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Effect of technological treatment of the mechanisms of infant food digestion

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Effect of the technological treatments on the digestion of infant foods



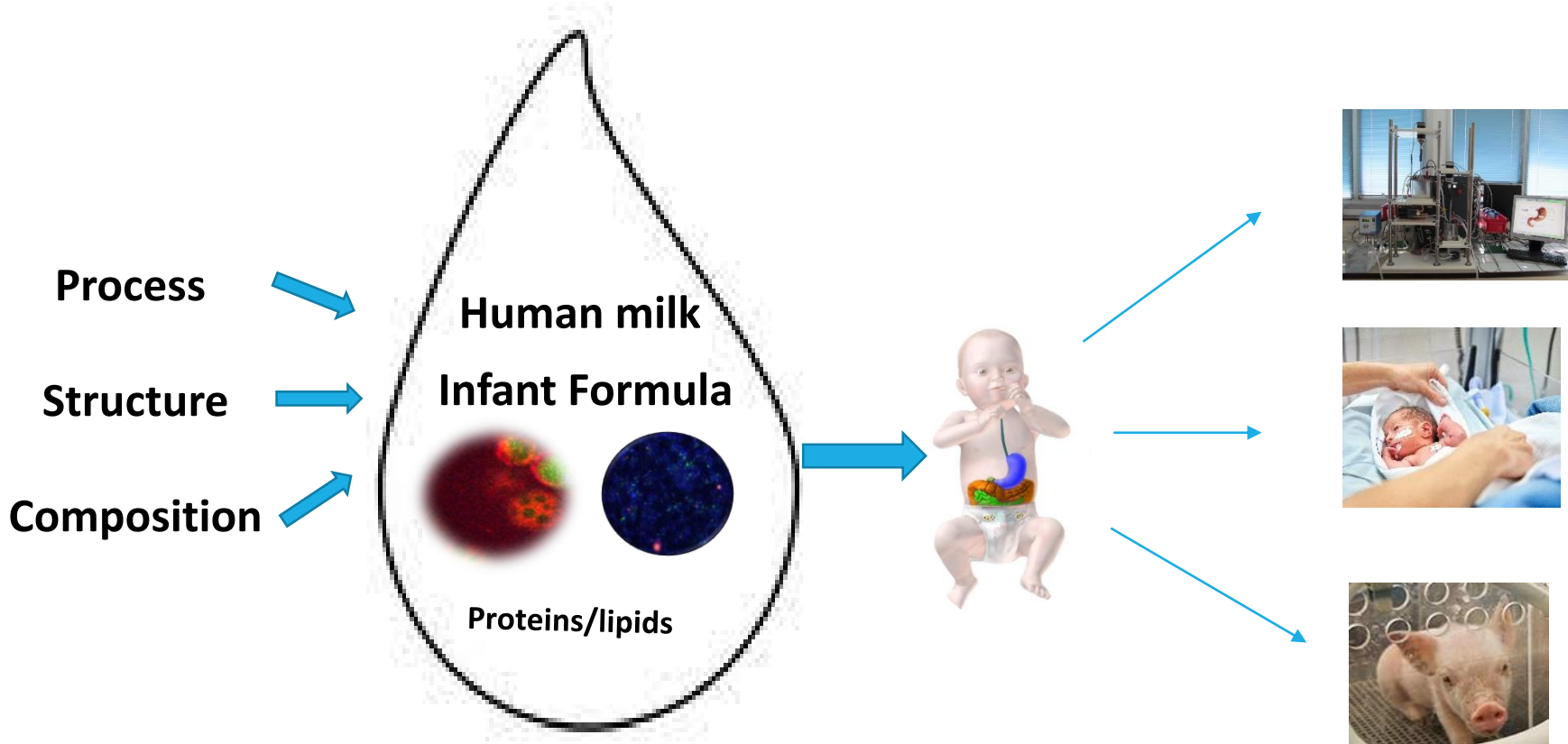
STLOpen Days
19-21 March
2019



Amélie Deglaire – Bioactivity & Nutrition

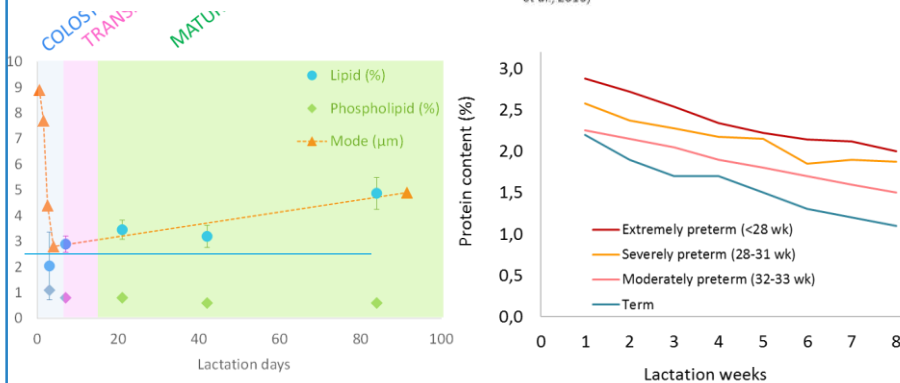
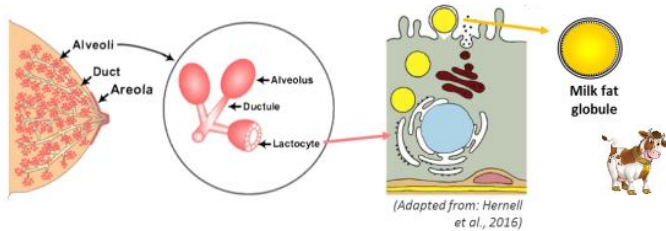


Infant food and digestion



Infant food production

Human milk : a secretory fluid



A very complex biological and evolving fluid
...that can undergo some heat treatment

(Keenan et al. J, 2001)

Infant formula : a transformed food



Wet mixing-spray drying process

Ingredients
(lactose, whey protein concentrate, vitamins, minerals, ...)

