Modulation of the texture of emulsified and acidified model systems by the addition of protein aggregates

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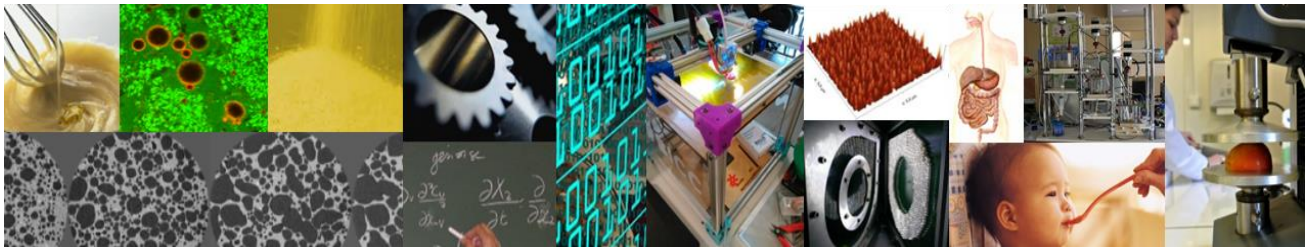


29th November – 1st December 2017 - Nantes

Biopolymers 2017

Key Ingredients for the Food Transition

Context

- **PROFIL :** Assemblages **PRO**téiques multi-**F**onctionnels pour l'**I**nnovation en industrie **L**aitière

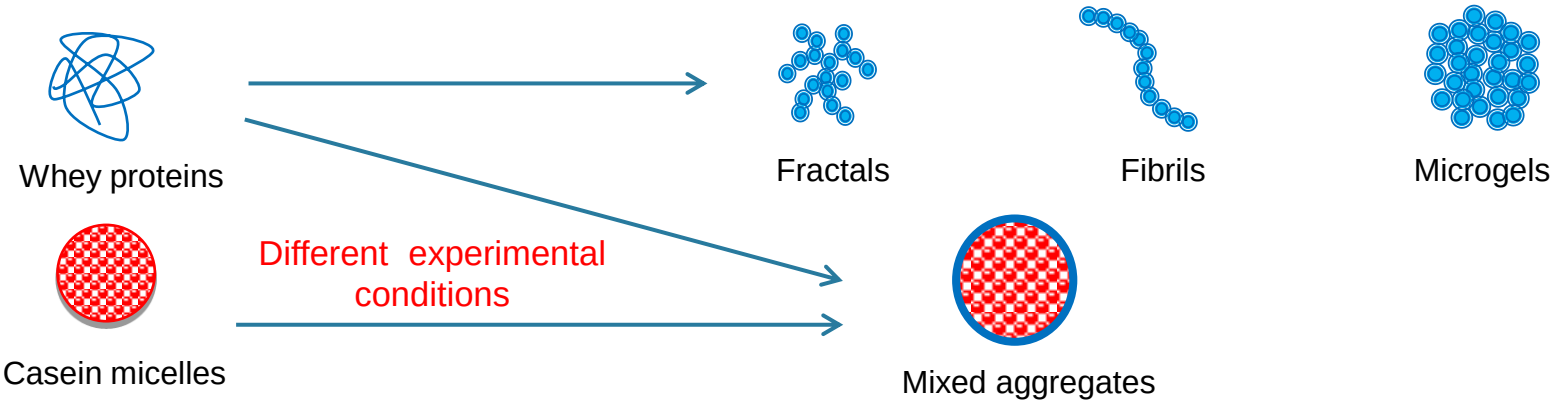
  (Multifunctional protein assemblies for innovation in milk industry)

  - Answer to **consumer expectations** with dairy products based on **100% milk ingredients** and "**clean label**" products (removal of texturing agents...)
  - Creating new products

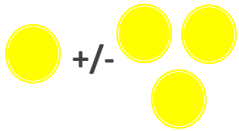
- **Texturizing properties**
  - *Texturizing emulsion at **neutral pH** with protein aggregates (T. Loiseleux)*
  - **Texturizing ACID milk gels with protein aggregates**

Objectives

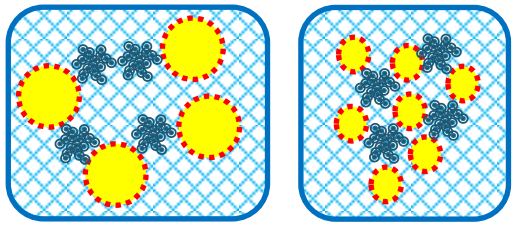
Preparation of different types of protein aggregates



Use in acidified systems: yoghurt (**pH 4.6**, gel formation by casein precipitation)



Variation in the number and size of fat droplets



Objectives :

