



Digestion des aliments chez l'homme: Comment la microscopie aide à comprendre l'évolution des structures dans le tube digestif

Steven Le Feunteun, Didier Dupont

► To cite this version:

Steven Le Feunteun, Didier Dupont. Digestion des aliments chez l'homme: Comment la microscopie aide à comprendre l'évolution des structures dans le tube digestif. 11èmes Journées Scientifiques et Techniques du Réseau des Microscopistes de l'INRAE, INRAE, Nov 2022, Rennes, France. hal-03880338

HAL Id: hal-03880338

<https://hal.inrae.fr/hal-03880338>

Submitted on 1 Dec 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

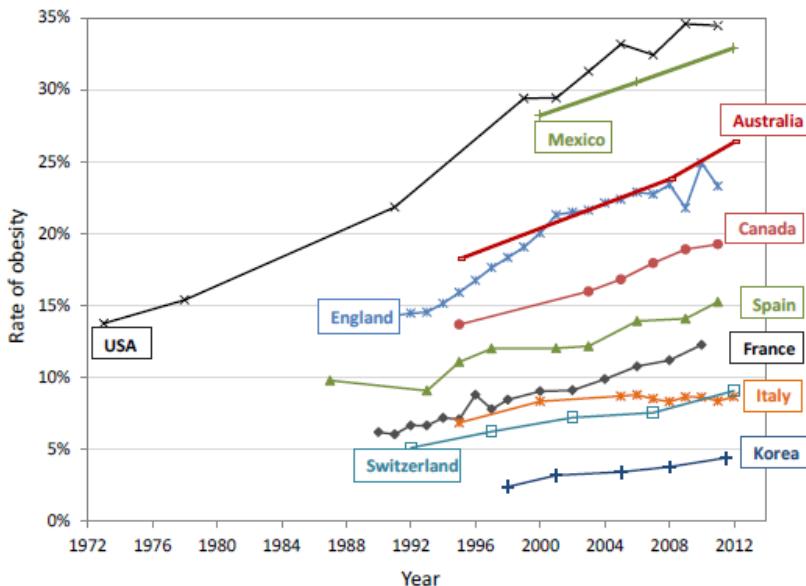


➤ Digestion des aliments chez l'homme:
Comment la microscopie aide à
comprendre l'évolution des structures
dans le tube digestif

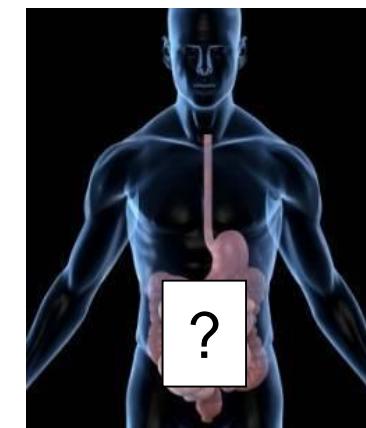
Steven LE FEUNTEUN et Didier DUPONT

INRAE – Institut Agro, STLO, Rennes, France

Food and human health: the key role of digestion



Diet-related diseases ↑
Prevent these pathologies rather than
cure them



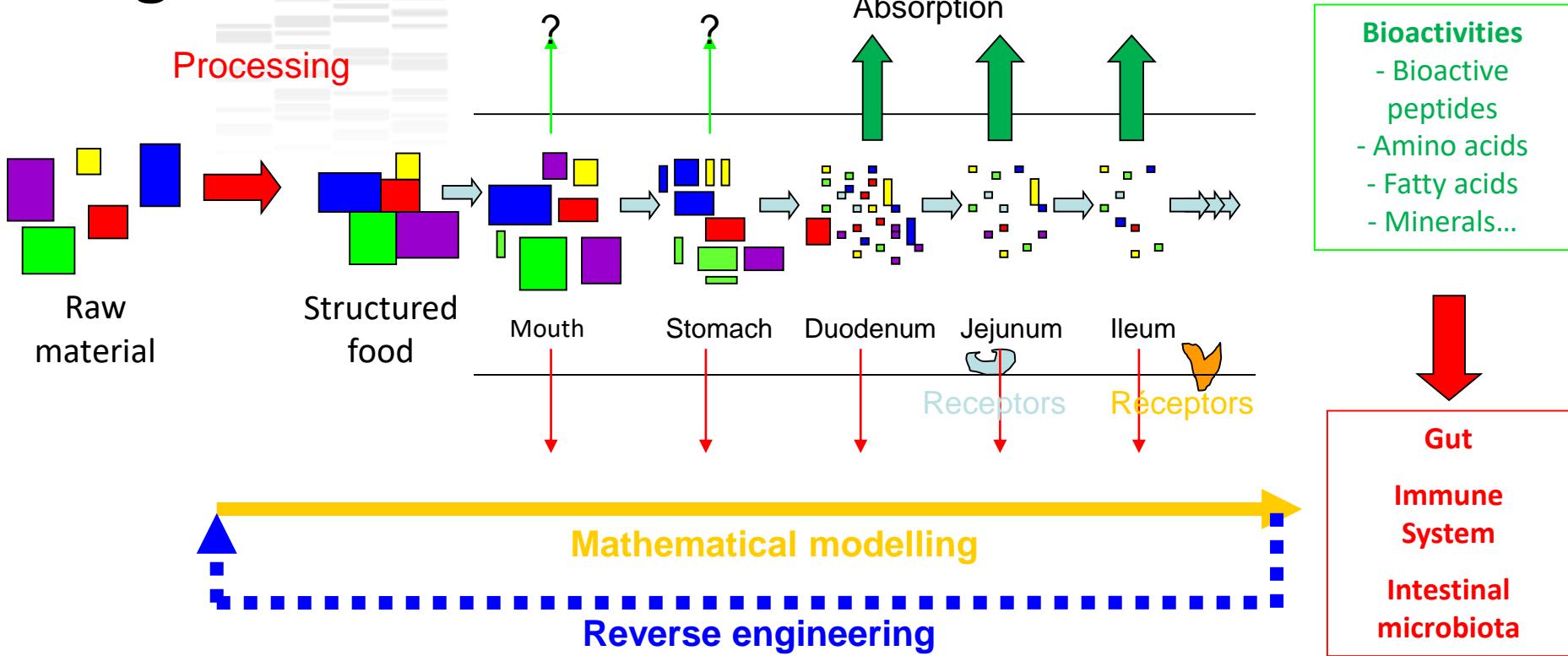
Gut = interface between food and human body

