In vitro digestion procedures to estimate the (micro)nutrient bio-availability of foods

Identification

Key words in vitro digestion, bio-availability, bio-accessibility, nutrient, carbohydrate, starch, fat, protein, allergen, vitamin, antioxidant, carotenoid, mineral

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How does it work?

Primary objective Analytical tool

In vitro digestion procedures are rapid, cost-effective and high through-put analysis methods to measure the bio-accessibility of (micro)nutrients in food systems, that is an estimation or prediction of the (micro)nutrient bio-availability in those food systems.
**Working principle**

The bio-availability of (micro)nutrients, (the fraction of ingested nutrients available for utilization in normal physiological functions or storage), depends on many host- and diet-related factors. The food matrix in which the (micro)nutrient is incorporated affects (micro)nutrient release, a critical step for (micro)nutrient absorption. In this context, the (micro)nutrient bio-accessibility has been defined as the fraction of ingested (micro)nutrients that is released from the food matrix (to mixed micelles) and thereby made available for absorption.

By simulation of human digestion, (micro)nutrient bio-accessibility can be measured in vitro. Hereto, numerous digestion models have been developed to simulate the physiological conditions and sequence of events that occur during digestion in the human gastrointestinal tract. Most of these in vitro models include an oral, gastric and intestinal phase, but the model complexity varies. The most simple, basic models, are called static or biochemical models and involve the use of digestive enzymes (most commonly amylases, proteases and lipases) and fluids to simulate and measure the release of (micro)nutrients or the transfer of (micro)nutrients to micelles during gastric and intestinal digestion. To simulate in vivo absorption of (micro)nutrients, divers models such as Caco-2 human intestinal cells can be used. More complex, multicompartmental models, such as the TNO intestinal model (1) and the dynamic gastric model (2), take into account the dynamic character of the physiological digestion process. Recently, also models, critically taking into account mechanical disintegration during oral and gastric digestion have been developed (3, 4). In vitro digestion procedures have been shown very useful to estimate or to predict the (micro)nutrient bio-accessibility. As the models are cost-effective and in general rapid methods, they are increasingly used for high through-put analysis to screen the bio-availability for large numbers of samples. It is however difficult to accurately simulate human digestion as in vivo digestion will be dependent on the host and on the amount and type of food that is consumed. No standard in vitro digestion procedure is thus available. Because in vitro tests are moreover being developed depending on the (micro)nutrient and on the food matrix that are studied, experimental parameters across in vitro models can differ remarkably. Therefore, it is advised to carefully interpret results obtained by in vitro digestion analysis and to avoid comparison of the absolute values (5). For comparing differently processed samples, in vitro digestion methods however have been shown extremely useful. Most predominant food systems tested by in vitro digestion analysis include plant-based foods, meat, fish, dairy, and emulsion-based foods (6). In vitro digestion research has been shown very useful in the context of for example targeted release of bio-active micronutrients, structural design for tailored fat digestion, understanding the fate of proteins to comprehend the basis of food allergies which is for example important in the context of GM crops (7), analysis of glycaemic properties of foods (8)...

**Images**

**Additional effects**

In vitro digestion methods are useful in the context of targeted release of bio-active micronutrients (cf. carotenoids), structural design for tailored fat digestion (cf. satiety, satiation), understanding the fate of proteins (cf. food allergy in for example GM crops), analysis of glycaemic properties of foods...

**Important process parameters**

Knowledge on human digestion is a prerequisite to develop an in vitro digestion procedure specific for a particular (micro)nutrient in a particular food system and an advantage to interpret results obtained by in vitro digestion tests. Most commonly used enzymes are amylases, proteases and lipases.

**What can it be used for?**

**Products**

Plant-based foods, meat, fish, dairy, emulsion-based foods...

**Operations**

Product development (assessment of nutritive value)
Solutions for shortcomings
Product development for personalized nutrition.
Cost-effective and high throughput analysis

What can it NOT be used for?

Products
None
Operations
Not applicable
Other limitations
These systems remain in vitro approximations of in vivo digestibility. Incomplete knowledge on human digestion processes can limit accuracy of in vitro procedures.
Risks or hazards

Implementation

Maturity
Different in vitro digestion procedures (for specific (micro)nutrients in specific types of food matrices and with different degrees of complexity) are available. Continuously, models are further developed and new models are developed. Validation of different in vitro procedures under a variety of conditions and critical evaluation of the procedures could further improve the methods.
Modularity
Not applicable
Implementation
Not applicable
Consumer aspects
Not applicable
Legal aspects
Not applicable
Environmental aspects
Not applicable

Facilities that might be interesting for you

Title
Auditorium IRTA
Clean room – Histocell
Video observation system for market research and product development tasks - Keki
Institute/company
IRTA
Noray
NAIK EKI

Further Information

Institutes
KU Leuven LFT, IFR, TNO Institute, University of Massachusetts Amherst
Companies
References