Understanding the **interactions** between **protein aggregates at the interface** and **proteins in the continuous phase** of the acid gel

Use protein aggregates to **connect fat droplets** and **control the texture** of acidified systems

Scientific context

- Obtaining a milk acid gel:

Select fat and protein content

Homogenization

Heat treatment

Acidification kinetics
(lactic ferments or GDL)

Cooling and cold storage

↗ **protein concentration**: increase in gel strength and stabilization of the system (CHEFTEL and LORIENT, 1982 ; ANDOYO *et al.*, 2015)

↗ **fat concentration**: increase in gel strength and decrease gelation time (AGUILERA *et al.*, 1993)

Scientific context

- Obtaining a milk acid gel:

Select fat and protein content

Homogenization ⇢ Size of fat droplets, prevent separation of fat and whey (LUCEY and SINGH, 1998)

Heat treatment

Acidification kinetics
(lactic ferments or GDL)

Cooling and cold storage

Scientific context

- Obtaining a milk acid gel:

Select fat and protein content

↓

Homogenization

↓

Heat treatment

↓

Acidification kinetics
(lactic ferments or GDL)

↓

Cooling and cold storage

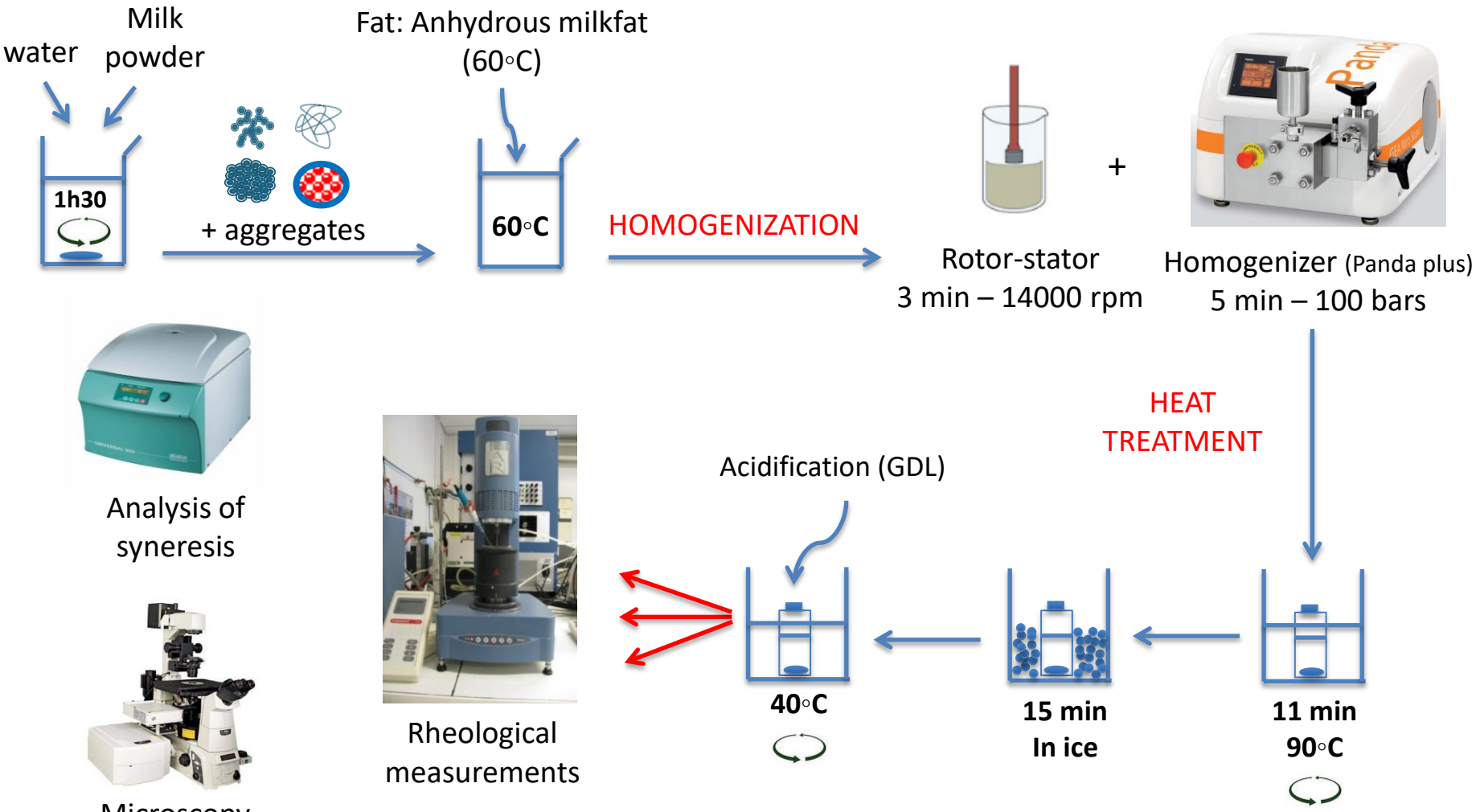
<u>Influence of protein aggregates addition</u>:

- **Best reactivity to gelation** → higher pI and hydrophobicity (LUCEY *et al.*, 1997 ; ANDOYO *et al.*, 2015)
- **Functionalization of micelles by protein aggregates** → gelation at higher pH (LUCEY and SINGH, 1998 ; FAMELART *et al.*, 2011)

↓

Use various protein aggregates to improve texture of acid milk gel

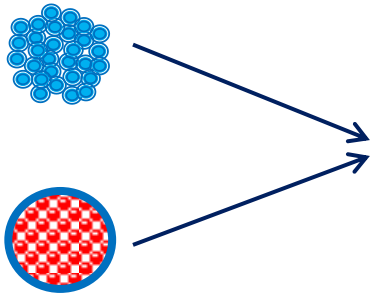
Methods


water
Milk powder
1h30
+ aggregates
Fat: Anhydrous milkfat (60◦C)
60◦C
HOMOGENIZATION
Rotor-stator
3 min – 14000 rpm
+
Homogenizer (Panda plus)
5 min – 100 bars
HEAT TREATMENT
11 min
90◦C
15 min
In ice
Acidification (GDL)
40◦C
Rheological measurements
Analysis of syneresis
Microscopy

Acid milk gel without fat

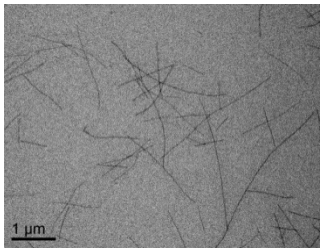
Better structuring and firmness, ↘ gelling time with **increasing concentration**
Decrease of syneresis

Good structuring and firmness, ↘ gelling time
Decrease of syneresis
Less efficient than WP

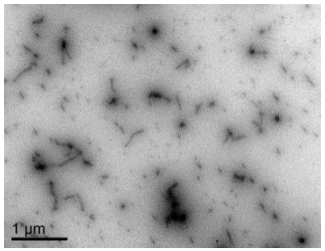


No improvement of firmness and no decrease of syneresis
→ Protein enrichment of products

Can not be used →
destructuration at pH 7



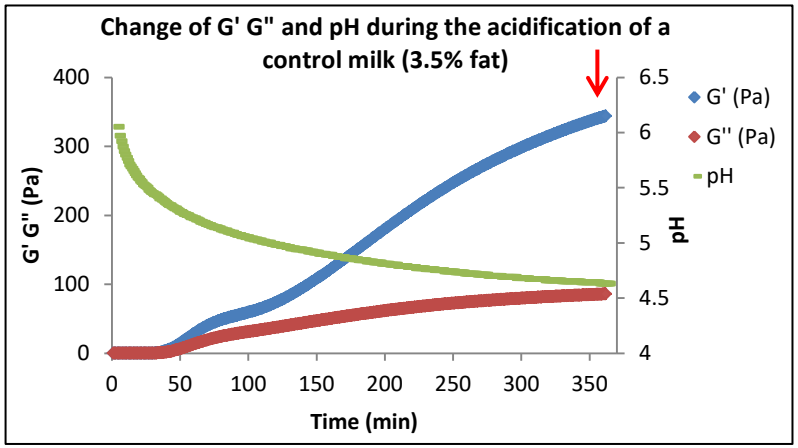
Fibrils pH 2

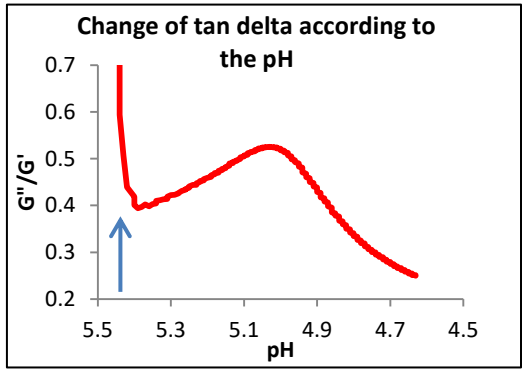


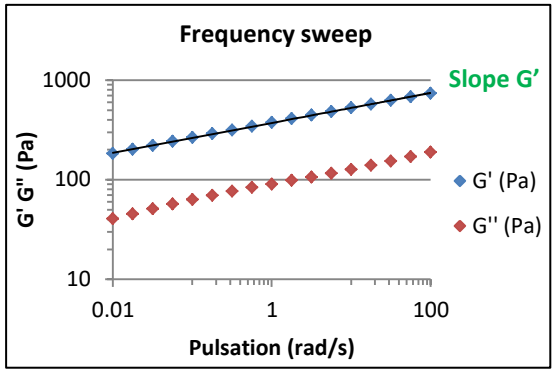
Fibrils pH 7

Control acid milk gels with 3.5% fat (100 bars)

