Food microstructure and gastric digestion: the egg white gel model

Francoise Nau

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STLOpen Days
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Françoise NAU

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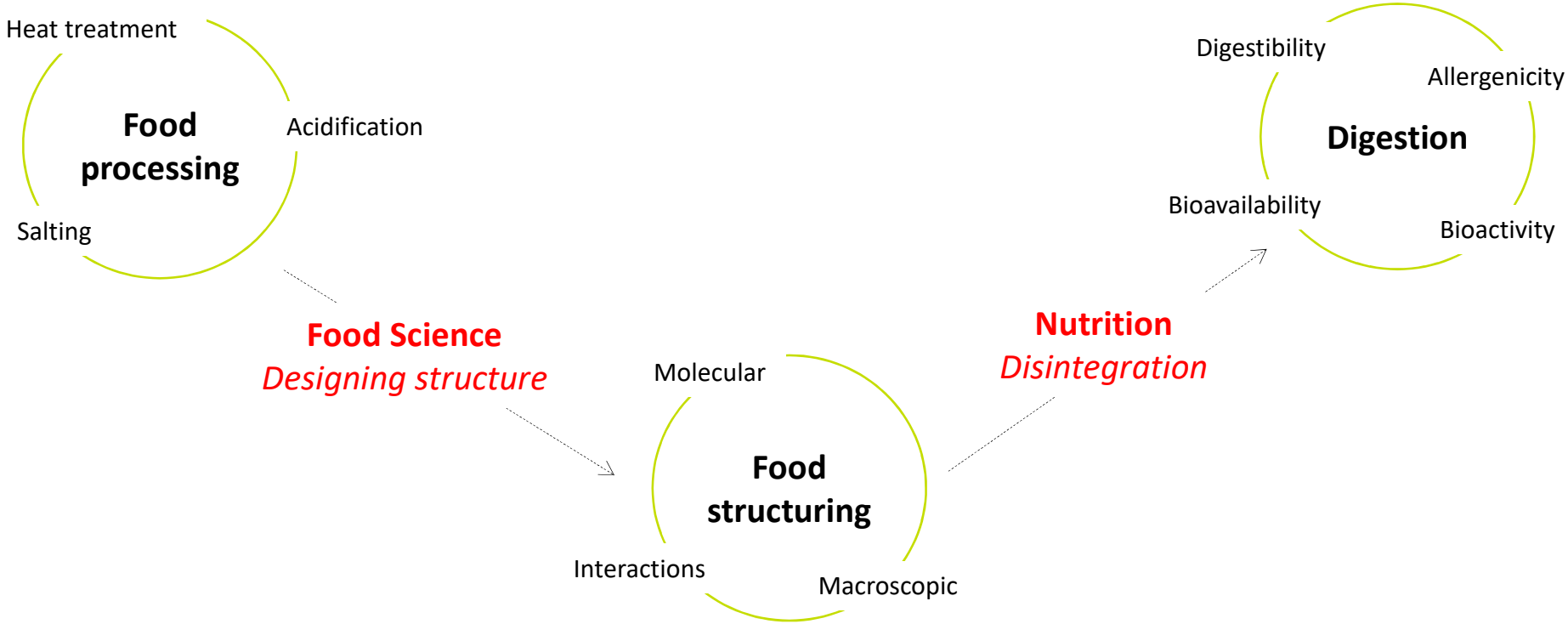
(Bioactivity & Nutrition Team)

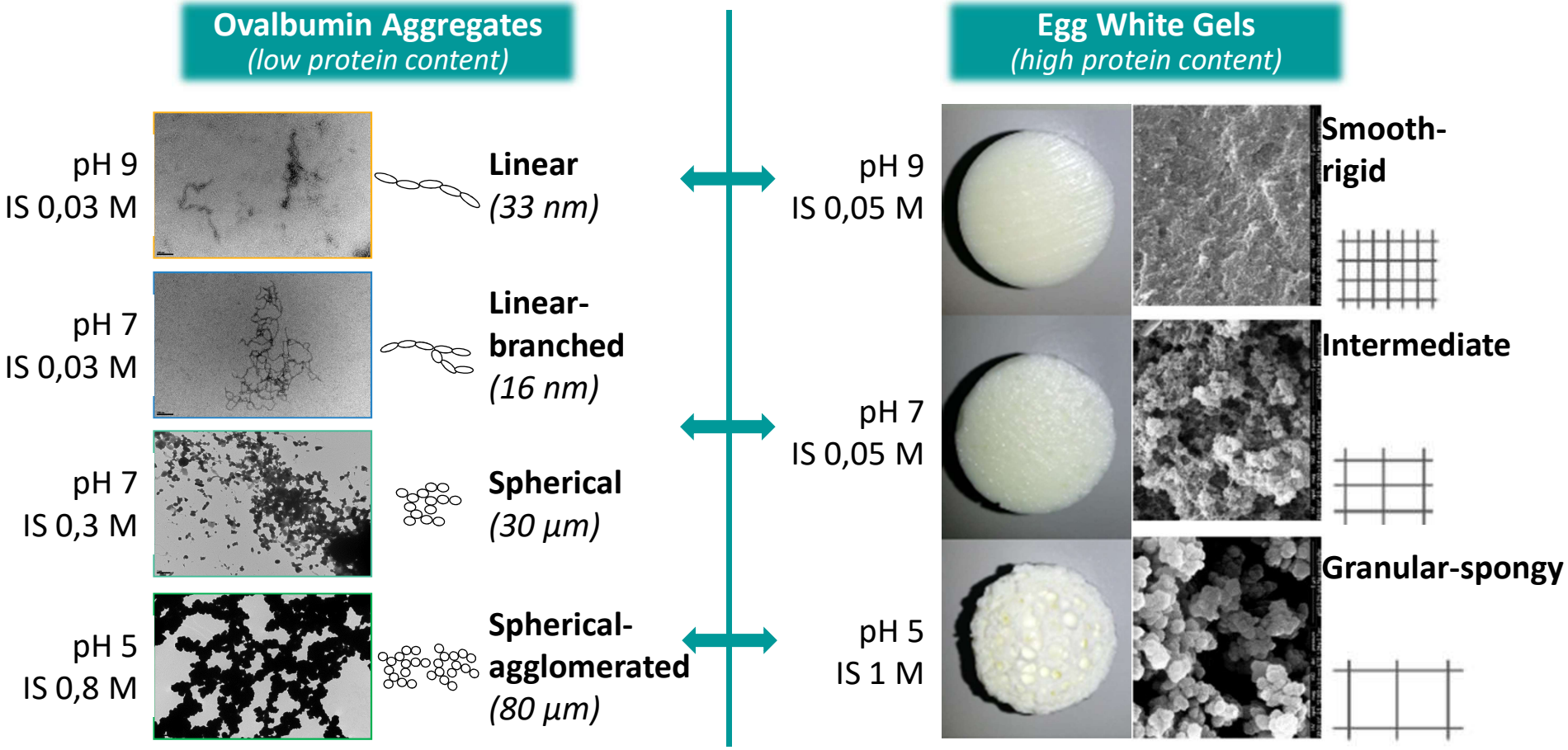
The nutritional value of food can be modulated by food structuring