Digestion releases food components that can have a beneficial or a deleterious effect on human health

... but the mechanisms of food disintegration in the gastrointestinal tract remain unclear and the digestive process has been considered as a black box so far

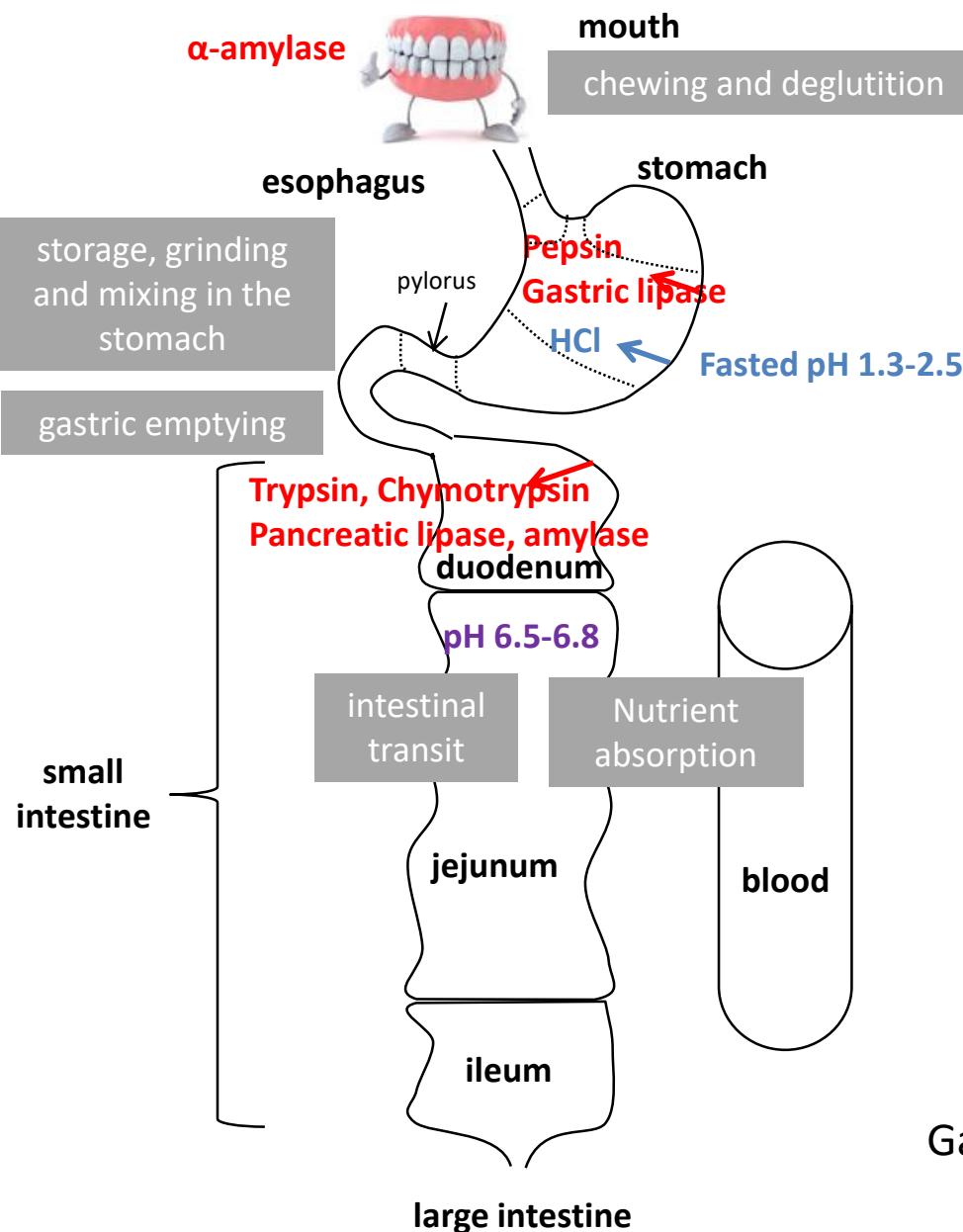
By increasing our knowledge on food digestion, we will increase our knowledge on the effect of food on human health

Our goals

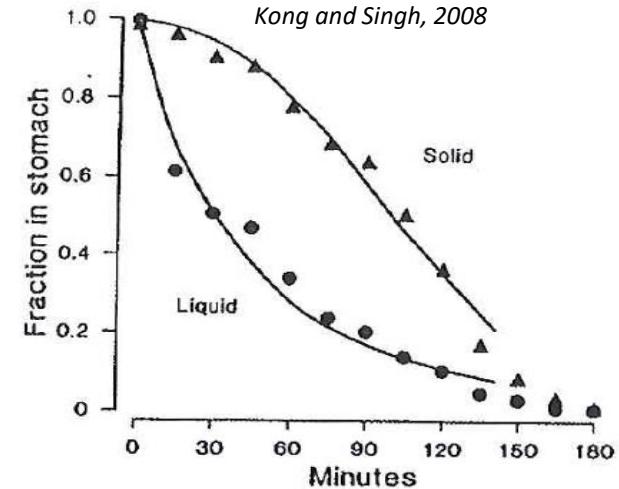


- >To understand the mechanisms of breakdown of food matrices and their constituents in the gut and identify the beneficial/deleterious food components released during digestion
- >To determine the impact of the structure of food matrices on nutrient bioavailability
- To model these phenomena in order to develop a reverse engineering approach