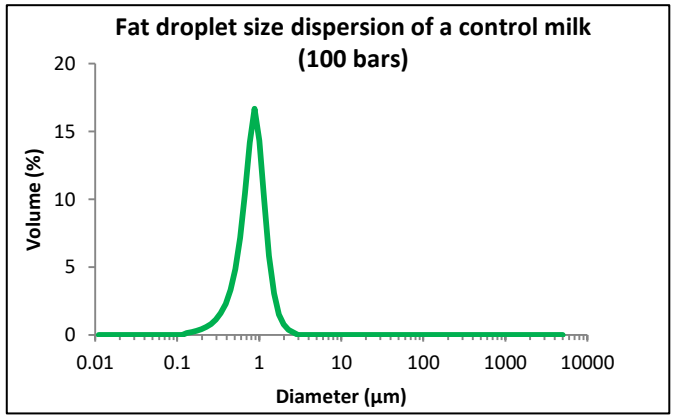
Sample	Gelation time (min)	Gelation pH	G' max (Pa)	Final pH	Slope G' (FS)
3.5% fat	**29.4**	**5.45**	**340**	**4.63**	**0.150**
Without fat	29	5.44	234	4.60	0.164



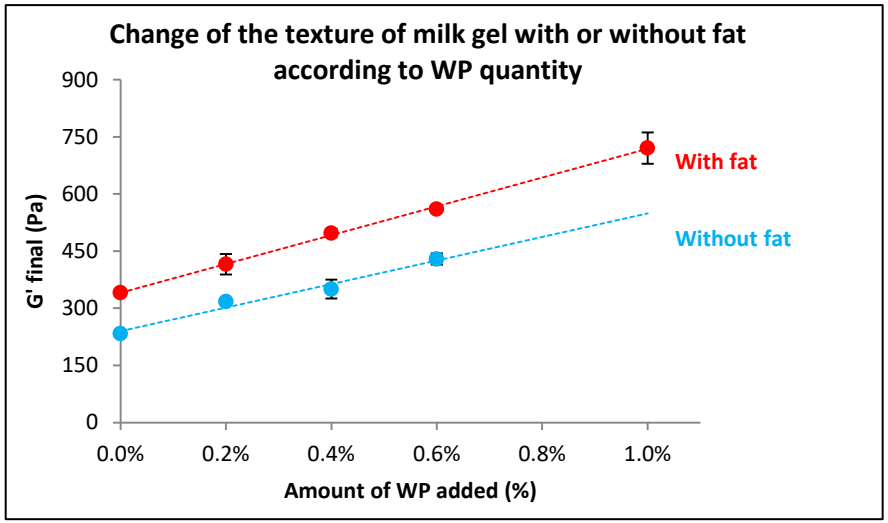


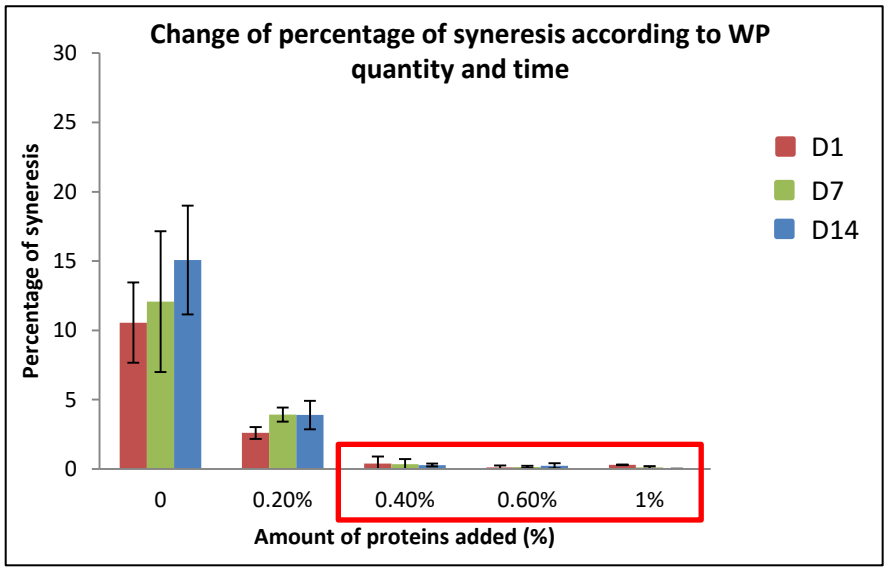


- **Time and pH of gelation similar** for control acid milk gels with or without fat
- **3.5% fat**: 100 Pa more than control acid gel without fat
- Average diameter of fat droplets : **0.8 µm**



