In vitro amino acid digestibility and availability

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Declaration of Interest

- My primary research focus lies in food digestion, aiming to understand the mechanisms of food breakdown in the different compartment of the gastrointestinal tract and its consequences on human health (infant, adult, elderly)

- I disclose the following [*financial, professional or other*] interest directly relevant to the topic of discussion.

Declaration of Interest

Type of interest, and basic descriptive details.	Name of company, organization, or institution	Current interest (or year ceased)
1. Employment and consulting including service as a technical or other advisor, or other type of management relationship*		
2. Research support including grants, collaborations, sponsorships, other funding and non-monetary support*	Sodiaal, Mondelez, Agro-Mousquetaires	Joint research projects
3. Financial relationship, including current stock or share ownership or investment interests		
4. Current intellectual property including patents, trademarks, or copyrights (also include pending applications) *		

*Report evidence within the past 4 years

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In vitro amino acid digestibility and availability

Introduction

Didier DUPONT

INRAE, Rennes, France

The digestive process

α-amylase

mouth

chewing and deglutition

esophagus

stomach

storage, grinding and mixing in the stomach

pylorus

Pepsin Gastric lipase

HCl

Fasted pH 1.3-2.5

gastric emptying

Trypsin, Chymotrypsin Pancreatic lipase, amylase

duodenum

pH 6.5-6.8

intestinal transit

Nutrient absorption

small intestine

jejunum

blood

ileum

large intestine
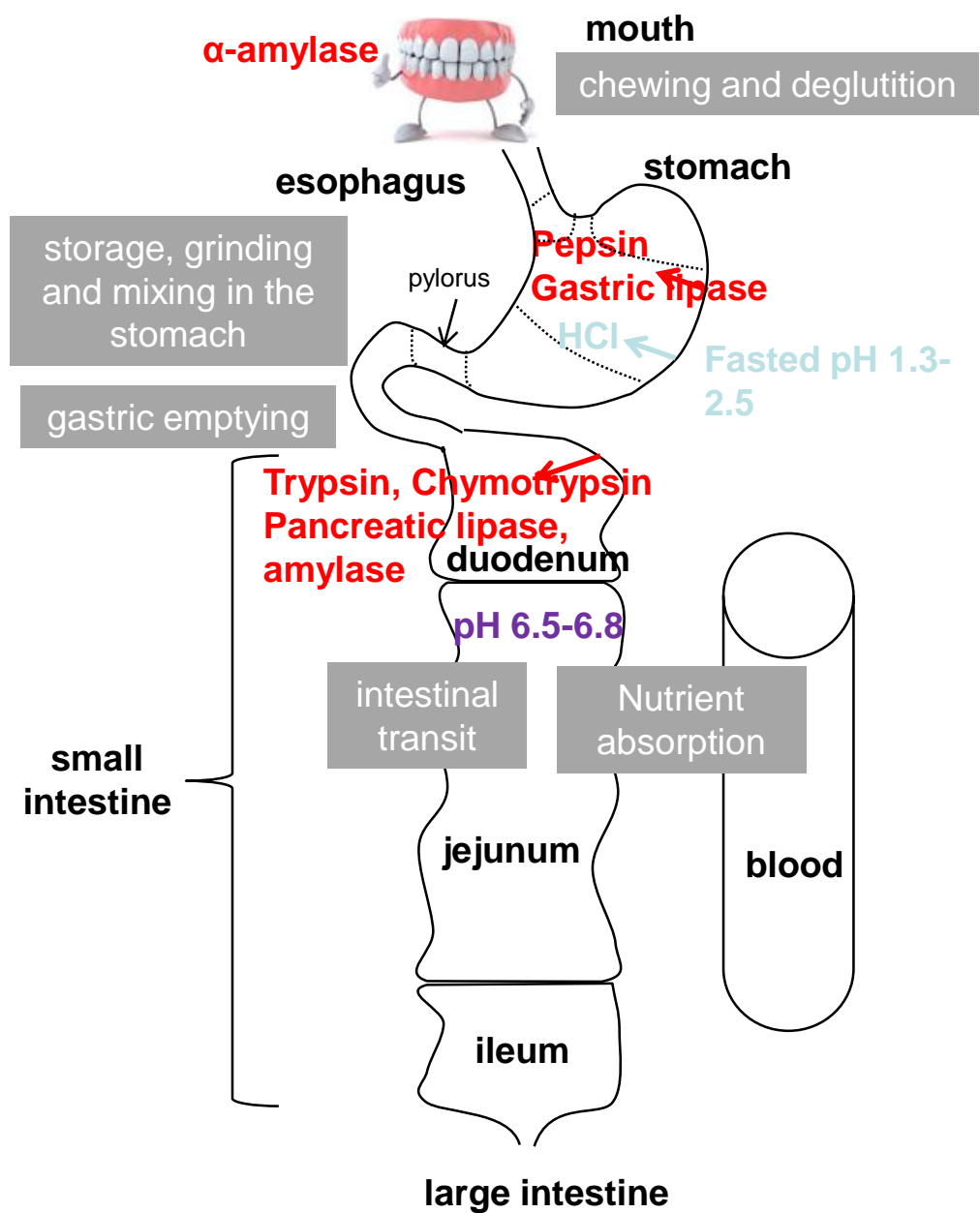
From Roger Lentle, Massey Univ. NZ

