Spatial-temporal mapping of the intra-gastric pH, pepsin concentration and proteolysis in pigs fed egg white gels

Francoise Nau, Steven Le Feunteun, Yann Le Gouar, Gwenaele Henry, Maryvonne Pasco, Catherine Guérin-Dubiard, Kéra Nyemb-Diop

ICFD 2022
CORK 3-5 MAY 2022

7th International Conference on Food Digestion

Spatial-temporal mapping of the intra-gastric pH, pepsin concentration and proteolysis in pigs fed egg white gels

F. Nau, S. Le Feunteun, Y. Le Gouar, G. Henry, M. Pasco, C. Guérin-Dubiard, K. Nyemb-Diop, D. Dupont

STLO, INRAE, Institut Agro, 35042 Rennes, France

Context

FOOD ⟷ NUTRITION ⟷ HEALTH

How **food characteristics** can modulate the digestion process and **nutrient utilization** by the human body?

PROTEIN DIGESTION

FOOD MATRIX STRUCTURE

A KEY ROLE OF THE GASTRIC PHASE ?

Previous *in vitro* results on Egg white gels

Food Chemistry 157 (2014) 429–438

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

The extent of ovalbumin *in vitro* digestion and the nature of generated peptides are modulated by the morphology of protein aggregates

Kéra Nyemb [a,b], Catherine Guérin-Dubiard [a,b], Didier Dupont [a,b], Julien Jardin [a,b], Shane M. Rutherfurd [c], Françoise Nau [a,b,*]

Food Hydrocolloids 54 (2016) 315–327

Contents lists available at ScienceDirect

Food Hydroc…

journal homep… …te/foodhyd

The struct… …tent of *in vitro* pro…

… Rezennec [a, b], Julien Jardin [a, b], …M. Rutherfurd [c], Didier Dupont [a, b],

The structure of OVALBUMIN AGGREGATES and of EGG WHITE GELS drive the proteolysis extent and the pattern of peptide fractions generated during *in vitro* digestion

Food Research International 63 (2014) 19…

Contents liste…

Foc…

journal homep…

Investigating the impact of ovalbum… …gate morphology on *in vitro* ovalbumin digestion using label-free quantitative peptidomics and multivariate data analysis

Kéra Nyemb [a,b], Julien Jardin [a,b], David Causeur [c], Catherine Guérin-Dubiard [a,b], Didier Dupont [a,b], Shane M. Rutherfurd [d], Françoise Nau [a,b,*]

Food Research International 88 (2016) 302–309

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Investigating the impact of egg white gel structure on peptide kinetics profile during *in vitro* digestion

Kéra Nyemb-Diop [a,b], David Causeur [c], Julien Jardin [a,b], Valérie Briard-Bion [a,b], Catherine Guérin-Dubiard [a,b], Shane M. Rutherfurd [d], Didier Dupont [a,b], Françoise Nau [a,b,*]

Previous *in vivo* results on Egg white gels (EWG)

Food Chemistry 280 (2019) 210–220

Contents lists available at ScienceDirect

Food Chemistry

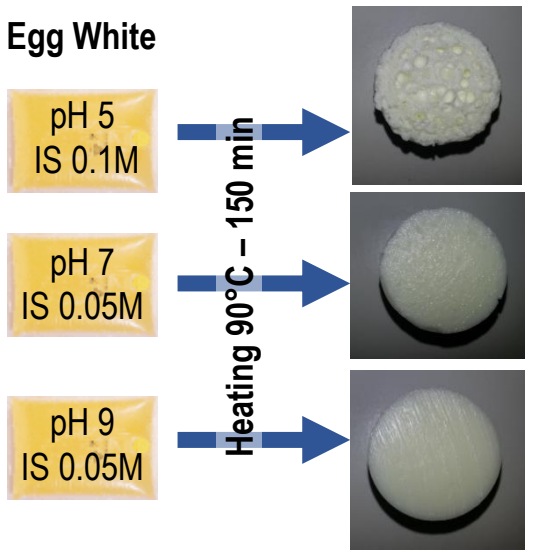
journal homepage: www.elsevier.com/locate/foodchem

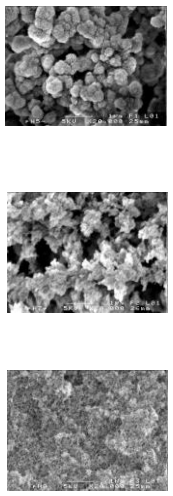
Spatial-temporal changes in pH, structure and rheology of the gastric chyme in pigs as influenced by egg white gel properties

Françoise Nau[a,b,*], Kéra Nyemb-Diop[a,b], Valérie Lechevalier[a,b], Juliane Floury[a,b], Chloé Serrière[c], Natascha Stroebinger[c], Thiébaud Boucher[a,b], Catherine Guérin-Dubiard[a,b], Maria J. Ferrua[c], Didier Dupont[a,b], Shane M. Rutherfurd[c]

[a] Agrocampus Ouest, UMR1253 Science et technologie du lait et de l'œuf, 65 rue de Saint-Brieuc, 35042 Rennes, France
[b] INRA, UMR1253 Science et technologie du lait et de l'œuf, 65 rue de Saint-Brieuc, 35042 Rennes, France
[c] Riddet Institute, Massey University, University Avenue, Palmerston North 4474, New Zealand

3 egg white gels: different structures, same composition





Granular-spongy gel

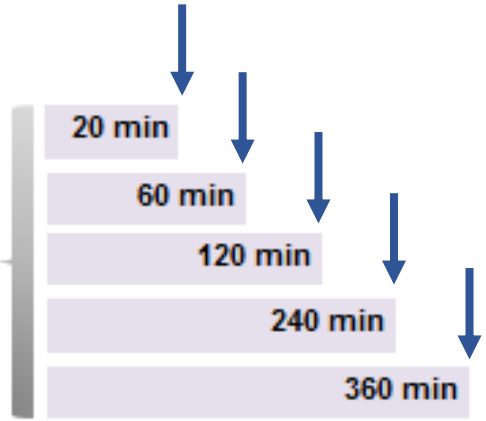
Intermediate gel

Smooth-rigid gel

Test meals: 1 kg

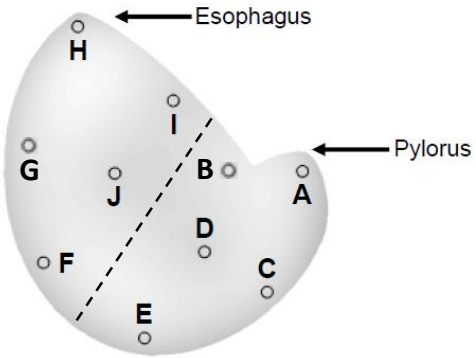
n=99

Euthanization



1 trial = 1 EWG x 1 time
5 to 6 pigs / trial

Gastric sampling in 10 locations



- pH
- Wet and dry mases
- Granulometric distribution
- rheological properties

Previous *in vivo* results on Egg white gels (EWG)