Skim milk



1. wet-blending

2. pasteurization/sterilization ★

3. concentration by evaporation ★

4. Fat addition

5. Pasteurization / sterilization ★

6. Homogenization ★★

7. Spray-drying

8. Packing in Big bag

9. Quality control

10. Packaging in cans

> 10 technological steps

> 30 ingredients

→ Protein structure ★

→ Fat structure ★★

(Le Huerou-Luron et al., 2013; Guo et al., 2014)

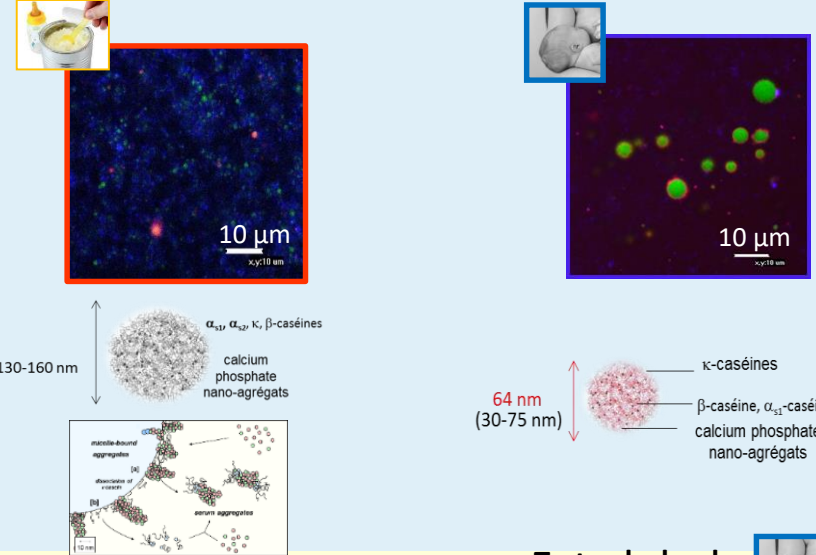
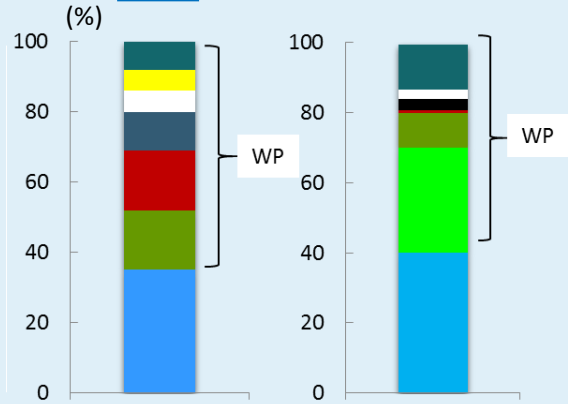
Infant food composition and structure

Composition

Structure

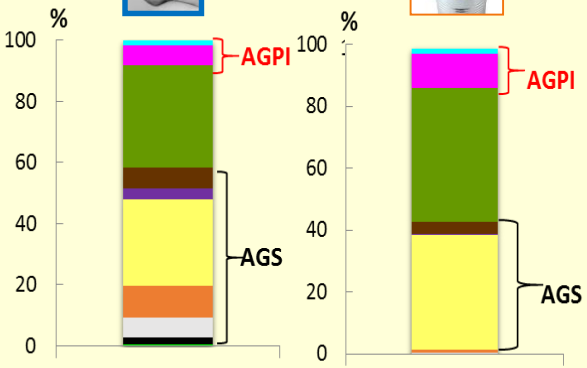
Proteins

- autres
- lyzo
- SA
- Ig
- Lf
- a-la
- b-Ig
- Cns

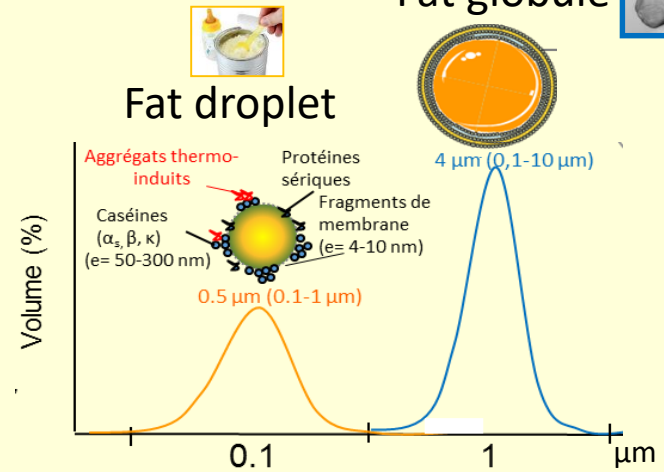


Lipids

- a-Linolénique
- Linoléique
- Oléique
- Stéarique
- Palmitoléique
- Palmitique
- Myristique
- Laurique
- Caprique
- Caprylique
- Caproïque
- Butyrique



Fat globule



Nasirpour *et al.*, 2005
 Zivkovic *et al.*, 2011, Gidrewicz *et Fenton*, 2014
 Hascoët *et al.*, 2011, Lönnerdal B *et al.*, 2016
 Andreas *et al.*, 2015, Hennet *et al.*, 2016

