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Food microstructure and gastric digestion: the egg white gel model

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Francoise Nau. Food microstructure and gastric digestion: the egg white gel model. STLOpendays, Institut National de Recherche Agronomique (INRA). UMR UMR INRA / AgroCampus Rennes : Science et Technologie du Lait et de l'œuf (1253)., Mar 2019, Rennes, France. hal-02097203

HAL Id: hal-02097203

<https://hal.science/hal-02097203>

Submitted on 5 Jun 2020

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Food microstructure and gastric digestion: the egg white gel model



STLOpen Days
19-21 March 2019

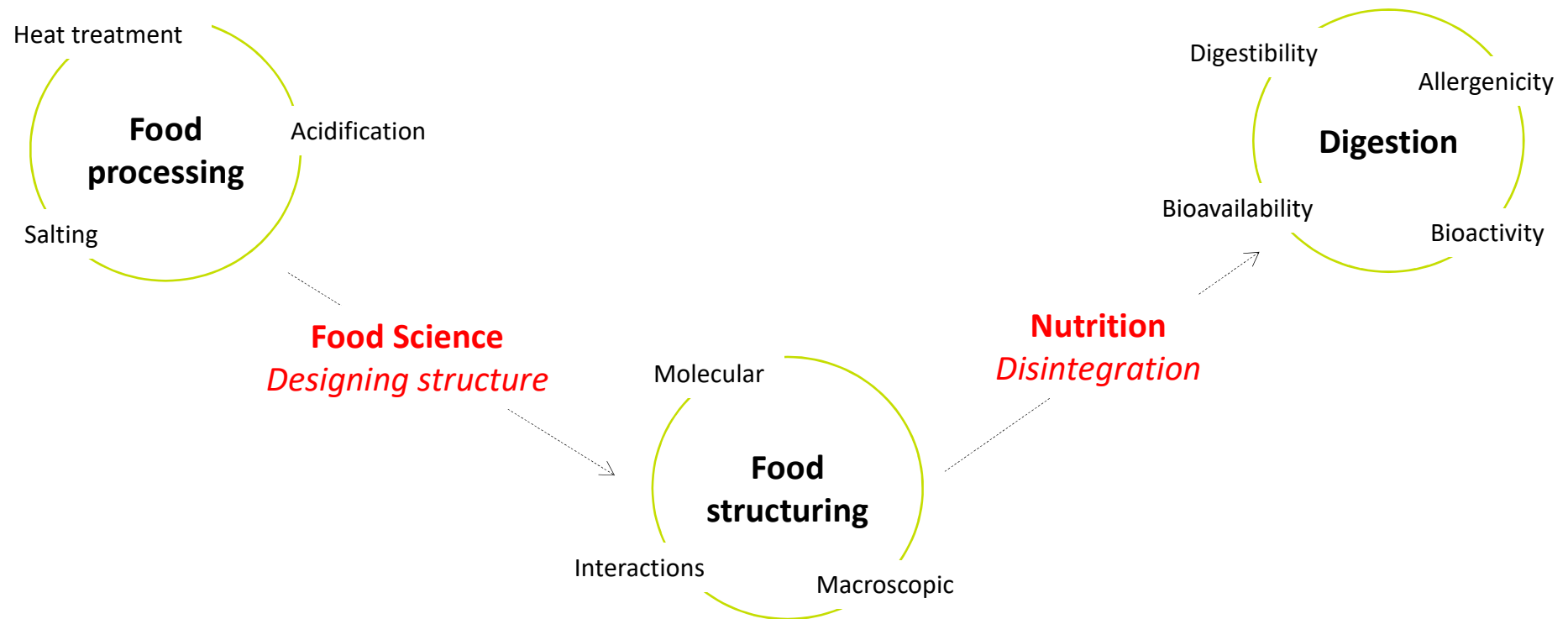


Françoise NAU

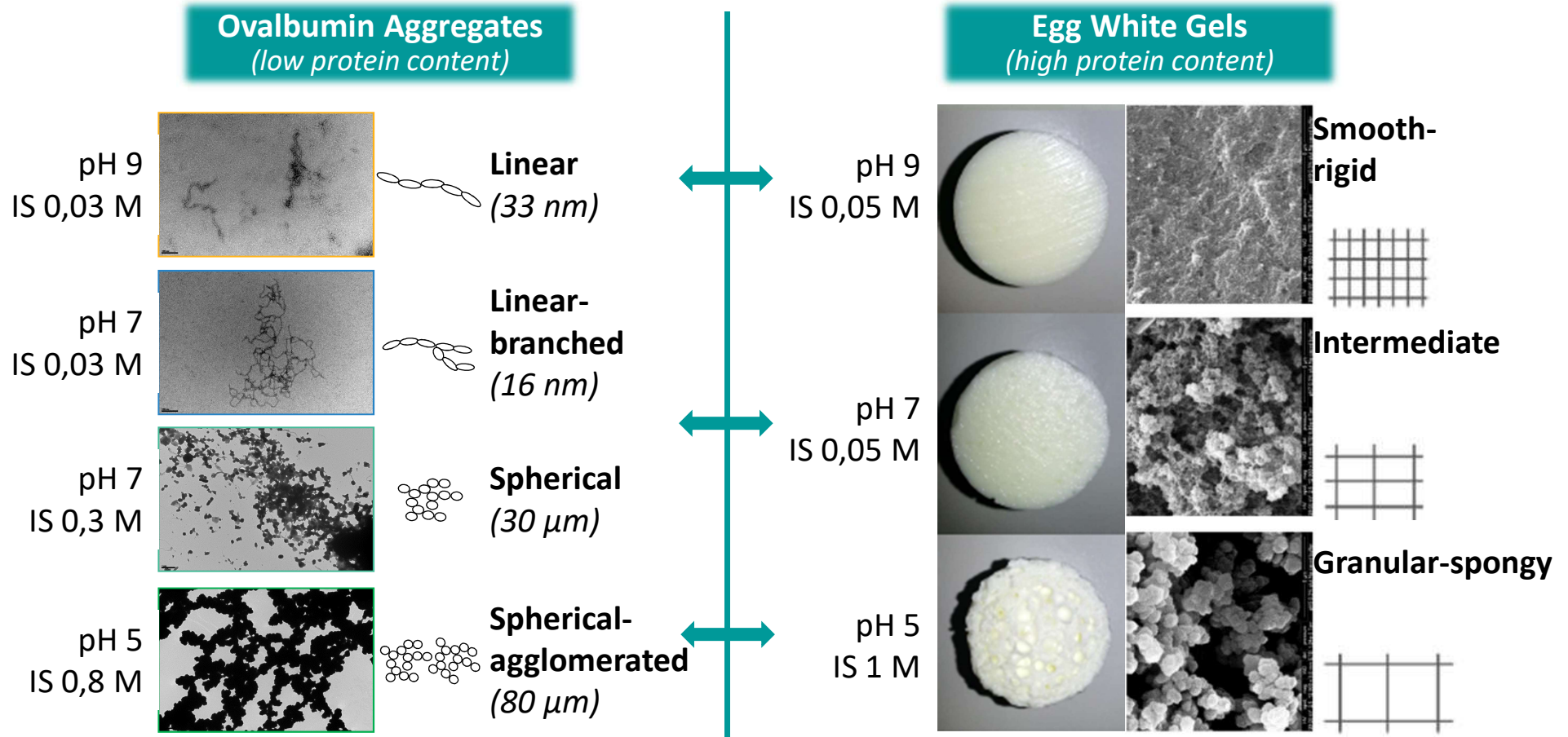
*K. Nyemb-Diop, S.M. Rutherford, D. Dupont
(Bioactivity & Nutrition Team)*



The nutritional value of food can be modulated by food structuring



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



1. Impact on the *in vitro* digestion process

Food Chemistry 157 (2014) 429–438



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. Rutherford^c, Françoise Nau^{a,b,*}

Food Research International 63 (2014) 192–202



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. Rutherford^d, Françoise Nau^{a,b,*}

Food Hydrocolloids 54 (2016) 315–327



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 Pézenec^{a,b}, Julien Jardin^{a,b}, Valérie Briard-Bion^{a,b}, Chantal Cauty^{a,b}, Shane M. Rutherford^c, Didier Dupont^{a,b}

Food Research International 88 (2016) 302–309



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. Rutherford^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?

