# An INFOGEST international consensus static in vitro digestion model adapted to the general older adult population and its application to dairy products

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# Static *in vitro* digestion model adapted to the general older adult population: an INFOGEST international consensus

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"*Ageing leads to changes in the functionality of the digestive tract*"

But the impact of ageing on digestion, and absorption of nutrients is still unclear

# 1. Exhaustive literature review

Oro-gastrointestinal tract physiological parameters

Healthy older adults ≤ 65 y.

*In vivo* data

# 2. Consensus static *in vitro* digestion model

Adaptation of the INFOGEST 2.0 digestion method

Brodkorb et al. *INFOGEST static in vitro simulation of gastrointestinal food digestion.* Nat Protoc 14, 991–1014 (2019)

EAT4AGE consortium & International workshop

WP 3: *In vitro* digestibility and nutrient bioaccessibility of age-tailored food products

**ICFD 2022**
CORK 3-5 MAY 2022

# Oral phase

**Ionic composition of saliva**
Very poorly documented, data available only for at-rest saliva

**Salivary amylase activity**
Data are scarce, and not easy to compare when determined with different assays

**pH**
1 study measured a slight increase (up to pH 8), 3 others no significant differences

**Food/saliva ratio**
2 robust studies about insalivation rates for different food matrices 🧀 🍞 🍗 🥩 🍮
Ratio of 1 : 1 (weight of SSF or saliva added : dry weight of food) is more physiologically relevant

**Food bolus particle size**
Adapt their oral processing (increased number of chewing cycles) to reach same particles size
Need for a robust, simple, reproducible protocol to grind the food

**Duration**
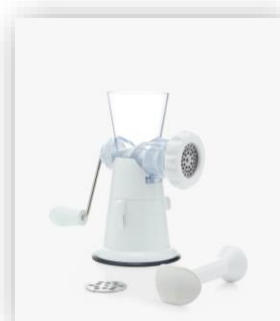Longer only for older adults equipped with a denture

# Oral phase

| | Young adults 18+ | Older adults 65+ |
|---|---|---|
| SSF composition | See Brodkorb et al., (2019) | Same |
| Food:SSF dilution | 1:1 | 1:1 (volume or according to DM) |
| pH | 7.0 | 7.0 |
| Duration | 2 min | 2 min |
| Chewing protocol | See Brodkorb et al., (2019) | Meat mincer, then add SSF or saliva |
| Amylase | 75 U ml$^{-1}$ (using the DNS assay) | Same |

Manual, 5 cm mincing disk,
0,5 cm mesh size, one pass

# Gastric phase

## Ionic composition of gastric secretions
No information, research extended to animal models

**Different from young adults**

## Gastric enzymes activities
Marked lack of knowledge in the postprandial state in older adult populations

**Pepsin**: reduced by 40% (basal & pentagastrin-stimulated pepsin output, n = 22)
**Feldman et al**. *Effects of ageing and gastritis on gastric acid and pepsin secretion in humans: a prospective study.* Gastroenterology, 110 (4), 1043-1052 (1996)

**Gastric lipase**: decline with age of activity (gastric mucosal biopsies, n = 22)
**Moreau et al.** *Human gastric lipase: variations induced by gastrointestinal hormones and by pathology*. Scand. J. Gastroenterol. 23 (9), 1044-1048 (1988)

## pH
Gastric pH curve in fasted and fed conditions followed w/ the Heidelberg capsule technique (n=79, ±71 y.), significant increase in gastric pH with age. **Russel et al.** *Upper Gastrointestinal pH in 79 healthy, elderly, north American men and women*. Pharm. Research, 10 (2) (1993)

In static model: consider the pH at gastric emptying half-time ($t_{1/2}$)

## Bolus/gastric secretions ratio
No specific data were found, following curve from *Russel et al.:* 50/50 dilution is calculated at $t_{1/2}$