The digestive process



From Roger Lentle, Massey Univ. NZ



Gastric phase = a very complex but crucial step for the whole digestion process

Models available at INRAE for simulating digestion

Dupont et al.
2010ab,
Mol Nutr Food Res

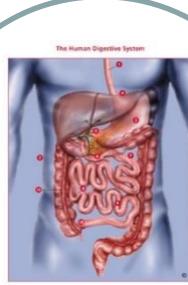


*In vitro static models
(infant, adult)*

Le Feunteun et al.
2014
Food Bioprocess
Tech

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

*In silico
models*



*In vitro dynamic models
(infant, adult, elderly)*



*Human
models*



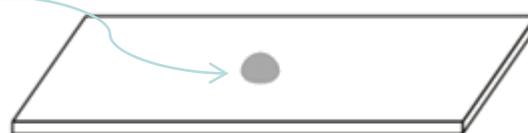
Animal models

De Oliveira et al. 2016
Am J Clin Nutr
De Oliveira et al. 2017
Clin Nutr

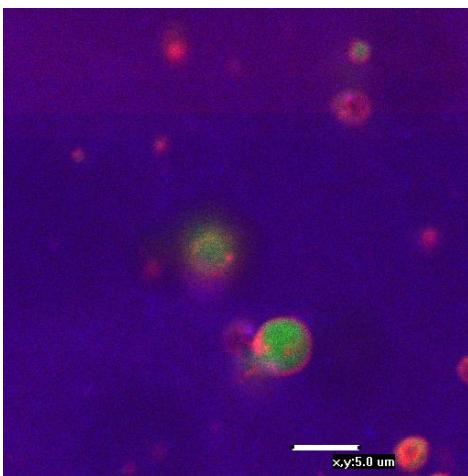
Menard et al. 2014,
Food Chem
Sanchez et al. 2015
Food Res Int

Microscopie confocale

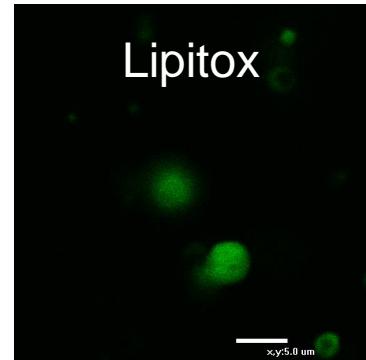
Digestas
+ 3 sondes
fluorescentes



OBS X60

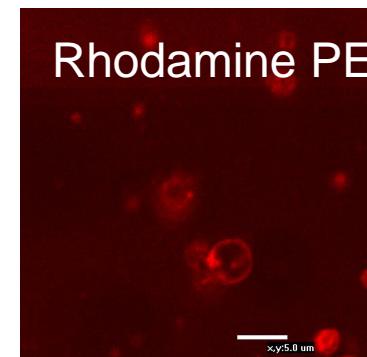


Lipides
Apolaires

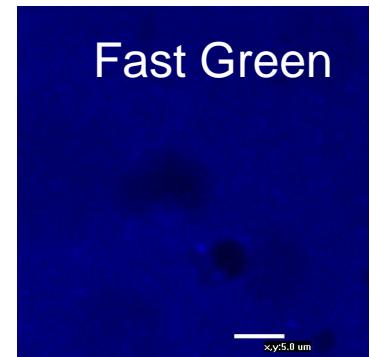


3 sondes

Amphiphiles



Protéines

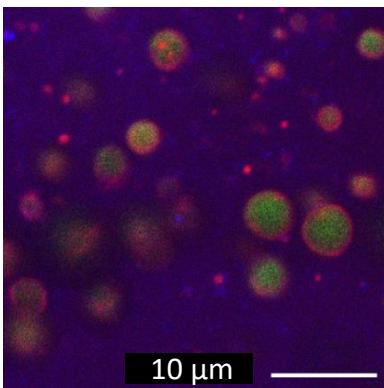


Pasteurization affected the initial structure and the emulsion disintegration of HM

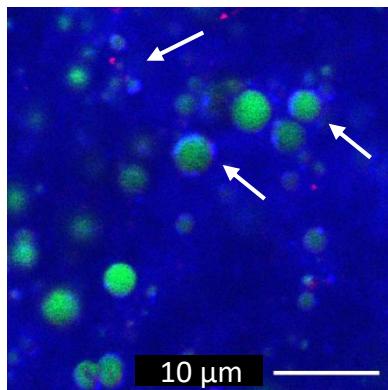
(n = 6 infants)

Initial structure

Raw HM



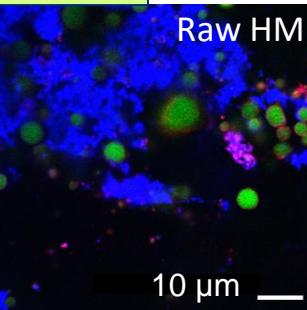
Past HM



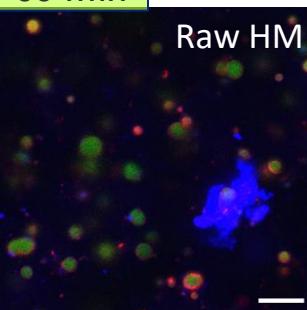
→ Protein heat-induced aggregation

Gastric disintegration

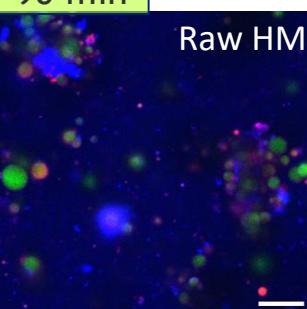
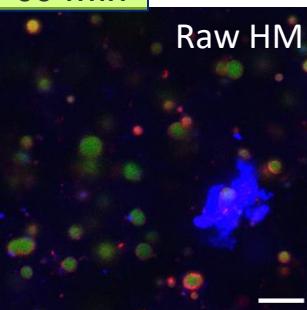
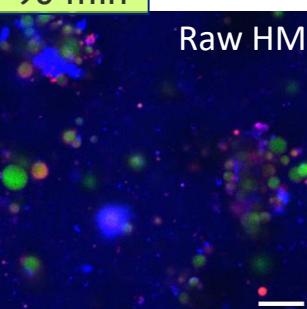
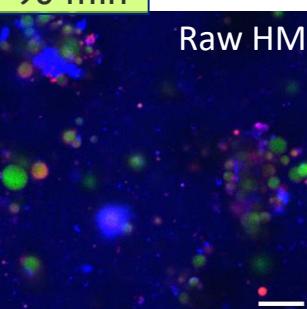
35 min



