# The DiDGI® system

Steven Le Feunteun

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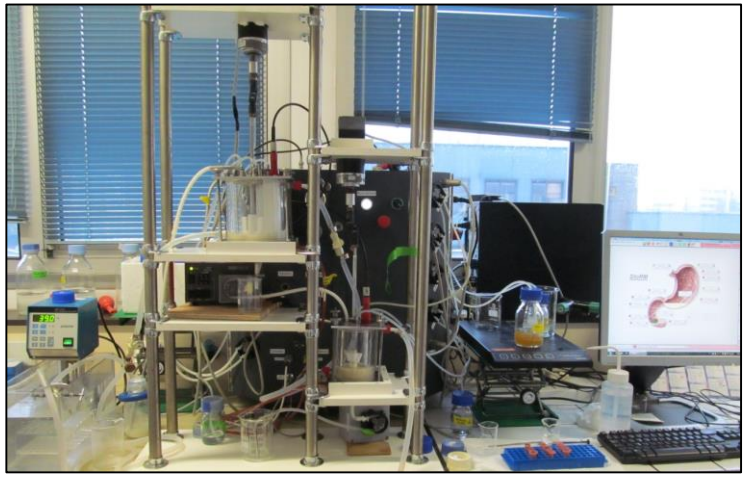

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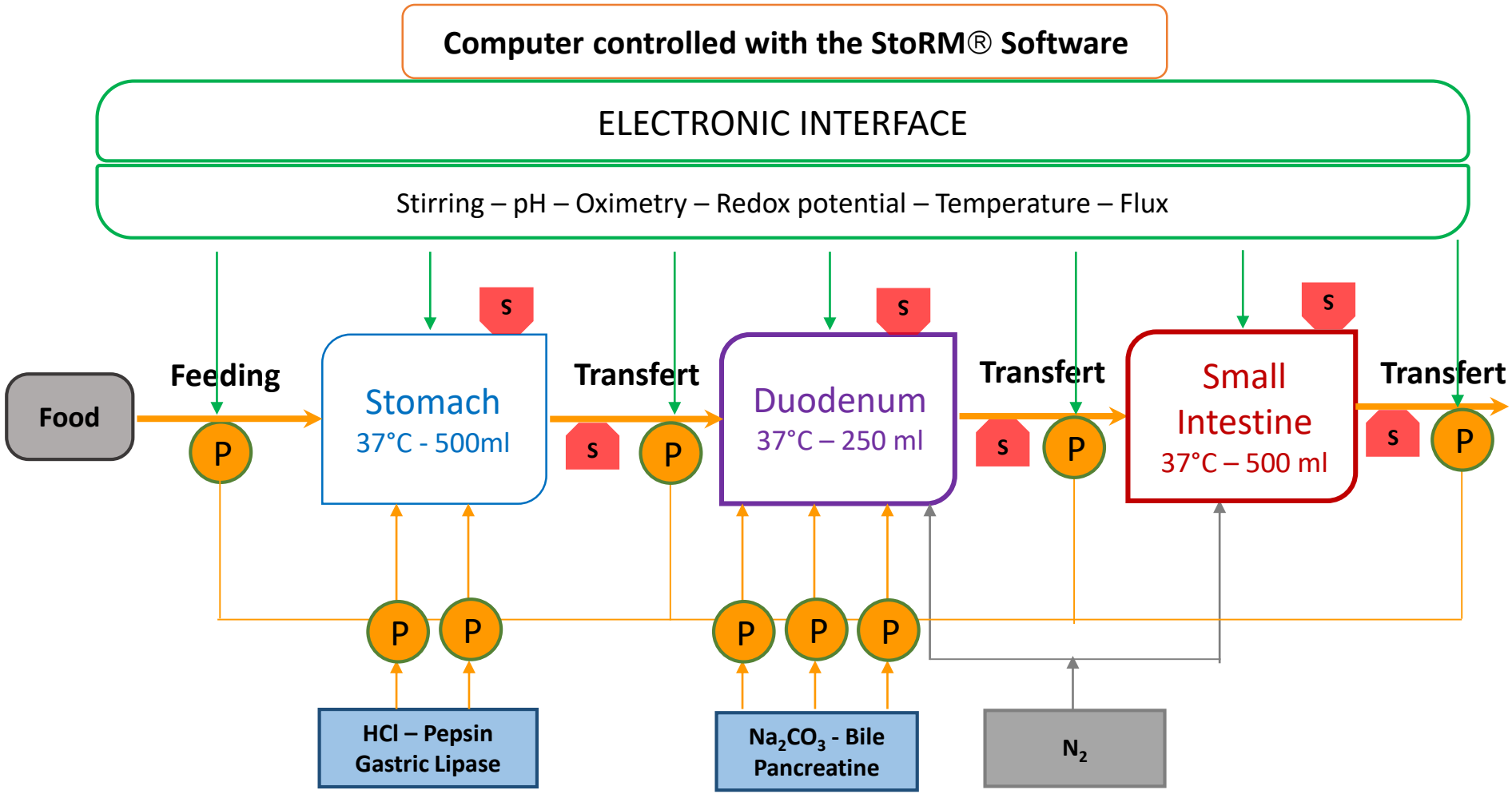
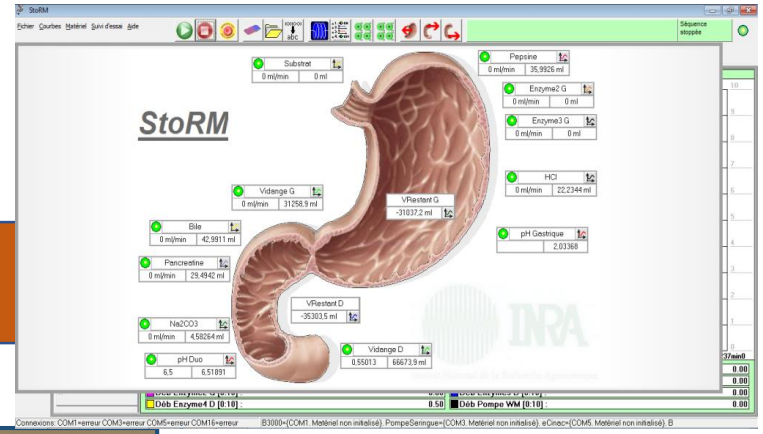
# Principles of the DiDGI (3rd version)




