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► To cite this version:

Lucile Chauvet, Yann Le Gouar, Olivia Ménard, Brunel Alexis, Marie-Françoise Cochet, et al.. Protein ingredient quality within infnat formulas impacts digestion and amino acid bioavailability: a combined in vitro and in vivo approach. ADSA annual meeting 2023, Jun 2023, Ottawa, Canada. , Journal of Dairy Science, 106 (supplement 1), pp.337-338, 2023, Abstracts of the 2023 American Dairy Science Association® Annual Meeting. hal-04155468

HAL Id: hal-04155468

<https://hal.inrae.fr/hal-04155468>

Submitted on 7 Jul 2023

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Protein ingredient quality within infant formulas impacts digestion and amino acid bioavailability: a combined *in vitro* and *in vivo* approach.

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Abstract #: 1396T

INTRODUCTION AND OBJECTIVES

- ✓ **Infant formula (IF)** is the only adequate substitute to **Human milk (HM)** even though **differences of fine composition and structure are still remaining**.
- ✓ **IF** is a **complex matrix** that require **numerous ingredients** and **processing steps**.
- ✓ **Protein ingredients quality differs** depending on their **origin** (whey vs. ideal whey) and

→ The present study aimed to **evaluate how protein ingredient quality (structure and composition) within IF modulates its structure, digestive kinetics and plasma amino acid (AA) content**

MATERIALS AND METHODS

SEMI-INDUSTRIAL PRODUCTION OF 4 IFs (A/B/C/D)

- **Ingredients:** **Commercial whey proteins (WPs) ingredients with different origin** (cheese : IFs-A & -B vs. ideal whey IFs-C & -D) and **structure**. **Casein with different supramolecular organization** (micellar : IFs-A, -B & -C vs. non micellar IF-D)
- **Processing:** **Same processing route**, representative of industrial methods



DIDGI® system

IN VITRO DYNAMIC DIGESTION

(Chauvet *et al.*, 2023)

Model of a 4-week old infant

- Sampling time: diet (G0), gastric phase (G20, G40, G80, G120, G180), intestinal phase (I20, I40, I80, I120, I180)

(Ménard *et al.*, 2015; De Oliveira *et al.*, 2016)

MACROSCOPIC → MICROSCOPIC SCALE

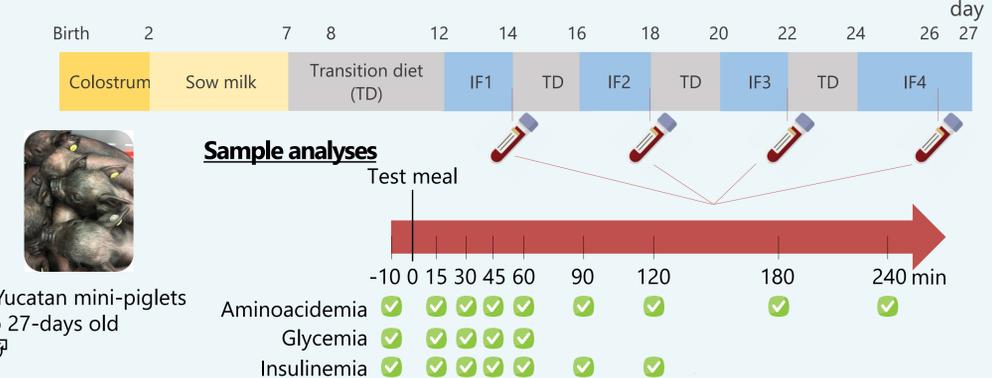
Evolution of the matrix structure

- Laser light scattering
- Confocal microscopy

Proteolysis

- SDS-PAGE
- LC-MS/MS
- OPA
- Ion-exchange chromatography

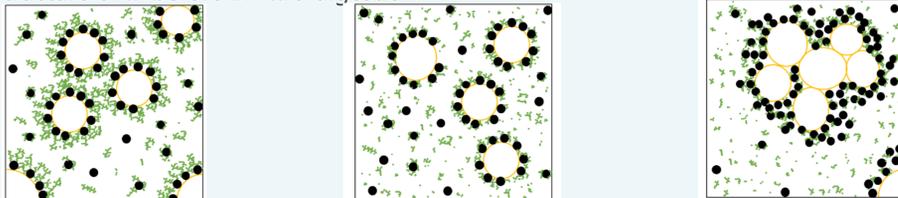
IN VIVO DIGESTION AND ABSORPTION MODEL



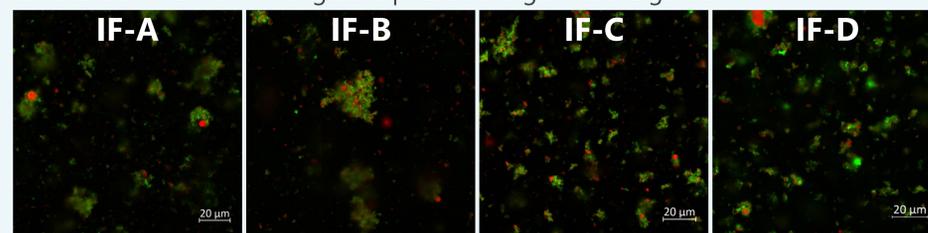
RESULTS

STRUCTURE BEFORE AND DURING IN VITRO DIGESTION

Structure of IF before *in vitro* digestion



Structure of IF at 40 min of gastric phase during *in vitro* digestion



Structure highlights before digestion :