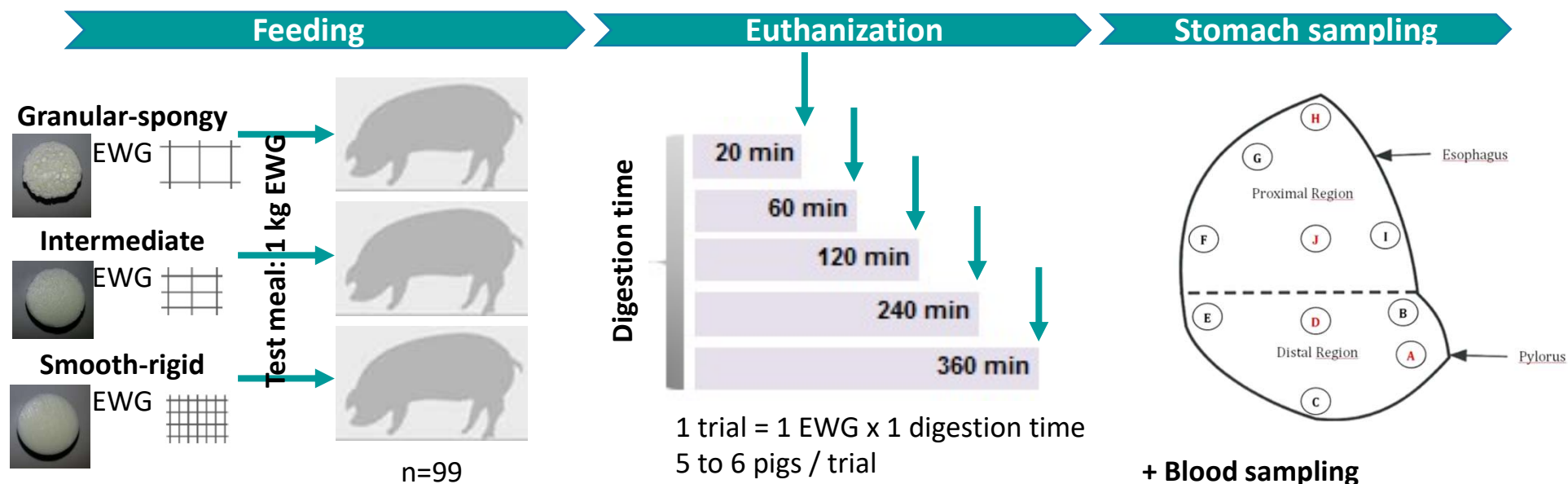


Focus on gastric digestion



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

Experimental design



Sample analyses

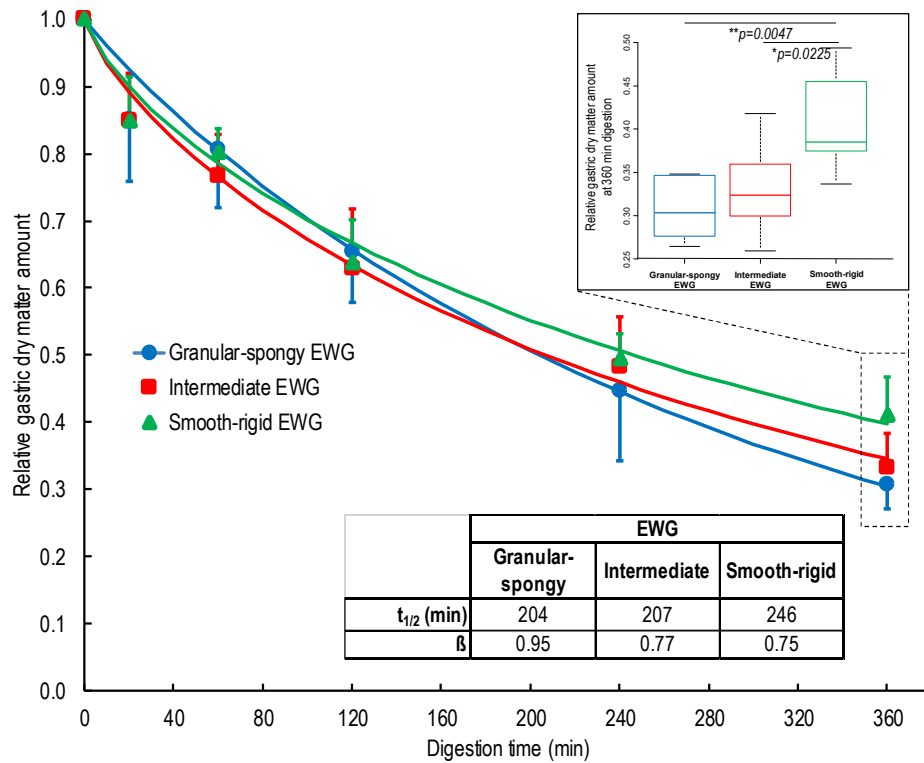
Stomach:

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

Blood:

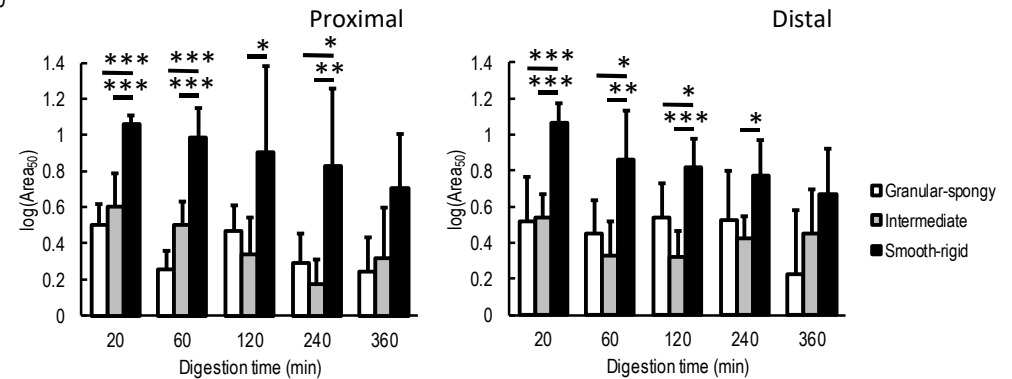
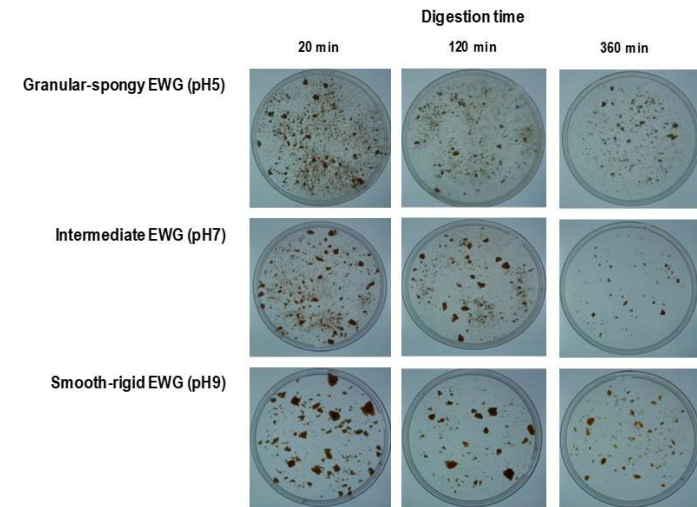
- Free amino acid content