Food Chemistry 280 (2019) 210–220

Contents lists available at ScienceDirect

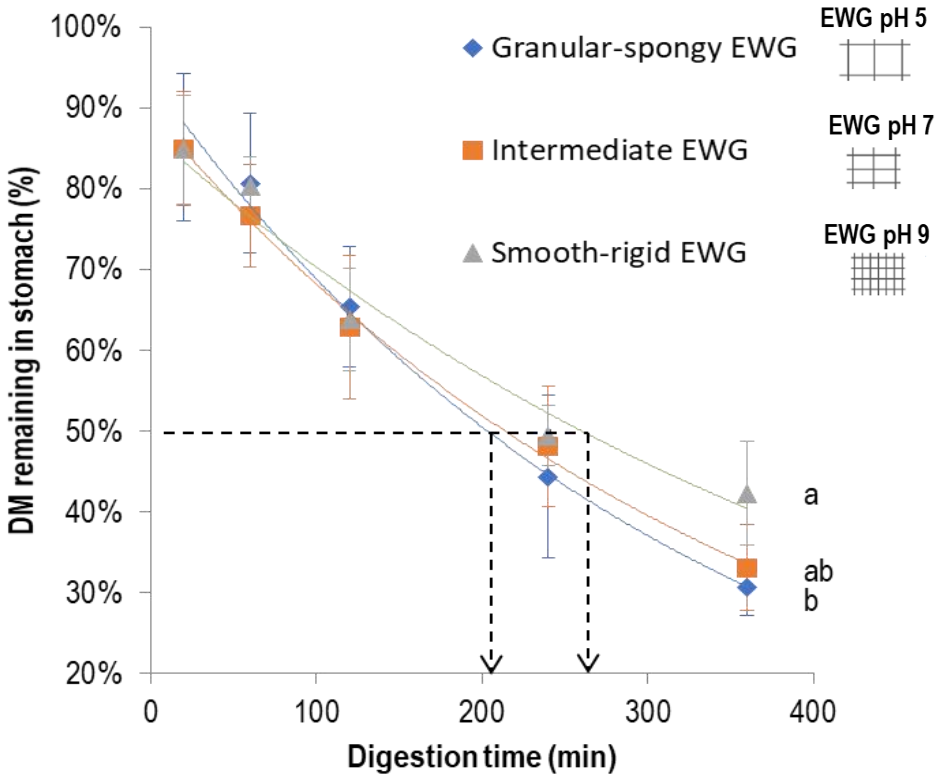
Food Chemistry

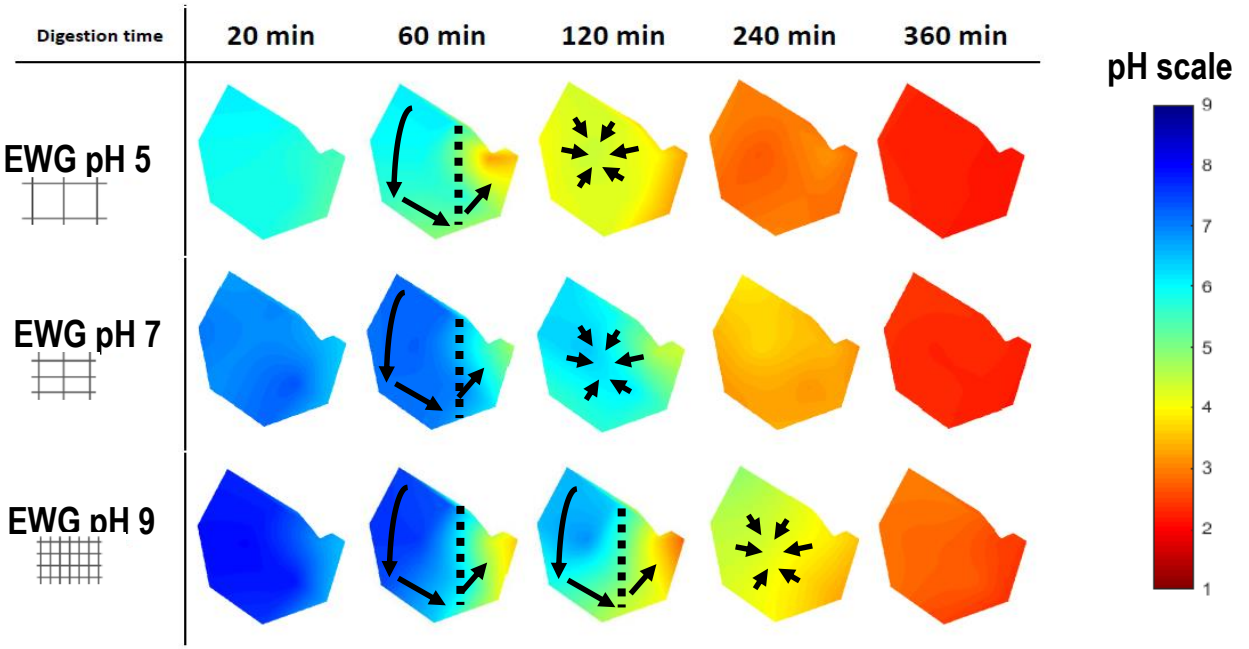
journal homepage: www.elsevier.com/locate/foodchem

Spatial-temporal changes in pH, structure and rheology of the gastric chyme in pigs as influenced by egg white gel properties

Françoise Nau[a,b,*], Kéra Nyemb-Diop[a,b], Valérie Lechevalier[a,b], Juliane Floury[a,b], Chloé Serrière[c], Natascha Stroebinger[c], Thiébaud Boucher[a,b], Catherine Guérin-Dubiard[a,b], Maria J. Ferrua[c], Didier Dupont[a,b], Shane M. Rutherfurd[c]

[a] Agrocampus Ouest, UMR1253 Science et technologie du lait et de l'œuf, 65 rue de Saint-Brieuc, 35042 Rennes, France
[b] INRA, UMR1253 Science et technologie du lait et de l'œuf, 65 rue de Saint-Brieuc, 35042 Rennes, France
[c] Riddet Institute, Massey University, University Avenue, Palmerston North 4474, New Zealand





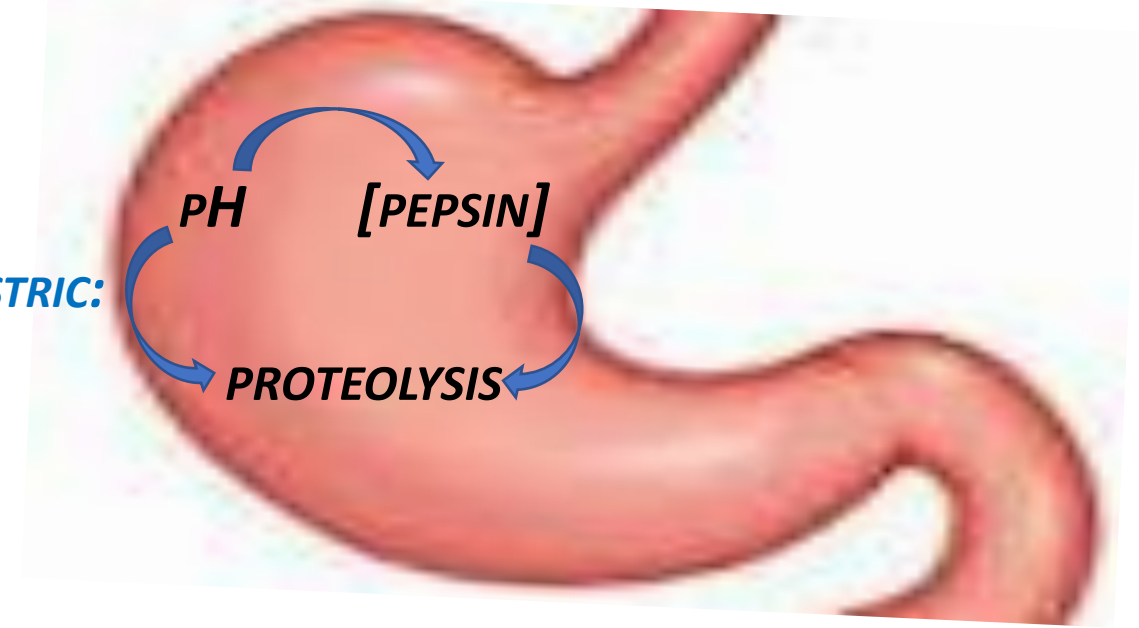
- ✓ **Gastric emptying profiles are influenced by EWG characteristics, but not in a great extent** ($t_{1/2}$ ~ 200-250 min => ~ 4h)