Kong and Singh, 2008
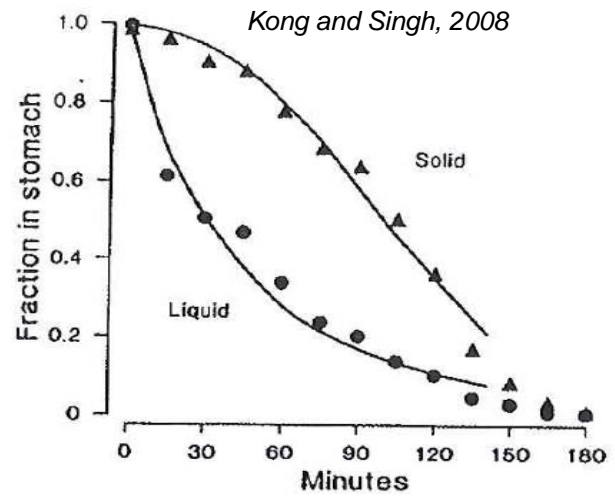
Gastric phase = a very complex but crucial step for the kinetics of the whole digestion process
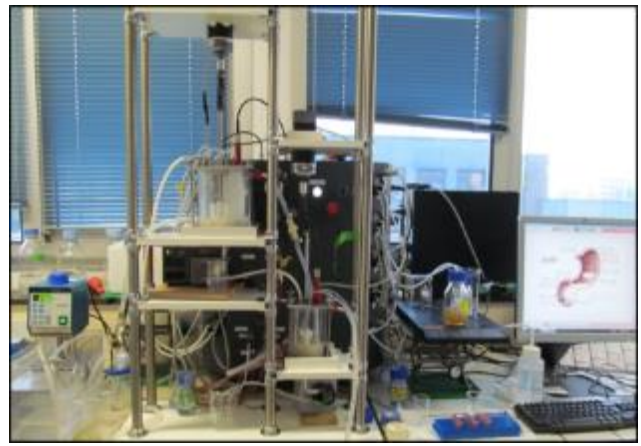
Models available to study digestion

In vitro static models (infant, adult, elderly)

In vitro dynamic models (infant, adult, elderly)

In silico models

$$\Phi_{12} = k_{12whey} \times \left(V_1 - m_{caswpd1} \times \alpha \right) + k_{12aggr} \times m_{caswpd1} \times \alpha$$

Human models

Animal models

Static *in vitro* digestion models: pro's & con's

Consist in a series of bioreactors where the enzymatic and physicochemical conditions of the different compartments of the gut will be mimicked

It is static since the conditions are kept constant throughout the different steps. No flow of the food between the compartments. A step starts when the previous one has been fully completed
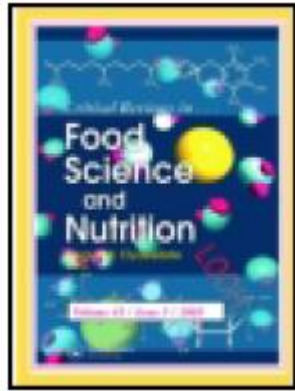
Widely used by the scientific community

Main Reasons :

Ethical - Technical – Financial

Advantages:

Standardisation of the experimental conditions
Good reproducibility and repeatability
Easy sampling, possibility to follow kinetics

Disadvantages:

Impossible to mimic the complexity of the GI tract in a test tube!!!