**Legend:** P = Pump
S = Sample collection

# Reality (3rd version)

**STORM® (STOmach Regulation and Monitoring)**

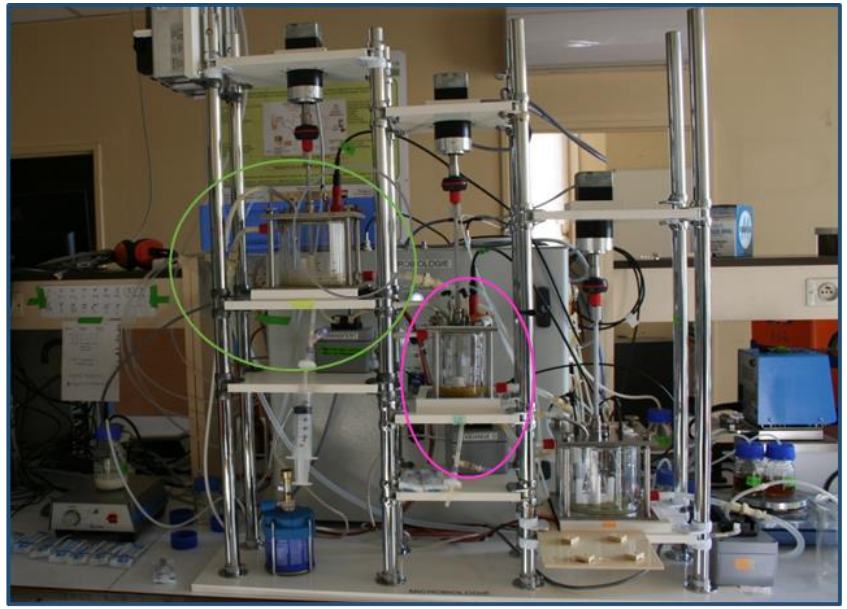




- Piston pump
- Stirring engine (blade)
- Gastric compartment
- Gastric emptying pump
- Dudodenal emptying pump
- Food
- Electronics
- Duodenal compartment
- Small intestinal compartment
- Small intestinal emptying

# Operating Parameters

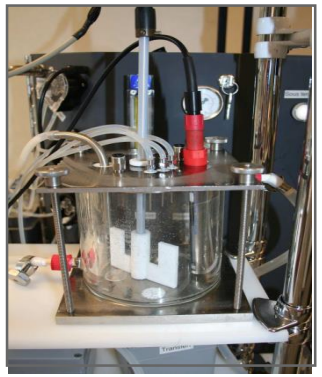
## *Ex: Human milk and Infant formula*



**HM/IF**

*Ingestion*
10 ml/min - 10 min
→ 100 ml, 37° C

**Stomach**



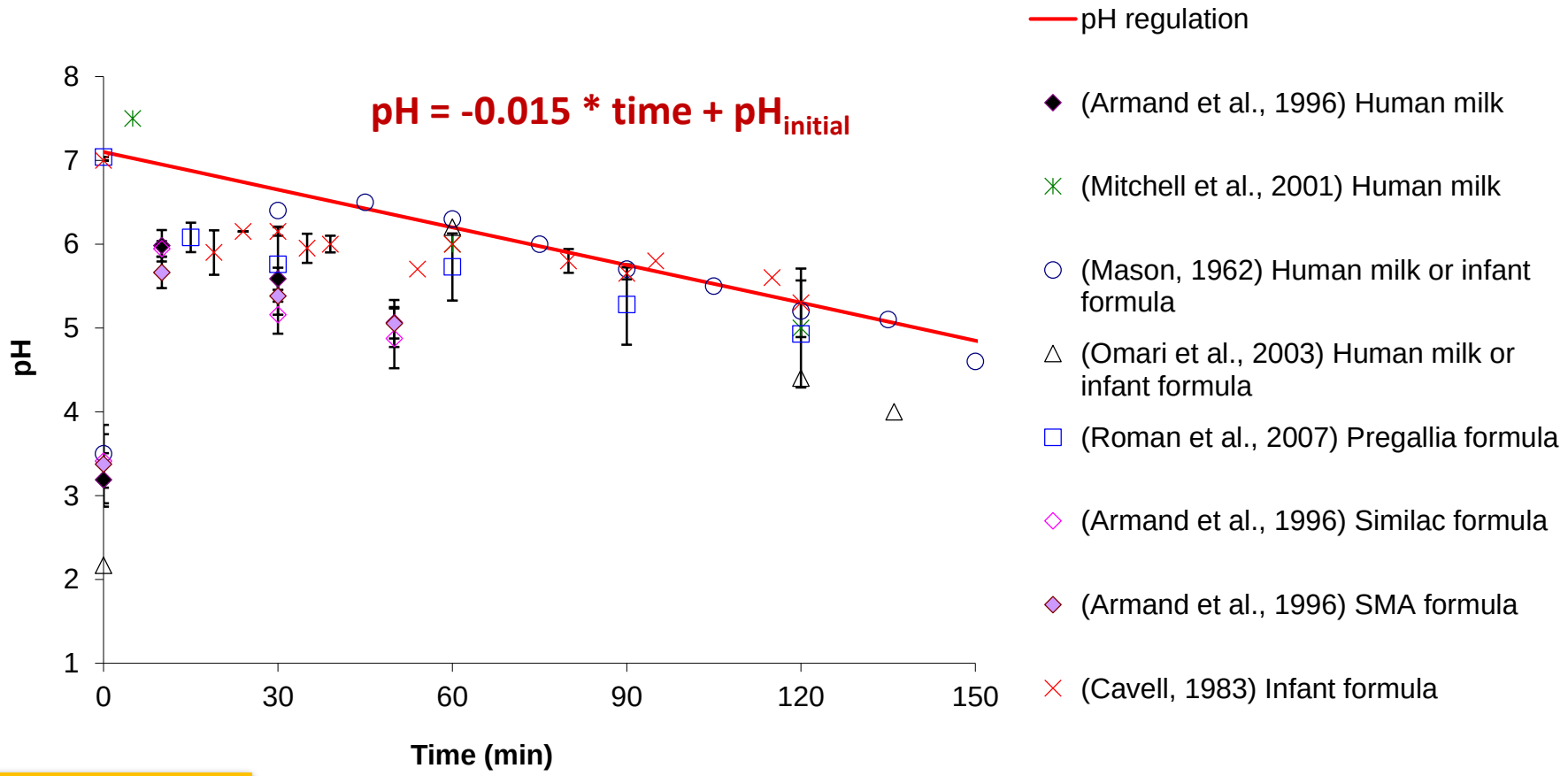
*Gastric fluids*
- Pepsin (260 U/mL)
- Lipase (18,4 U/mL)
- Simulated gastric fluid (NaCl, $CaCl_2$, pH=6.5)
- HCl for pH regulation