Bourlieu & Michalski, 2015

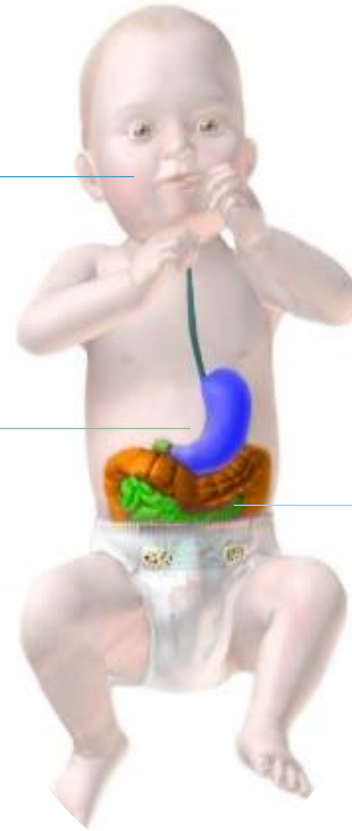
The developing digestive system of the infant

Oral phase

- Limited oral phase
- Preterm: frequent undeveloped reflex of suckling and swallowing and need of enteral nutrition

Gastric phase

- Relatively high pH (3.2 - 6.5)
- Mature secretion of human gastric lipase (HGL)
- Immature secretion of pepsin and limited proteolysis

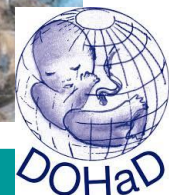
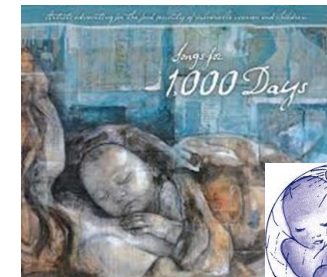


Intestinal phase

- Immature secretion of human pancreatic lipase (HPL)
- Low concentration of bile-salts
- Mature secretion of trypsin, immature secretion of chymotrypsin and carboxypeptidase B

A key step for infant digestion

- Immature digestive tract
- Immature Immune system
- Microbiota in construction



(Shani-Levi et al. 2016; Bourlieu et al., 2014)

Human milk: impact of pasteurization or homogenization on digestion in the preterm infant



©T. Pasquet

ClinicalTrials.gov

NCT02112331

2014 - 2016

- Preterm hospitalized babies → fed by a nasogastric tube

A Pasteurization impact (n = 12)

Own mother's milk



Raw milk



Pasteurized milk

B Homogenization impact (n = 8)

Donor pasteurized milk



Pasteurized

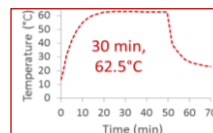


Homogenized milk

Milk bank

Pasteurization

62°, 30 min



Homogenization

(ultrasound)



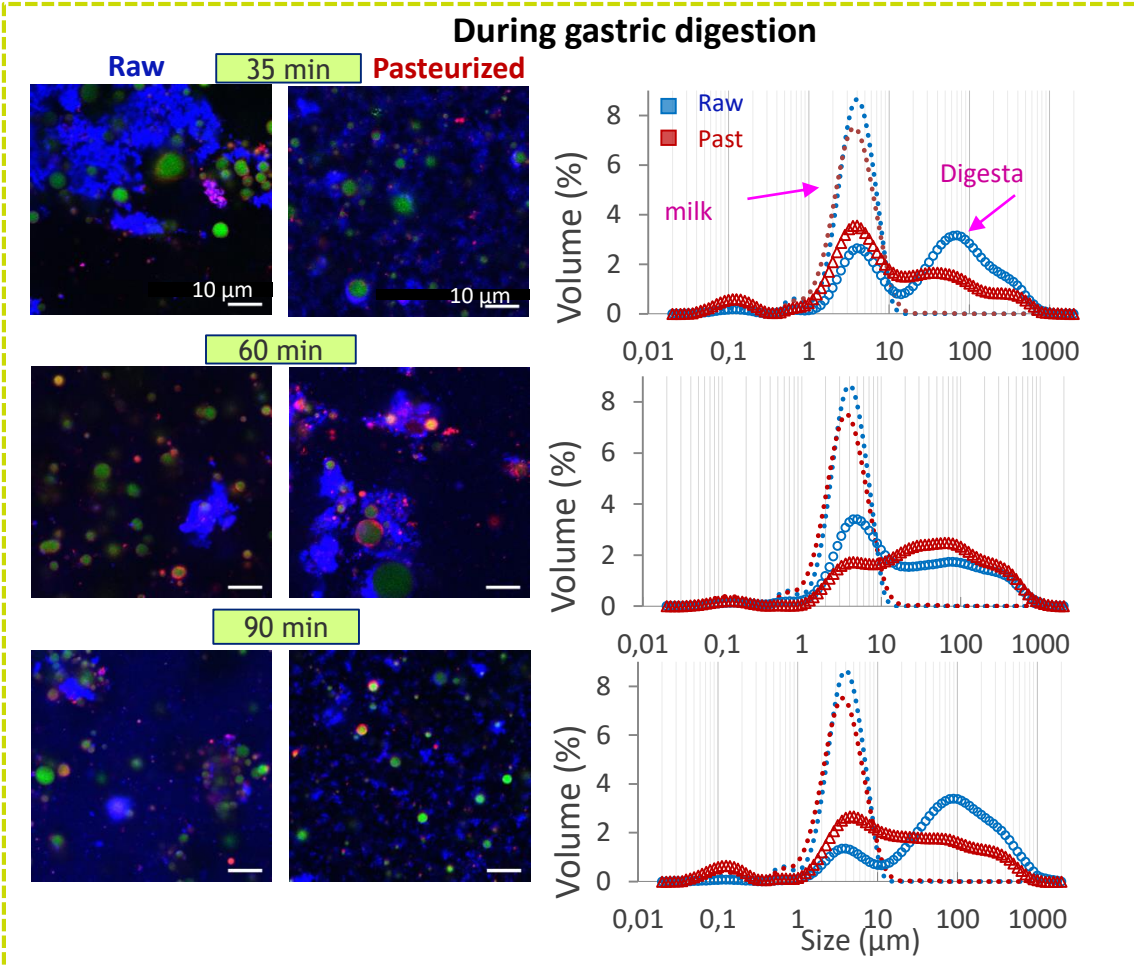
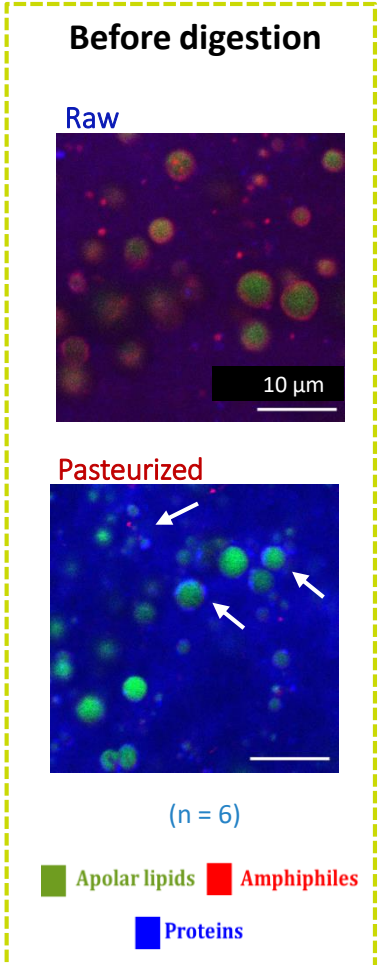
→ 595 W