REVIEW

Check for updates

Correlation between in vitro and in vivo data on food digestion. What can we predict with static in vitro digestion models?

T. Bohn[a], F. Carriere[b], L. Day[c], A. Deglaire[d], L. Egger[e], D. Freitas[f], M. Golding[g], S. LeFeunteun[f], A. Macierzanka[h], O. Menard[d], B. Miralles[i], A. Moscovici[j], R. Portmann[e], I. Recio[i], D. Rémond[k], V. Santé-Lhoutelier[l], T. J. Wooster[m], U. Lesmes[j], A. R. Mackie[n], and D. Dupont[d]

[a]Luxembourg Institute of Health, Strassen, Luxembourg; [b]CNRS UMR 7282 EIPL, Marseille, France; [c]Agresearch, Palmerston North, New Zealand; [d]INRA UMR 1253 STLO, Rennes, France; [e]Agroscope, Institute for Food Sciences, Bern, Switzerland; [f]INRA UMR GMPA 782, Grignon, France; [g]Massey University, Palmerston North, New Zealand; [h]Gdansk University of Technology, Gdansk, Poland; [i]CIAL CSIC-UAM, Madrid, Spain; [j]Technion—Israel Institute of Technology, Haifa, Israel; [k]INRA UNH UMR 1019, Theix, France; [l]INRA UR 370 QUAPA, Theix, France; [m]Nestlé Research Centre, Nestec S.A., Lausanne, Switzerland; [n]University of Leeds, Leeds, United Kingdom

CONTACT Dr. D. Dupont didier.dupont@inra.fr INRA UMR 1253 STLO, 65, rue de St Brieuc, 35042 Rennes Cedex, France.

Calyx
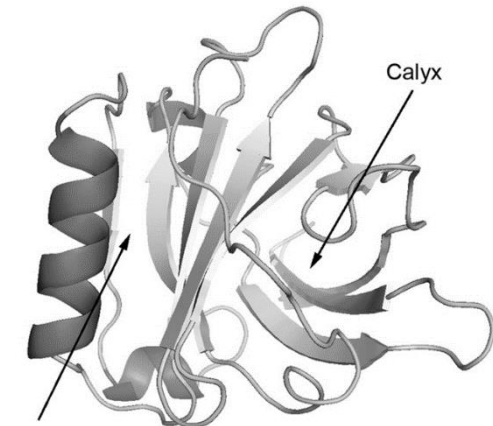
Putative secondary binding site

Interaction with PC slows β-lg gastric digestion

* Static *in vitro* digestion models can be useful to compare series of samples or understand molecular mechanisms

* Static *in vitro* digestion models can be relevant to estimate end-point values such as:
	- Glycaemic index
	- Some micronutrient bioaccessibility
	- Protein digestibility

* Static *in vitro* digestion models are too simple to study more complex phenomena like kinetics of digestion, food structure evolution in the GI tract...