**Intestine**

*Intestinal fluids*
- Pancreatin
- Bile
- $NaHCO_3$ (pH = 6.5)

# Gastric pH is regulated (data from literature when available)

## *Ex: Human milk and Infant formula*




Bourlieu et al. (2013)
Crit Rev Food Sci

# Emptying from one compartment to another

Mathematical model of ***Elashoff et al.*** **(1982)**

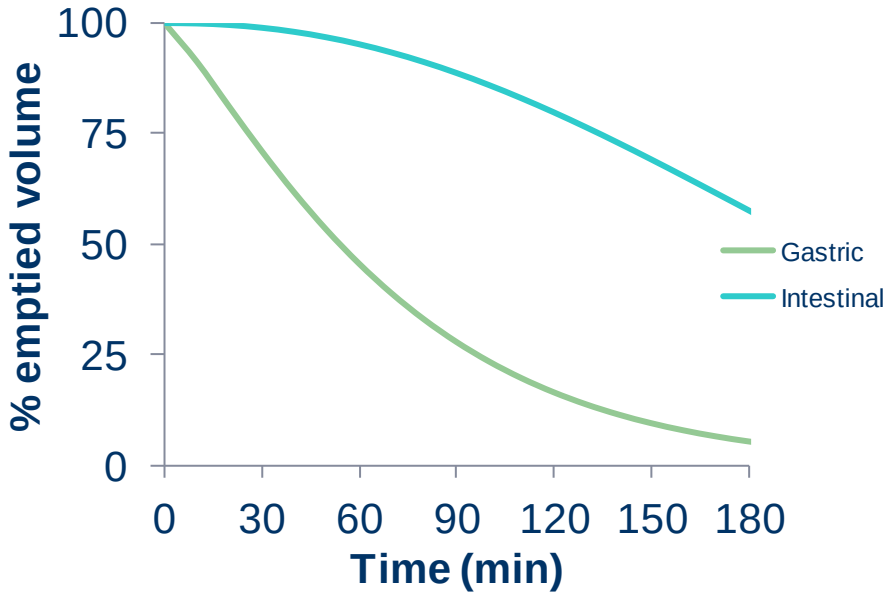
$$f = 2^{-(t/t_{1/2})^{\beta}}$$

**f** : residual volume
$\mathbf{t_{1/2}}$ (min) = time for which half of the meal has been emptied
**β** : curve shape

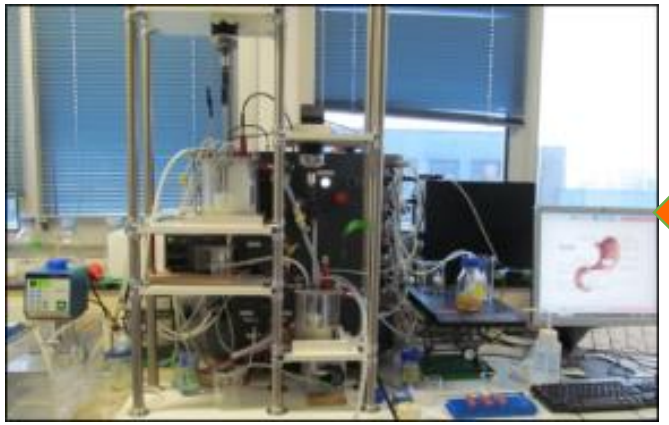
## *Ex: Human milk and Infant formula*

| | Gastric | | Intestinal | |
|---|---|---|---|---|
| | $t_{1/2}$ | β | $t_{1/2}$ | β |
| **HM** | 54 | 1.2 | 200 | 2.2 |
| **IF** | 78 | 1,2 | 200 | 2,2 |