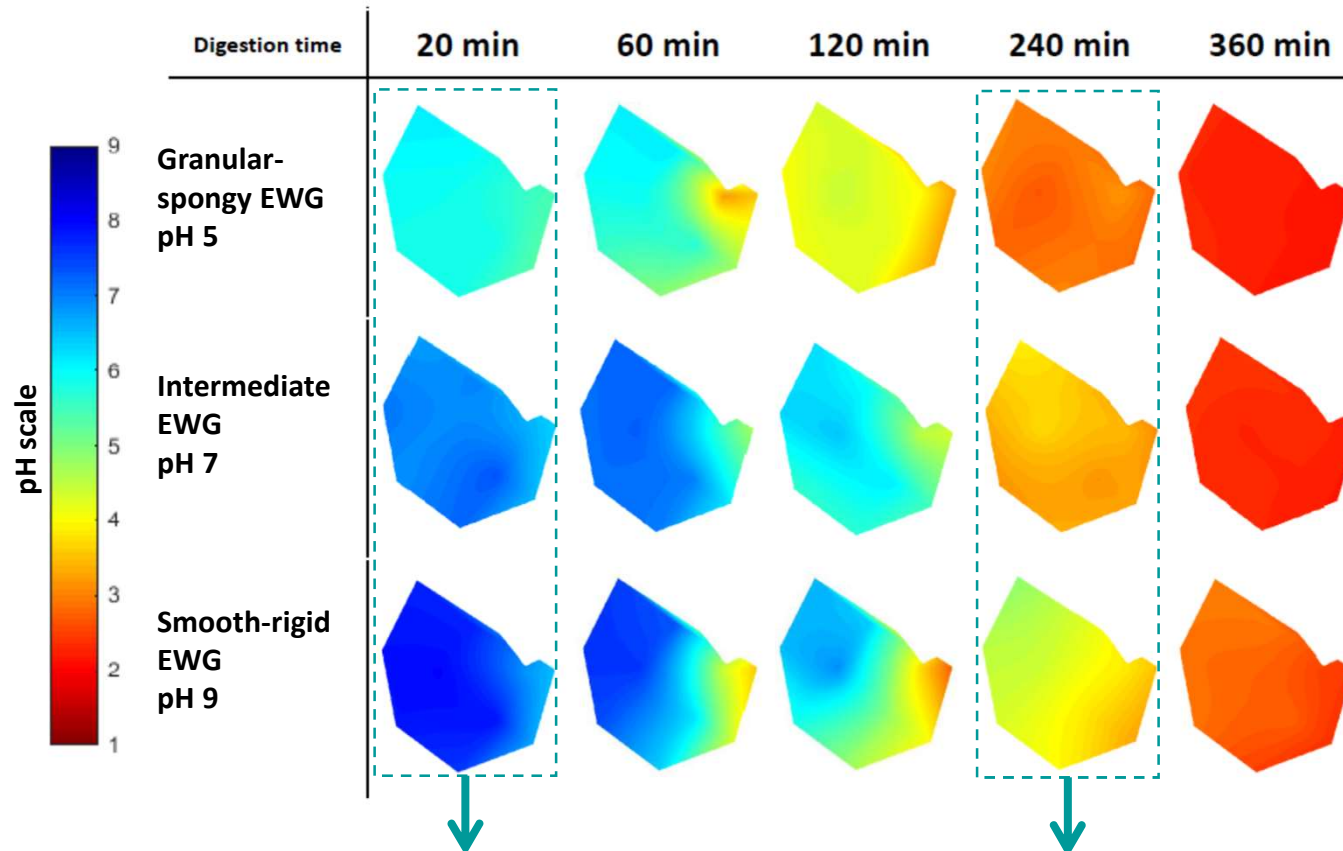
Results



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

	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

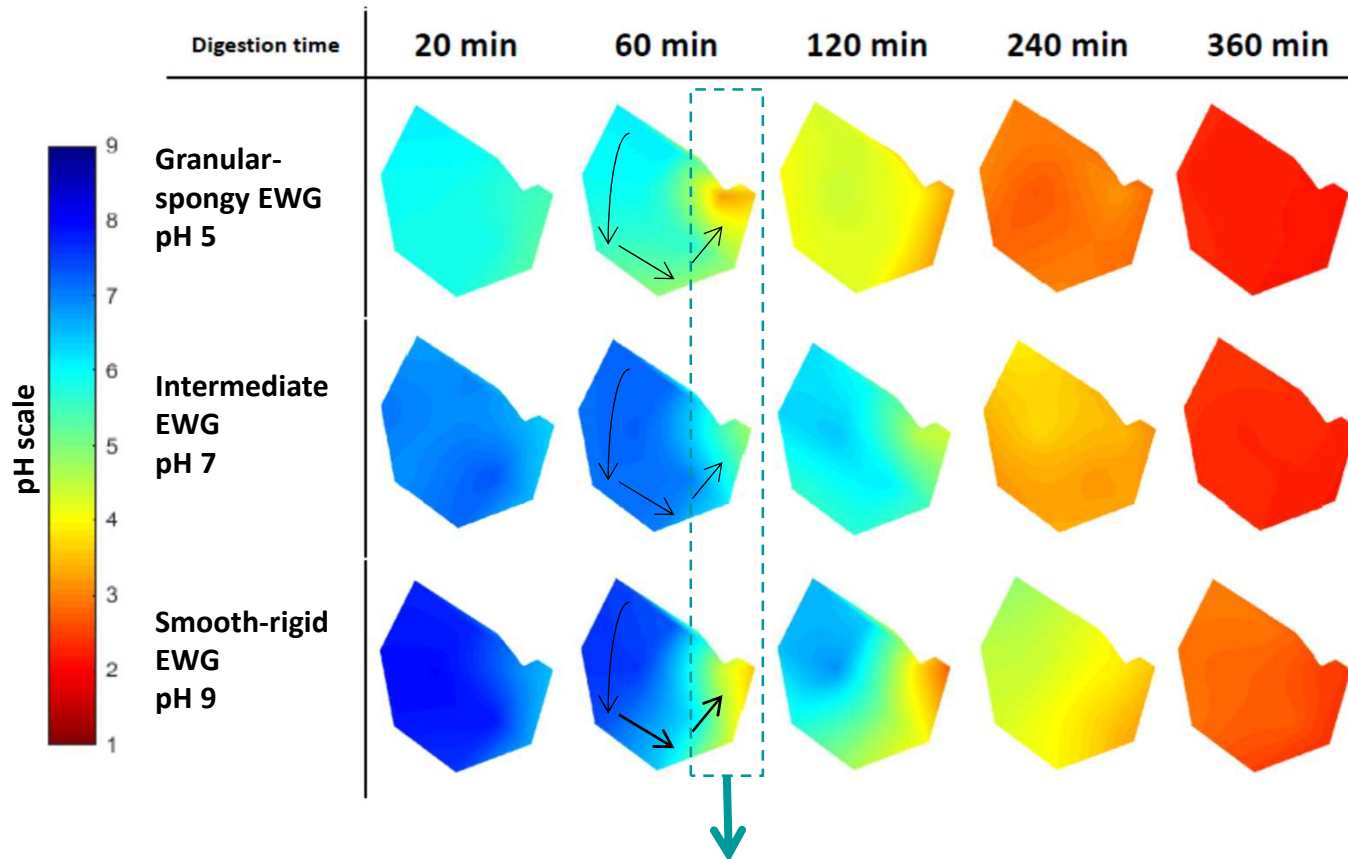




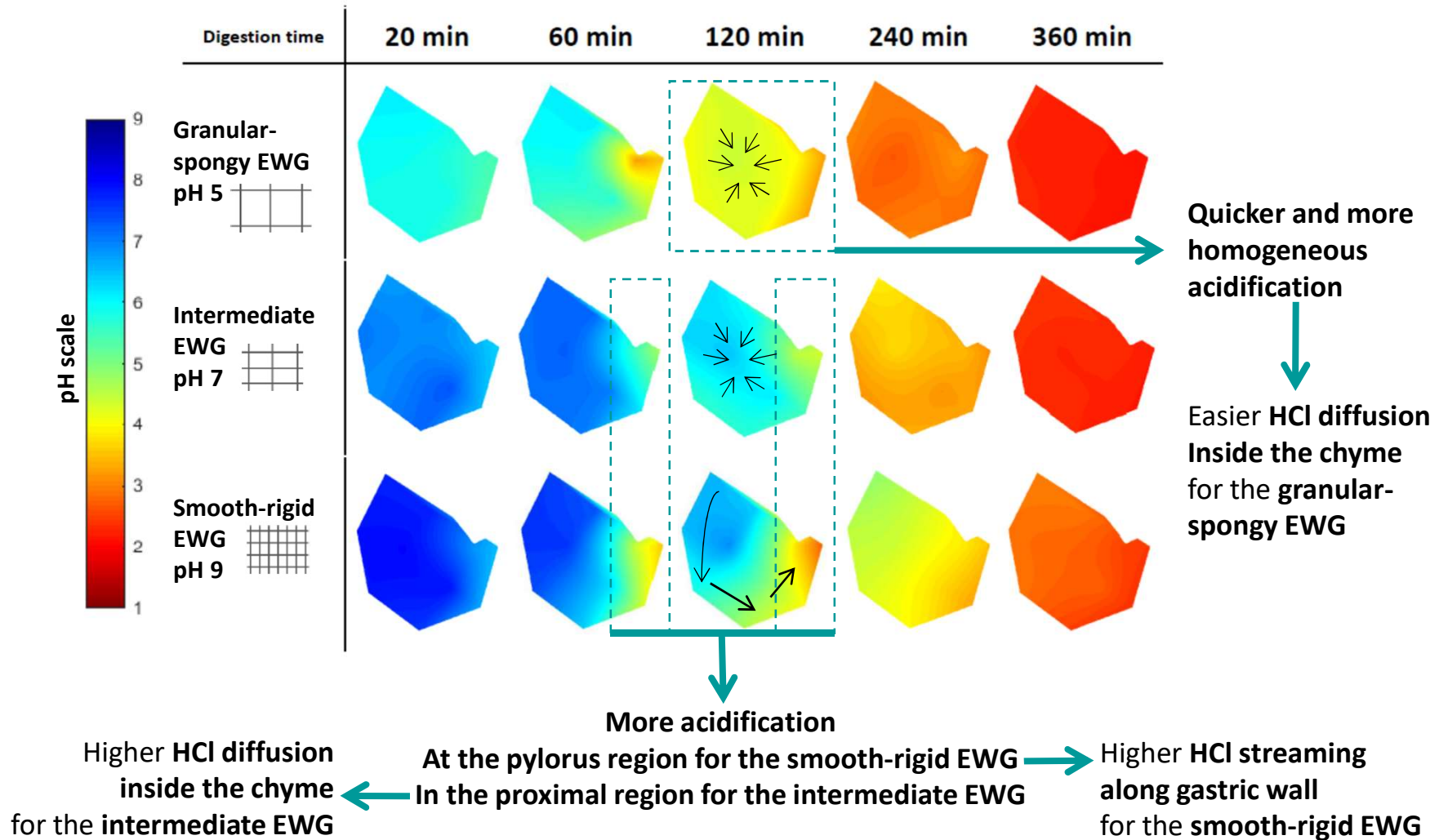