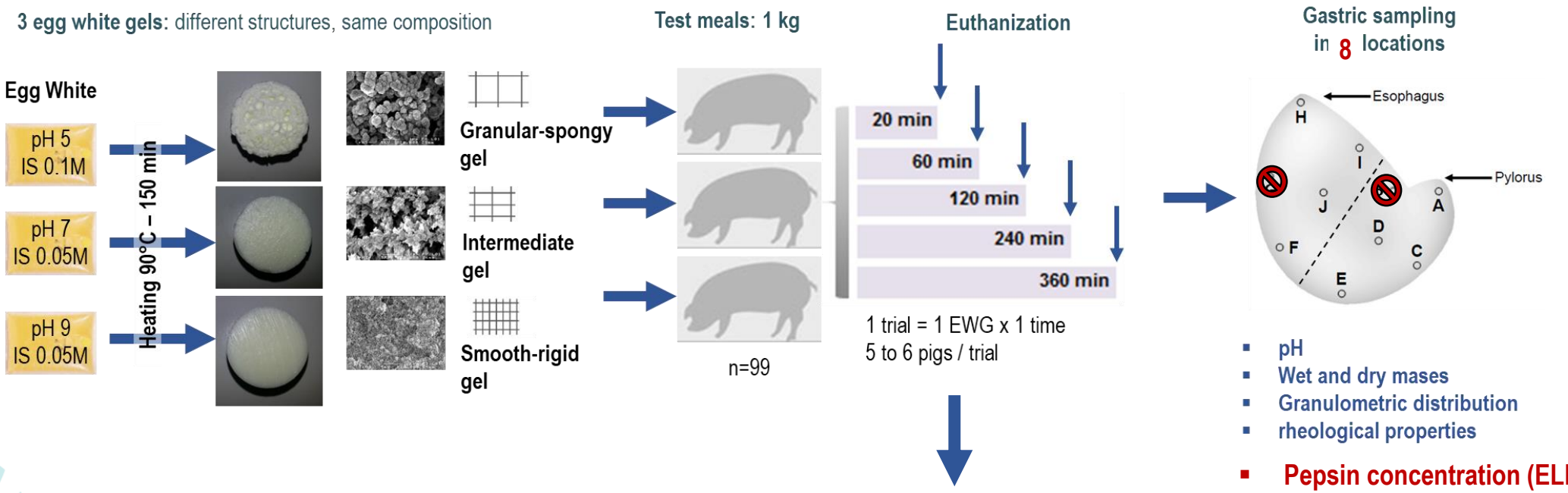
- ✓ **Acidification starts in the pylorus region** (HCl streaming along stomach walls)
- ✓ **Beyond the initial pH, the gel structure impacts the mixing kinetics**
- ✓ **Consistent with *(Bornhorst et al., Food Biophysics, 2014)* on almonds and rice**

Objectives of the present study

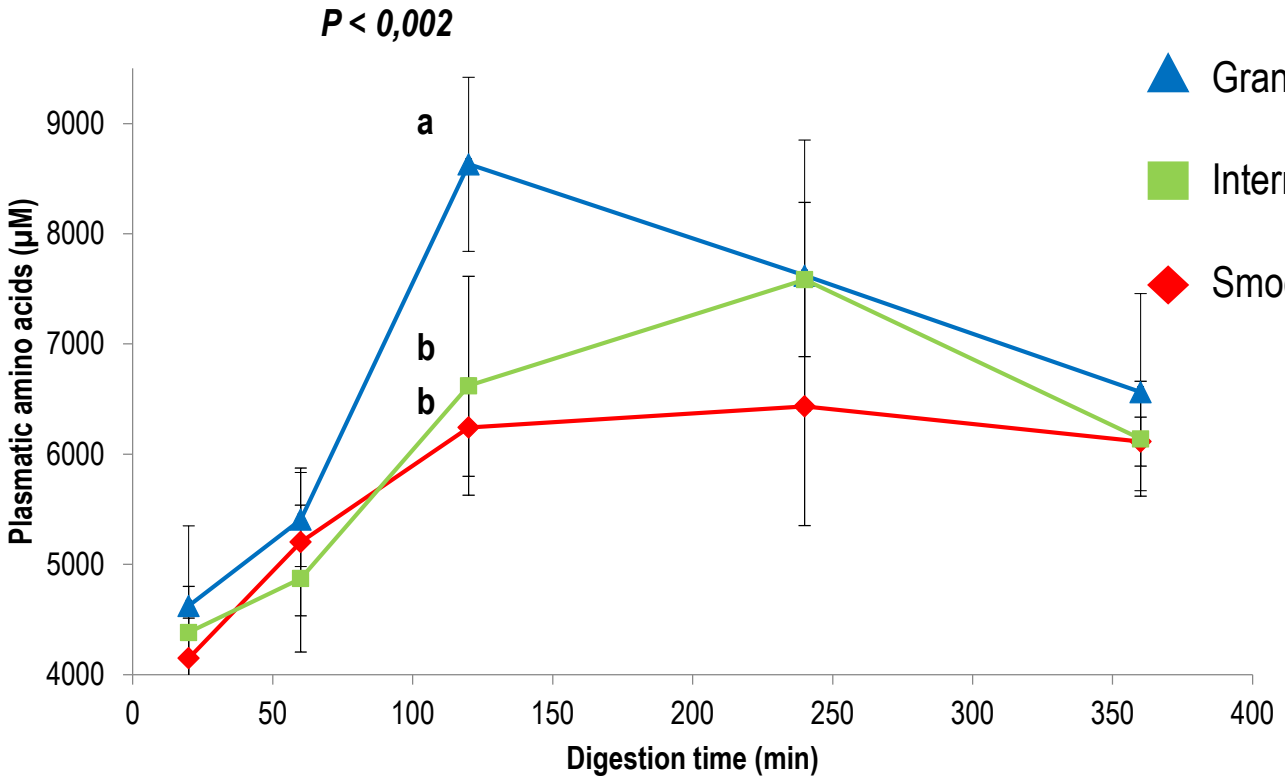
COMPLEMENTARY ANALYSES OF THE SAME SAMPLES TO:

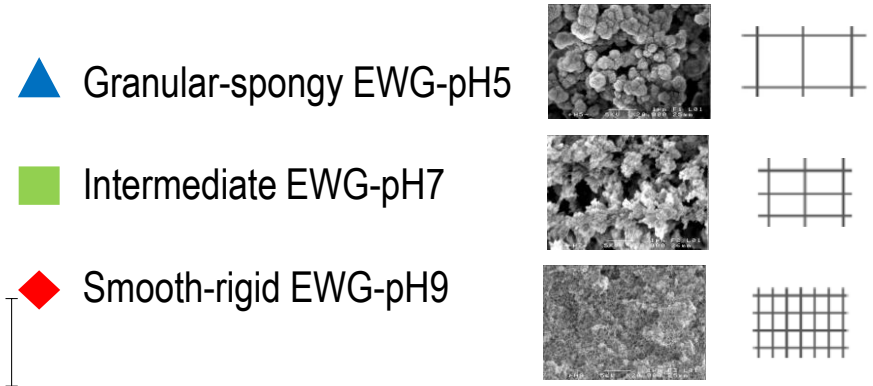
- ***FURTHER STUDY THE RELATIONSHIPS BETWEEN INTRAGASTRIC:***
  - ***pH***
  - ***[PEPSIN]***
  - ***PROTEOLYSIS***
- ***THE CONSEQUENCES ON SUBSEQUENT AMINO-ACID ABSORPTION***