## Duration
Still controversial, but several studies have shown that gastric emptying slows down with age: increases by 34 - 46%
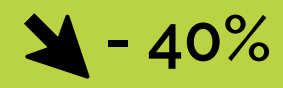
# Gastric phase

| | Young adults 18+ | Older adults 65+ | |
|---|---|---|---|
| SGF composition | See Brodkorb et al., (2019) | Same | |
| Bolus:SGF dilution | 1:1 | 1:1 | |
| pH | 3.0 | 3.7 | ↗ |
| Duration | 2 h | 3 h | |
| Pepsin | 2000 U ml⁻¹ | 1200 U ml⁻¹ | ↘ - 40% |
| Gastric lipase | 60 U ml⁻¹ | 36 U ml⁻¹ | |

# Intestinal phase

## Ionic composition of intestinal secretions

No precise information, but 1 study shows an increase in Ca concentration with age: $[\mathbf{Ca}^{2+}] = 0.01 \times \mathbf{age} + 0.35$

**Laugier et al.** *Changes in pancreatic exocrine secretion with age: pancreatic exocrine secretion does decrease in the elderly*, Digestion, 50(3–4), 202–211 (1991)

## Pancreatic enzymes activities

Some studies showed no difference, but general trends indicate a decrease in activity/output of enzymes of 13 to 35%

**Pancreatic amylase**: More data are available compared to the other pancreatic enzymes

**Trypsin:** Two studies showed opposite results

**Chymotrypsin:** No dif. or decrease in chymotrypsin output with ageing

**Pancreatic lipase**: Reported results highly controversial

## Bile salts content

Limited data, decrease in bile acid synthesis

**Different from young adults**

## Chyme/intestinal secretions ratio

Extremely difficult to assess, if we consider pancreatic exocrine secretions data are controversial: some saw a reduced volume of secretions, others no significant changes (n = 1615).

**Dreiling et al**. *The effect of age on human exocrine pancreatic secretion*. The Mount Sinai journal of Medicine, 52(5) (1985)

## Duration

Not often monitored, if we consider whole gut transit time: no significant change in a recent study (n=111).

**Nandhra et al.** *Normative values for region-specific colonic and gastrointestinal transit times [..]* Neurogastroenterology & Motility, 32(2) (2020)
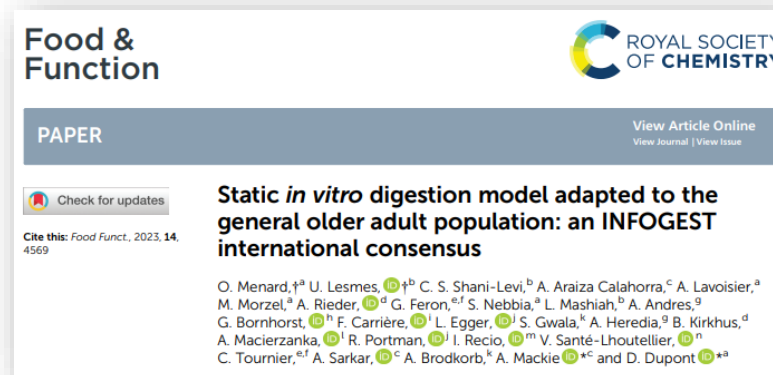
# Intestinal phase

| | Young adults 18+ | Older adults 65+ |
|---|---|---|
| SIF composition | See Brodkorb et al., (2019) | Same, except for [Ca2+] = 1 mM |
| Chyme:SIF dilution | 1:1 | 1:1 |
| pH | 7.0 | 7.0 |
| Duration | 2 h | 2 h |
| Pancreatin | 100 U ml$^{-1}$ trypsin | 80 U ml$^{-1}$ trypsin ↘ - 20% |
| Bile salts | 10 mM | 6,7 mM ↘ - 33% |

## Food & Function

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**Static *in vitro* digestion model adapted to the general older adult population: an INFOGEST international consensus**

O. Menard,†[a] U. Lesmes, [iD]†[b] C. S. Shani-Levi,[b] A. Araiza Calahorra,[c] A. Lavoisier,[a] M. Morzel,[a] A. Rieder, [iD][d] G. Feron,[e,f] S. Nebbia,[a] L. Mashiah,[b] A. Andres,[g] G. Bornhorst, [iD][h] F. Carrière, [iD][i] L. Egger, [iD][j] S. Gwala,[k] A. Heredia,[g] B. Kirkhus,[d] A. Macierzanka, [iD][l] R. Portman, [iD][i] I. Recio, [iD][m] V. Santé-Lhoutellier,[n] C. Tournier,[e,f] A. Sarkar, [iD][c] A. Brodkorb,[k] A. Mackie [iD]*[c] and D. Dupont [iD]*[a]