Uniform intra-gastric pH values,
equal to the initial EWG pH

More than 4 h
to reach pH < 3

Slow acidification
High buffering capacity of EWG and high quantity ingested



Acidification starts at the pylorus region
HCl streaming along the stomach wall



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
Visc _{0D}	NS	NS	NS	0.0242
Visc _{0P}	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

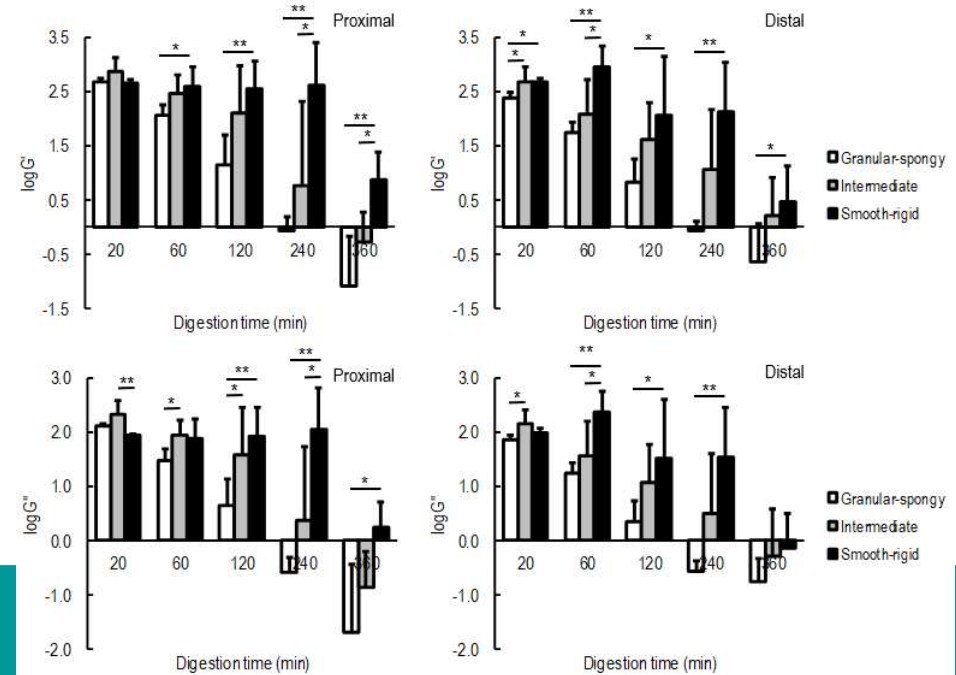
Intra-gastric dry matter unaffected by EWG type