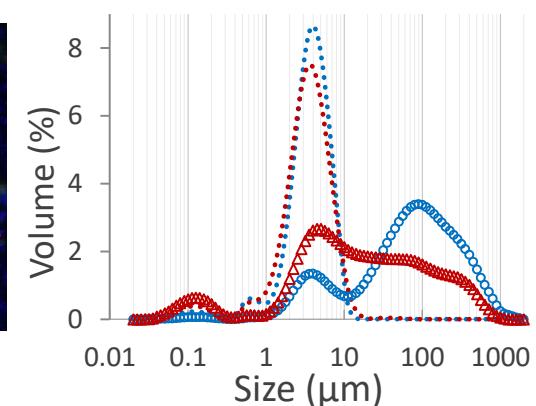
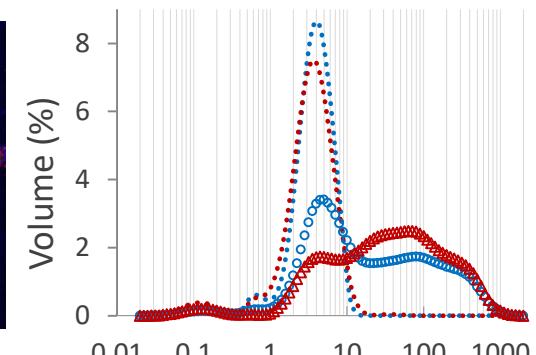
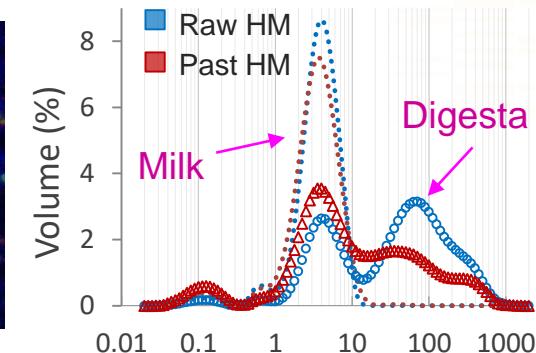
60 min



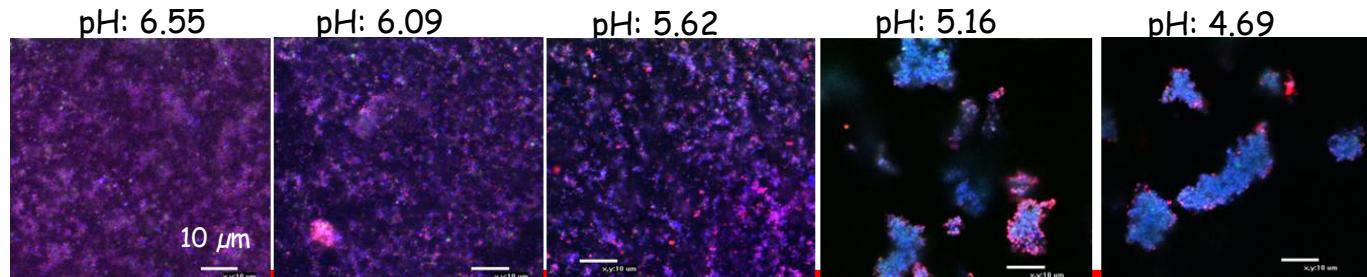
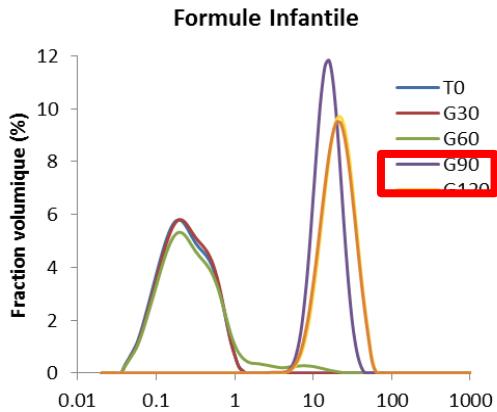
90 min



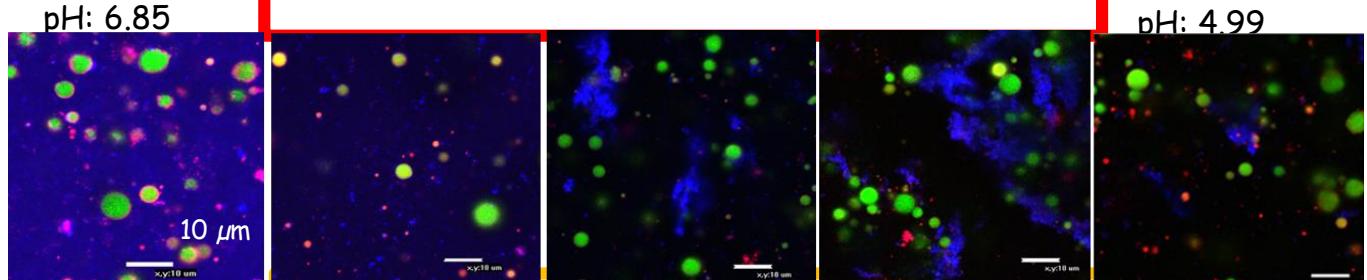
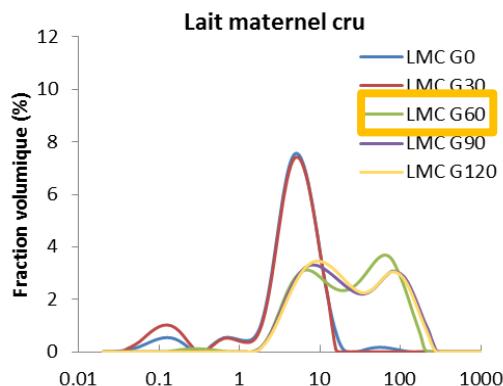
■ Apolar lipids ■ Amphiphiles ■ Proteins