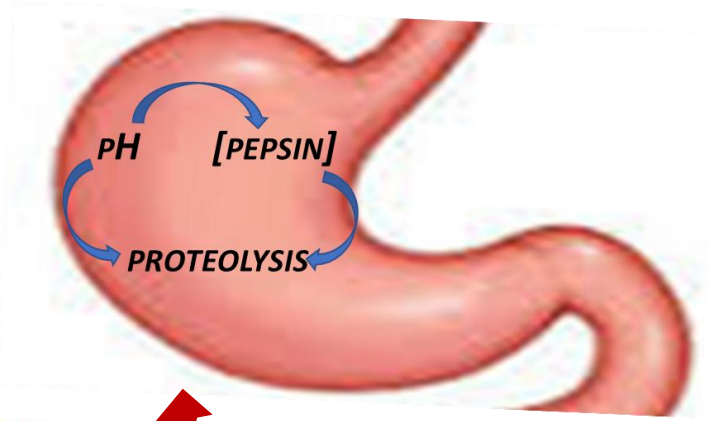




Peripheral blood aminoacidemia



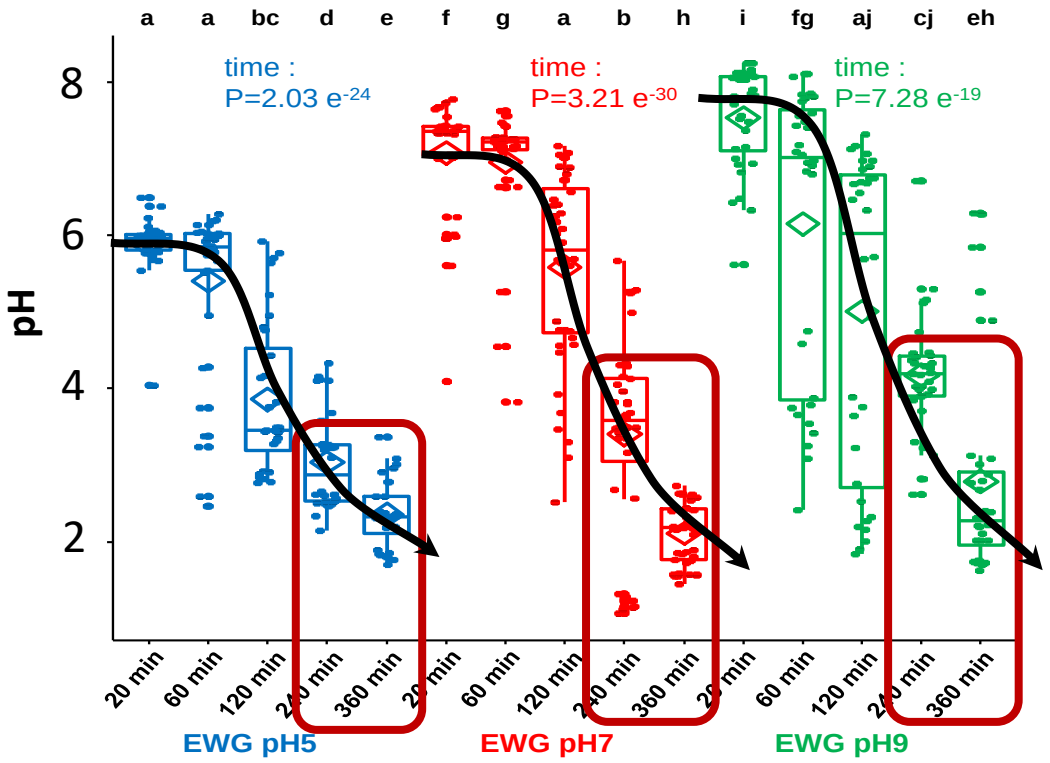




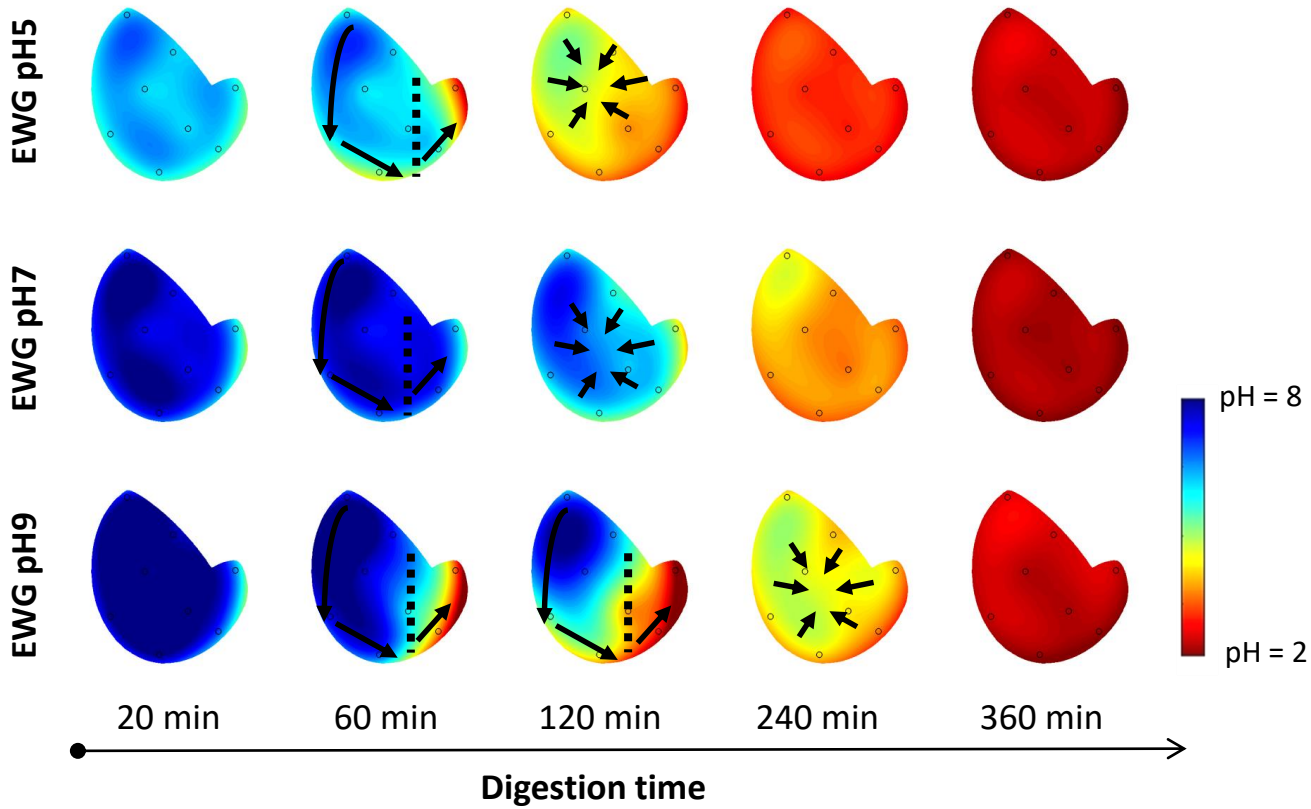
✓ **The loosest protein network is the more quickly digested & leads to the highest and earliest plasmatic amino acid peak**