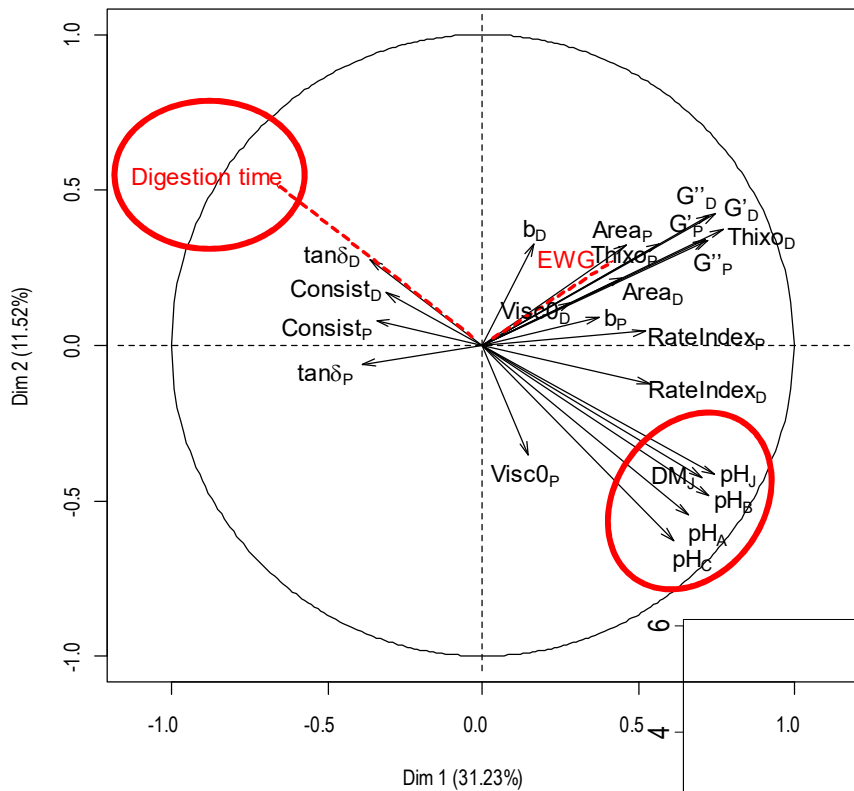
Particle size and distribution spread affected by EWG type

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

*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.
 Area₅₀: 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.

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 matter content or particle size distribution

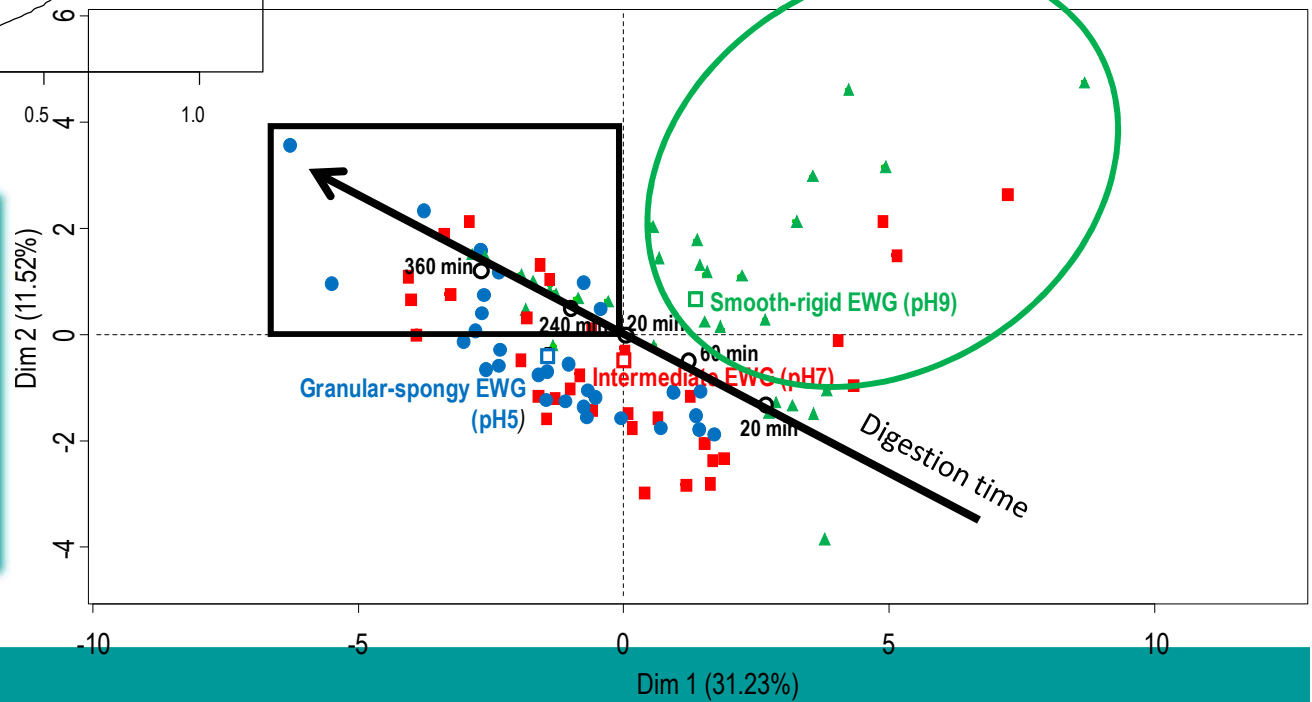


Spatial-temporal changes in pH, structure and rheology of the gastric chyme in pigs as influenced by egg white gel properties