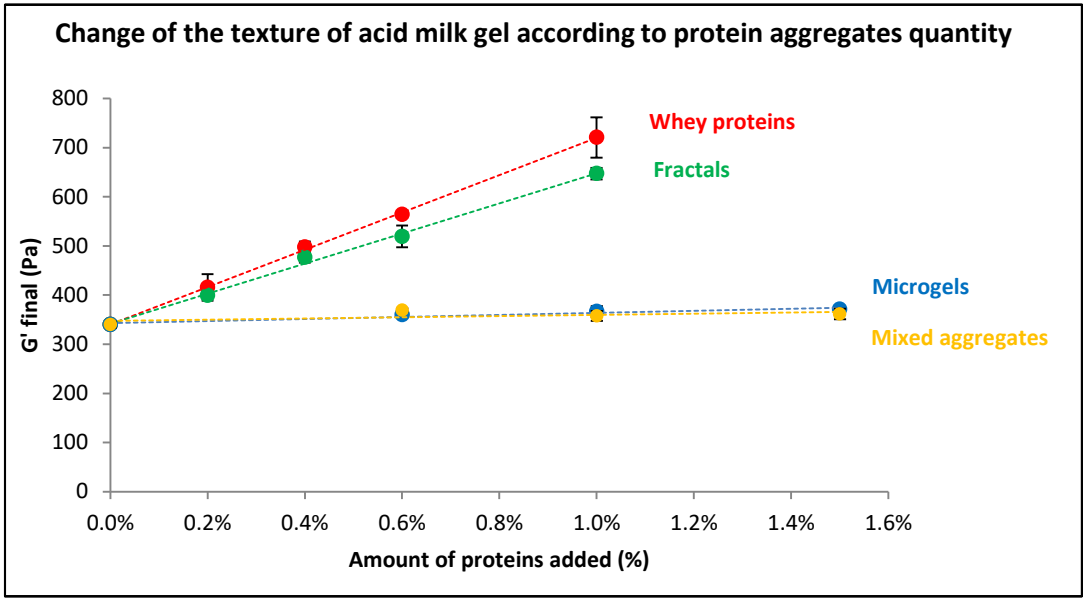
Acid milk gels with 3.5% fat and WP

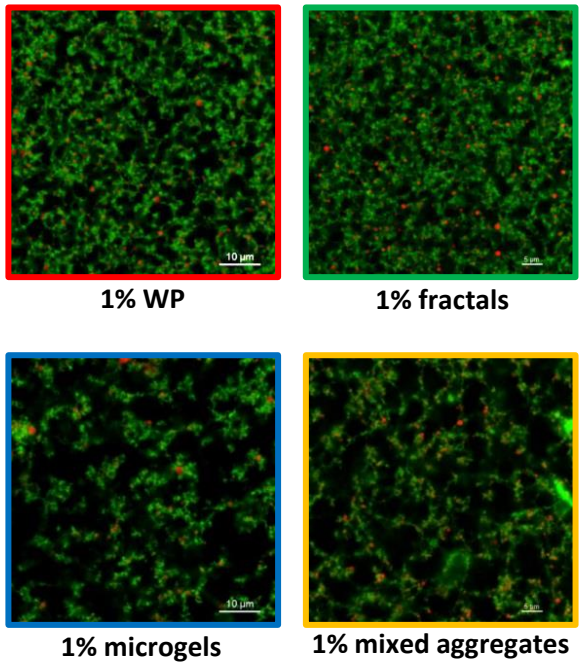




- Linear increase of the strength of gels (final G') with WP concentration (up to 1% WP)
- Decrease of tan (delta) amplitude and FS slope with increasing concentration of WP → **more structured protein network**
- Similar changes with or without fat → **no implication of the interface**
- Syneresis: close to 0% from 0.4% added WP and **stable over time** (D1, D7 and D14)
- Without fat: 50%

