An Engineering Approach to Study Food Digestion

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UNIVERSITY OF BIRMINGHAM: SCHOOL OF CHEMICAL ENGINEERING

- Founded in the early 1900's as department of oil engineering, changed to chemical engineering in the 1940's, one of the largest chemical engineering schools in the UK
- Focused on research into formulation engineering, with a large food formulation group

INTRODUCTION: GUT RESEARCH GROUP

- Working towards an understand of the processes and phenomena occurring during digestion
- Understanding will help develop functional foods to help combat food related diseases.
- Research carried out with a experimental model, Dynamic duodenum (DDuo), and computational modelling
- Digestion system can be treated as a series of ideal reactors (fig. 1)
- The *in-silico* model analyses the effect of gastric emptying rate and mass transfer within the small intestine (SI) on absorption rate of nutrients as case study.

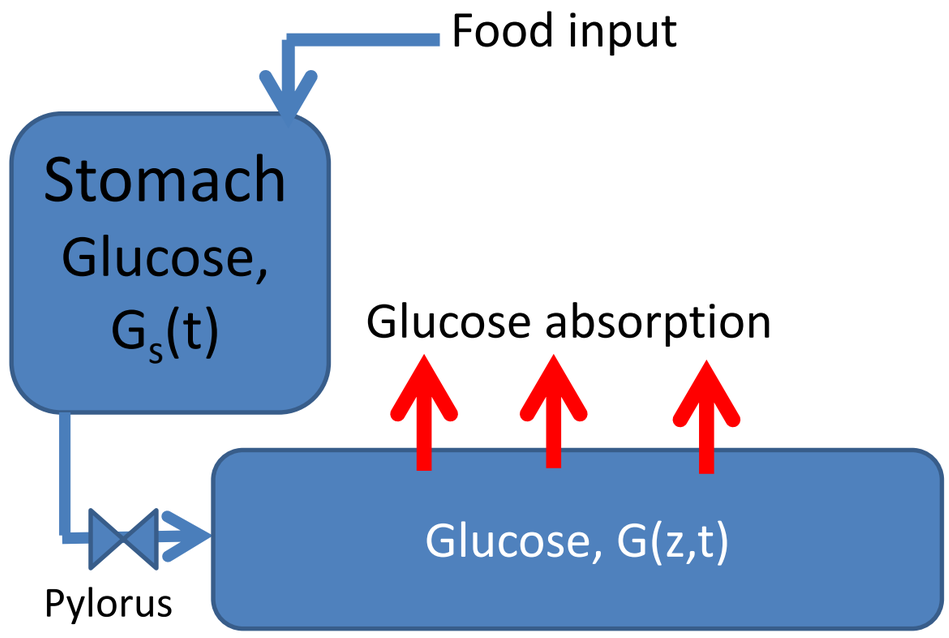

Figure 1: model of digestive system as a series of ideal reactors

$$\frac{\partial G_s(t)}{\partial t} = -\gamma . G_s(t) \qquad \textit{Eq. 1}$$

$$\frac{\partial G(z,t)}{\partial t} = -\vec{u} . \frac{\partial G(z,t)}{\partial z} - \frac{2.f}{r_m} . K . G(z,t) \qquad \textit{Eq. 2}$$

METHODS

- Stomach content modelled as exponential decay- Eq.1
- SI modelled as advection-reaction equation- Eq.2
- Absorption is a function of the mass transfer coefficient (K) – evaluated from the relationship between Sh, Re, and Sc
- Protrusions and folds within the SI increase the surface area for absorption (parameter f in *eq. 2*)

RESULTS

- Longer half-times of gastric emptying (fig. 2) resulted in slower initial rate of absorption, and lower glucose absorption after 3h (fig. 3)
- Fractional glucose absorption after 3h changed with mass transfer and emptying rate (fig. 4)
- Fig. 4 can be split into 4 regimes:
  - A: emptying rate is limiting
  - B: both emptying rate and mass transfer rate are limiting
  - C: mass transfer rate is limiting
  - D: near maximum absorption is reached.

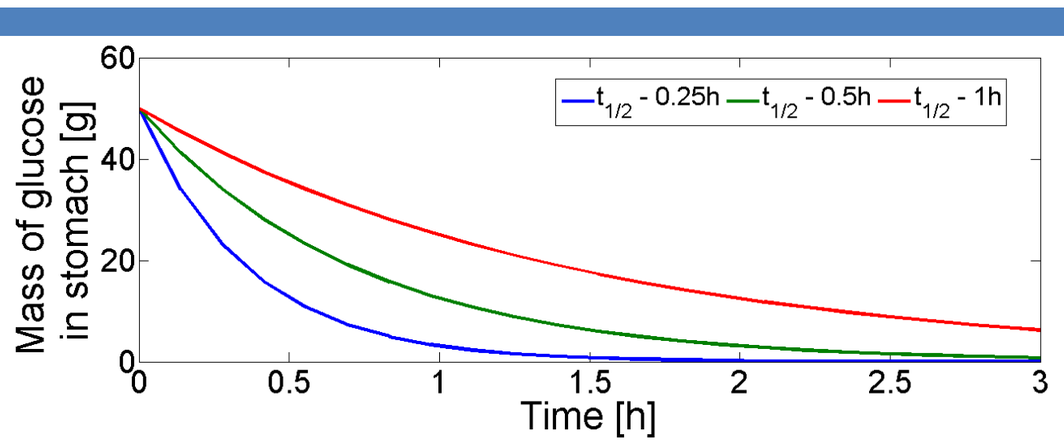

Fig. 2: stomach mass for 3 different gastric emptying rates

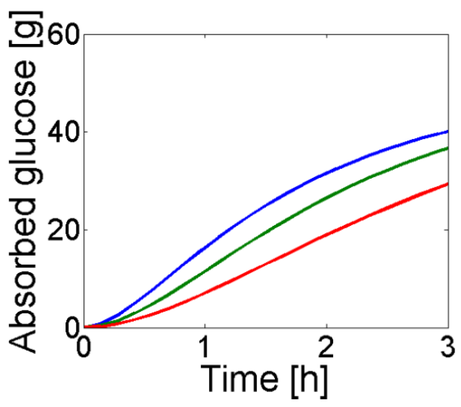

Fig. 3: absorbed glucose for 3 different gastric emptying rates

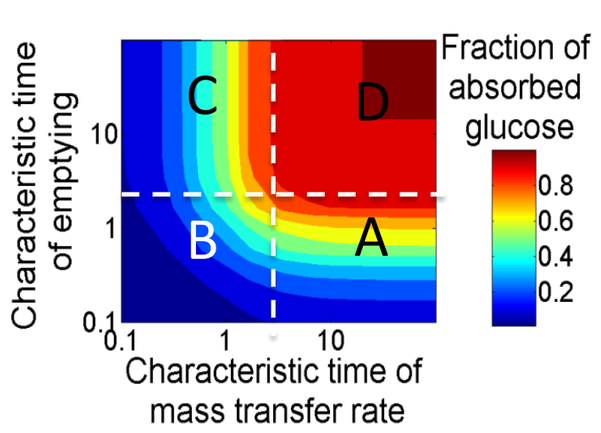

Fig. 4: contour plot of fractional glucose absorption

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