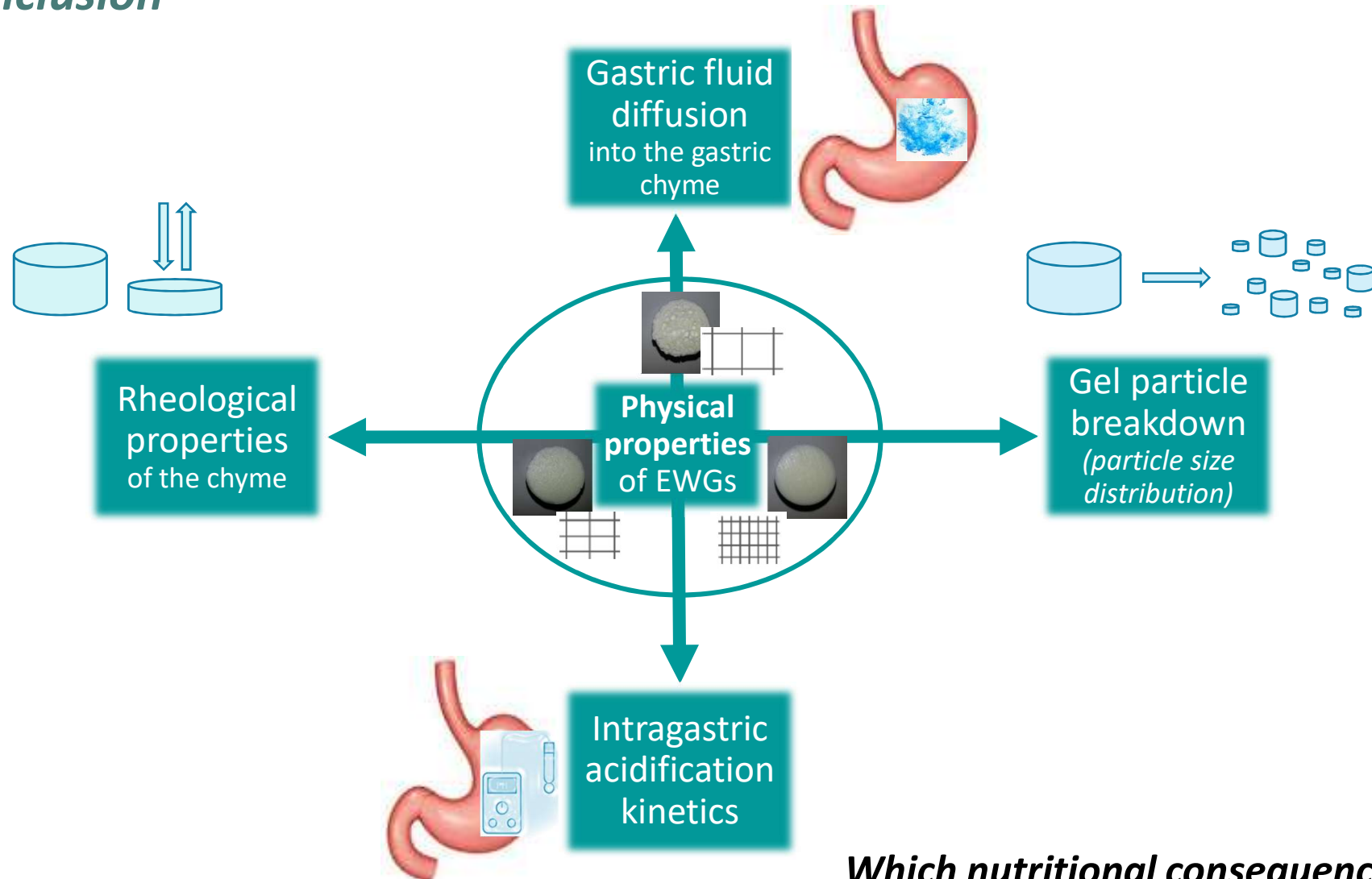
Françoise Nau^{a,b,c}, Kéra Nyemb-Diop^{a,b}, Valérie Lechevalier^{a,b}, Juliane Floury^{a,b}, Chloé Serrière^c, Natascha Stroebinger^c, Thiébaud Boucher^{a,b}, Catherine Guérin-Dubiard^{a,b}, Maria J. Ferrua^c, Didier Dupont^{a,b}, Shane M. Rutherford^c

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....*



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***THANK YOU FOR
YOUR ATTENTION***