Acid milk gels with 3.5% fat and aggregates





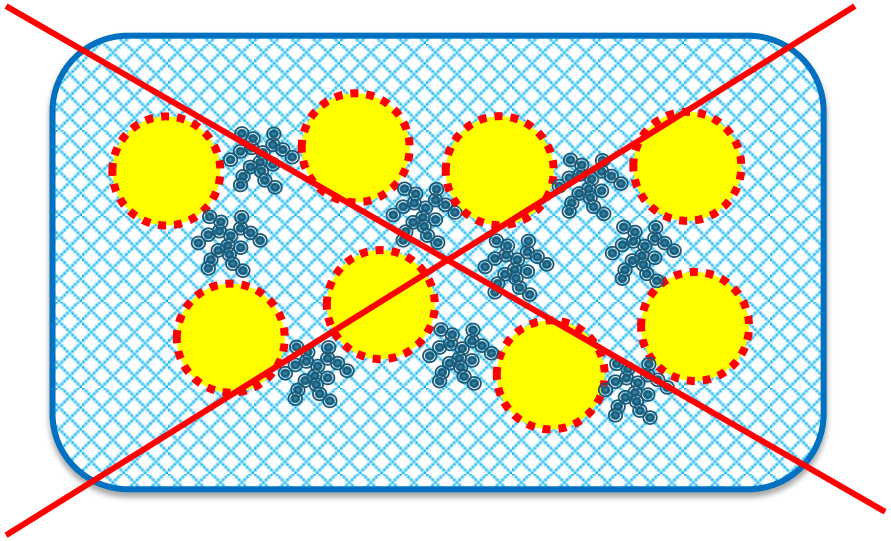
- + Fractals: **Increase of the gel strength** (slightly lower than for WP addition)

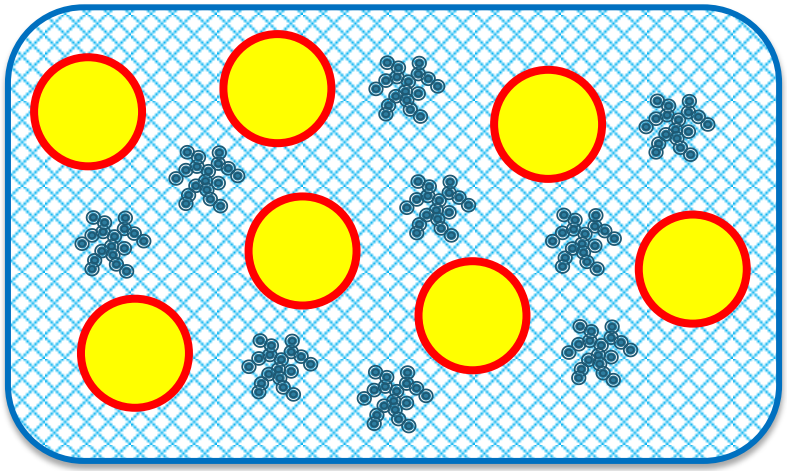
  - Same evolution WP/fractals → **no impact on the interface, role in the continuous phase**

- + Microgels and mixed aggregates: **constant** final G', no modification with increasing concentration → **no connection with the network**

Hypothesis on modulation of the texture

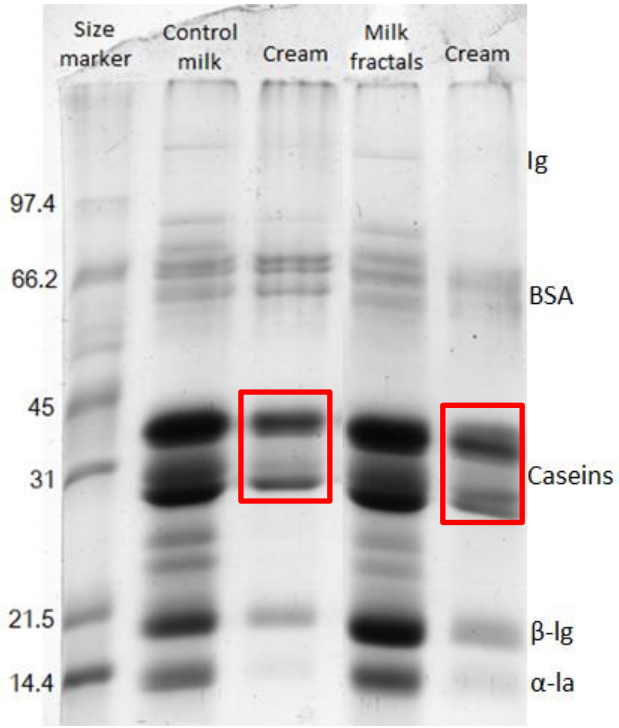
- **Hypothesis**: Modulation of the texture by control of the continuous phase
  - Aggregates in the continuous phase (connected or not to the protein network)
  - Saturation of the surface of fat droplets by caseins