pH results

All values

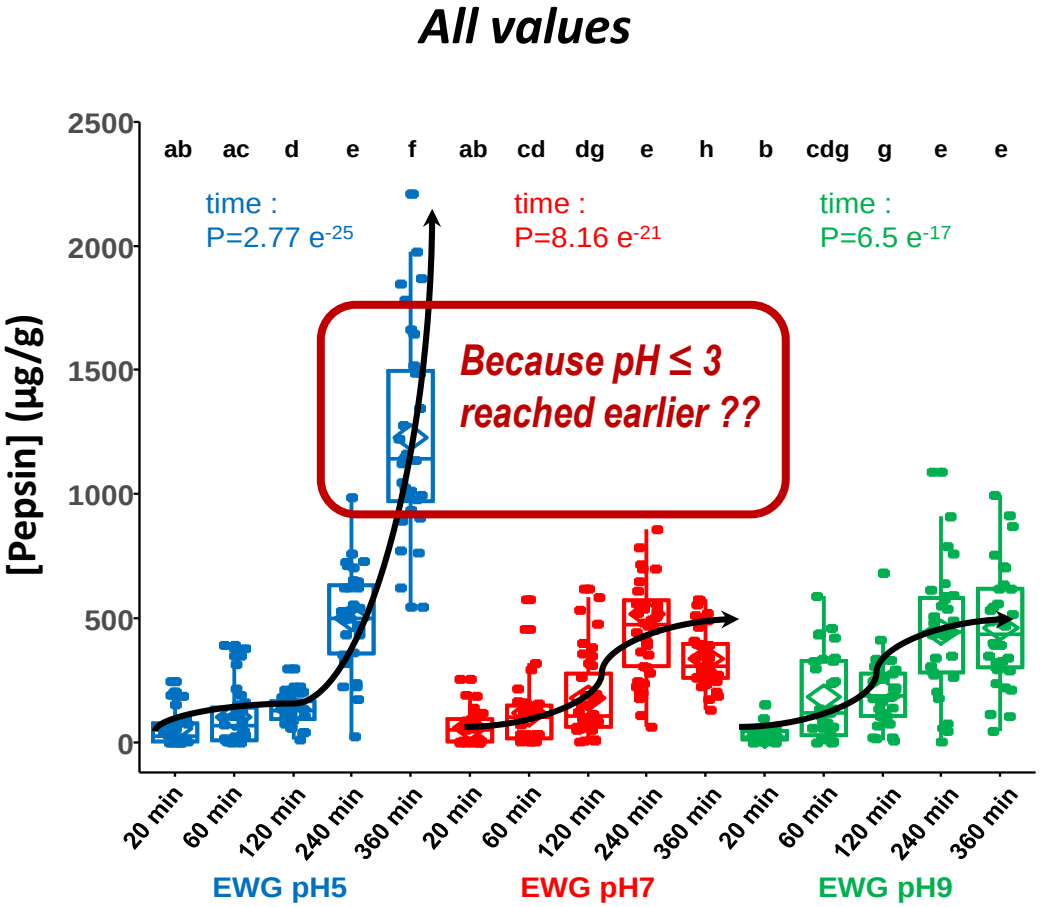


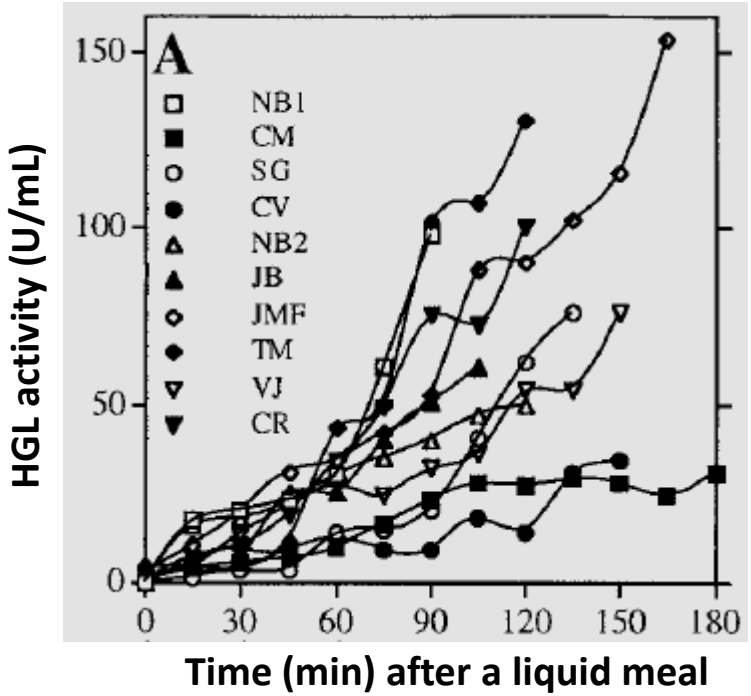
Maps



- ✓ At $t_{1/2}$ (~ 4h), pH range between 3-4
- ✓ 1.5 × $t_{1/2}$ (6h) to reach pH 2

Pepsin results (µg/g of wet chyme)



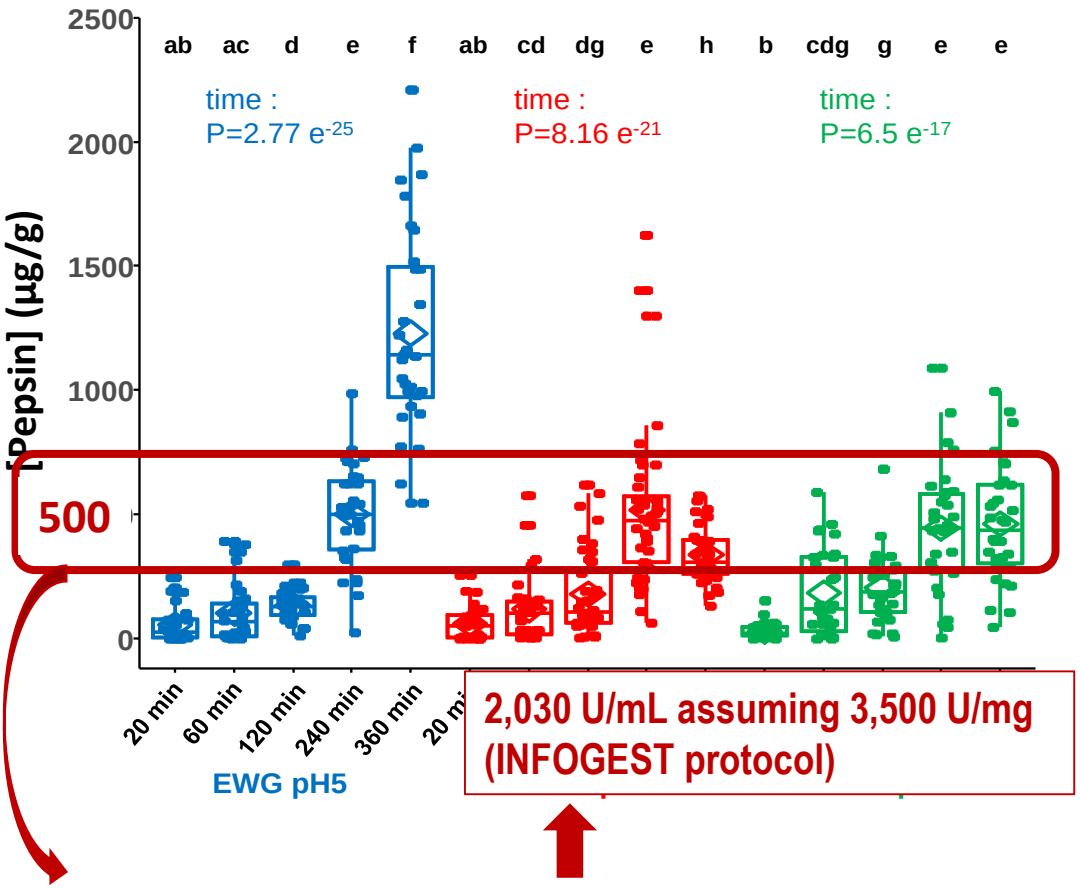


- ✓ Max [Pepsin] reached at ≥ $t_{1/2}$ (4-6h, as for pH ≤ 3)
- ✓ 2 shapes of concentration profiles depending on the gels

