Corn-starch solution: a phantom with a short T2/T1 ratio (T2*/T1)

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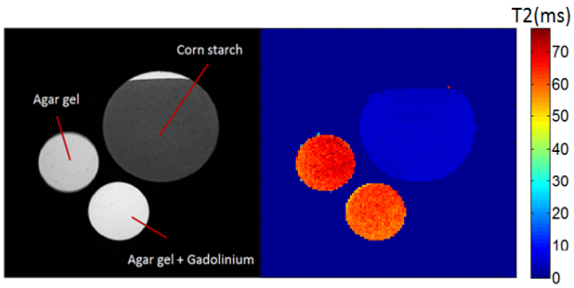

Fig. 1(Left): Image of the phantom used in this work. **Fig. 2**(right): T2map

Introduction: Corn starch with water creates a white liquid which has generated particular interest in several groups[1,2]. When this gel is under action of a shear stress, its viscosity increases, making it a dilatant liquid and so belonging to the class of non-Newtonian fluids. This solution is different from the gel continually used in literature, inasmuch the relaxation times values are close to the ones we could have *in vivo*. Herein T1, T2 and T2*, the D coefficient of corn starch and water solution were measured and, finally, a magnetization transfer study was performed to evaluate the width of the spectra of macromolecules.

Materials and methods: A tube filled with water and a concentration of 66% in volume of corn starch was prepared. Two additional tubes, filled with agar gel and agar gel + 0.5mmol/l gadolinium, were also added to the phantom as a reference for relaxation and diffusion measurements (**Fig. 1**). MRI measurements were performed at 4.7T (47/40 Bruker Biospec). T1 and T2 relaxation times were calculated from spin-echo images acquired at six repetition times (272 to 7500ms) and six echo times (14 to 84ms), respectively. The T2* was calculated from gradient-echo images acquired at thirty echo times (1.4ms to 71ms). For the calculation of the diffusion coefficient, images from a spin-echo sequence at six b-values (100 to 1600 s/mm2) were used. Magnetization transfer were measured with a FLASH sequence with TR/TE = 17.7ms/4.1ms, number of average = 30 and flip angle = 5°; the values used for the MT pulse were: length = 7.68ms, BW = 356Hz, RF Peak Amplitude = 6mT and a set of 29 irradiation offset, logarithmically spaced from 1 to 50100Hz. All images were taken in axial single slice with 4mm slice thickness, FOV = 5x5cm2, BW = 100kHz and Matrix size = 128x128. Data analysis was performed with MATLAB® (MathWorks).

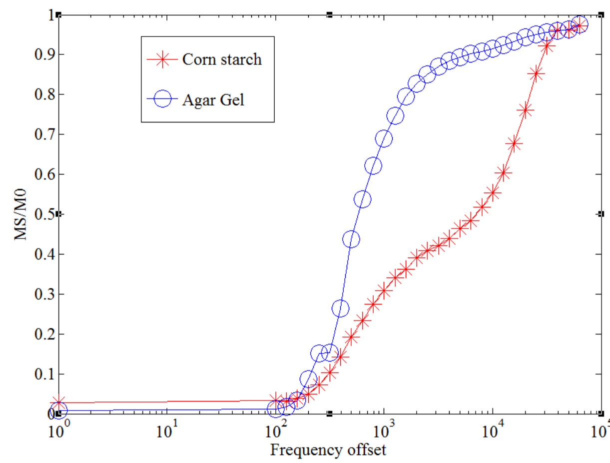

Fig. 3: MS/M0 ratio vs Irradiation pulse frequency offset curves

Results: The T1 value of solution with corn starch was intermediary between the T1 value of agar gel and the T1 value of agar + gadolinium.

	T1(ms)	T2(ms)	T2*(ms)	D(mm²/s)
Corn starch	796 ± 138	4,9 ± 0,2	4,2 ± 0,2	5,5 x 10^{-4}
Agar gel	2507 ± 28	67 ± 3	66 ± 3	1,6 x 10^{-3}
Agar gel+gad	400 ± 6	62 ± 2	55 ± 2	1,6x10^{-3}

Tab. 1: T1, T2, T2* (in ms) and D value (mm^2/s) for the three tubes

(**Tab. 1**). The T1 map (not shown) had non-uniform T1 values within the tubes containing corn starch (**Fig. 2**). T2 and T2* of corn starch solutions were significantly shorter than those in the reference tubes with agar and agar + gadolinium. The value of D was significantly smaller in the solution with corn starch than in the agar tubes. The MS/M0 ratio curves (**Fig. 3**, where M0 represents the signal in the ROI for the image without pulse while MS with the irradiation pulse) of the corn starch solutions were markedly different than the agar gels, arriving at plateaus of widely different frequency offsets.

Conclusions: The dilatant, non-Newtonian fluid of the corn starch solution with water displays interesting MR relaxation characteristics, with low T2 and T2* values and a low T2/T1 ratio. As such, it could serve as a valuable phantom for testing short T2 and T2* as we typically have *in vivo*.

Reference

1. Cornillon P, Salim L C. Characterization of water mobility and distribution in low and intermediate-moisture food systems. *Magn. Reson. Imag.* 18(2000)335–341
2. Kou Y, Dickinson L C, Chinachoti P, Mobility characterization of waxy corn starch using wide-line [1]H NMR. J. Agric. Food Chem. 48(2000):5489-5495.