Bourlieu et al. (2013)
Crit Rev Food Sci



# DIDGI®- Validation on protein digestion in infant formula



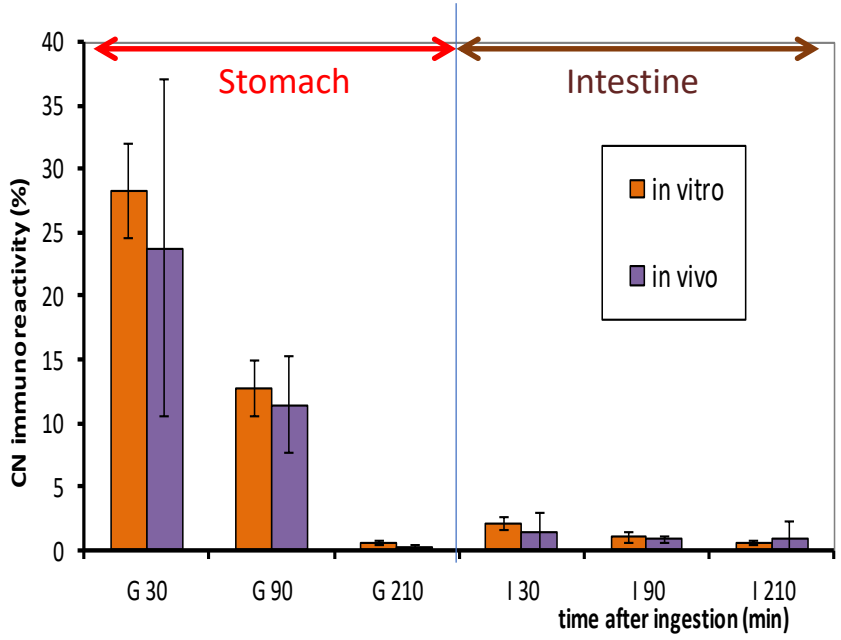
*In vitro*

N=3

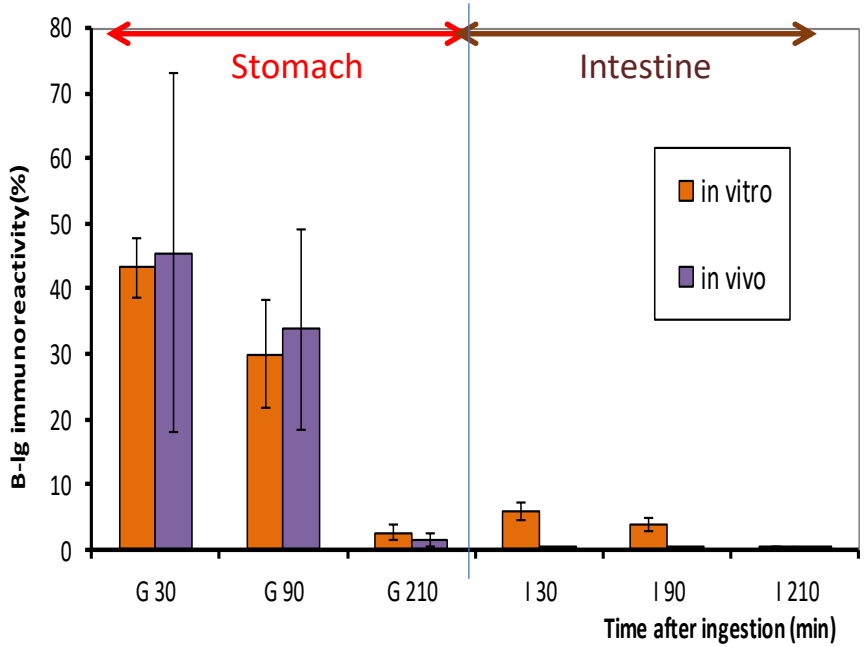
Infant Formula

*In vivo*

18 piglets




Caseins




β-lactoglobulin

Ménard et al. (2014)
Food Chem. 145

# Estimation of protein digestibility

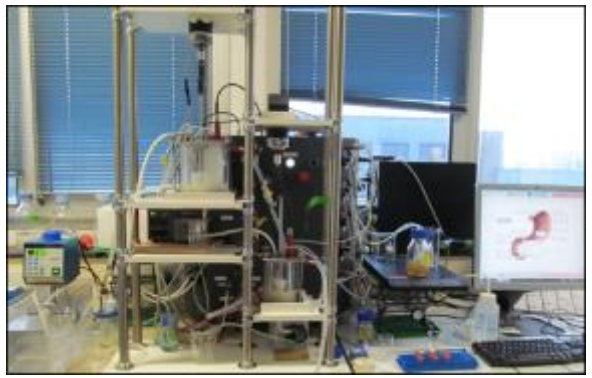
*Study of 4 plant-based foods: 2 solids / 2 liquids*

