Can Portable Magnetic Resonance Detect Sugar Adulteration in Lokum? A preliminary study

Robert H. Morris[1], Erdem Mercan[2], Nicola Doy[3], Kerry Worton[1], Johanna Stafford[1], Mecit Halil Oztop[4], Michael I. Newton[1]

[1]Nottingham Trent University, Nottingham, UK.[2]Durukan Şekerleme San. Tic. A.Ş., Ankara, Turkey [3]Bilborough College, Nottingham, UK, [4]Middle East Technical University, Ankara, Turkey

Introduction

- Turkish Delight or Lokum is soft candy confectionery product which utilises starch as a gelling agent. The main ingredients are sugar, water, starch, acid.
- The most significant quality parameters of Turkish Delight are texture, surface brightness, and transparency, which are all attained through starch gelatinisation.
- The type and quantity of sugar used effects starch gelatinisation.
- According to the Turkish Food Codex, only sucrose is permitted however manufacturers sometimes use corn syrup instead of sucrose to decrease the cost and prevent crystallisation [1].
- Fructose-based syrups such as high fructose corn syrup (HFCS) are also attractive since they are sweeter than sucrose and cost less to produce.
- There are no current techniques to determine the sugar solution used to make the confectionary which are inexpensive, rapid, suitable for use by non-experts and which do not require pre-treatment of the sample.
- In this study, a method utilising T_1 and T_2^{eff} measured with portable magnetic resonance devices to determine the sugar syrup used in the production of Lokum samples is presented.

Magnetic Resonance Setup

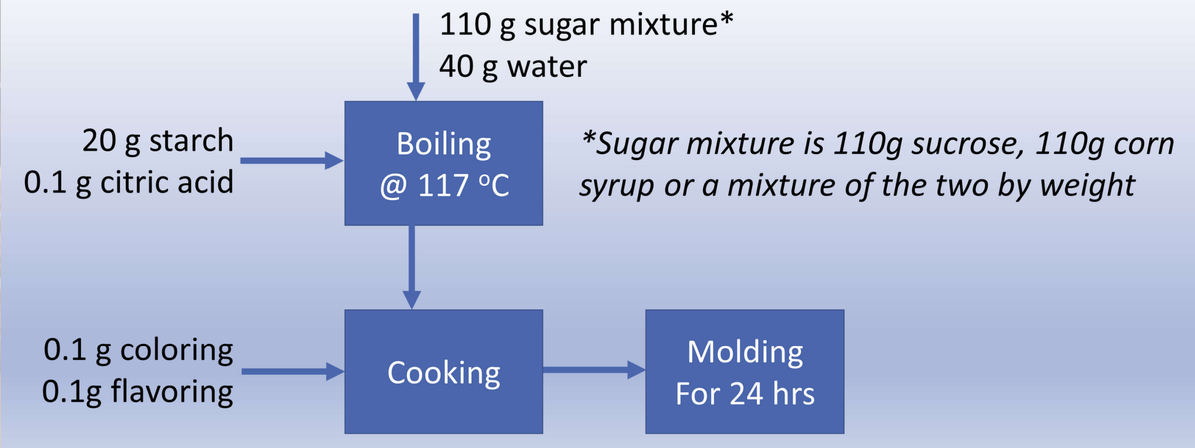
- Experiments are conducted using a Mobile Universal Surface Explorer (MR-MOUSE®) [2] (Magritek, Wellington, New Zealand) with a Kea2 spectrometer as shown in Figure 1.
- The significant inhomogeneity of the field means that a standard inversion recovery sequence cannot be used to measure T_1. Instead a CPMG sequence is used with a variable repetition time. Echoes are summed to improve the signal to noise ratio.
- Parameters are shown in Table 1.

Figure 1 Left - Photograph of a Turkish Delight sample in the scanning position on top of the MR-MoUSE®. Top - Example of Turkish Delight Samples

Parameter	T_2^{eff} Measurement	T_1 Measurement
Repetition Time	400 ms	(1:20:200) ms
Echo time	150 µs	50 µs
Number of Echoes	64	4
Averages	128	32

Table 1: Pulse sequence parameters for MR measurements.