Egg white *(10% proteins)* can lead to **various micro- and macro-structures**

Ovalbumin Aggregates
(low protein content)

Egg White Gels
(high protein content)



1. Impact on the *in vitro* digestion process

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 Research International 63 (2014) 192–202

Contents lists available at ScienceDirect

Food Research International

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

Investigating the impact of ovalbumin aggregate 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 Hydrocolloids 54 (2016) 315–327

Contents lists available at ScienceDirect

Food Hydrocolloids

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

The structural properties of egg white gels impact the extent of *in vitro* protein digestion and the nature of peptides generated

Kéra Nyemb [a, b], Catherine Guérin-Dubiard [a, b], Stéphane Pézennec [a, b], Julien Jardin [a, b], Valérie Briard-Bion [a, b], Chantal Cauty [a, b], Shane M. Rutherfurd [c], Didier Dupont [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,*]

The **structure** of ovalbumin aggregates and of egg white gels drives the **protein digestibility** and the **nature of peptide released** during ***in vitro*** digestion

3. What happens ***in vivo?***

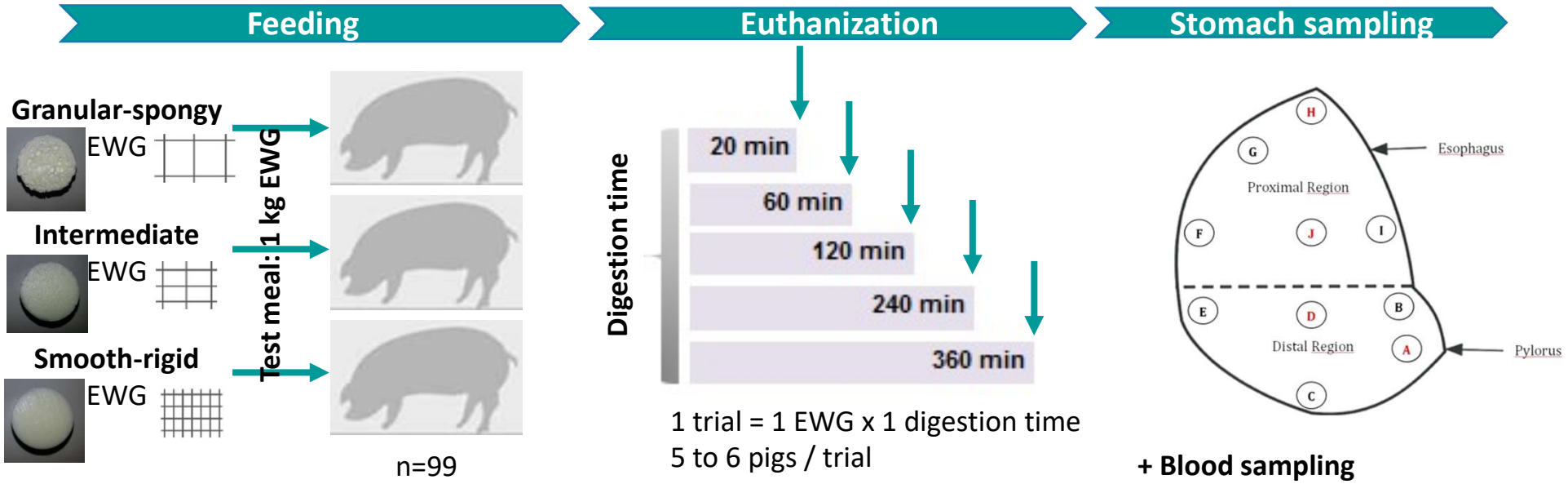
Which impact on digestion process?

Which consequences on nutrient bioavailability?

