P-049

# Survey of *in vitro* models for gastric transit of food – relevance for encapsulation and targeted delivery

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## INTRODUCTION

A correctly balanced diet is known to contribute to the well-being and healthy ageing of humans. Although manufactured foods are safer than ever, excessive food intake in conjunction with a decrease in physical activity has led to an increase in lifestyle-related diseases (such as obesity, cardiovascular diseases, type-2 diabetes, a range of cancers and arthritis) in most Western countries. As consumers become more health conscious, food manufacturers are pursuing innovative ways to produce food that can deliver specific health benefits without compromising the taste or quality of their products. Incorporation of bioactive compounds, or 'nutraceuticals', into food systems can provide a simple way of developing novel 'functional foods' with health-promoting and/or disease-preventing properties. Well-accepted examples of functional foods are probiotic drinks or cholesterol-lowering spreads. Bioencapsulation, i.e. the protection of health-promoting ingredients by means of encapsulation or entrapment is one approach being used in the development of functional foods. This is designed to protect the ingredients of interest during production, storage and gastrointestinal (GI) digestion. However, it is of utmost importance that the health-promoting ingredient is released 'at the right time, at the right place' and delivered to the target site (e.g. the small or large intestine) in a bioavailable form.

### *Food digestion*

There are several standard protocols to simulate the *in vitro* digestion of food. However, most are based on pharmaceutical standard procedures that do not take into account variations in food matrices or even varying amounts of food. In other words, consuming a health beneficial compound with a glass of milk or cola, a bowl of salad or a sumptuous dinner will dramatically affect its bioavailability. Several models (*in vitro* or *in vivo*) have recently been developed to study the digestion of food, however but most of them need validation with human data. The harmonization of such screening models is urgently needed by food industries. Comparing experiences associated with an integrated approach (in silico modelling) could help define the parameters that are essential in such models, making them more physiologically relevant. It would be valuable for the scientific community to share relevant and more standardised protocols that could be used. Since digestive conditions change significantly during human life, it seems crucial to have not one but several models specifically designed for the different population types (infant, adult and elderly), for different food types and for different purposes such as validation of encapsulated ingredients.

## MATERIALS AND METHODS

Rather than reviewing the vast literature on the subject of food digestion, a survey was undertaken of food scientists with background experiences related to GI digestion of food and pharmaceuticals. Initially, the survey was limited to members of the recently established COST action FA1005 Infogest (Dupont et al. 2011). A Microsoft Excel® based questionnaire was sent to approximately 50 scientists and commercial operators, resulting in 18 responses to date with more than 30 gastric transit procedures, most of them are published. Parameters included standard conditions as outlined in Figure 1, such as pH, $Na^+/Ca^{2+}$ concentration, ionic strength, temperature, residence time, choice and source of enzyme including activity, mechanical condition, substrate (amount, structure, pre-treatment), presence of internal standards, static vs. dynamic model, infant/adult/elderly model. In addition, published material was provided in cases where the *in vitro* methods were correlated to *in vivo* experiments.

## RESULTS AND DISCUSSION

The collected data were compiled and attempted to classify by groups, such as digestive phase (oral, gastric, intestinal), *in vitro/ex vivo/ in vivo*, dynamic/static models, population types (infant, adult and elderly), purpose of GI, compartmentalised/simple set up etc. At a first glance, procedures are fairly similar, however, closer examination revealed subtle but significant differences, for example very high/low substrate to enzyme ratios, gastric residence times and presence/absence of non-proteolysis enzymes such as lipases or amylases, presence of internal standards for validation and even gastric/intestinal pH.

While static models, i.e. samples are placed straight into high concentration buffers of low (stomach) or high (intestine) pH, are widely used as rapid and robust evaluation or proof of concept studies, there are a surprisingly high number of dynamic digestive models being used. Dynamic models usually involve instrumental/computer directed pH control or gradients and are thought to be more accurate.