STRUCTURE - PHASE GASTRIQUE



Agrégation protéique et lipidique à G90



Agrégation protéique et lipidique moins prononcée à G60 – distribution bimodale
Reste quelques GG natifs

Protéines

Apolaires

Amphiphiles

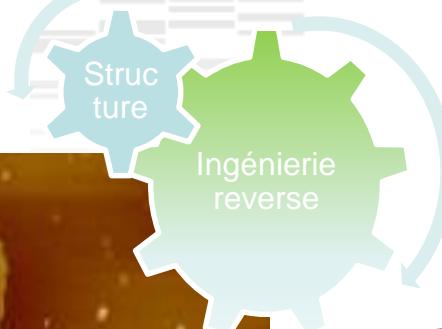
G0

G30

G60

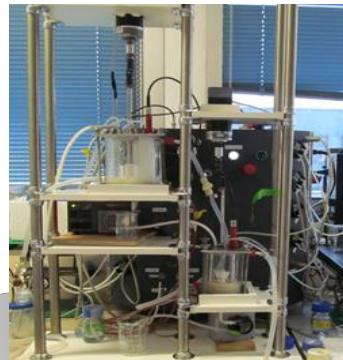
G90

G120 min



Etude interactions lipases / substrat laitier en interface plane et en émulsion

in vitro digestion



Samira de Oliveira (FRI)

in vivo digestion



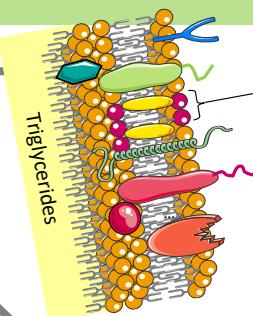
ARCHILACT clinical trial (2014-2015)

Systèmes de complexité croissante

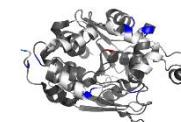
En quoi la composition et l'organisation latérale de la membrane de globule gras de lait (bovin ou humain) régulent l'activité des lipases digestives ?

Globule gras natif

4 μ m (0,1-10 μ m)

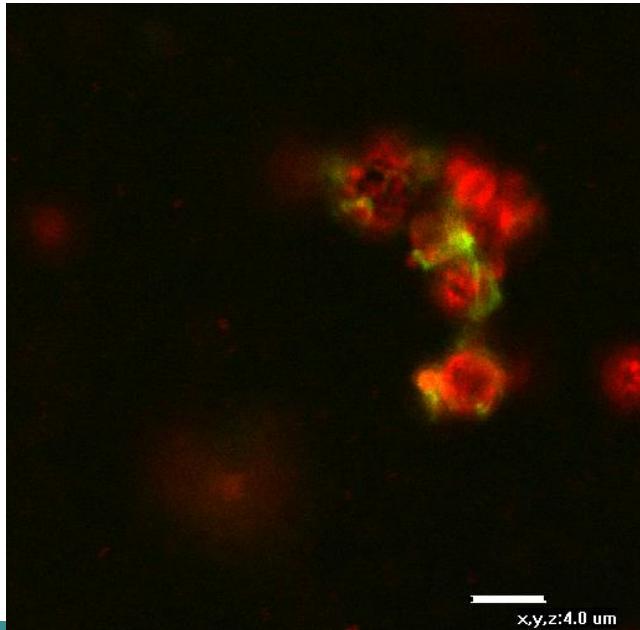
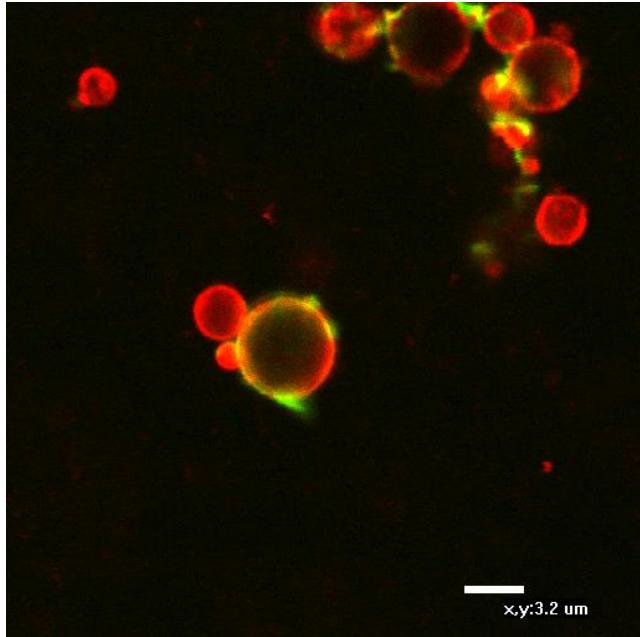