Experimental design

- Cross-over design : 2 test meals per day for 6 days
- 2 gastric sampling for each feeding :
 - Before meal administration
 - 35, 60 ou 90 minutes** after meal ingestion



Pasteurization affected the structure and the emulsion disintegration



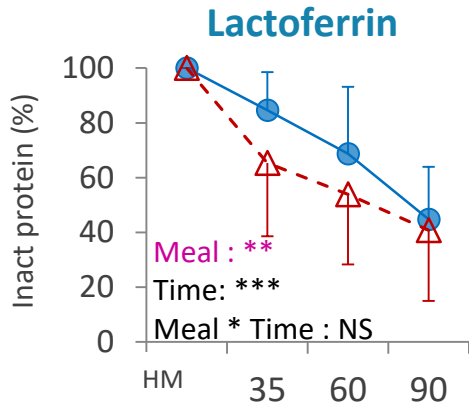
But pasteurization did not impact the gastric lipolysis at the preterm stage

Pasteurization impacted the gastric proteolysis

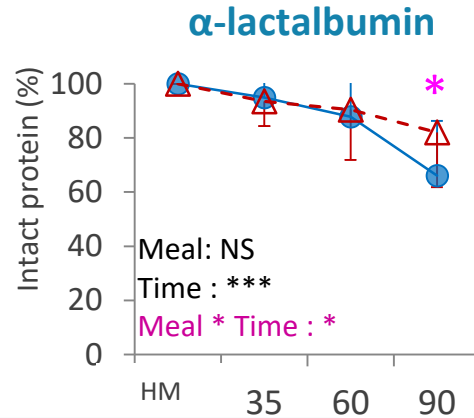


Gastric phase

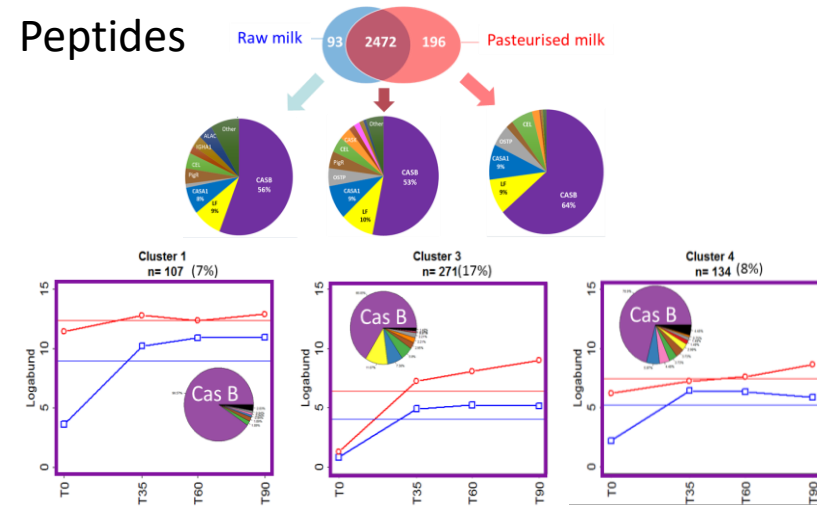
● Raw
 ---▲--- Pasteurized



Proteins

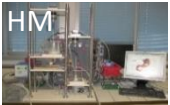


Peptides



Selective impact on proteolysis
 Lactoferrin → nutritional impact?