Focus on gastric digestion

Does the **Structure / Texture**
of **EW Gels**
modify the **Gastric *In Vivo* Digestion**
while keeping the ***composition constant*** *?*

Experimental design



Sample *analyses*

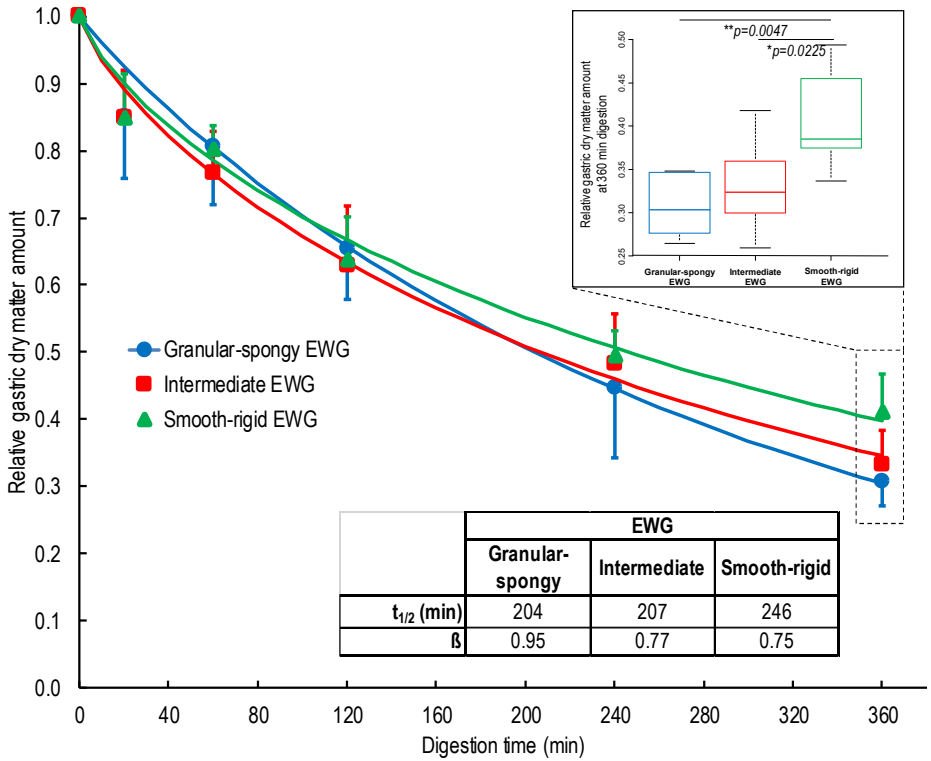
Stomach:

- pH
- Proteolysis degree (OPA method)
- Granulometric distribution
- Rheology measurements
- Total weight and dry matter of stomach content

Blood:

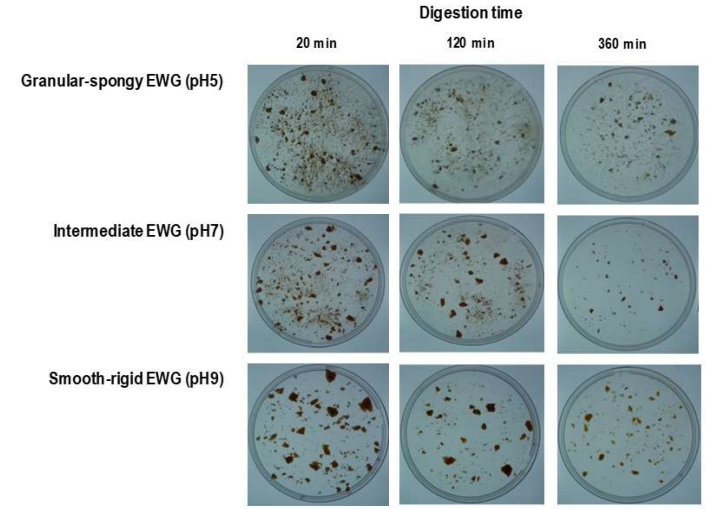
- Free amino acid content

Results

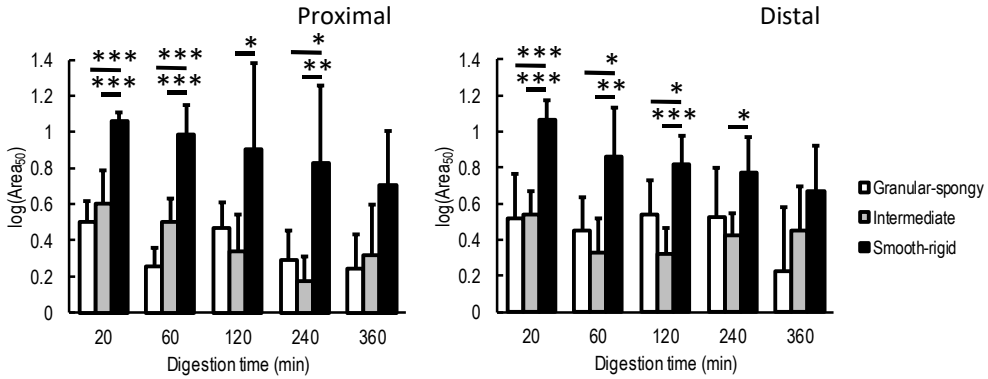


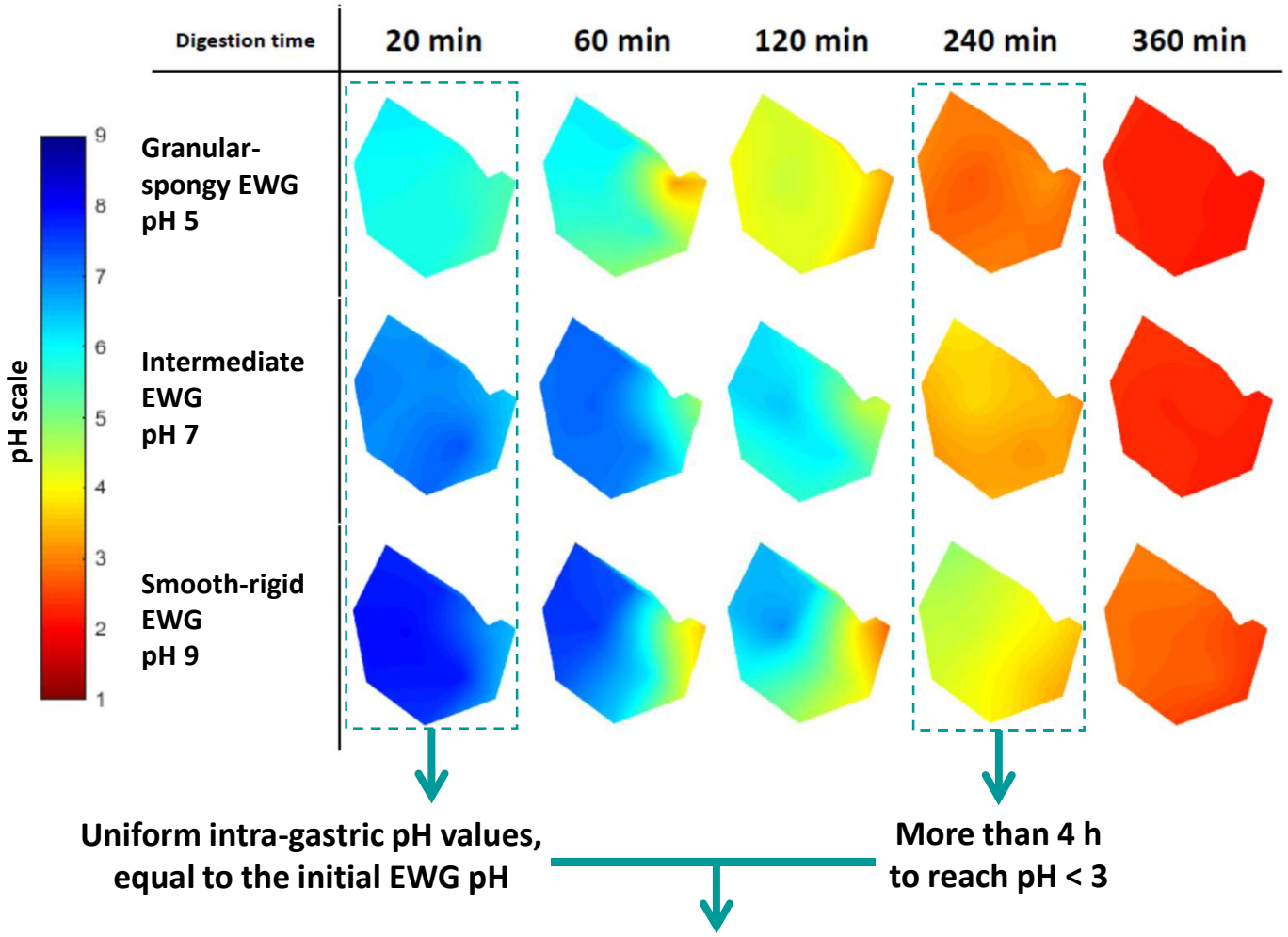
	EWG		
	Granular-spongy	Intermediate	Smooth-rigid
$t_{1/2}$ (min)	204	207	246
ß	0.95	0.77	0.75

	Elastic modulus (Pa)	Cohesiveness
Granular-spongy	2268 ± 309	0.72 ± 0.07
Intermediate	2543 ± 54	0.73 ± 0.00
Smooth-rigid	3854 ± 205	0.9 ± 0.01