**Bohn et al. 2018
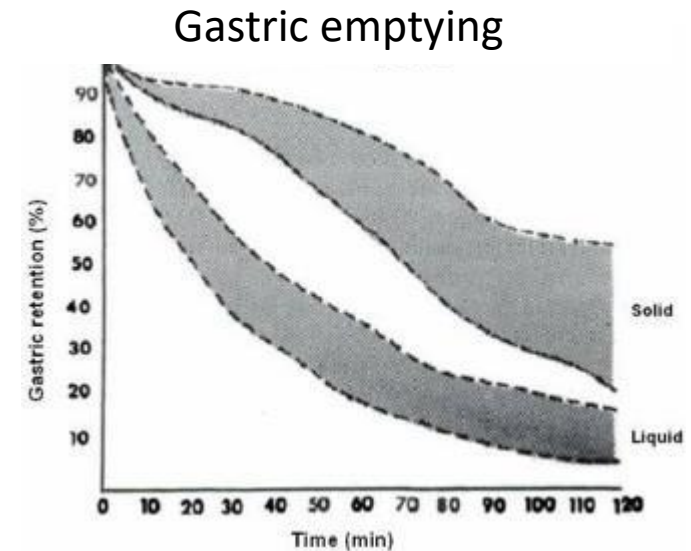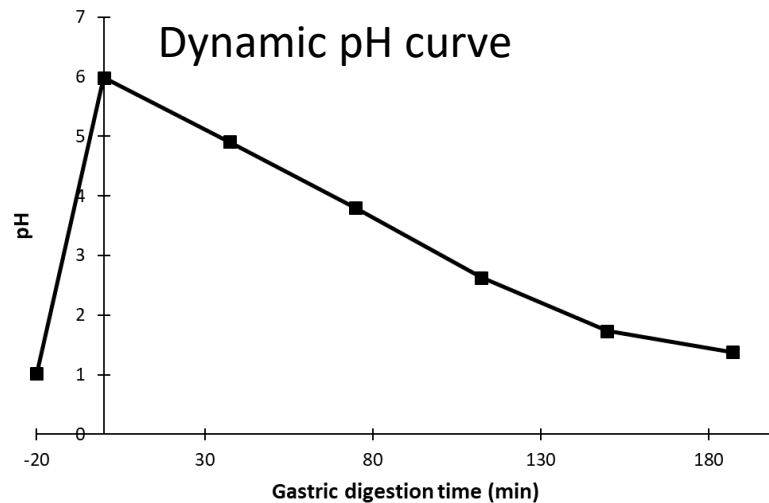Crit Rev Food Sci Nutr
215 citations
Highly Cited**

Semi-dynamic in vitro model

Simulation of:

- ✓ Progressive acidification
- ✓ Gradual enzyme and fluids secretion
- ✓ Continuous emptying

Dynamic pH curve

Gastric emptying

What does it simulate?

Simulation of:
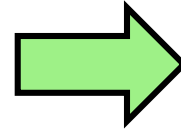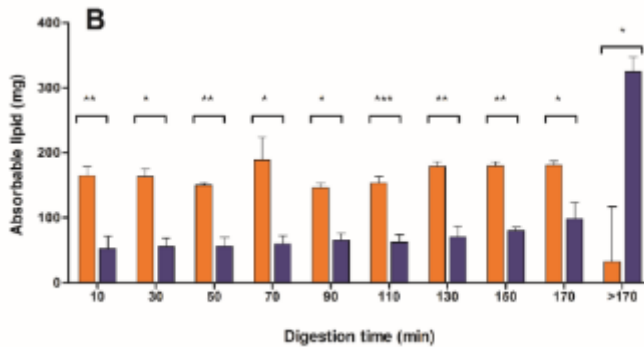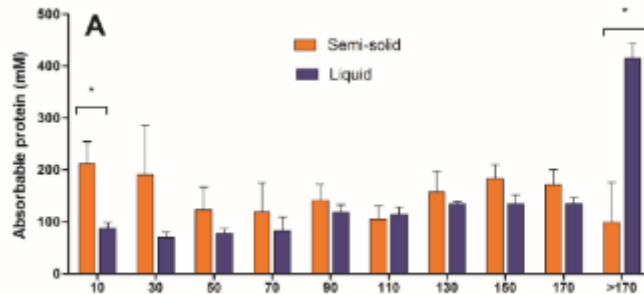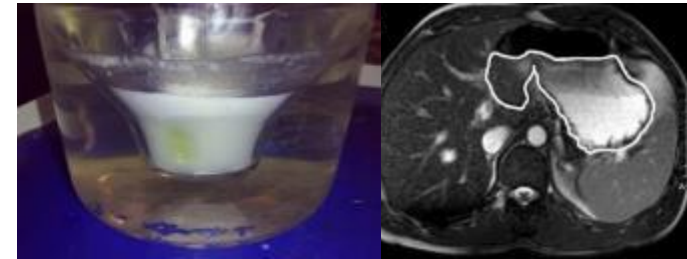
- ✓ Progressive acidification
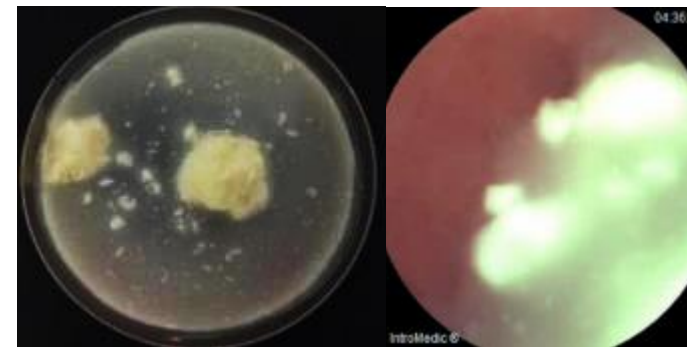- ✓ Gradual enzyme and fluids secretion
- ✓ Continuous emptying

