cooking

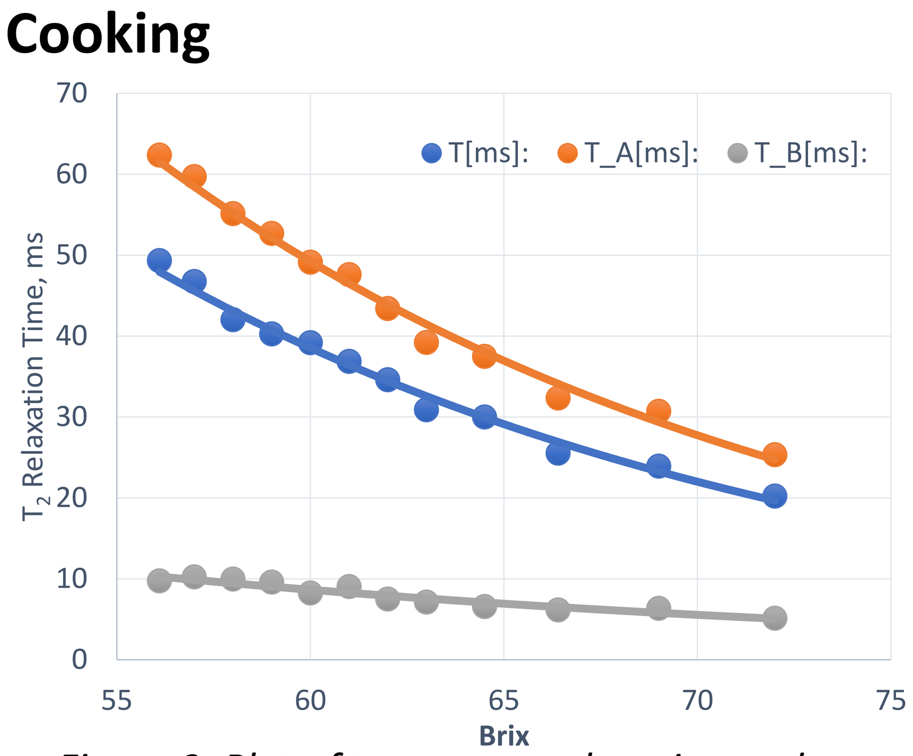

Figure 2. Plot of transverse relaxation and components of biexponential fit

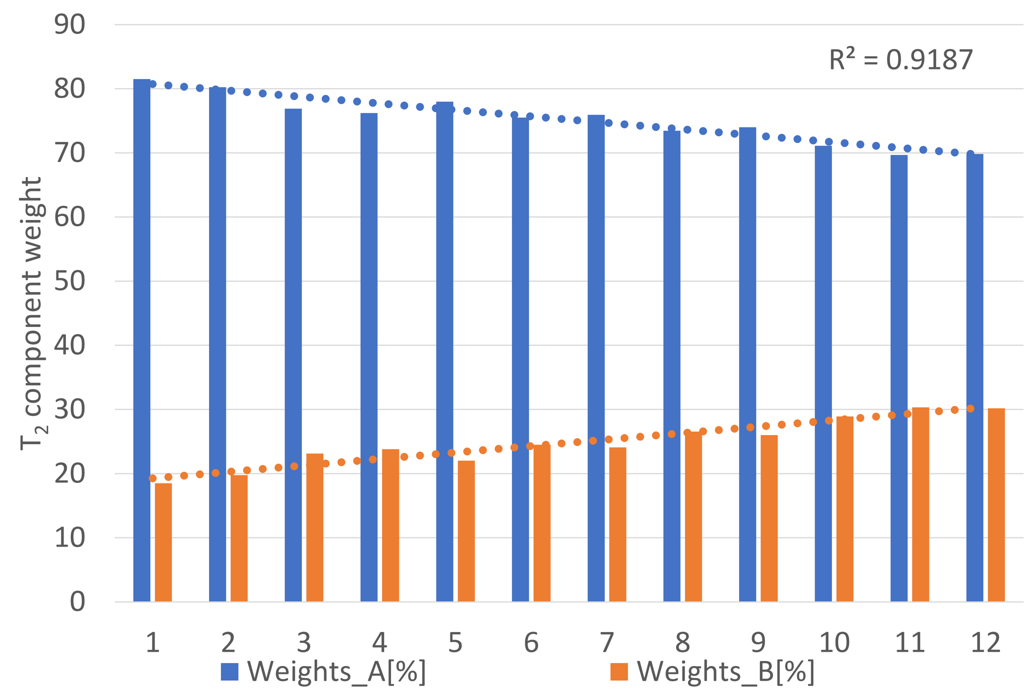

Figure 3. Column Chart of NNLs Distribution Weights

- Transverse relaxation time decreases as brix increases due to sugar concentration reducing mobility of water molecules within the matrix.
- Changes in T_A and T_B correlate with changes in the candy's structure and composition due to varying sugar concentration and gelatin network.
- T_A is from free-moving water molecules that become more bound with increasing sugar concentration.
- These changes signify a shift in the gelatin-sugar-water interactions within the soft candy during cooking.

Molding

- T_2^{eff} consistently decreases as cooling proceeds. This is indicative of an increased matrix rigidity during solidification.