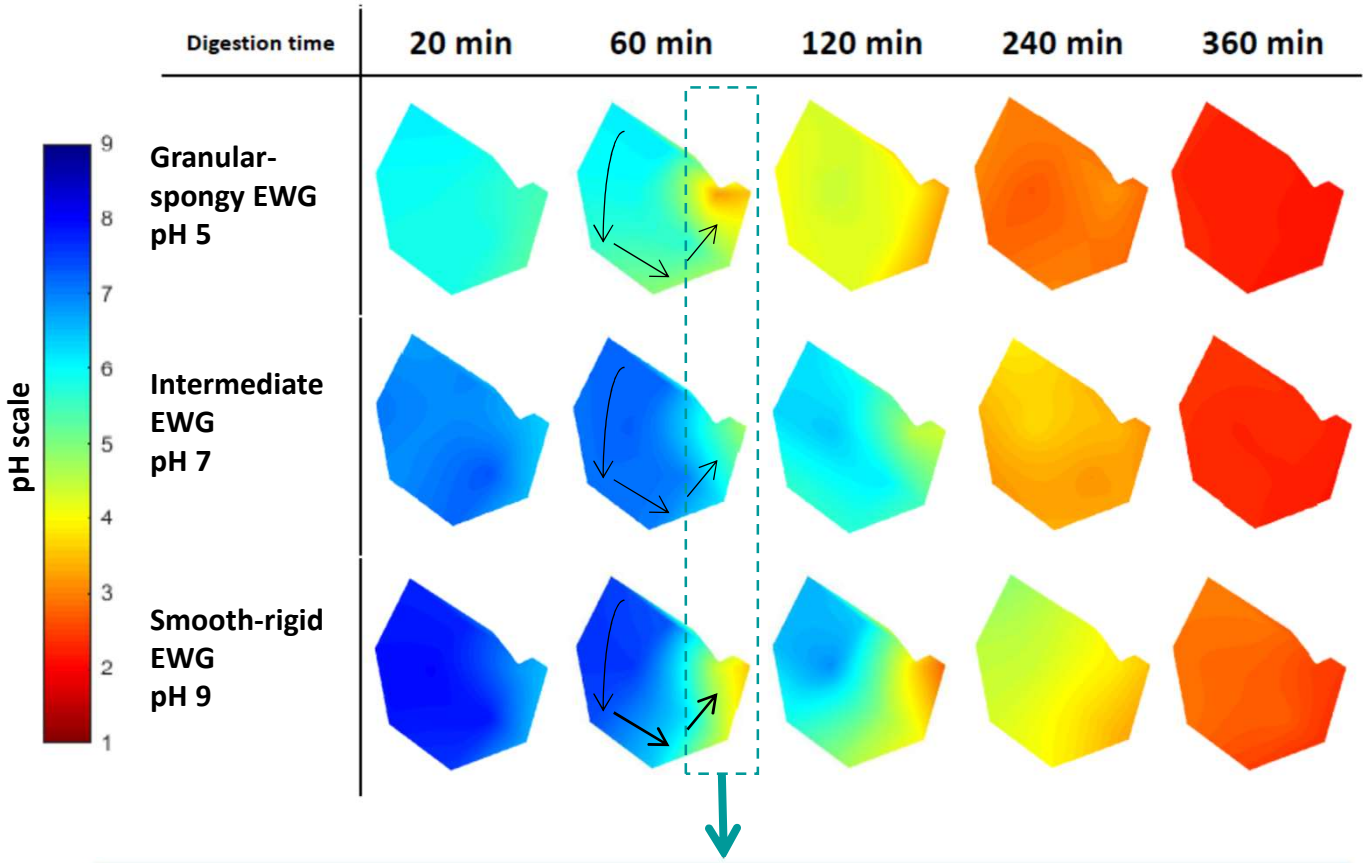
Slower gastric emptying and
Larger particle size
with the most elastic and cohesive
Smooth-rigid EWG





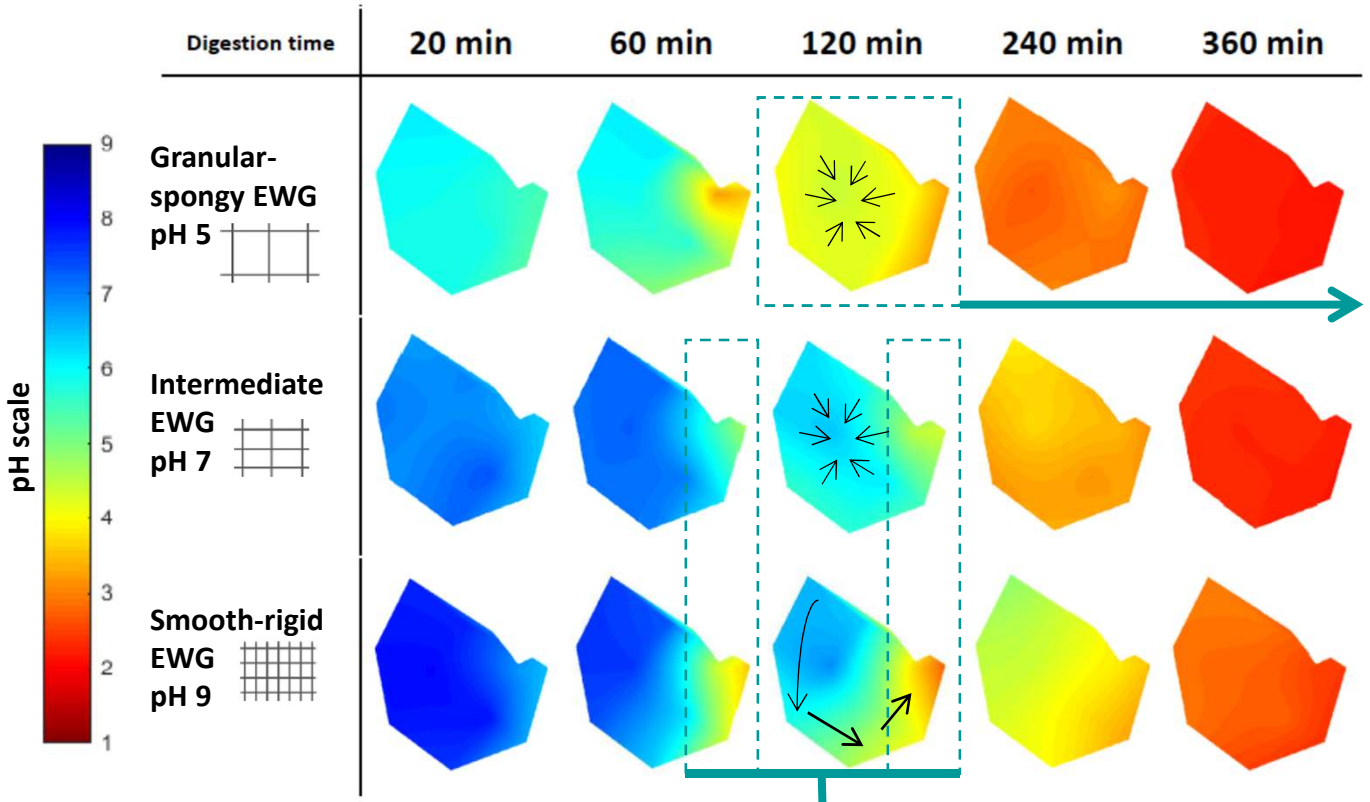
Slow acidification

High buffering capacity of EWG and high quantity ingested



Acidification starts at the pylorus region

HCl streaming along the stomach wall



Quicker and more homogeneous acidification

Easier **HCl diffusion Inside the chyme** for the **granular-spongy EWG**

More acidification
At the pylorus region for the smooth-rigid EWG
In the proximal region for the intermediate EWG