➡️
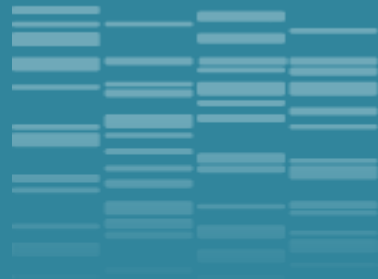- ✓ Rate of nutrient digestion
- ✓ Structural changes in stomach

Layering

Coagulation

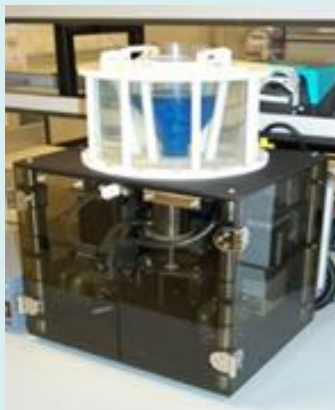**Dynamic *in vitro* digestion models**

Dynamic Gastric Model (DGM)

Human Gastric Simulator (HGS)

Artificial Colon (ARCOL)

Mono-compartmental models

Multi-compartmental models

Digestion Dynamique Gastro-Intestinale (DIDGI)

INFOGEST

Dupont et al. 2018
Crit Rev Food Sci Nutr
167 citations
Highly Cited

Engineered Stomach and small INtestinal (ESIN)

TNO Gastro-Intestinal ModelTIM

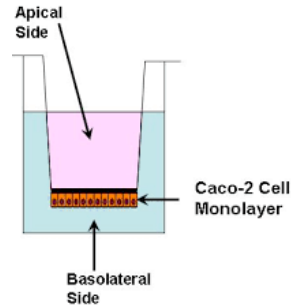SIMulator of the GastroIntestinal tract (SIMGI)

Simulator of the Human Intestinal Microbial Ecosystem (SHIME)

For bioavailability estimation in vitro digestion models must be connected to absorption models

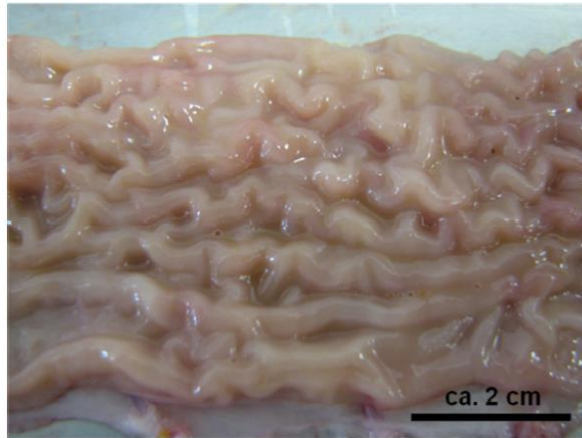The most oftenly used at the international level:

Caco2 cell monolayers
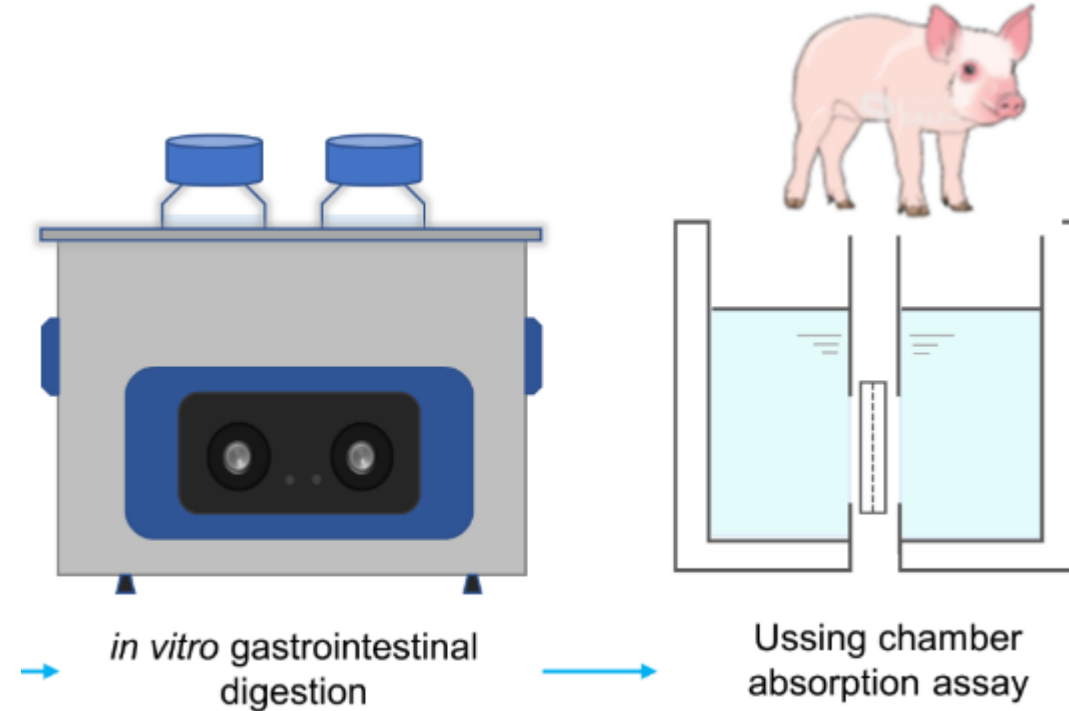

**Kondrashina et al. 2023
Crit Rev Food Sci Nutr**

More promising: coupling *in vitro* digestion with Ussing chambers experiments?

Limit: role of the mucus in absorption?

Porcine Intestinal Mucus

ca. 2 cm

>95% water
>5% mucins
+ cholesterol
+ other proteins
+ DNA

in vitro gastrointestinal digestion
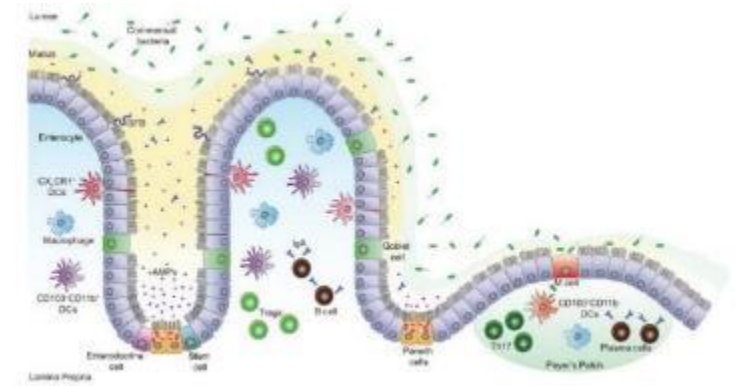
Ussing chamber absorption assay

**Ozorio et al. 2021
Foods, 9 (10), 1415**

More complex models: Caco-2 + HT-29-MTX co-cultures
tri or quadricellular absorption models (with M-cells, immune cells…)

Colon and intestinal microbiota

Hot topic!!!

There are bacteria all over the gastrointestinal tract

Most of the scientific studies are focused on the microbiota found in the colon or in the fecal material

Does the microbiota present in the stomach and small intestine play a role in food digestion?