- ✓ Consistent with previous reports on Gastric Lipase in Humans *(Carrière et al., Digestion, 2001)*

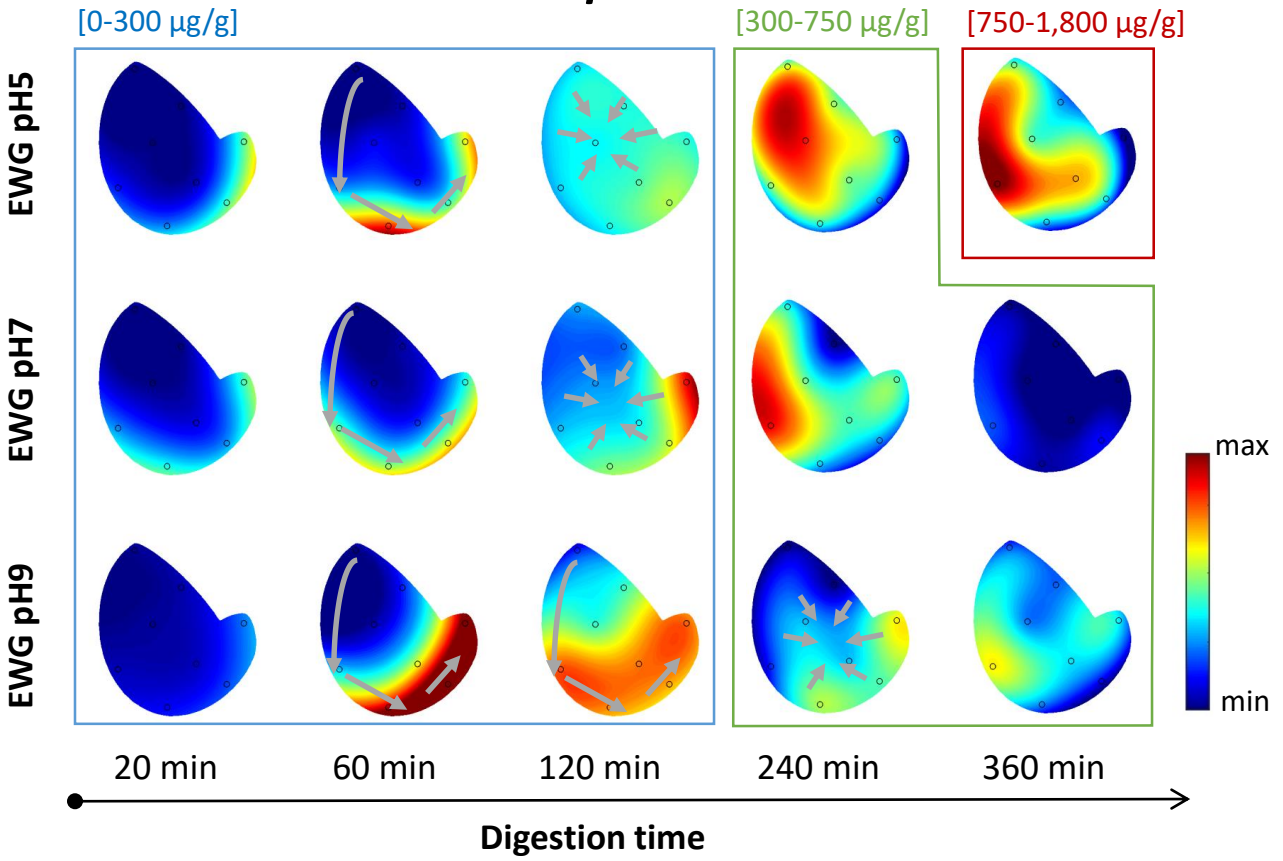
Pepsin results (µg/g of wet chyme)

All values



- ✓ 500 µg/g at 240 min ≈ 580 µg/g at 210 min in humans *(Kalantzi et al., Pharm. Res., 2006)*
- ✓ Mean flow rate of 2.1 mg/min ≈ 2.5 mg/min in humans *(Malagelada et al., Dig. Dis. Sci., 1979)*