- **IF A = denatured WPs aggregated** at the interface of casein micelles, themselves **adsorbed at the surface of fat droplets**.
- **IF B & C = mixture** of both **native and denatured/aggregated WPs** in the soluble phase, and with **caseins adsorbed at the surface of fat droplets**.
- **IF D = large aggregates** of **fat droplets, denatured/aggregated WPs and caseins**

Structure highlights during *in vitro* digestion :

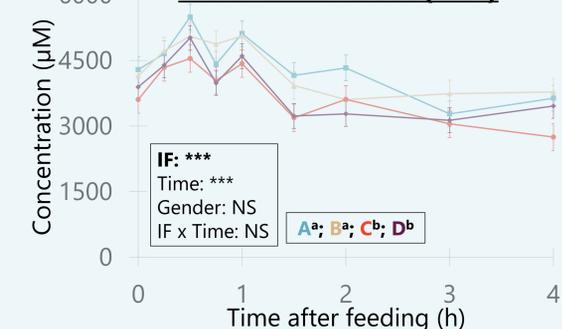
- Aggregates size → **IFs-A/-B > IF-C > IF-D**
- Aggregates size differences were directly related to the **proteolysis of κ-casein by pepsin** which led to the **rapid aggregation of caseins and fats droplets**

Peptide release kinetics :

- More **abundant release of casein-derived peptides at 80 min of gastric phase in IF-D** digesta than in other IFs digestas → Related to the **difference in casein supramolecular organization**
- More **abundant and late release** (intestinal phase) of **α-lactalbumin and β-lactoglobulin derived peptides** in digestas of **IFs-C and -D** than in digestas of IFs-A and -B → related to the **higher level of native WPs** in IFs-C and -D. (Chauvet *et al.*, 2023)

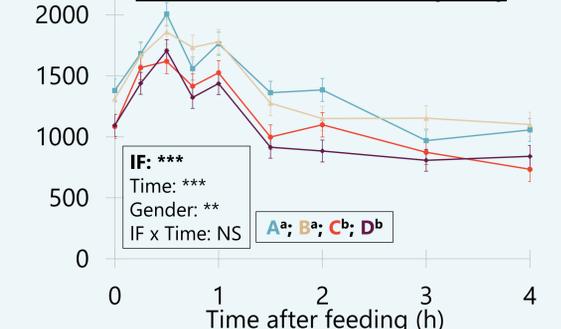
IN VIVO DIGESTION AND ABSORPTION

Total amino acids (TAA)



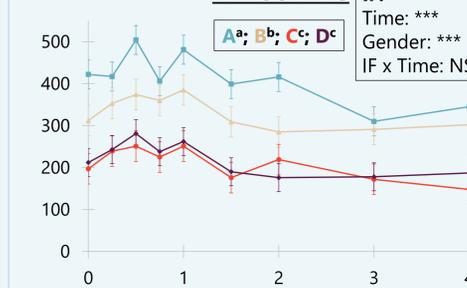
Plasma TAA concentrations : IFs-A & -B > IFs-C (+17%) & -D (+12%) at both preprandial and postprandial times.

Essential amino acids (EAA)



Plasma TAA differences are mainly due to the plasma EAA concentrations : IFs-A & -B > IFs-C (+20%) and -D (+26%)

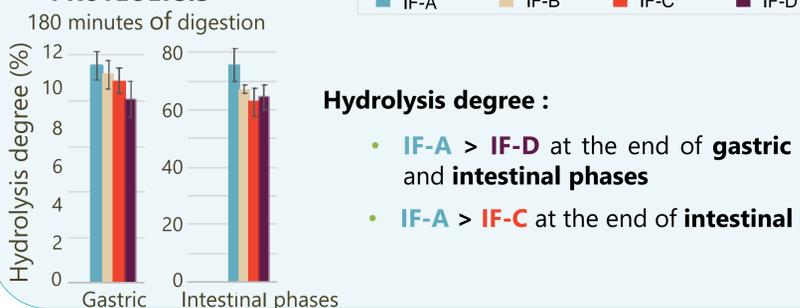
Threonine



↑ **dietary Thr level** (IFs-A and -B) + **limited Thr degradation enzyme capability** in piglets = **modification of Thr homeostasis**

Modifications since preprandial time = **Modification of AA homeostasis**
↓
Rapid metabolic adaptation after a 2-day period of IF consumption.

PROTEOLYSIS



CONCLUSIONS & PERSPECTIVES

- ↳ **WPs denaturation and casein supramolecular organisation** impact the **emulsion microstructure** within IFs
- ↳ **Proteolysis is favoured** during *in vitro* dynamic digestion when **WPs are more denatured** and **peptide-release kinetics** are modulated by the **casein organisation**

- ↳ The **origin of the WP ingredients** (cheese vs. ideal whey) resulted in the main **differences** in plasma AA levels **due to the presence or not of GMP**.
- ↳ **Homeostasis of many AAs was modified** after a **short adaptation period** and most of the differences observed preprandially explained the differences observed postprandially.

THESE RESULTS HIGHLIGHT THE IMPORTANCE OF CONSIDERING THE QUALITY OF THE PROTEIN INGREDIENTS WHEN MANUFACTURING IFs