

Sweet NMR: T2 relaxometry of different chocolate varieties

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Introduction: Time-Domain Nuclear Magnetic Resonance (TD-NMR) has proven to be a valuable tool for non-invasive analysis of complex food systems, offering insights into molecular mobility and phase behavior through relaxation time measurements. Chocolate, as a multi-component material, exhibits temperature-dependent structural changes, particularly due to the phase transitions of cocoa butter—a key fat component with well-defined melting characteristics. In this study, we applied TD-NMR with variable temperature control to investigate the thermal behavior of different types of chocolate. By monitoring T2 relaxation times across a temperature range, we aimed to characterize structural transitions and their reversibility, providing a deeper understanding of how composition and processing influence the physical properties of chocolate.

Methods: The study examined the following chocolate varieties:

- Cheap dark chocolate (no name)
- Milk chocolate (Schogetten)
- Aerated chocolate (Milka Luflee, Mondelez)
- As reference sample of vegetable oil was used.

The chocolate was cut into shavings and pressed into a 15 mm glass tube to ensure good thermal contact to the tube.

The sample was put into the variable temperature (VT) probe which was set to room temperature (26°C). The temperature was increased in 2°C steps up to 40°C. In this range most of the relaxation time changes were expected. Further temperature increase was performed in 10°C increments up until a maximum temperature of 100°C. After reaching the maximum of 100°C, the temperature was decreases in reverse. After 5 minutes tempering at the target temperature (waiting time), a T2 CPMG measurement was performed. The acquired data was fitted to a single exponential model. For further evaluation, the fitted T2 values as well as the fitted signal amplitudes at time $t = 0$ were used.

Results: Figure 1: right shows the T2 values for the increasing temperature profile. One can see the melting of the cocoa butter occurs between 28°C and 36°C, which agrees with literature values [2]. The temperature dependency of the T2 values for the different varieties of chocolate is also clearly different.

Conclusion: The relaxation times show interesting effects at different temperatures. The effects can be correlated to the phase transition of the cocoa butter. Boltzmann calibrated measurements can for example be used for SFC (solid fat content) determination of chocolates.

References: [1] J. van Duynhoven et al., Ann Rep on NMR Spectroscopy, 69:145-97, 2010. [2] Ullmann's Food and Feed. Vol. 2, Wiley, 655 f 706, 2017.

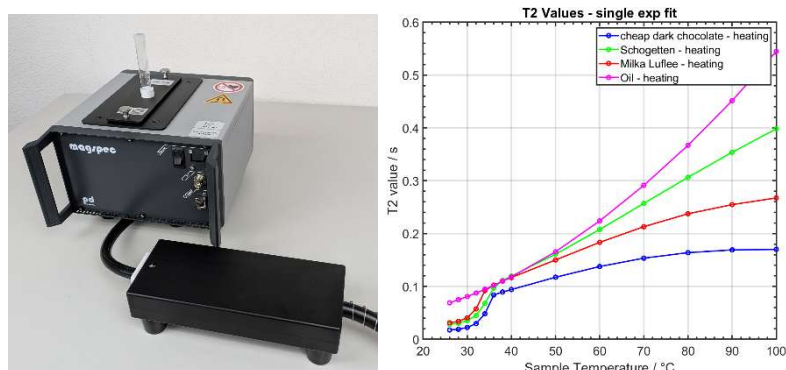


Fig. 1: left: Portable MagSpec MRI system with 0.5 T B0-field strength and heating device. **Right:** T2 values of different chocolate varieties.