~ 15 nm

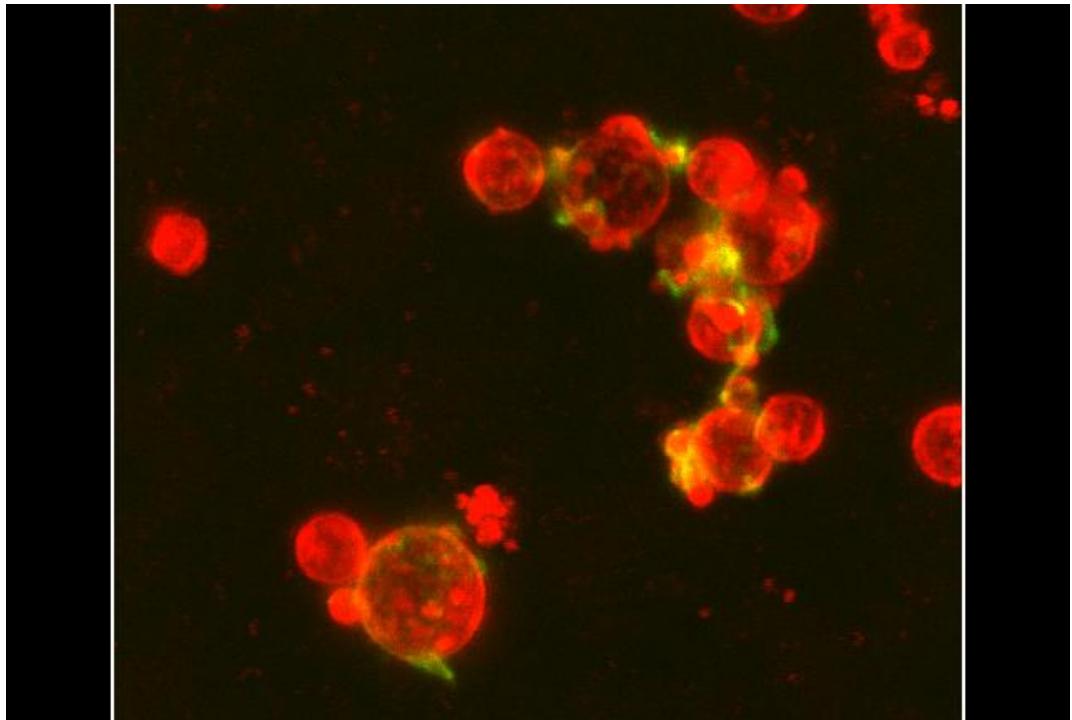


Lipase gastrique humaine

$\uparrow S=19.6 \text{ nm}^2$
 $\downarrow Q=5 \text{ nm}$



Immunolocalization lipase gastrique(pH 6)



Observation des micro-domaines **membranaires**
Lipase adsorbée à l'interface (colocalisation zones rouge et verte) – mais limite de résolution en microscopie confocale

→ COMPLEMENT synchrotron SOLEIL – ligne UV

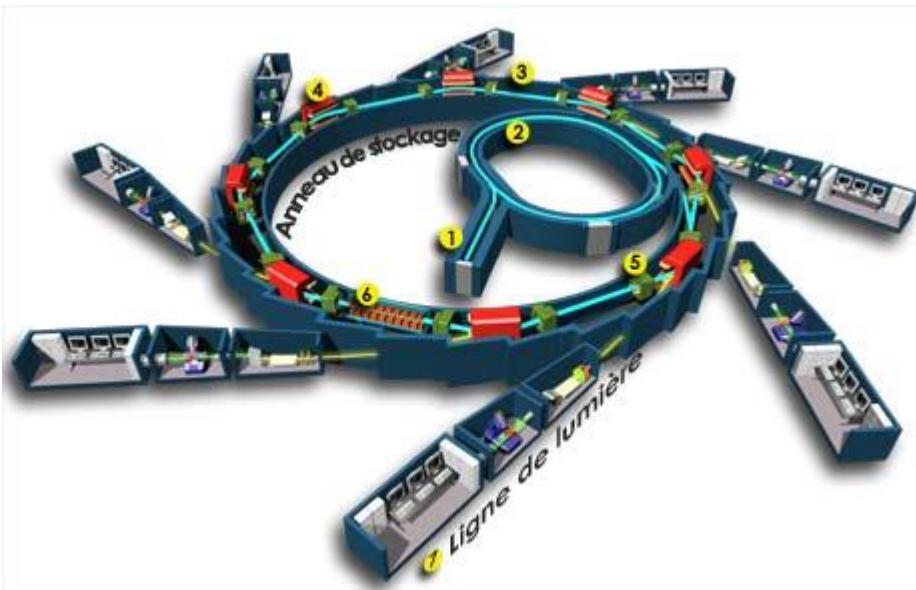


Soleil is a particle (electron) accelerator that produces the synchrotron radiation, an extremely powerful source of light that permits exploration of inert or living matter

o|SCo

DISCO is a VUV to visible beamline dedicated to biochemistry, chemistry and cell biology. The spectral region is optimized between 60 and 700 nm with conservation of the natural polarization of the light