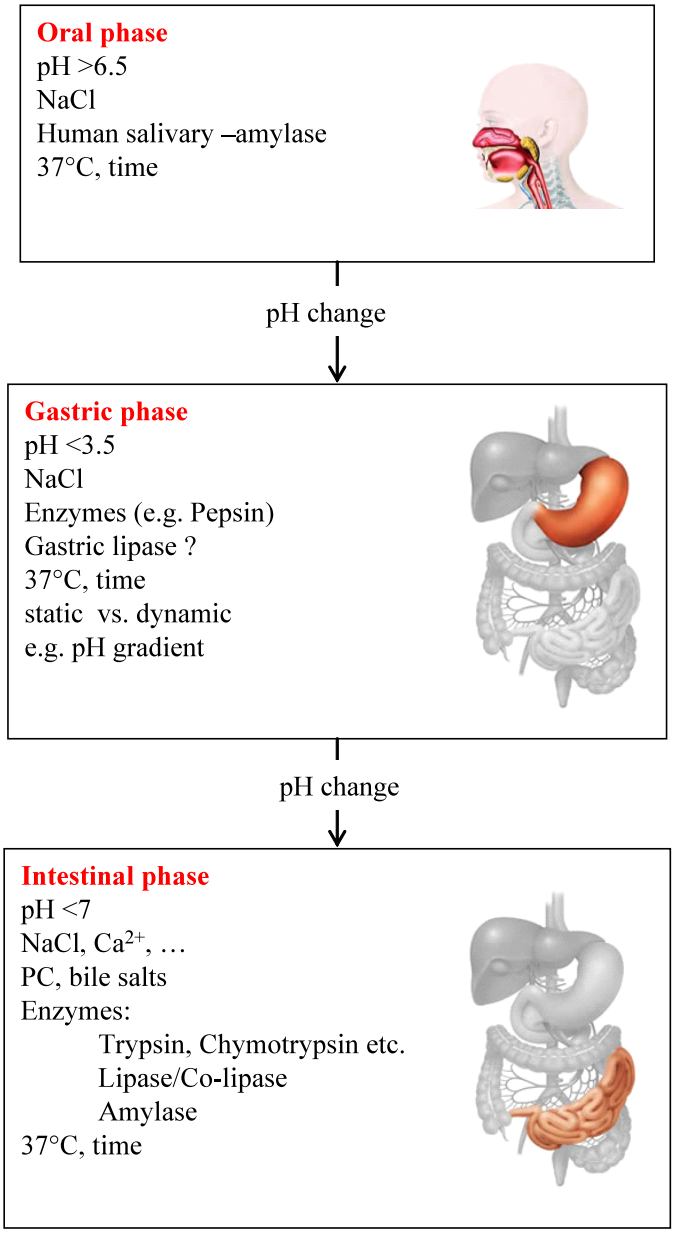


**Figure 1: Schematic of some *in vitro* digestion parameters compiled in a survey of commonly used digestion procedures**

In this paper, some of the significant digestive parameters will be presented and put into context with available *in vivo* data.

Although both literature and survey provide a large number of digestion procedures, very little comparative work has been done on the subject (Dupont *et al.* 2010), i.e. several procedures using the same substrate. It is therefore envisaged:
(i) to expand the outlined survey to a wider scientific and industrial audience, including those who use bioencapsulation to deliver bioactive ingredient in food matrices
(ii) to plan and complete a round-robin experiment for *in vitro* digestion
(iii) to test and validate digestive models with known encapsulation systems

## CONCLUSIONS

It is one of the aims of the COST action INFOGEST to use some selected *in vitro* procedures on foods and food components (including encapsulation matrices) and compare the results to newly generated or available *in vivo* data. Deliverables of these comparative studies will be standard operational procedures (SOP) for GI transit with identified and validated critical process parameters (CPP), which are fit for one particular purpose at a time. The SOP's are validated against relevant *in vivo* models. Both SOP and CPP will be available to both the academic and industrial research community.

## REFERENCES


- COST action FA1005 Infogest (2011), http://www.cost.esf.org/domains_actions/fa/Actions/FA1005
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