Tofu

Soymilk

Seitan

Pea Emulsion



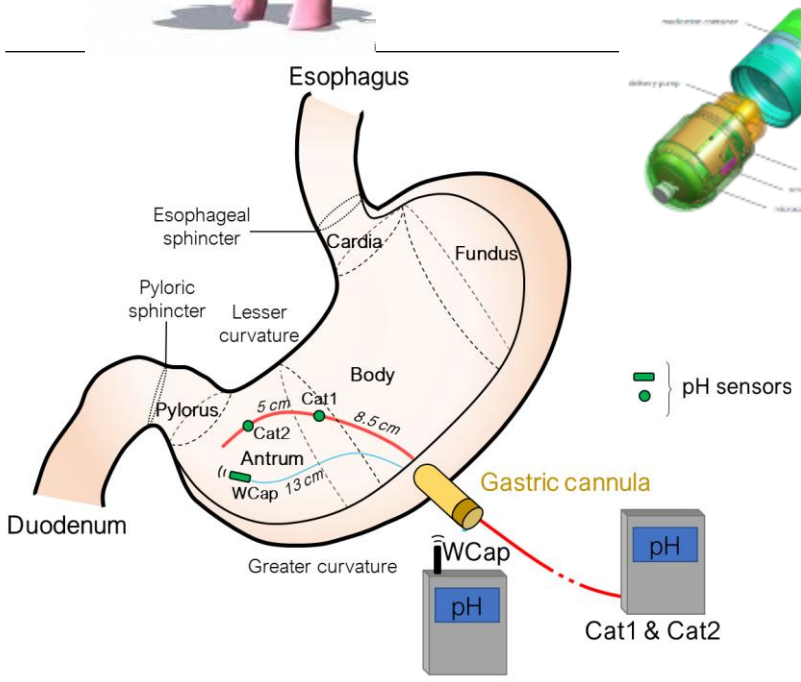
Dynamic *in vitro* digestion DiDGi®

*In vitro* digestibility (%)

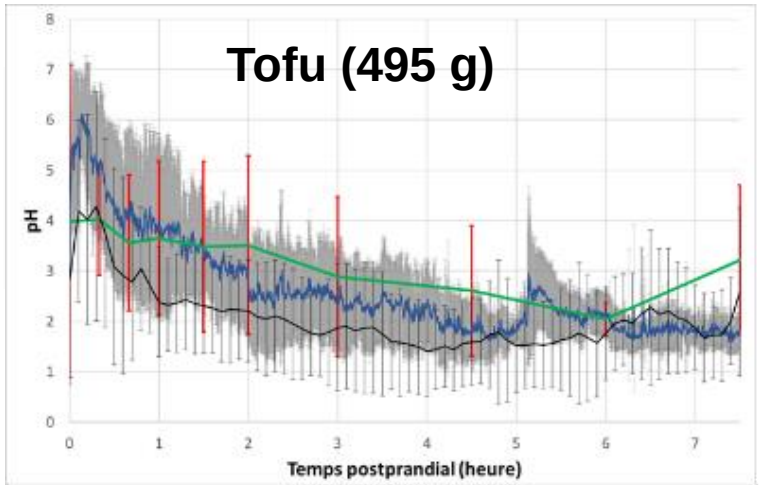
Reynaud et al. (2021) Food Chem. 341

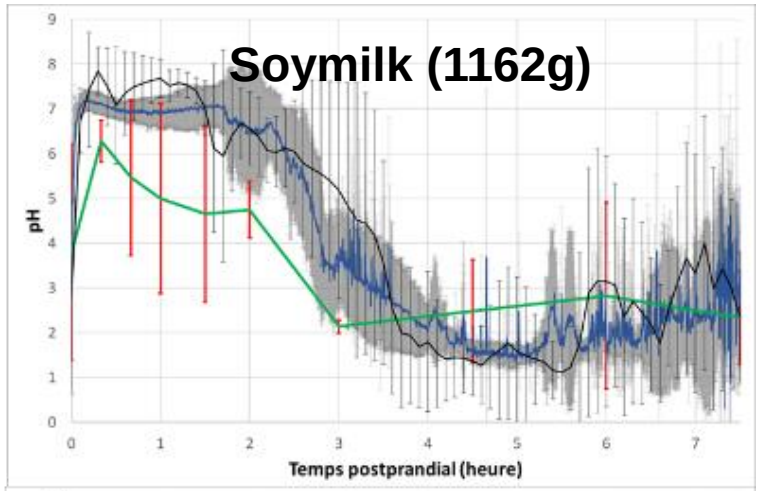
# *In vivo* data used for the gastric pH