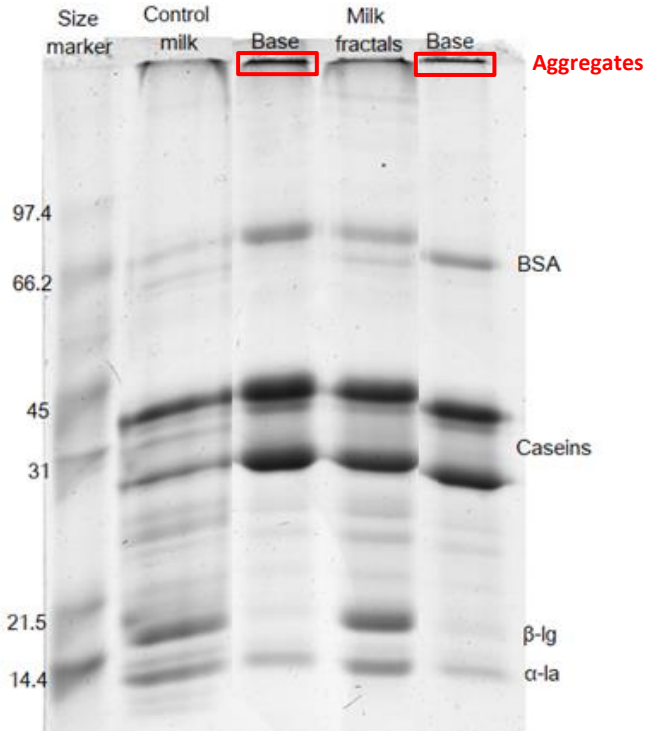


- **Checking the interfacial composition** by electrophoresis gel

Interfacial composition of acid milk gels (control and with fractals)



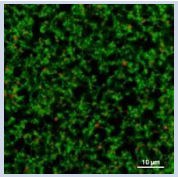
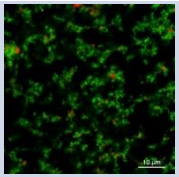
Denaturing conditions



Non-denaturing conditions

	Control milk		Milk with 1% fractals	
Protein concentration (g/l)	Cream	Base	Cream	Base
	3.7	**21.0**	3.6	**26.9**

Conclusions on acid milk gels with fat and aggregates

Protein aggregates	Whey proteins	Fractals	Microgels	Mixed aggregates
Rheology	↗ strength of the gels with the concentration (+ WP) ↘ gelation time		Stable force up to 1.5%, ↗ gelation time	
Percentage of syneresis	++++	+++	-	+
Structure	More dense and homogeneous network 		Heterogeneous network (large whey zone) 	
Major interests	Strengthening of gels, ↘ syneresis (WP the most efficient)		Stable texture with ↗ concentration Protein enrichment	

- Results dependent on the type of added aggregates → **Modulation of the texture** (specific products)
- Similar changes for systems with or without fat → **saturation of the interface by milk caseins**
- Different results depending on the type of aggregates → **role in the continuous phase**

Modulation of the interface

Classic protocol

Modulation of the interface

Milk with **3.5%** fat (**100** bars)

Variation in the concentration of aggregates

Milk with **3.5%** fat (**50** or **500** bars)

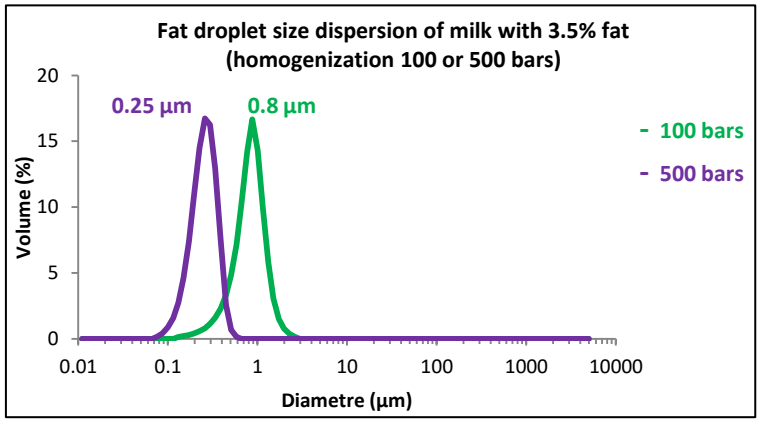
Constant concentration in aggregates (1%)

Milk with **10%** fat (**100** or **500** bars)

Constant concentration in aggregates (1%)

Milk with **3.5%** or **10%** fat (**100** or **500** bars)

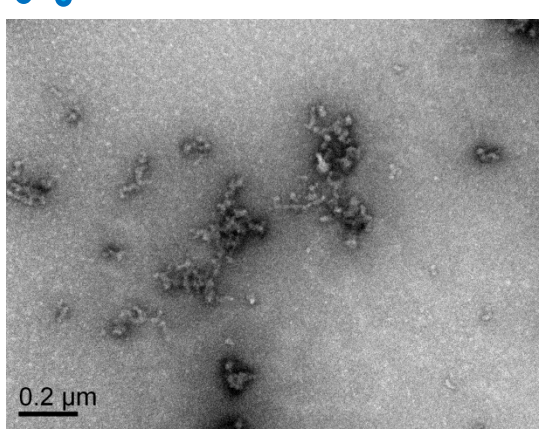
Constant concentration (1%) but variable fractal size