# High-protein dairy products digestion

Skyr = commercial fermented dairy product containing mainly caseins (10% w/w)

**Protein hydrolysis, gastric phase**

**Leucine release, intestinal phase**
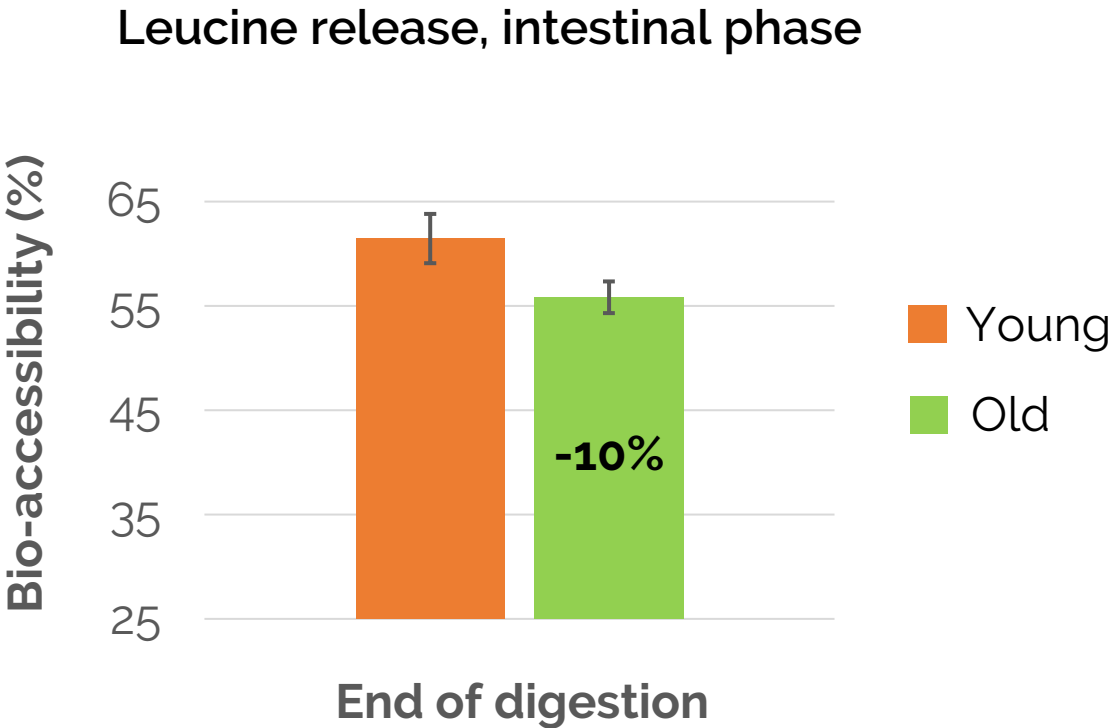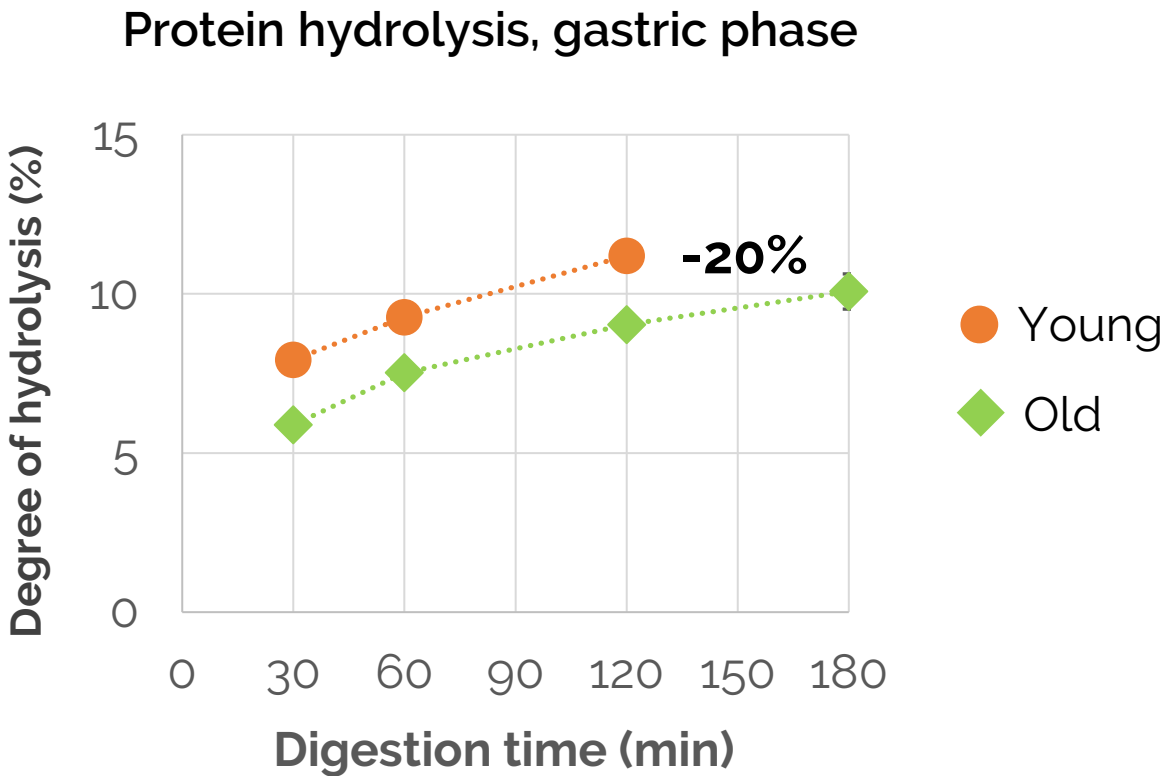