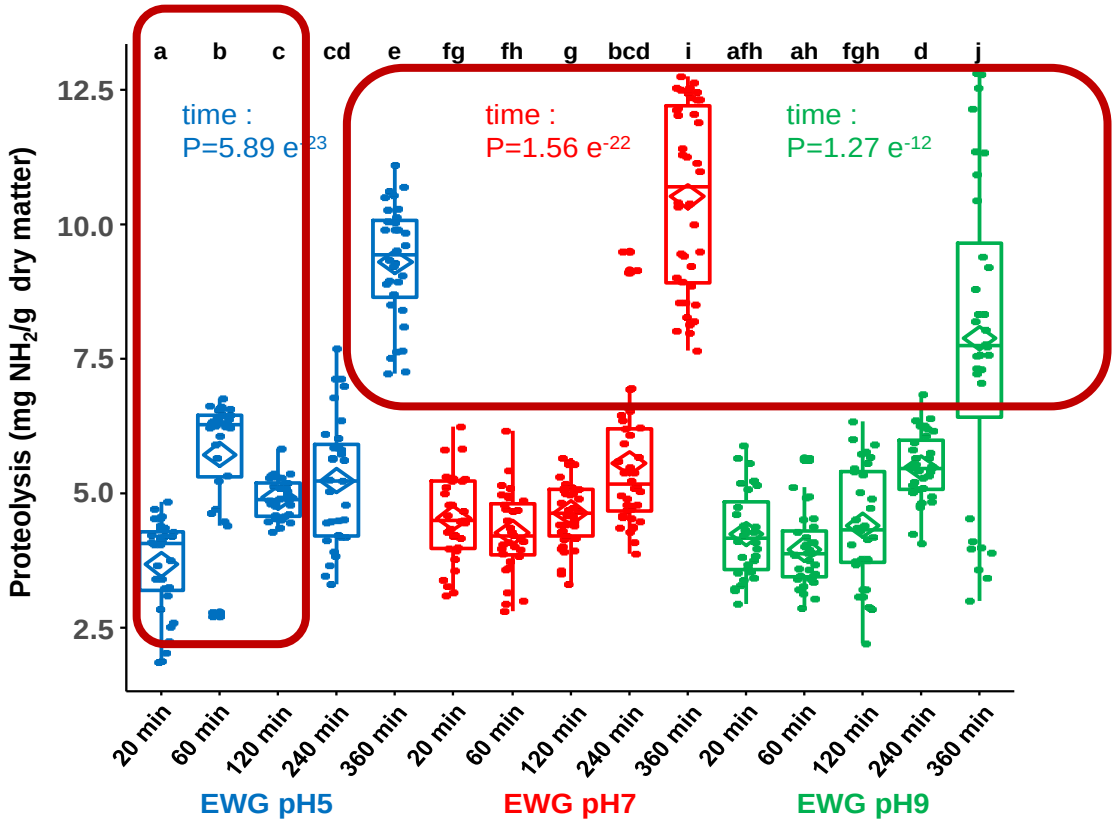
Maps



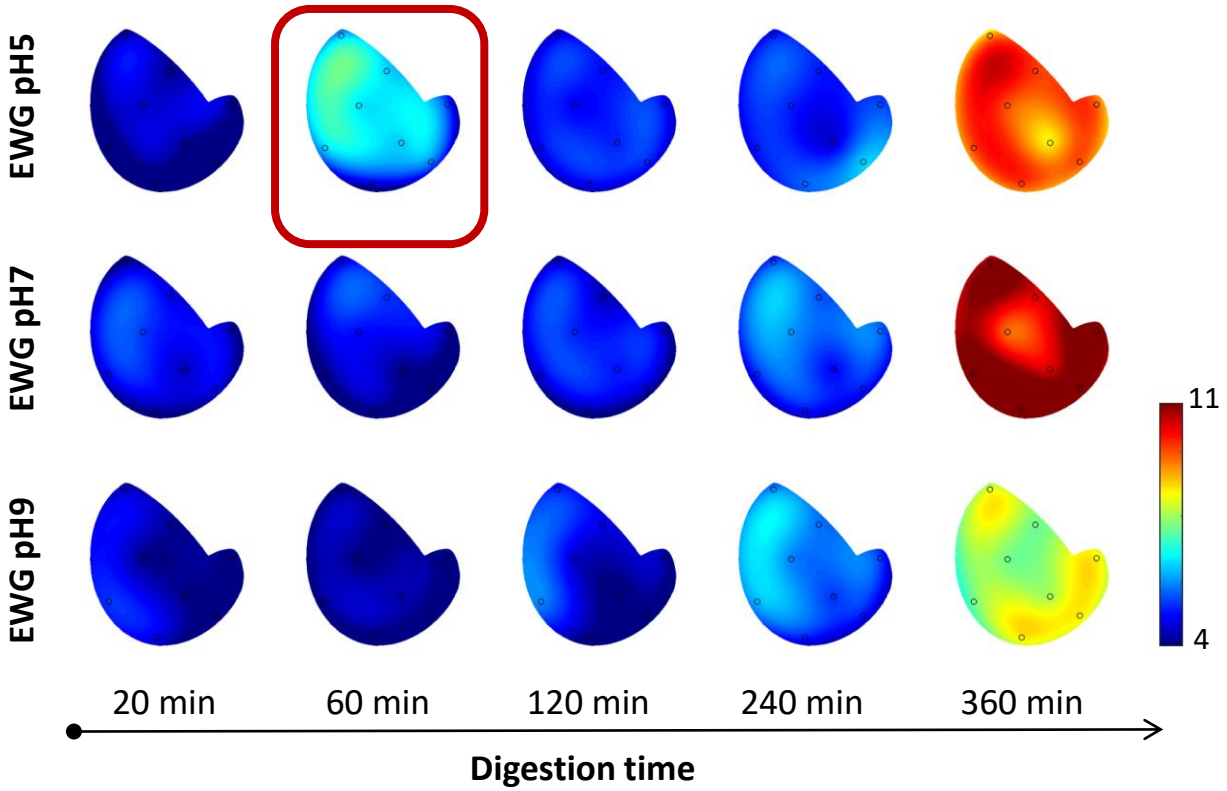
- ✓ Very similar as for the pH (pepsin streaming along the walls)…
- ✓ … before it turns to accumulate in the proximal region
- ✓ pH and pepsin maps are ≠ in the end because:
  - pH is not a concentration (it is a Log)
  - Food buffers

Proteolysis results (mg of free NH_2 / g of dry matter)

All values



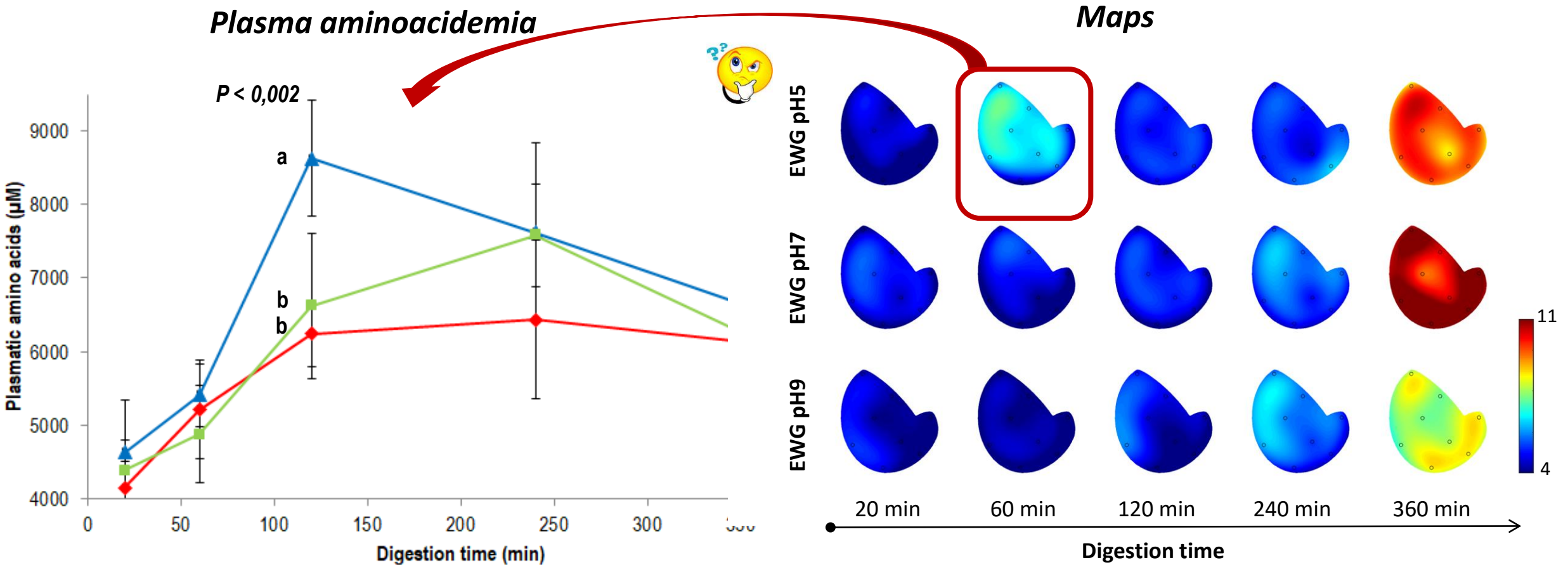
Maps



- A clear increase in proteolysis only at 6h (not 4h) !
  A matter of time (kinetics) / of pepsin real activity ?
- Similar extents of proteolysis despite variable pH and [Pepsin] ??