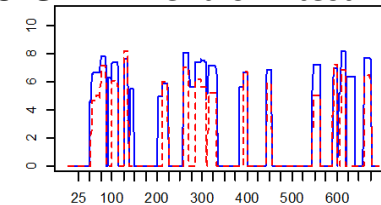
→ Influence of plasmin and pepsin



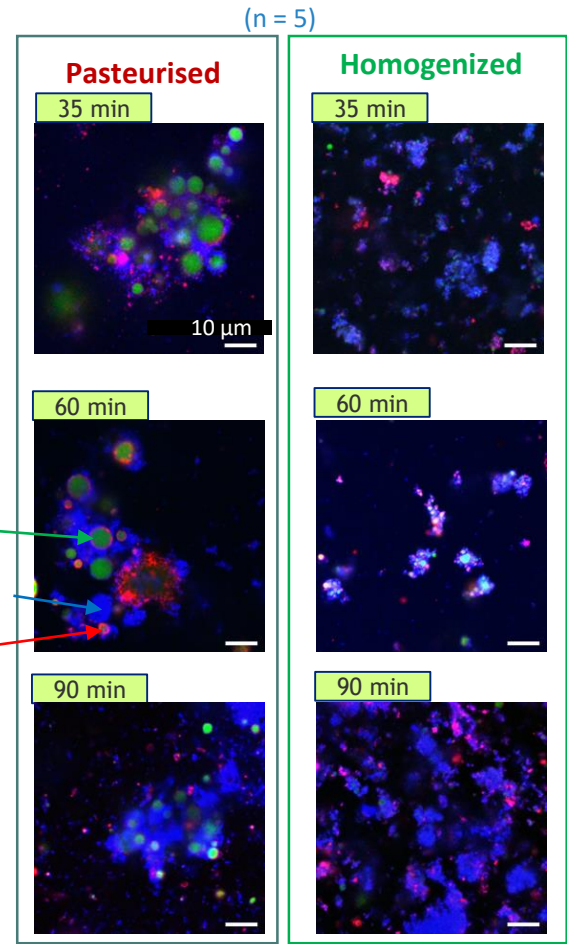
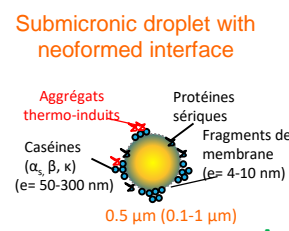
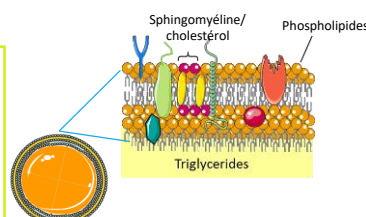
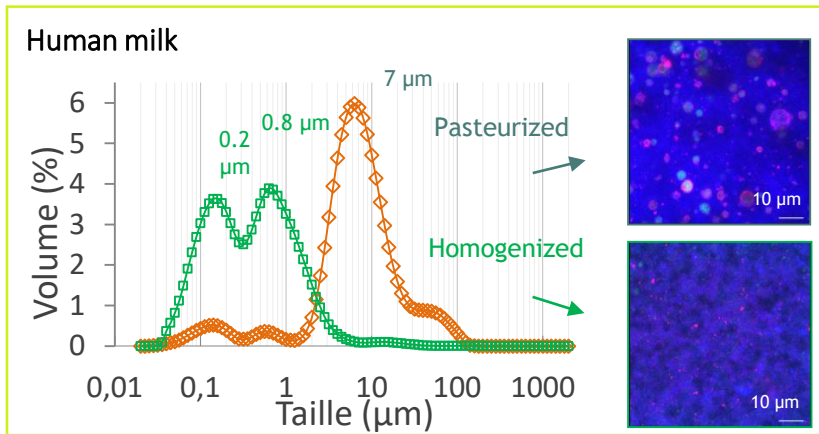
Intestinal phase

→ no impact on the bioaccessibility of most amino acids

Lactoferrin – end of intestinal digestion



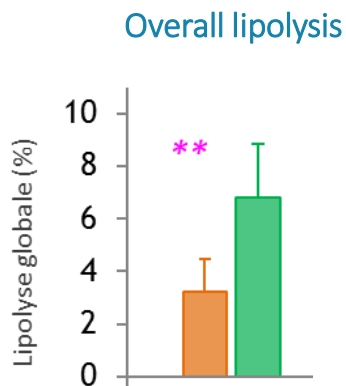
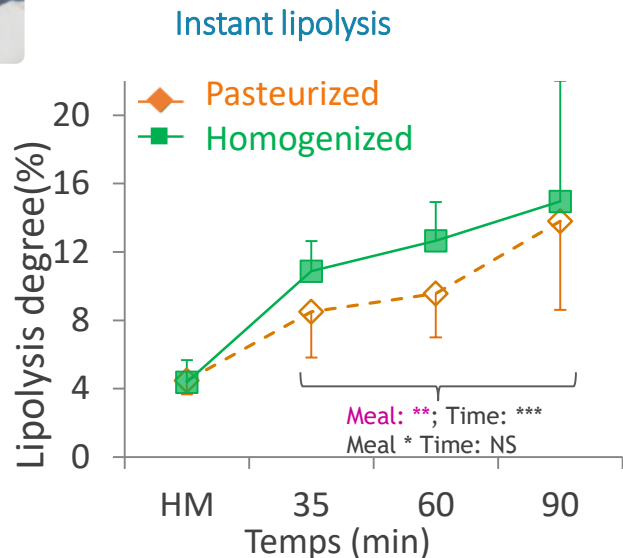
Homogenization impacted the structure



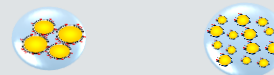
Specific surface area x 6 in homogenized milk