No difference in DH at the end of the digestion: **75-85%** in both conditions

# Does age have an impact on food digestion?



**Yes**, but

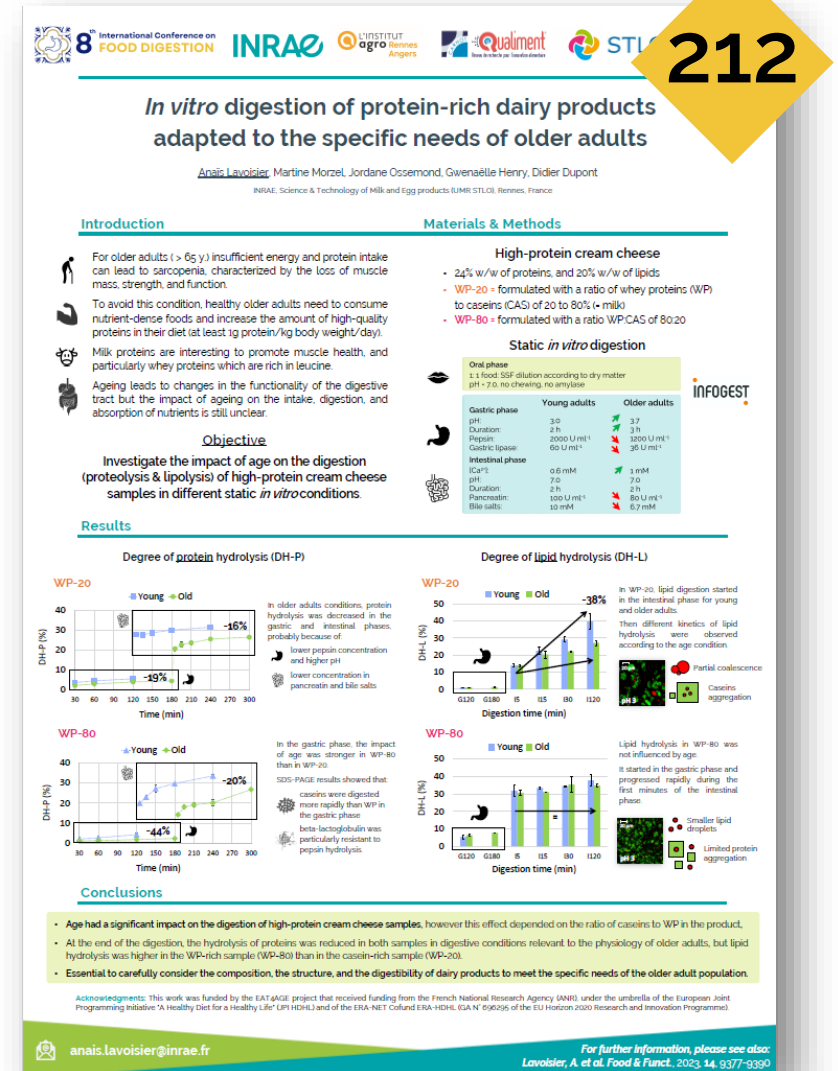different scenarios depending on the composition & structure of the dairy products studied