Higher **HCl diffusion inside the chyme** for the **intermediate EWG**

Higher **HCl streaming along gastric wall** for the **smooth-rigid EWG**

Initial microstructure of the gels, not only initial pH, **impacts acidification profile in the stomach**

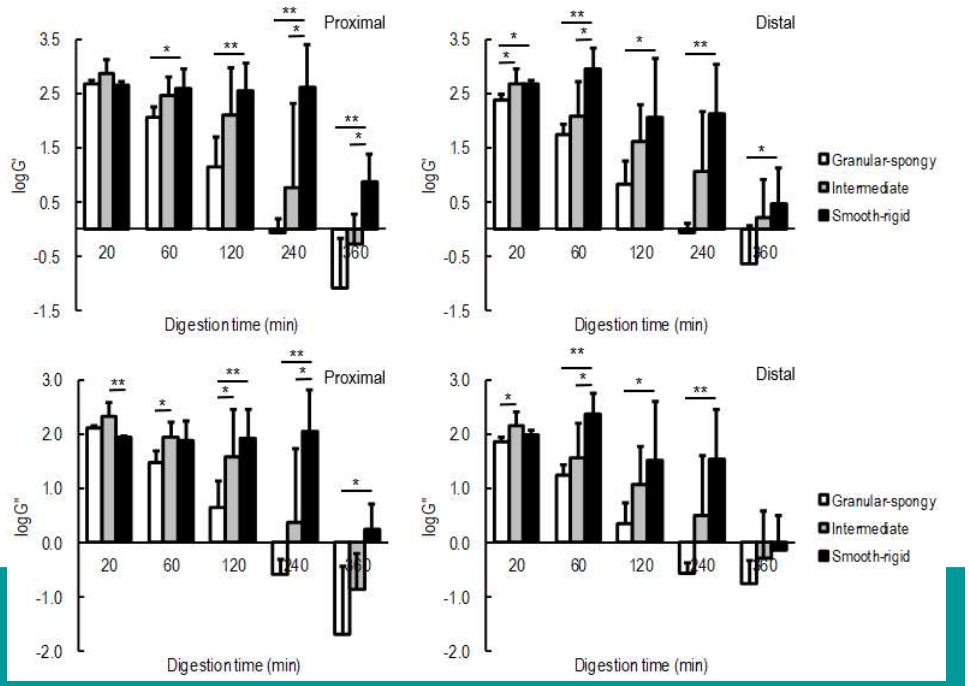
	Digestion time	*EWG*	*Digestion time x EWG*	R^2
DM_A	$<2\ 10^{-16}$ ***	NS	NS	0.6565
DM_B	$<2\ 10^{-16}$ ***	NS	NS	0.6769
DM_C	$<2\ 10^{-16}$ ***	0.0198 *	NS	0.6353
DM_D	$<2\ 10^{-16}$ ***	NS	NS	0.5764
DM_E	$<2\ 10^{-16}$ ***	NS	NS	0.6580
DM_F	$<2\ 10^{-16}$ ***	NS	NS	0.6241
DM_G	$8.6\ 10^{-13}$ ***	NS	NS	0.4344
DM_H	$<2\ 10^{-16}$ ***	NS	NS	0.6452
DM_I	$<2\ 10^{-16}$ ***	NS	NS	0.6622
DM_J	$<2\ 10^{-16}$ ***	NS	NS	0.6209
$log(Area_{50D})$	0.0298 *	$1.5\ 10^{-7}$ ***	NS	0.3031
$log(Area_{50P})$	$3.1\ 10^{-4}$ ***	$2.3\ 10^{-11}$ ***	NS	0.4655
b_D	NS	$1.6\ 10^{-7}$ ***	NS	0.3254
b_P	NS	$4.0\ 10^{-9}$ ***	NS	0.3570
$Visc0_D$	NS	NS	NS	0.0242
$Visc0_P$	NS	NS	NS	0.0564
$Thixo_D$	$2.8\ 10^{-4}$ ***	0.0171 *	NS	0.2029
$Thixo_P$	0.0323 *	NS	NS	0.0799
$logG'_D$	$< 2.2\ 10^{-16}$ ***	$3.6\ 10^{-9}$ ***	NS	0.6942
$logG'_P$	$< 2.2\ 10^{-16}$ ***	$4.3\ 10^{-10}$ ***	$1.3\ 10^{-5}$ ***	0.7431
$logG''_D$	$< 2.2\ 10^{-16}$ ***	$3.2\ 10^{-7}$ ***	NS	0.6583
$logG''_P$	$< 2.2\ 10^{-16}$ ***	$4.1\ 10^{-9}$ ***	$4.5\ 10^{-6}$ ***	0.7378

*significant effect at $p < 0.05$; **significant effect at $p < 0.01$; ***significant effect at $p < 0.001$; NS no significant effect.
DM_X: dry matter content at location X.
$Area_{50}$: median particle area; b: distribution spread.
Visc0 (zero-rate viscosity), and Thixo (thixotropy parameter) are determined from rheological flow tests.
G' (storage modulus), and G'' (loss modulus) are determined from rheological oscillatory tests.
D and P in subscript refer to distal and proximal regions, respectively.