- Persistence of structural characteristic during gastric digestion
- Strong destabilization of the emulsion since 35 min
- Different types of aggregates

Homogenization impacted the gastric lipolysis



- ❖ Faster and greater lipolysis
- ❖ Same composition but **different structure**
- ➔ **Increased specific surface area**

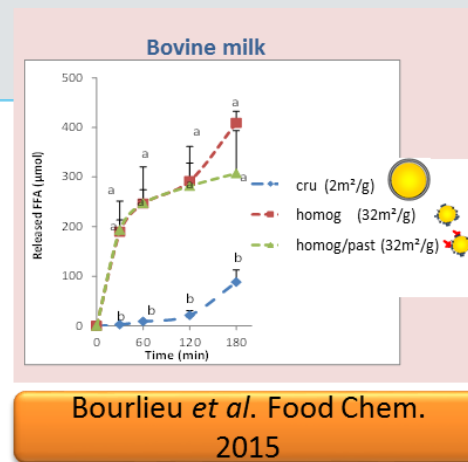


Past



Homogenized

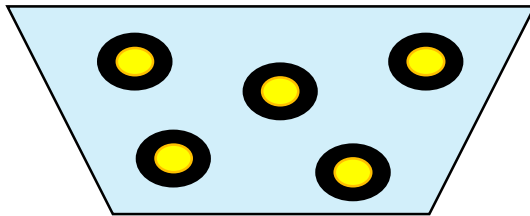
➔ Easier adsorption of lipase



But homogenization did not greatly impact proteolysis

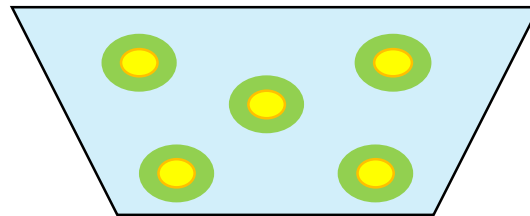
Infant formulas: can we create lipid structures biomimetic on the native fat globule?

Formula T1



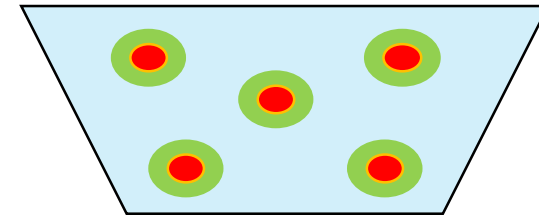
Interface 100 % Proteins
100% vegetable oil

Formula T2



Interface proteins + MFGM
100% vegetable oil

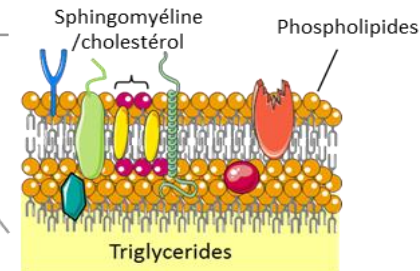
Formula T3



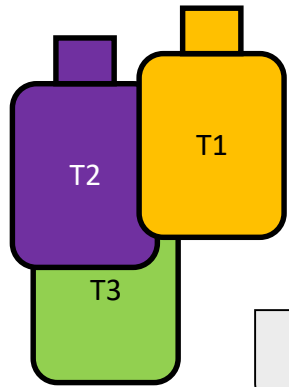
Interface proteins + MFGM
40% vegetable oil + 60% milk fat



Bourlieu & Michalski, 2015

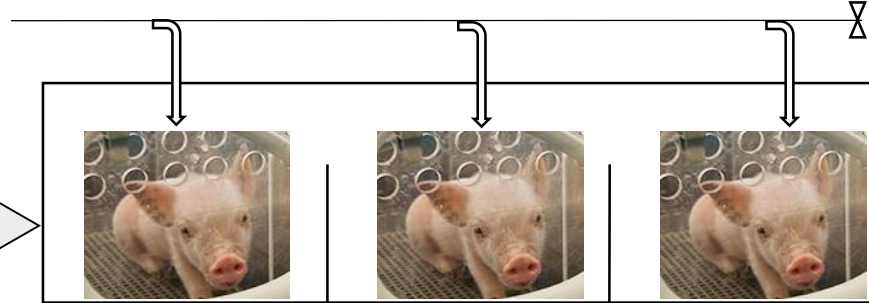


Can the composition of infant formula modulate the physiological response of the neonate?



- Veg
- Veg + MFGM
- Dairy Fat + MFGM

Automatic meal delivery (10 meals/ day)



+
Mother-fed piglets
(MF = + control)



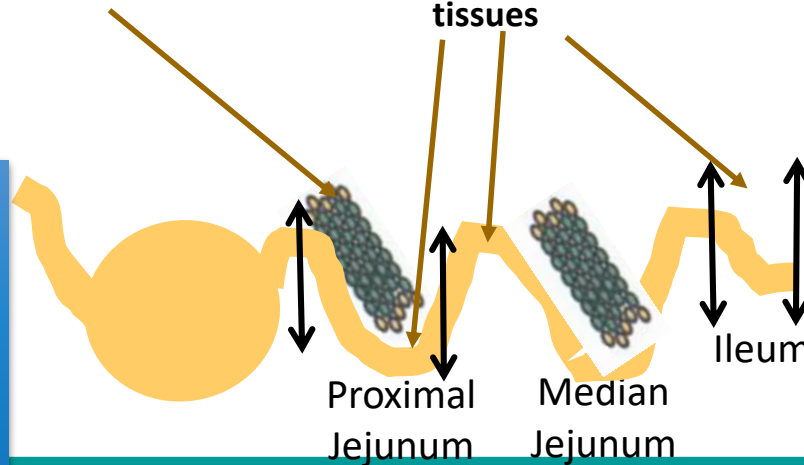
Slaughtering after

7 days

28 days

(90 min postprandial)