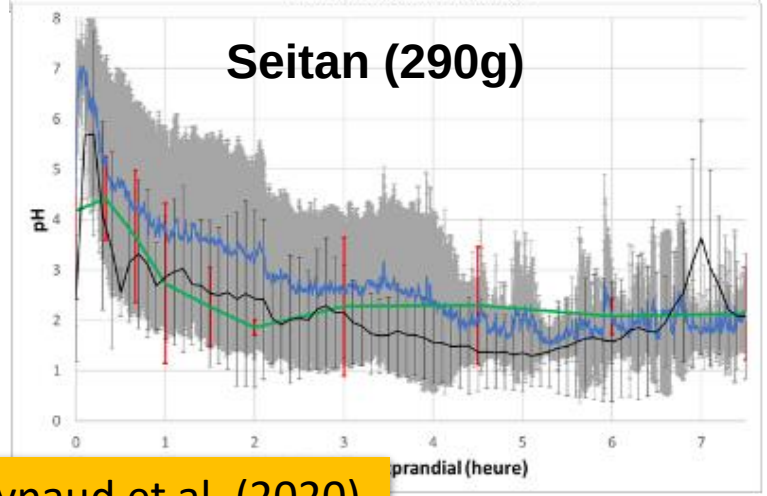
Minipigs

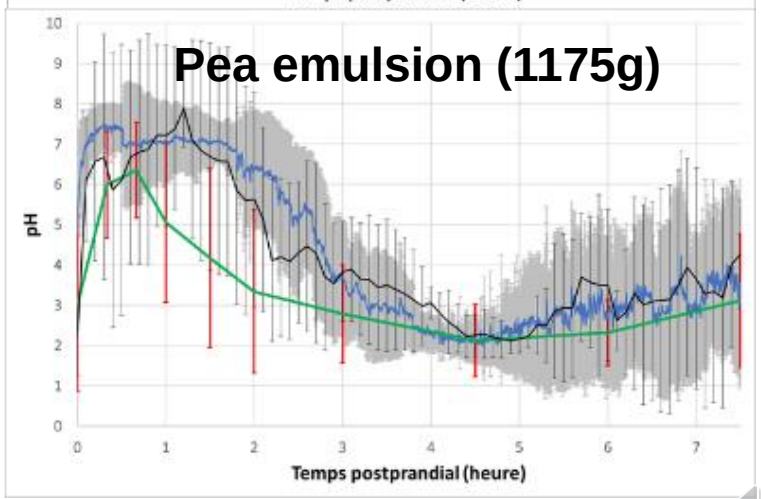



- pH catheter
- pH wireless capsule
- Ex-vivo pH measurments



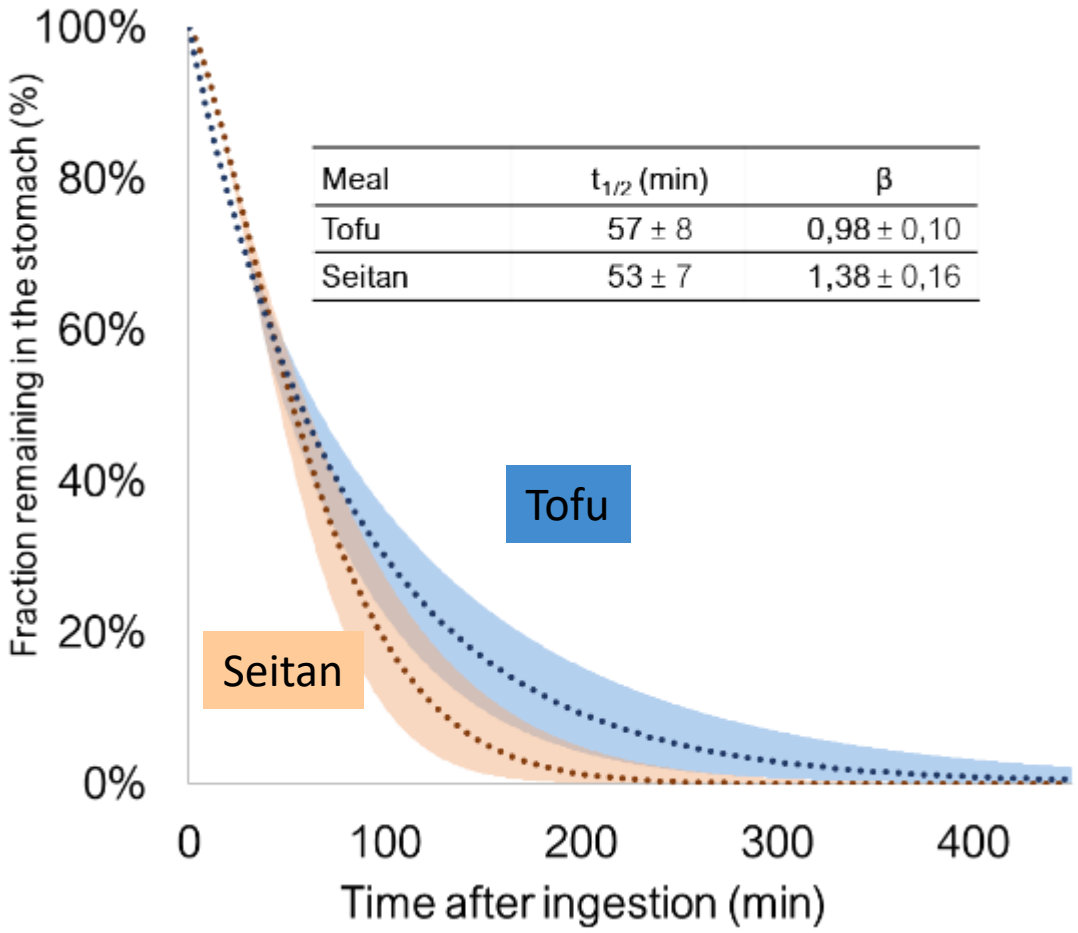



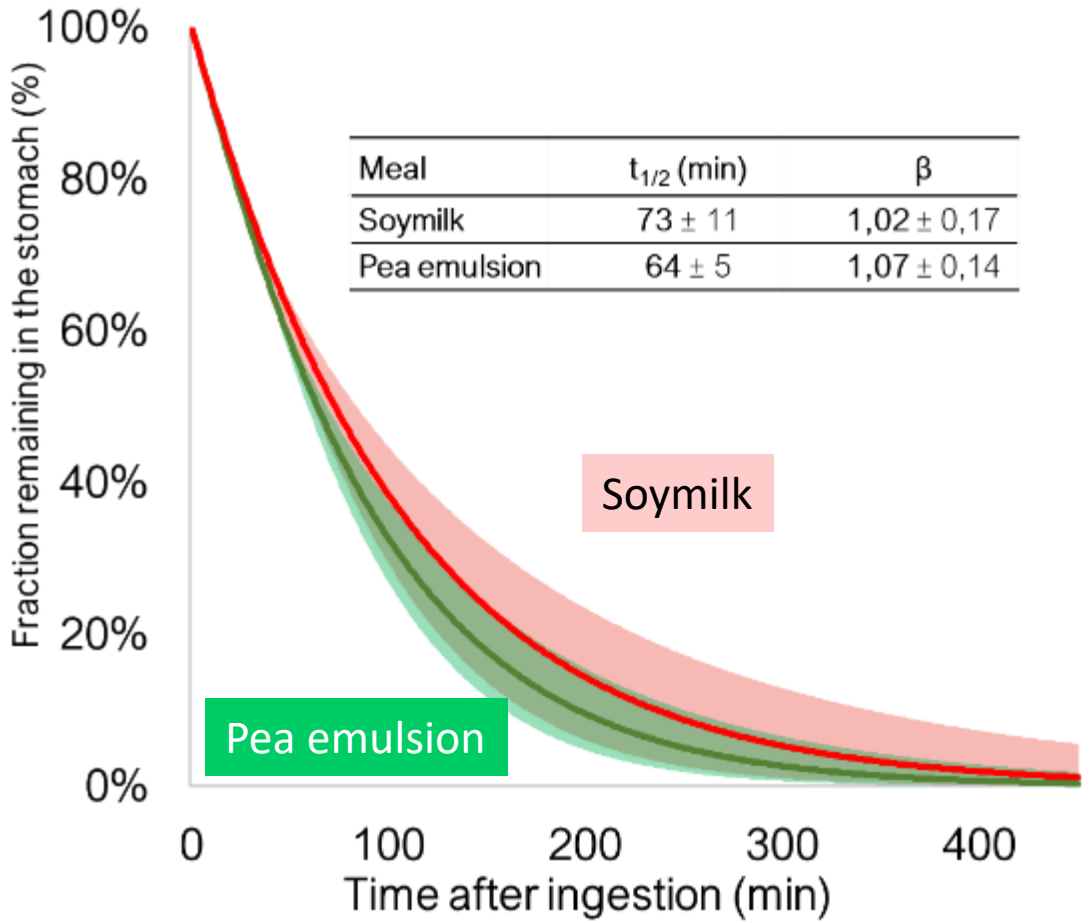




Reynaud et al. (2020)
Food Res Int 128

# *In vivo* data used for gastric emptying




| Meal | $t_{1/2}$ (min) | β |
|---|---|---|
| Tofu | 57 ± 8 | 0,98 ± 0,10 |
| Seitan | 53 ± 7 | 1,38 ± 0,16 |




| Meal | $t_{1/2}$ (min) | β |
