A novel biorelevant in vitro dynamic digestion simulator reproducing the biomechanics of the gastrointestinal tract Structure

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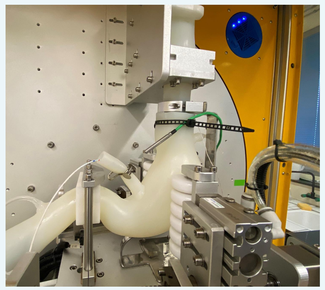
INTRODUCTION AND OBJECTIVES

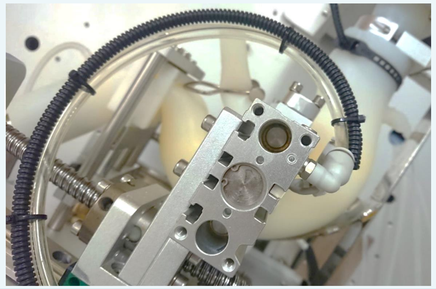
- ✓ The biomechanics of the gastrointestinal strongly influence food disintegration and digestion in vivo. Most currently available in vitro dynamic digestion models lack, however, the ability of mimicking the gastrointestinal morphology and contractions, possibly overlooking the effect of mechanical forces in the digestive process.
- ✓ The Near Real Digestive Tract system (NERDT) is a biomechanically-relevant digestion simulator that has a silicon real-size models of human oesophagus and stomach (Peng et al. 2021). It mimics the gastrointestinal anatomical structures, biochemical environments and dynamic aspects present in vivo in adult humans.
- ✓ **Aim of the study**: To reproduce the gastric emptying curves and evolution of gastric pH of different food matrices based on existing literature data

MATERIALS AND METHODS

A J-shaped stomach model is fabricated based on a 3D-printed wrinkled internal mould of the human stomach. A dual-sensor pH-catheter records pH at 2 different locations in the stomach model (fundus/body). The liquid fraction of the digesta flows out from the stomach through the pylorus



The stomach system can be continuously inclined −40° to +40° (anticlockwise and clockwise rotation). Rotation promotes or delays the movement of digesta from the body toward the antrum and pylorus.

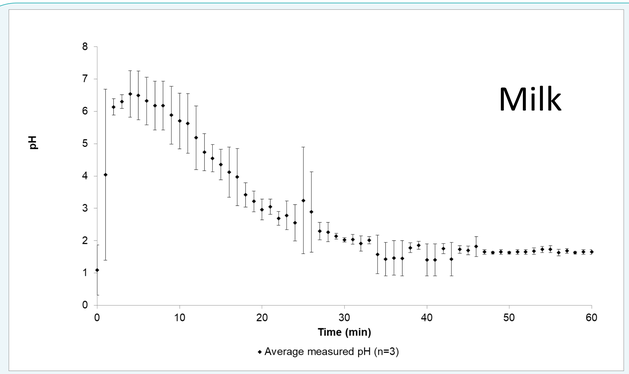


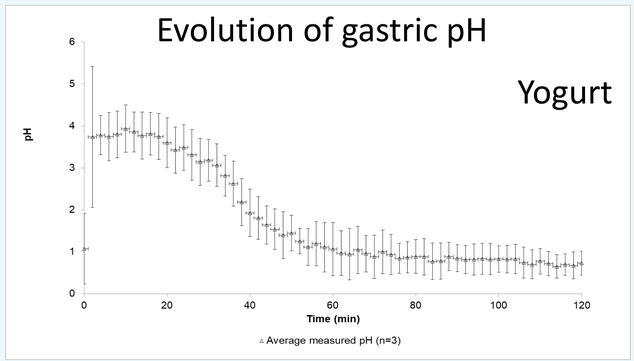
Experiment

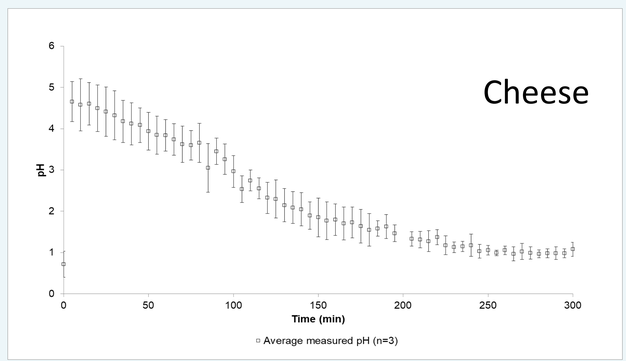
Food matrices tested:

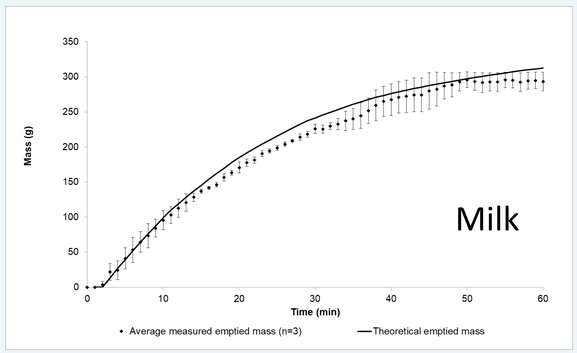
- water (250 mL)
- 10% skimmed milk powder (200 mL + 50 mL Simulated Salivary Fluid SSF)
- yogurt (200 g + 50 mL SSF)
- cheddar cheese (100 g+100 g water + 50 mL SSF)

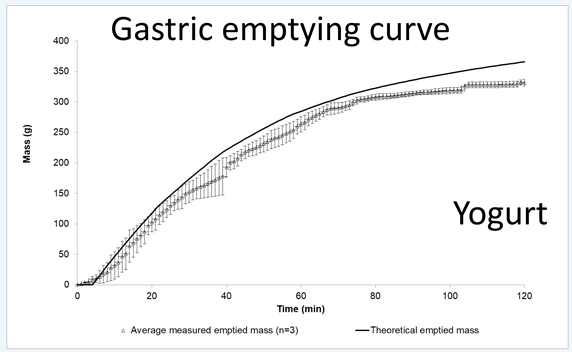
- Milk, yogurt and cheese were mixed with before or during ingestion with SSF
- Cheese was ground in particles of ≈3-5 mm
- Acidification was performed with 0,5 M HCl at T=37°C
- Gastric emptying curves were modified by a modulation of the rotation (tilting angle)/time, the initial angle of rotation, HCl and Simulated Gastric Fluid flow and the pylorus opening size

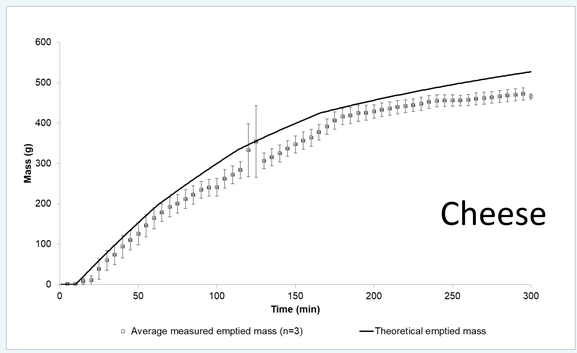












RESULTS

- The flow rate of simulated gastric fluid and the concentration of pepsin were calculated to obtain a pepsin activity of 2000 U/mL in the gastric compartment at 2 t½, while the flow of HCl was designed to reach pH 2 in a time interval between t½ and 2 t½ as proposed by (Mulet-Cabero et al. 2020)
- The pH Values (Top) recorded are in accordance with data measured in vivo on the content of the human upper gastrointestinal tract (Carrière et al. 2001; Kalantzi et al. 2006).
- The measured gastric emptying profiles in every experiment matched the expected target emptying curves with a good level of accuracy and a high level of repeatability was also observed through the experiments.
- Non-uniform emptying of meal contents as well as non-homogeneous mixing in the stomach did not affect the reproducibility of the system; on the other hand, they confirmed the ability of the NERDT system to reproduce physiological phenomena taking place in vivo.

Ground cheddar cheese – starting material

Cumulative digesta emptied from the stomach at the end of a typical experiment

CONCLUSION

The parameters of the NERDT can be set to reproduce the gastric emptying and pH curve observed *in vivo* for foods
The emptying can be predicted and instrument parameters modulated to achieve the desired emptying kinetics for each type and amount of food

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