Mesenteric Lymph Nodes (MLN) Collect of effluents and tissues



Effluents:

- SDS-PAGE
- Elisa

Tissues:

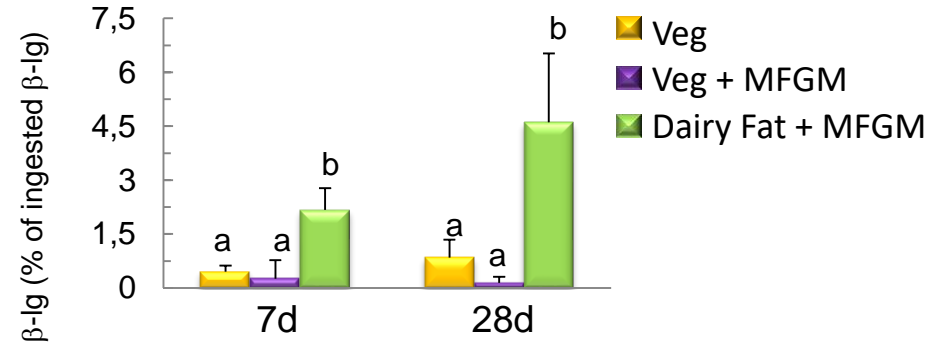
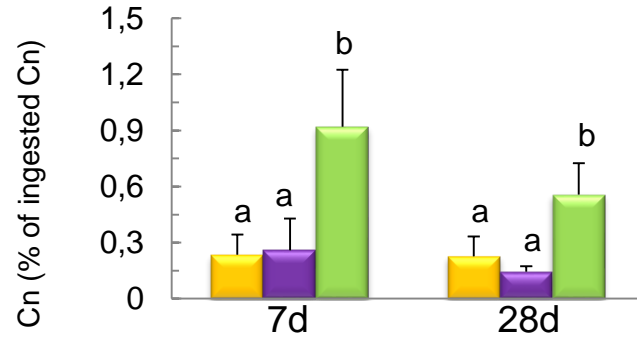
- Morphometry
- Enzyme Activities
- Intestinal Permeability
- Local immune response
- Microbiota

The most biomimetic infant formula exerted a greater protein resistance

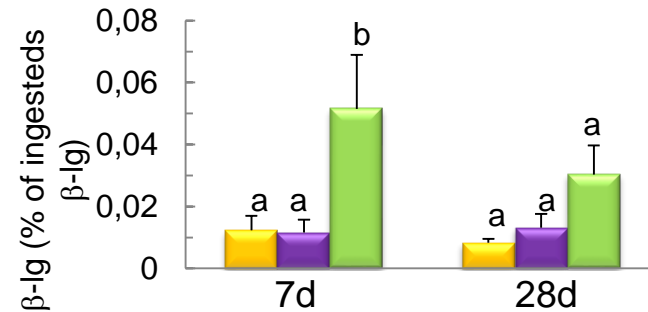
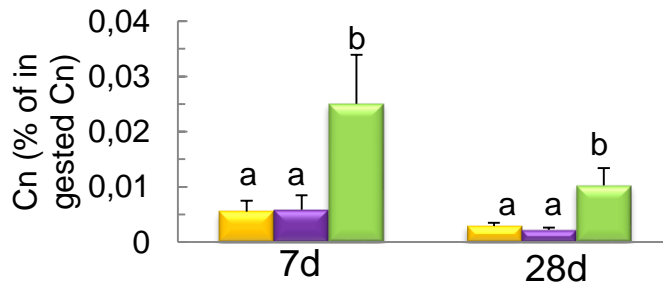
Casein

β -lactoglobulin

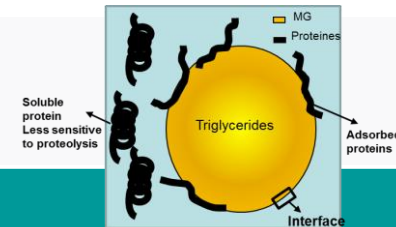
Jejunum



Ileum



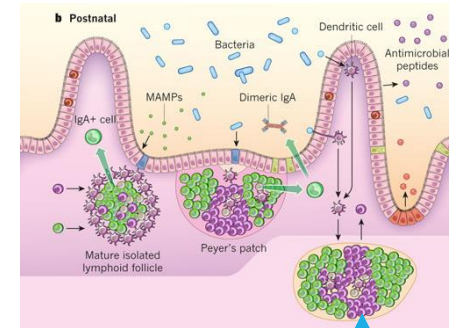
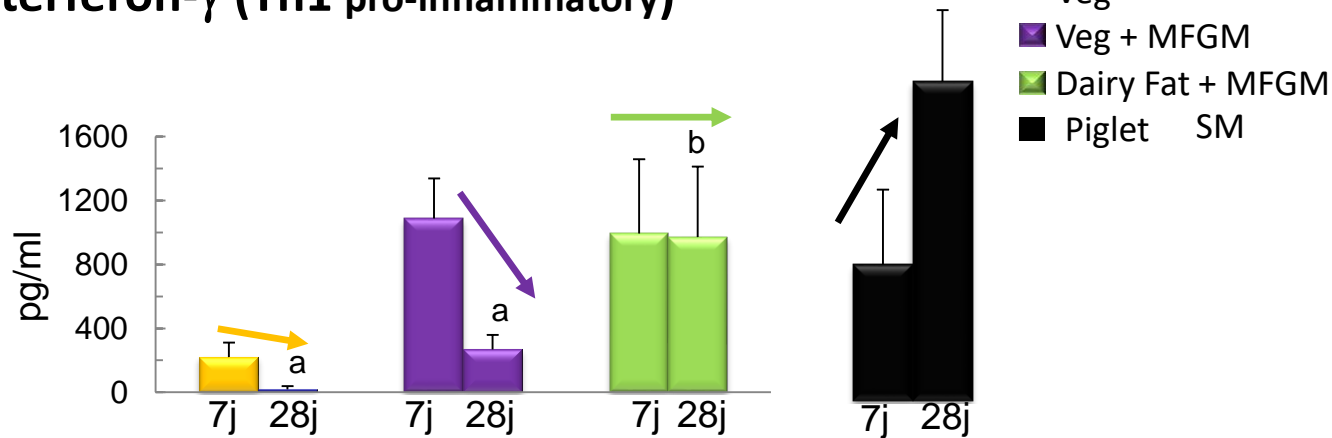
Milk Proteins better resist to intestinal digestion in the presence of dairy fat
 → Modification of the interface and of the susceptibility to proteolysis