|---|---|---|
| Soymilk | 73 ± 11 | 1,02 ± 0,17 |
| Pea emulsion | 64 ± 5 | 1,07 ± 0,14 |

Reynaud et al. (2021)
Food Chem 341

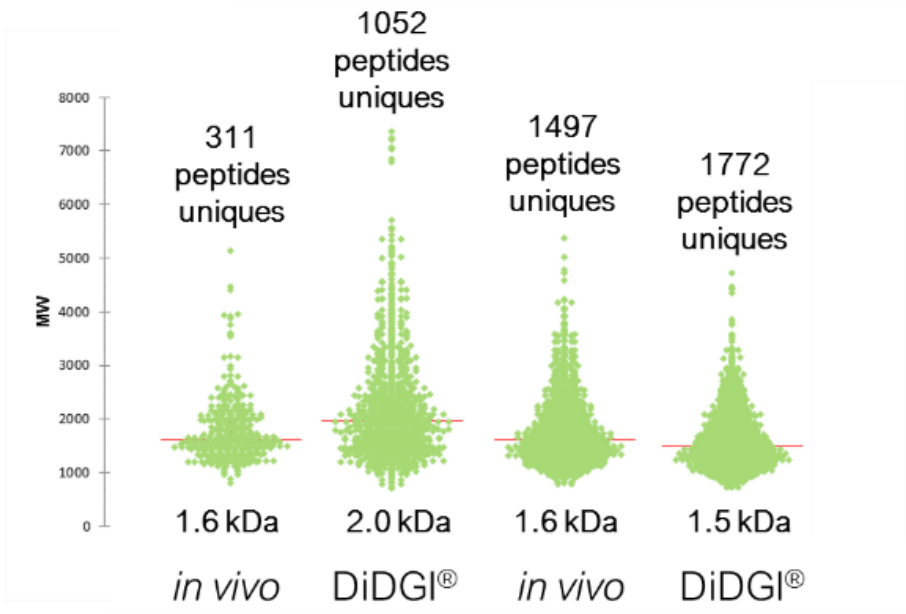
# *In vivo* & *in vitro* comparison

| Model | Digestibility | Tofu | Soymilk |
|---|---|---|---|
| ***in vivo*** | True | 97.1 ± 4.8% | 99.4 ± 2.2% |
| | **Apparent** | **56.5 ± 7.8%[b]** | **71.3 ± 2.5%[a]** |
| ***in vitro*** | **Apparent simulated** | **63.7 ± 3.5%[b]** | **72.7 ± 1.4%[a]** |