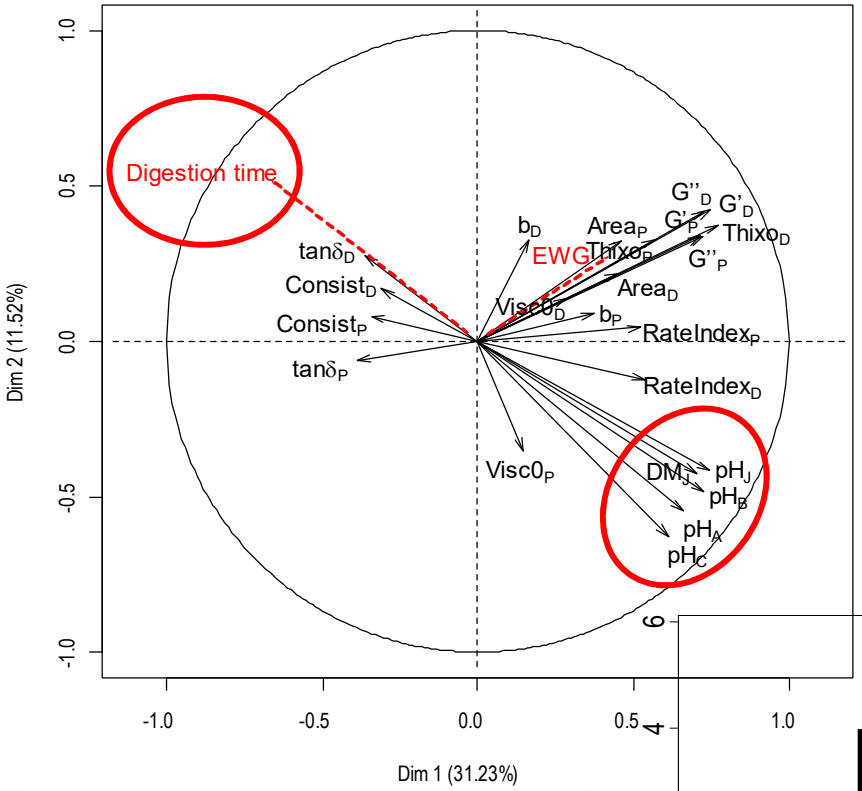
Intragastric **dry matter unaffected** by EWG type

Particle size and distribution spread affected by EWG type

Storage and loss moduli affected by EWG type
in both distal and proximal regions of the stomach



EW gels characteristics influence the physico-chemical parameters of the gastric chyme, all along digestion



Dry matter content and pH values negatively correlated to digestion time

No correlation of the rheological variables with dry mater content or particle size distribution

Food Chemistry 280 (2019) 210–220

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Food Chemistry

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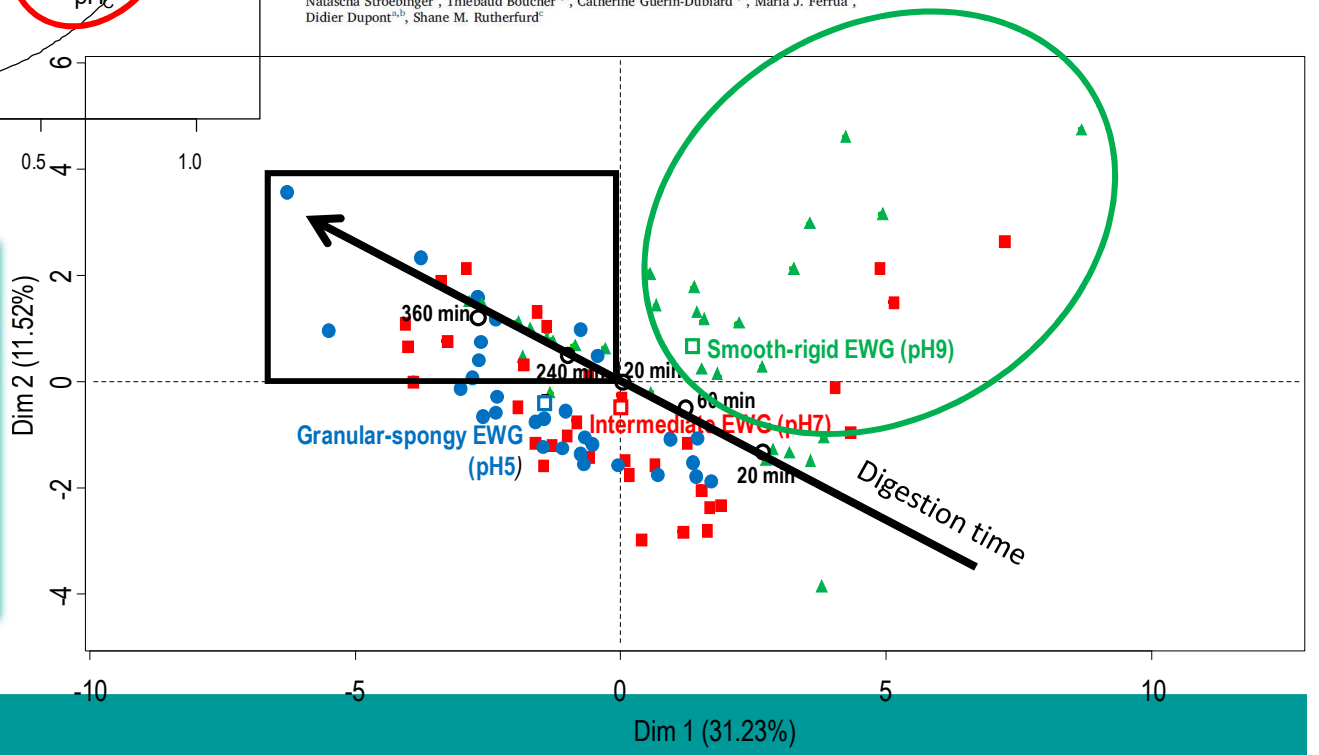
Spatial-temporal changes in pH, structure and rheology of the gastric chyme in pigs as influenced by egg white gel properties