(Macierzanka et al., 2009)

The most biomimetic infant formula induced a more physiological maturation of the immune system

Interferon- γ (Th1 pro-inflammatory)



Mesenteric Lymph Node

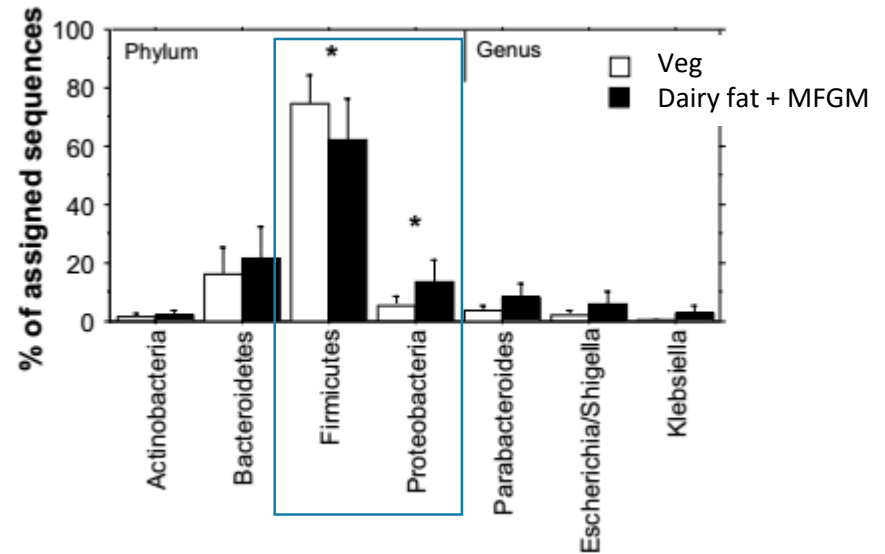
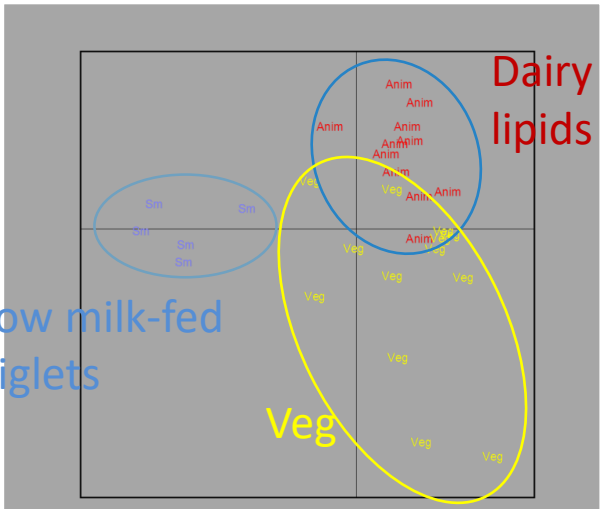
Interleukine-10 (Th2 anti-inflammatory) : no significant difference

Milk lipids \rightarrow maturation of the piglet's immune system (Th1) more similar to that with sow's milk

Le Huerou et al.
Eur J Nutr 2018

The infant formulas impacted differently the fecal microbiota

D28

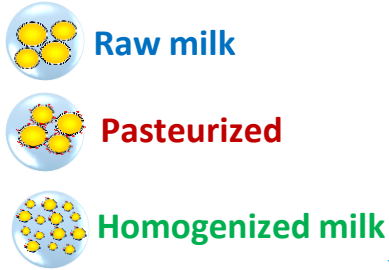


The composition/structure of the infant formula
« orientates » the microbiota

More *Proteobacteria* and less *Firmicutes* with dairy lipids

→ Similar to those observed in breast-fed infants vs. formula-fed infants (Donovan et al., 2012)

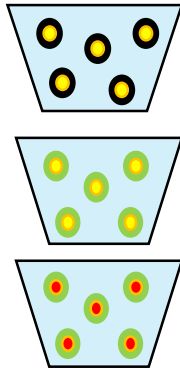
CONCLUSION



Structure



Modulation of digestive kinetics for proteins or lipids
Physiological impact?



Structure + composition of the fat droplets



Protein digestive resistance
Immune system maturation
Microbiota



Protein structure in infant formula and nutritional impact ?

THANKS TO...



THANK YOU FOR YOUR ATTENTION

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19-21 March 2019

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