# Other applications

255

## Fermented lentils and quinoa, whole and flours

Sánchez-García et al. *Protein digestibility and ACE inhibitory activity of fermented flours in older adults and standard gastrointestinal simulation.* FRI, 180, 114080 (2024)

Sánchez-García et al. *In vitro digestion assessment (standard vs. Older adult model) on antioxidant properties and mineral bioaccessibility of fermented dried lentils and quinoa.* Molecules, 28(21), 7298 (2023)

## Cooked lentils

Duijsens et al. *From static to semi-dynamic in vitro digestion conditions relevant for the older population: starch and protein digestion of cooked lentils.* Food Funct.,15, 591-607 (2024)

## Semi-dynamic & dynamic models
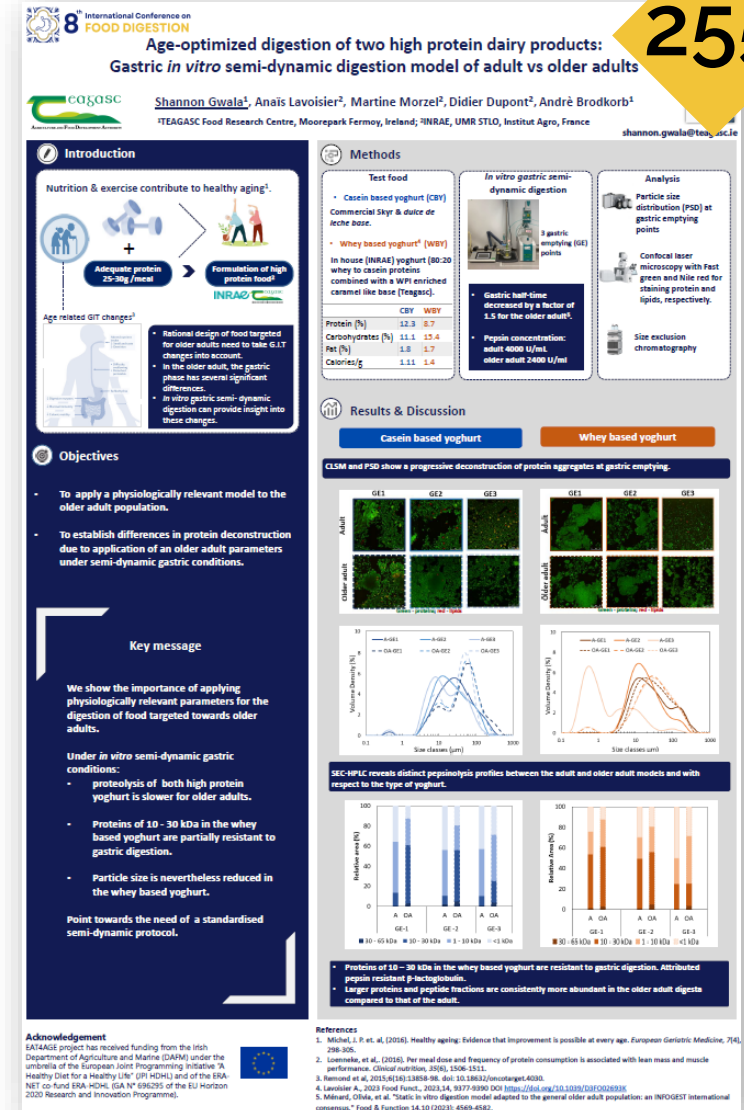
# Thank you



EAT4age
Palatable, nutritious and digestible foods for prevention of undernutrition in active aging

Bioactivity and Nutrition (BN) team