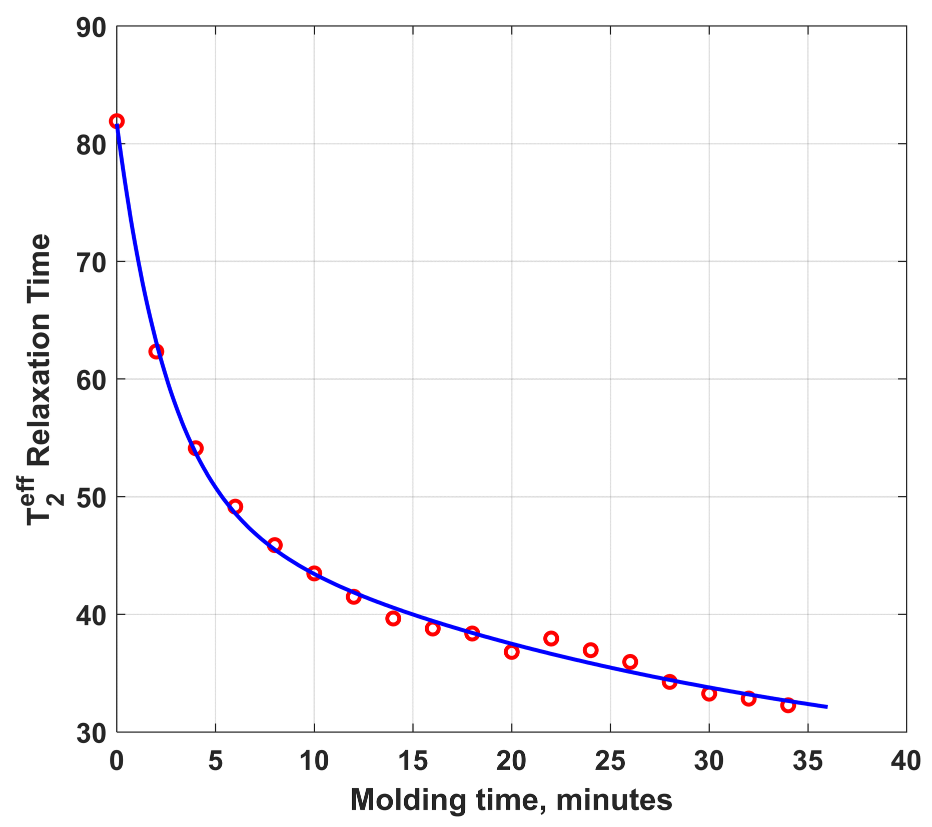

Figure 4. Plot of transverse relaxation during cooling time with biexponential fit

- Trends in T_A and T_B could represent the water interacting with different constituents in the gelatin-sugar matrix, growing progressively constrained as the candy solidifies.
- On the other hand, the third component T_C, decreases in relaxation time and weight after 16 minutes.
- This could indicate a critical transition phase in the candy's cooling process, perhaps associated with the gelatin and sugar matrix's structural changes.

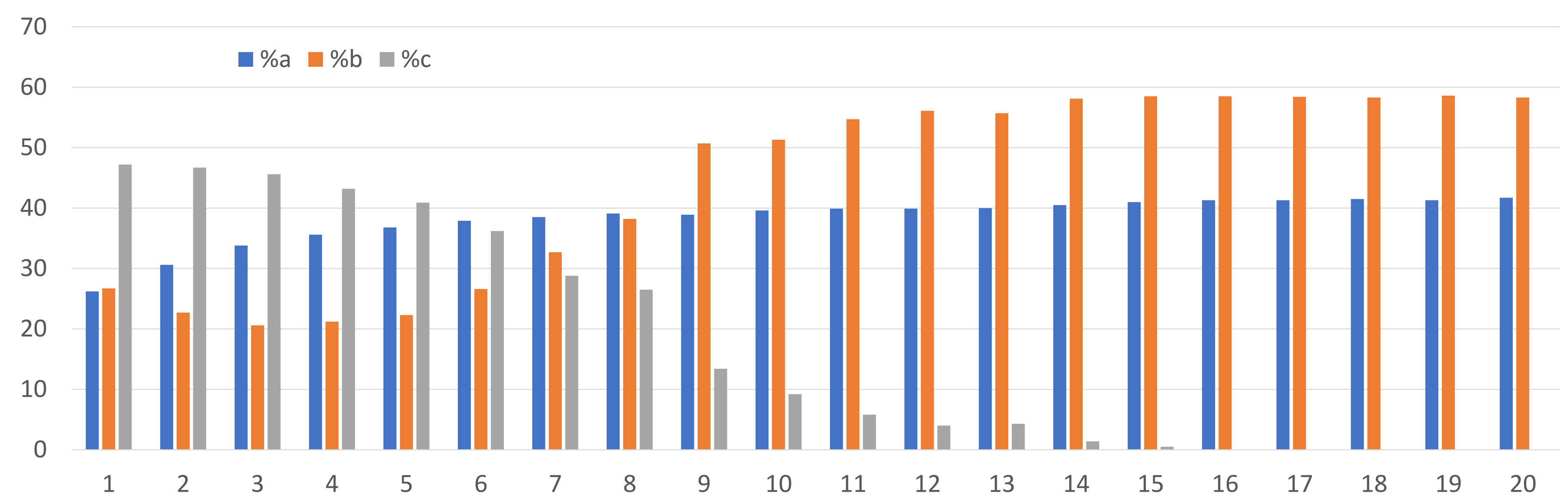

Figure 5. Column Chart of NNLS Distrubution Weights

Conclusion

- Magnetic resonance can help monitor complex transformations during cooking and can be undertaken online during production.
- Transverse relaxation times and weighting correlate with cooking times and sugar content.
- This design holds promise for monitoring cooking processes in the food industry, leading to improved quality and product consistency.

Acknowledgments

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