Sample Preparation



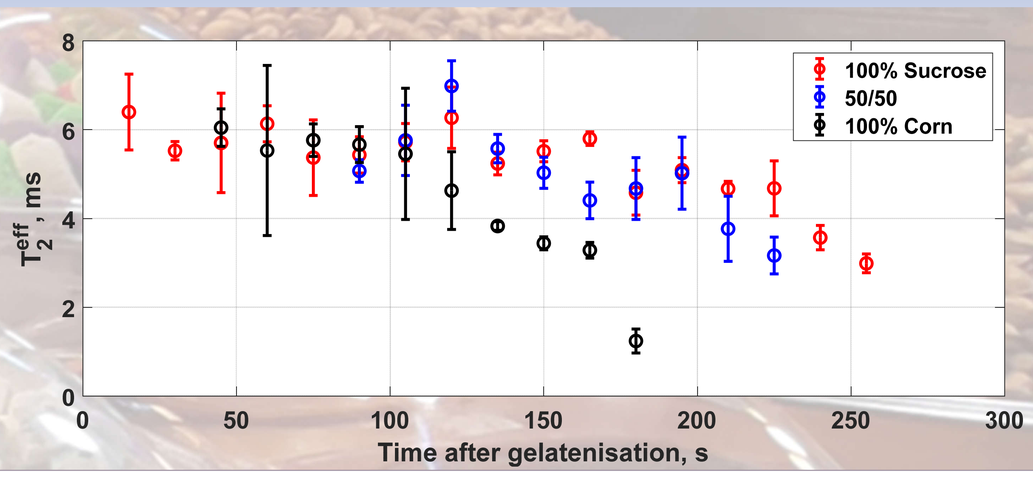


Figure 2 – T_2^{eff} values of Turkish Delight for different cooking times for different compositions.

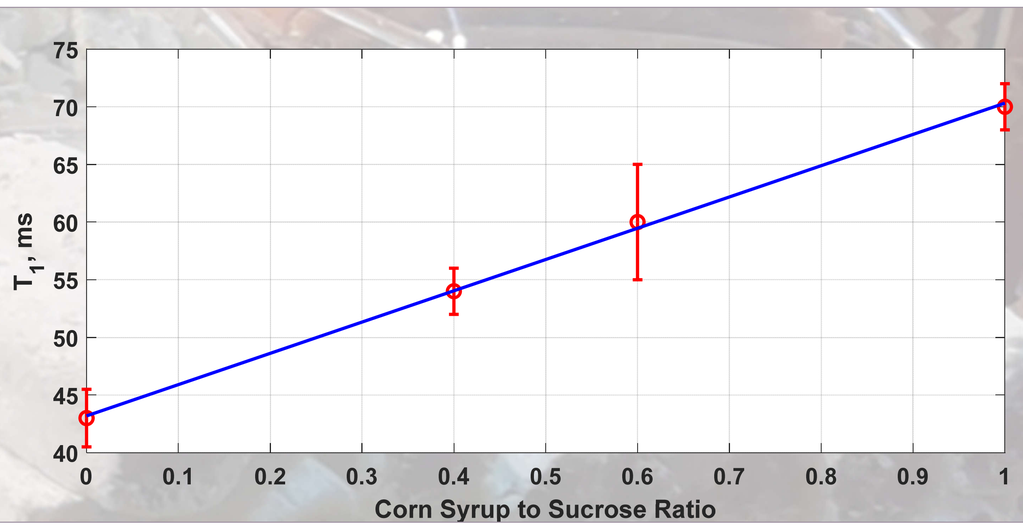


Figure 3 – T_1 values of Turkish Delight for different ratios of Corn Syrup to Sucrose. Gradient of fit is 0.27x+45ms.%$^{-1}$

Results and Disscussion

- T_2^{eff} is plotted as a function of time after gelatinisation for three different recipes in Figure 2.
- T_1 is plotted after complete gelatinisation and cooking for four different concentrations of corn syrup to sucrose in Figure 3.
- Corn syrup increases moisture content increasing coupling between the protons and providing stronger spin-spin interaction, resulting in shorter T_2^{eff} values.
- T1 increases with corn syrup concentration as expected given the decrease in size of the sugar molecules.

Conclusion

- We have demonstrated useful relationships between Turkish delight which have different sugar source compositions and two relaxation parameters, T_1 and T_2^{eff}.
- Sensitivities for both measurements are similar (35% for T_1 and 40% for T_2^{eff}), though T_1 better resolves different concentrations.
- A portable system which is customised for this application could now be constructed to allow for point-of-sale analysis of such samples which will be tested on adulterated samples.

Acknowledgments

This study has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement 101008228.

References

[1] Ünlü, E. and Soysal, C. *Eur. J. Food Sci. and Techn.* (2017), 1(1), 38 – 42.
[2] Perlo, J., Casanova, F. and Blümich, B. *J. Magn. Reson. (2005),* 176, 64–70.

SuChAQuality

Funded By the European Union

Nottingham Trent University

BILBOROUGH SIXTH FORM COLLEGE

ODTÜ METU

durukan