*Comparison of the gastric peptidome*

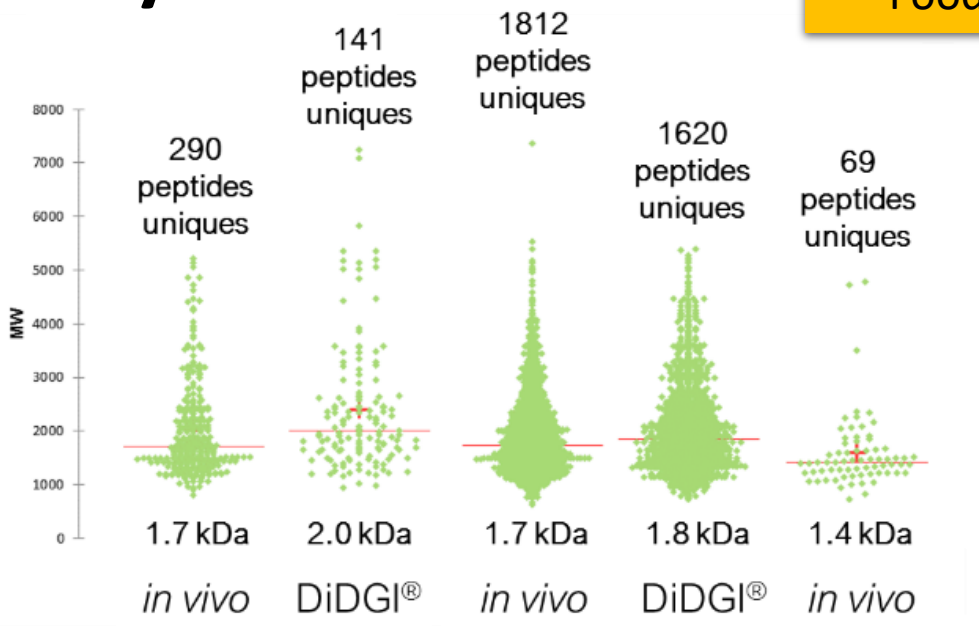
Reynaud et al. (2021)
Food Chem 341

## Tofu




20 min 360 min

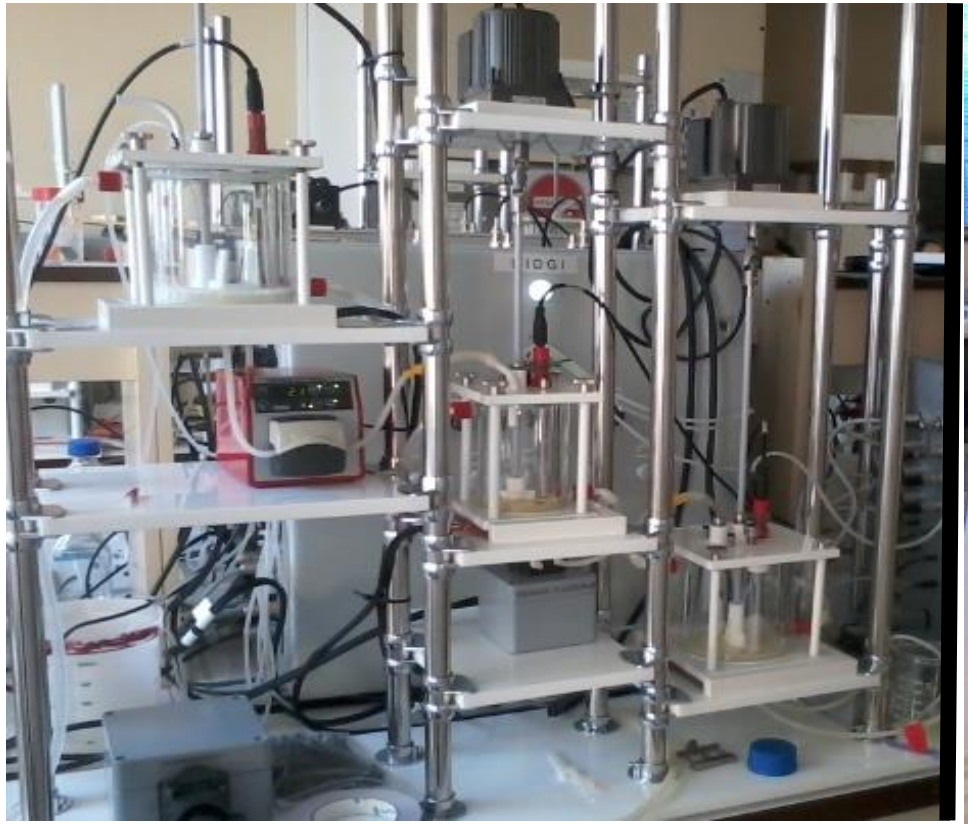
## Soymilk



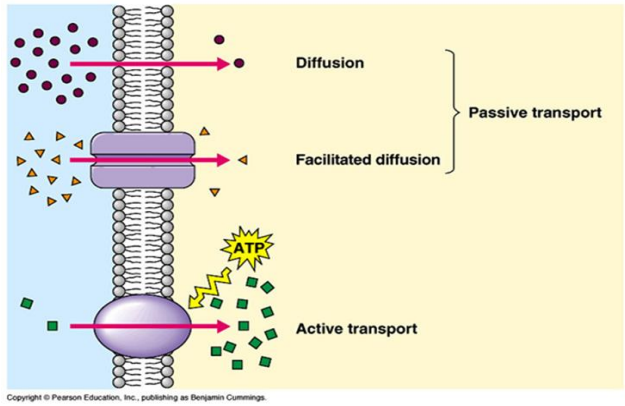

20 min 180 min 360 min

# Ongoing development

**Absorption (Dialysis Fibers)**



**Objective: Mimic the intestinal absorption**




Dialysis fibers to simulate nutrient absorption from the intestinal bowl

# 5 laboratories of INRAE are equipped


***Used to study:***

- Various kinds of foods (dairy and egg products, bread, cakes, meat, lipid emulsions, fruits, vegetables…)
- Bioaccessibility of micro- & macronutrients
- Digestibility
- Lipid oxidation
- The chronology of enzyme actions (ex: salivary amylase and gastric lipase in the stomach)
- The survival of microorganisms to GI conditions (probiotics)
- …

# Thank you for your attention !

## & Special thanks to the DiDGI creators:

- Thomas Cattenoz, Hervé Guillemin, Isabelle Souchon & Daniel Picque (SayFood, Paris)
- Olivia Ménard & Didier Dupont (STLO, Rennes)

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