- ☞ Allow the imaging of protein intrinsic fluorescence with a UV microscope



Protocol

Ultra-low-heat skim milk powder
rehydrated at 30 g/l

+ GDL

+ Chymax

Acid Gel

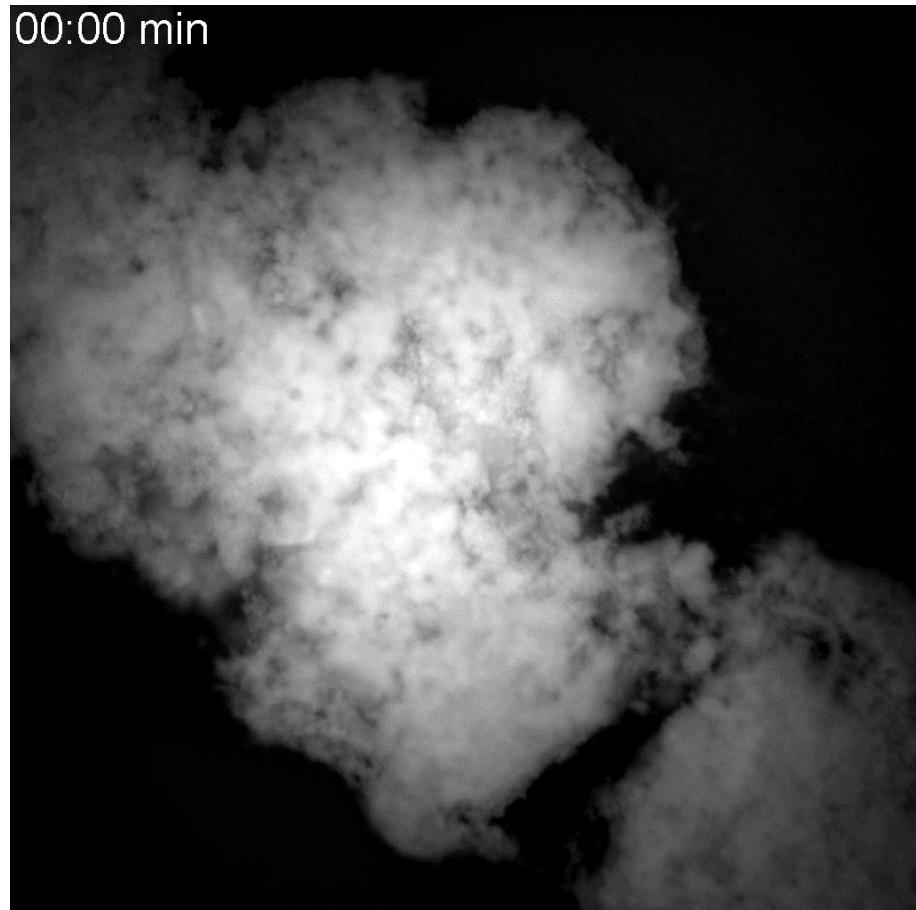
Rennet Gel

Gels soaked in SGF at pH 2.0 with or without pepsin (2000 U/mL)

Observation 2h UV microscope (x10 and x100)

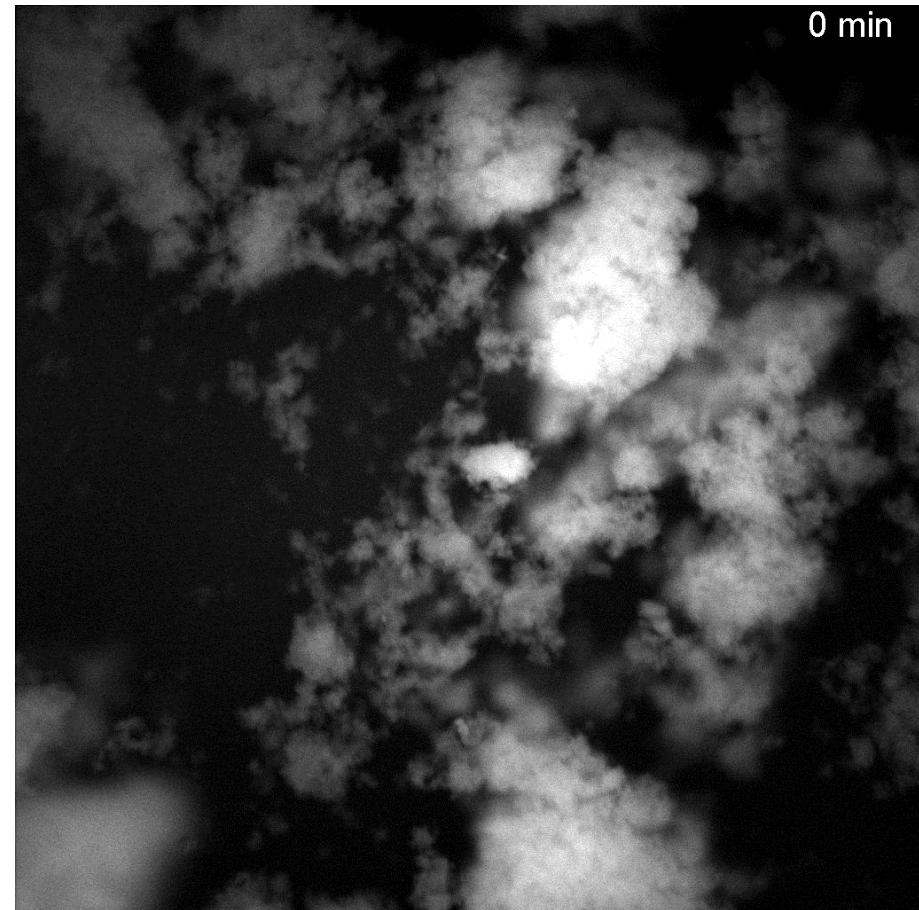
Kinetics of gel particles disintegration