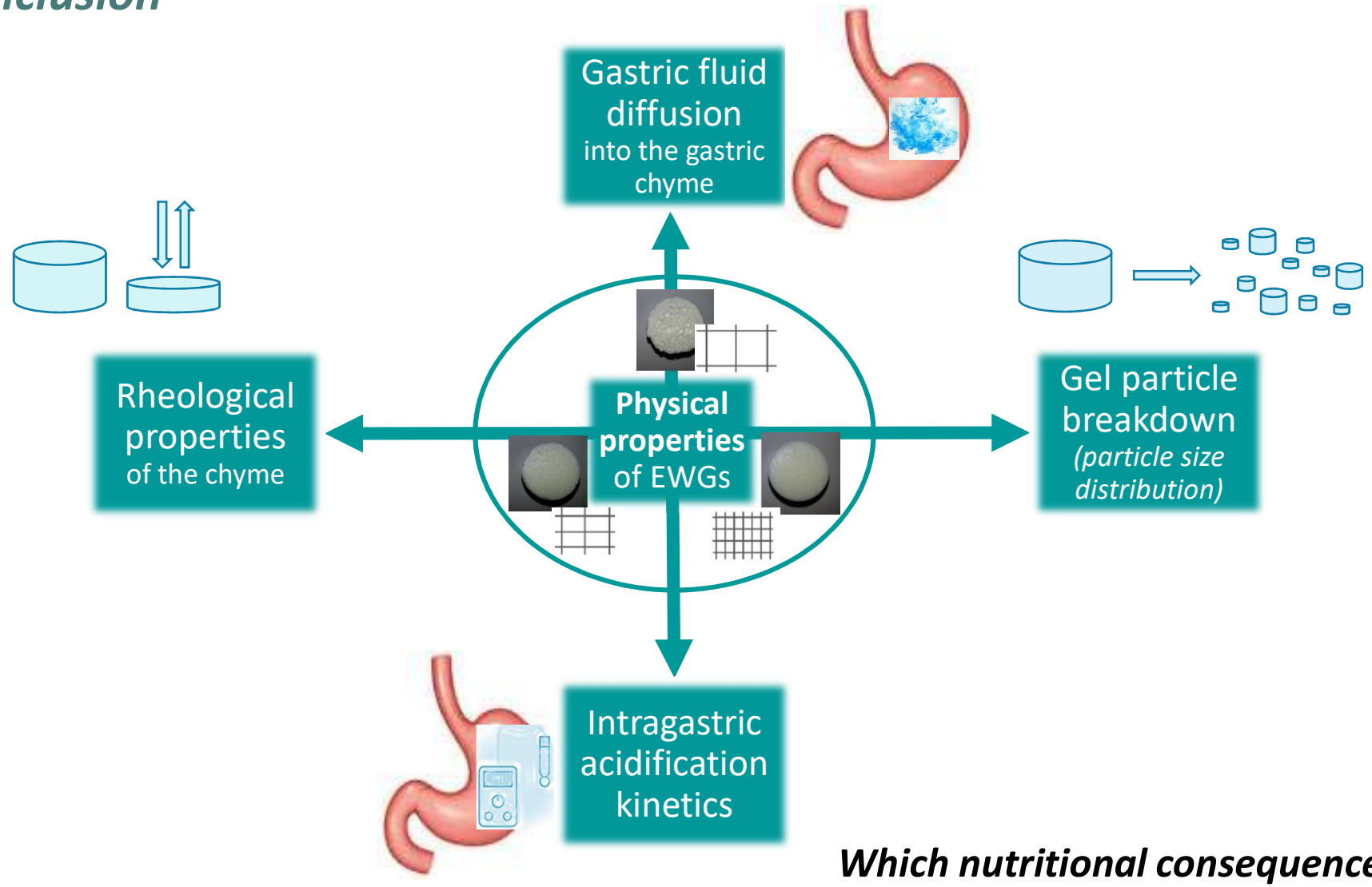
Françoise Nau[a,b,*], Kéra Nyemb-Diop[a,b], Valérie Lechevalier[a,b], Juliane Floury[a,b], Chloé Serrière[c], Natascha Stroebinger[c], Thiébaud Boucher[a,b], Catherine Guérin-Dubiard[a,b], Maria J. Ferrua[c], Didier Dupont[a,b], Shane M. Rutherfurd[c]



The smooth-rigid EWG resulted in more viscoelastic gastric chymes

The chymes from the three EWGs became more similar as digestion progressed

Conclusion



Which nutritional consequences?
A story to follow….

STLO

MERCI

THANK YOU FOR YOUR ATTENTION