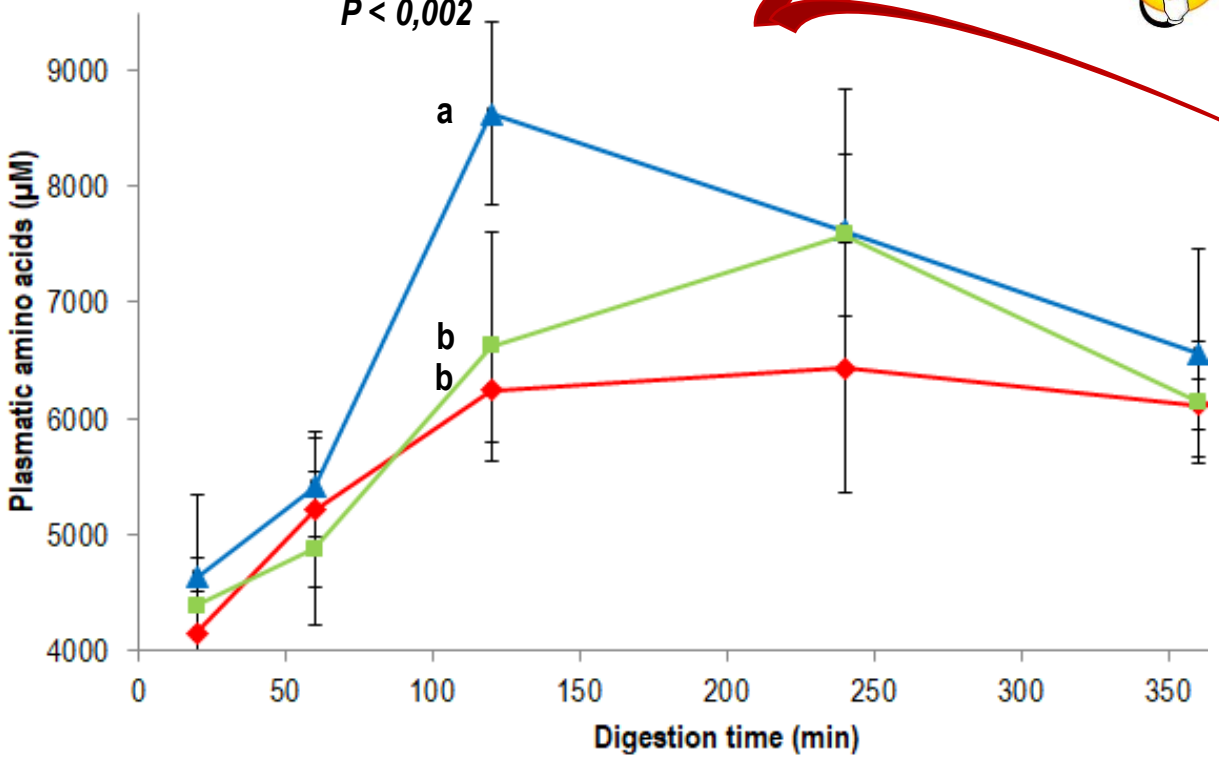
- Nothing special in the pylorus region (0-120 min) & only slightly in the proximal region (from 240 min) ??
- Significant increase at 60 min for EGW-pH5 ??
  (pH ≥ 4 & [Pepsin] range ≤ 300 µg/g)

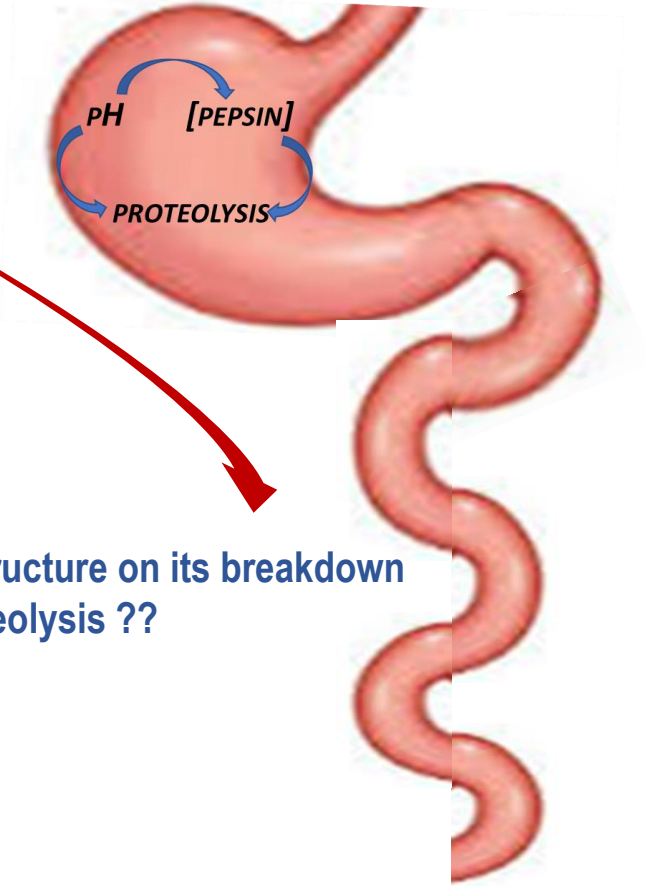
Proteolysis results (mg of free NH_2 / g of dry matter)



Proteolysis results (mg of free NH_2 / g of dry matter)

Plasma aminoacidemia



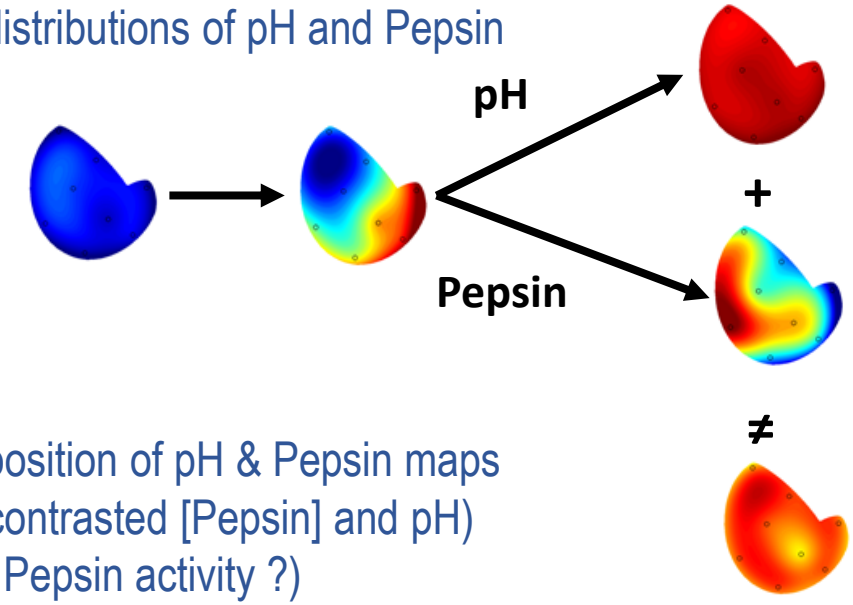


Effect of food structure on its breakdown & intestinal proteolysis ??

Main Conclusions

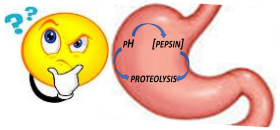
- ✓ **pH and [Pepsin] values are consistent with:**
  - The available literature
  - INFOGEST static and semi-dynamic protocols

- ✓ **Effects of EWG structure were observed on:**
  - Gastric emptying
  - Gastric mixing ⟹ Intragastric distributions of pH and Pepsin



- ✓ **Gastric proteolysis was:**
  - Not simply explained by a superimposition of pH & Pepsin maps
  - Robust (similar for all gels despite contrasted [Pepsin] and pH)
  - Late (a matter of: time ? [Pepsin] ≠ Pepsin activity ?)

- ✓ **Gastric proteolysis does not seem the one key to understand the effect of EWG structure on plasmatic AA** (=> intestinal behaviour ?)



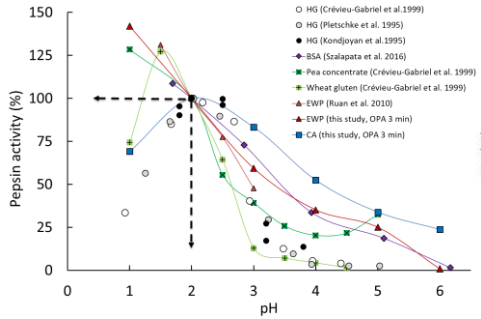
Nau et al., just accepted in

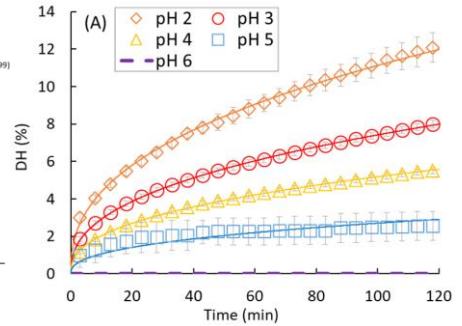
Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Pepsin activity as a function of pH, substrates & time:
(Salelles et al., Food Funct., 2021)
***Poster 12* (Session 1, Sherrard Suite)**





$$DH(\%) = \alpha \times time^{\beta}$$

Thank you for your attention !