00:00 min



Rennet Gel

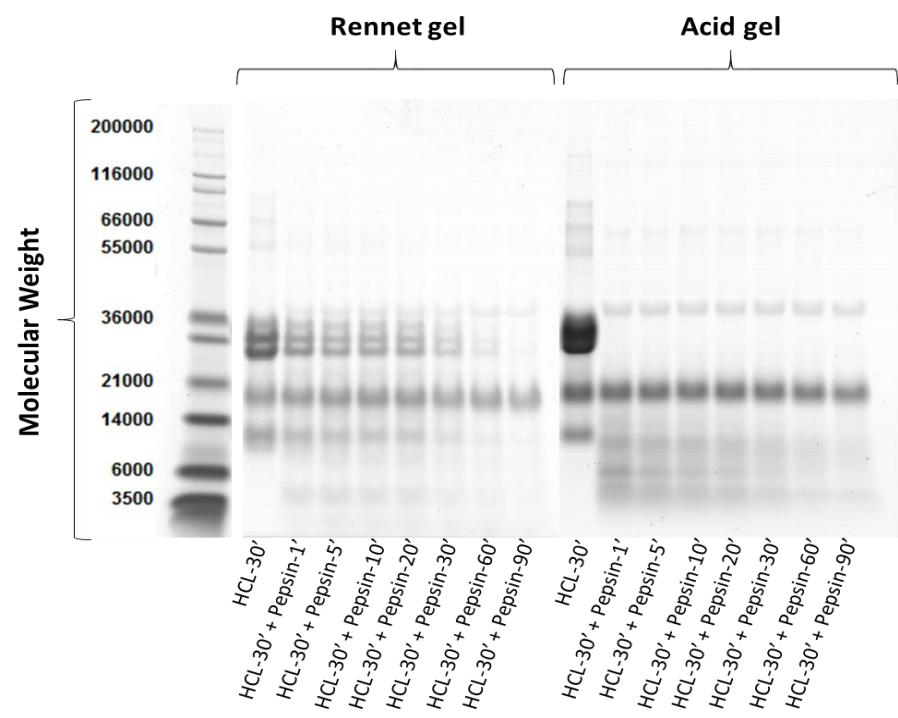
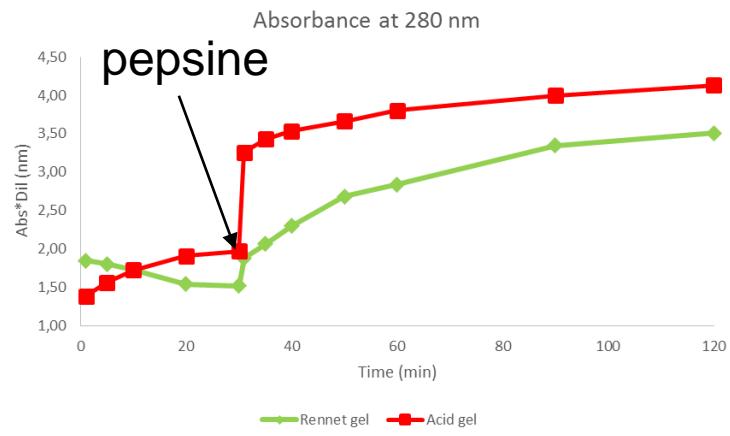
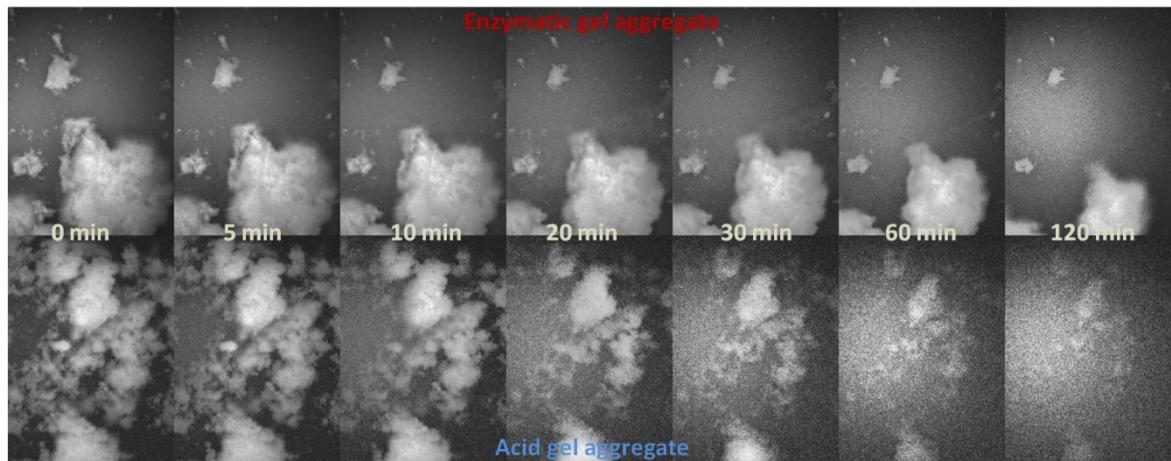
0 min



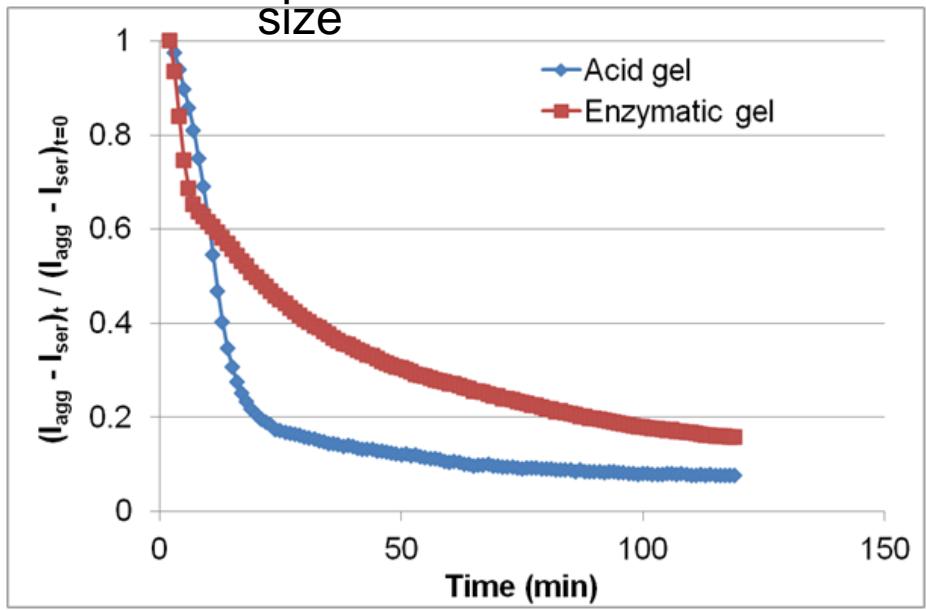
Acid Gel

Disintegration of an acid gel particle is faster than that of a rennet gel particle

Evolution of soluble proteins



Evolution of particle size



The Bioactivity & Nutrition Team

20-25 people, 15 permanent staff



2015-2021 : 12 PhD, 7 post-docs, 5 international visiting scientists

Head
Didier DUPONT – DR

Scientists
Françoise NAU – PR
Amélie DEGLAIRE – MC
Juliane FLOURY – MC
Catherine GUERIN – MC
Frédérique PEDRONO – MC
Steven LE FEUNTEUN – CR
Martine MORZEL – CR



Engineers & Technicians

Yann LE GOUAR – TR
Gwénaële HENRY – AI
Julien JARDIN – IE
Olivia MENARD – IE
Jordane OSSEMOND – IE
Marie-Françoise COCHET – IE

PhDs

Elise CHARTON (2019-2022)
Lucile CHAVET (2020-2023)
Ousmane SUWAREH (2019-2022)
Jiajun FENG (2020-2023)
Rozenn LE FOLL (2020-2023)

Post-docs

Ines GRECO (2021-2023)
Stefano NEBBIA (2020-2022)
Imen JEBALIA (2021-2023)



INFOGEST
International Conference
**Porto, Portugal
2024**

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



in Porto, Portugal, April 2024