Beside colonic models, most of the in vitro digestion models mimicking the upper part of the gastrointestinal tract lack of the presence of bacteria
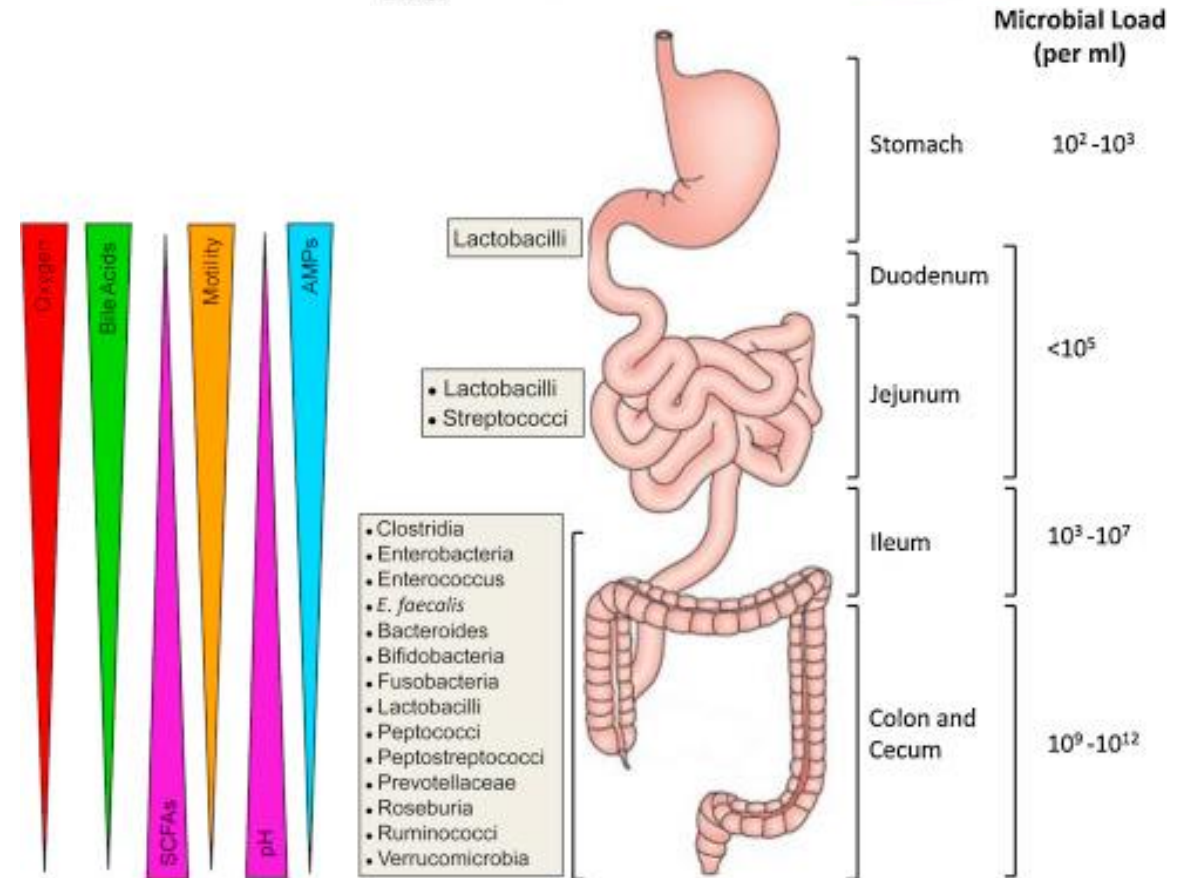
Improving health properties of food by sharing our knowledge on the digestive process

International Research Network

Dr. Didier DUPONT, Senior Scientist, INRAE, France

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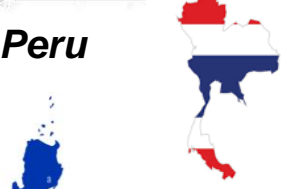
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746 scientists - 250 institutes – 57 countries

INFOGEST
International Conference

**Porto, Portugal
2024**

We are pleased to announce the next
8th International Conference on Food Digestion

in Porto, Portugal, 9-11 April 2024