Investigation of the fate of different fat emulsion meals in the Gastro-intestinal using MRI and MRS

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Background: The relationship between meal structure and composition, the way the meal is handled by the body and the resulting sense of satiety are critical to understanding how to control and reverse the rising tide of obesity. MRI can monitor gastrointestinal **(GI)** function[1,2], including the spatial distribution and emptying rates of fat and water in the stomach separately[3,4,5] and these parameters can be related to hormonal responses and the sense of satiety[6]. This work aims to determine the effect of emulsion microstructure on the handling of fat by the GI tract, using model fat emulsion meals and MRI and MRS to monitor the response of the GI tract. Since emulsions with larger mean droplet size will usually cream in the acidic gastric environment, Locust Bean Gum **(LBG)** was used to control the emulsion stability. Objective: To determine how emulsion stability and droplet size modulate GI handling of fat emulsions.

Methods: Meal preparation: Three emulsion meals were prepared: CONTROL coarse unstable emulsion (mean droplet diameter ~8 µm), COARSE stable emulsion (mean droplet diameter ~7 µm) and a FINE stable emulsion (mean diameter ~0.4 µm). The CONTROL meal contained 79% water, 20% sunflower oil, 1% Tween20 emulsifier, sweetener and flavouring. For COARSE and FINE meals the water was replaced by 0.6% LBG solution. Emulsions were blended at 13,500 rpm: CONTROL for 20 min, FINE and COARSE for 5 min. FINE emulsion was then passed through a high pressure Microfluidizer. Subjects: The study was approved by the local Ethics Committee. 11 healthy male volunteers aged 18-35 years with no history of GI disease attended on 3 mornings each having fasted overnight. Initial baseline scans were acquired and then the volunteer was given 300g of a meal (60g fat in total) in random order. Scanning was performed hourly for 5 hours. Scanning: Abdominal scans were acquired using a Philips 1.5T Achieva MR scanner and SENSE-body coil in ~15 min: 40 transverse slices acquired in two 13s breath-holds, flip angle=80°, TR/TE=2.8/1.4ms, FOV=400mm, in plane resolution 1.56x1.56mm, SL=7mm, SENSE 2.0. Proton spectroscopy to determine intragastric fat distribution: STEAM (90°x90°x90°), TR=4s, TE=9ms, 2 dummies, resolution=25x25x25mm, spectra bandwidth 1000 Hz, 512 samples, 4 repeats in 24 s; 2 VOIs acquired separately in the upper and lower regions of the gastric lumen corresponding to different components of the gastric contents due to layering in the supine position were identified on the bTFE images. The areas of the water and fat peaks were measured using in-house software, and lipid/water ratios were calculated. To measure Small Bowel Water Content **(SBWC)**: 24 coronal FSE images in a single breathhold, in-plane resolution =1.56x2.83mm, SL=7mm, with no gap between slices. Data were analysed with in-house software[7].

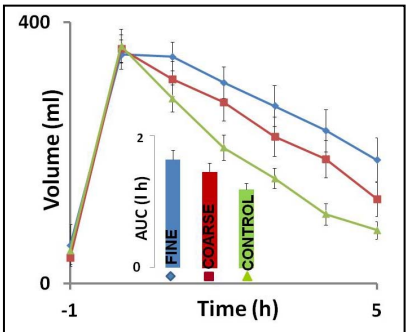

Figure 1 Gastric emptying curves for total meal volume (inset: AUC).

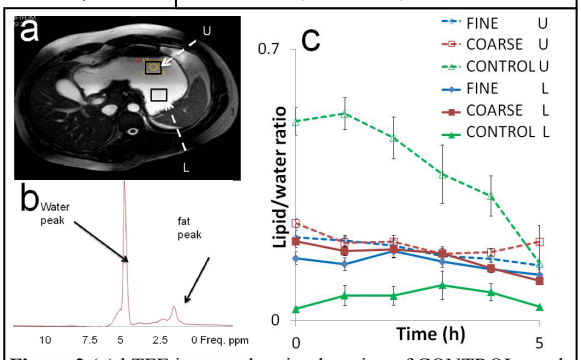

Figure 2 (a) bTFE images showing layering of CONTROL meal and typical Upper (U) and Lower (L) voxels; **(b)** typical spectrum acquired from gastric contents; **(c)** time course of lipid/water ratio measured in U and L voxels.

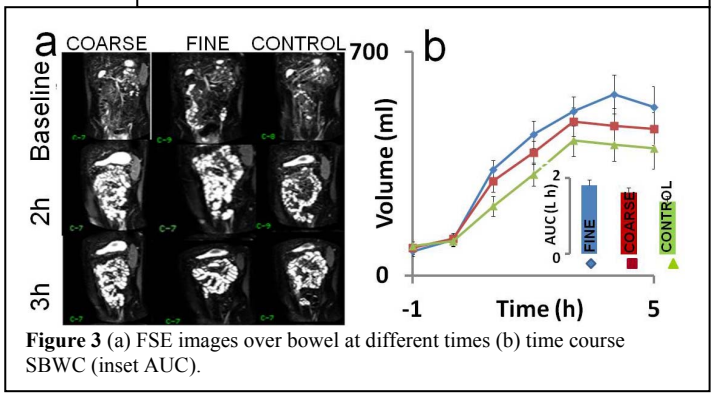

Figure 3 (a) FSE images over bowel at different times (b) time course SBWC (inset AUC).

Results: Fig 1 shows differences in gastric emptying curves (overall $p = 0.006$; FINE vs CONTROL $p<0.01$). Fig 2 shows a typical bTFE image, spectrum and variation of fat content in different regions of the stomach with time, and demonstrates layering of the CONTROL emulsion, but not of the other meals. Fig 3 show SBWC images and volume time course. The FINE emulsion significantly reduced the amount of an ad libitum pasta meal eaten after the experiment compared to COARSE ($p<0.05$) and also compared to CONTROL($p<0.001$).

Discussion: LBG prevented creaming of the FINE and COARSE emulsions. Gastric emptying was faster after CONTROL meal (Fig 1), which is expected since creaming of fat to the top of the lumen away from the pylorus would have led to less fat being delivered to the small bowel early during gastric emptying. For the meals containing LBG fat delivered early during emptying would trigger duodenal receptors which form part of the feedback loop that slow gastric emptying. However the FINE emulsion emptied slower than the matched COARSE emulsion possibly reflecting increased activation of duodenal fat receptors by the FINE emulsion (Fig 2b). The FINE meal induced greater SBWC than both COARSE and CONTROL and reduced the amount of objective pasta meal eaten afterwards. **Conclusion:** MRS and MRI can be used to monitor the GI response to different fatty emulsions. A highly emulsified stable emulsion leads to delayed gastric emptying (generally associated with an increased sense of fullness) and increased SBWC (generally associated with increased fat).

References: [1] Marciani et al. JMRI, 2005, 21, 82-85. [2] Schwizer, W. at al. Digestive Diseases and Sciences, 1994. 39(12): p. S101-S103. [3] Marciani et al. Brit. J. Nut., 2006, 95, 331-339. [4] Kunz, P. et al. Journal of Magnetic Resonance Imaging, 2005. 21: p. 383-390. [5] Boulby et al. Neurogastroenterol Motil, 1997. 9, 41-47. [6] Marciani et al. Am J Physiology, 2007. 292, G1607-G1613 [7] Hoad et al. Phys. Med. Biol. 52 (2007), 6909-6922.