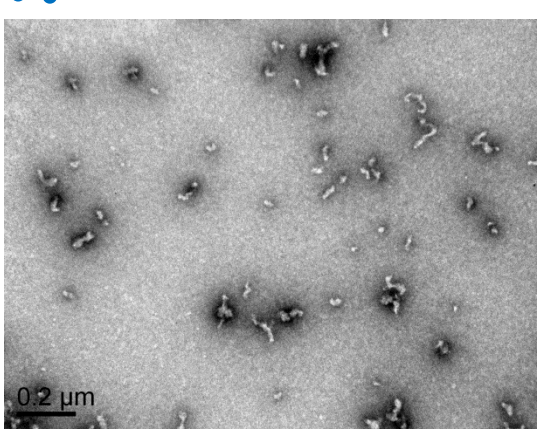
Variation of fractal aggregates size

- Preparation of fractal aggregates:
  - Heat treatment: **2h at 80°C**
  - **Variable concentration of NaCl** (to change the size of aggregates)

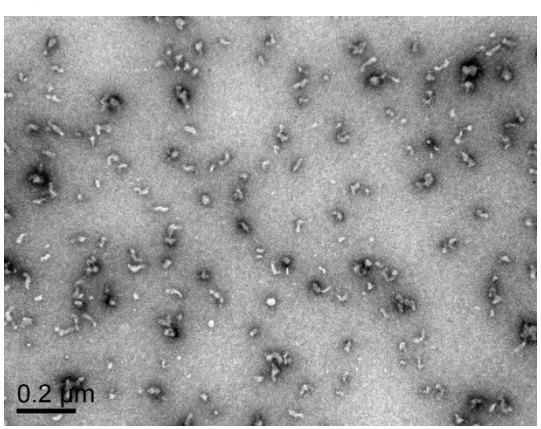
- Observation of fractal aggregates by Transmission Electron Microscopy (TEM):



45 mM NaCl
228 nm



20 mM NaCl
93 nm



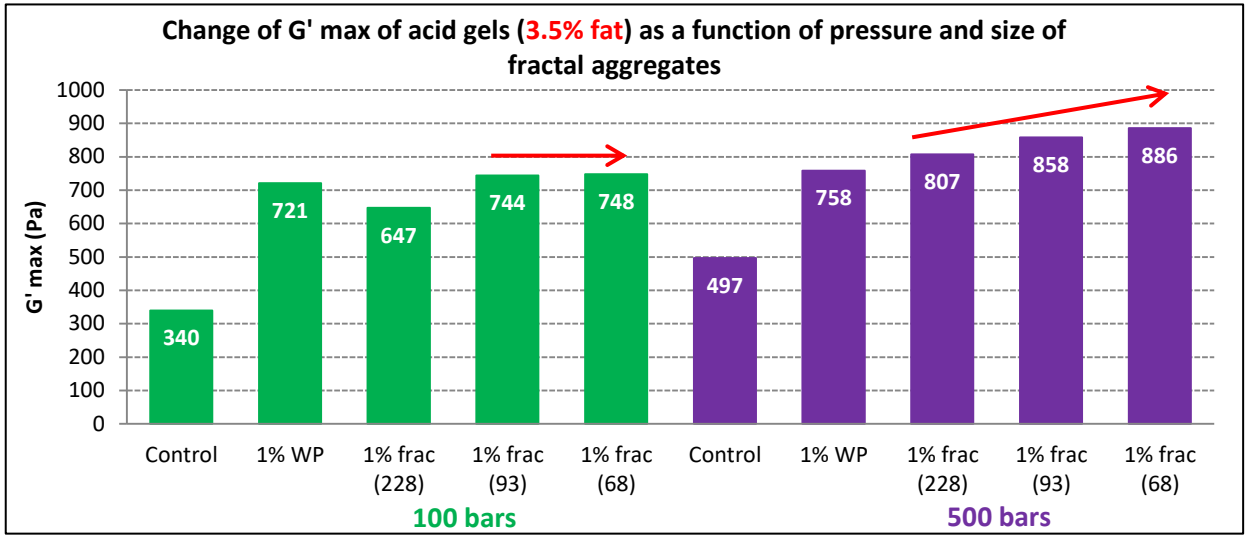
Without NaCl
68 nm

Variation of fractal aggregates size

Milk with **3.5%** fat (**100** or **500** bars)

228 nm 93 nm 68 nm

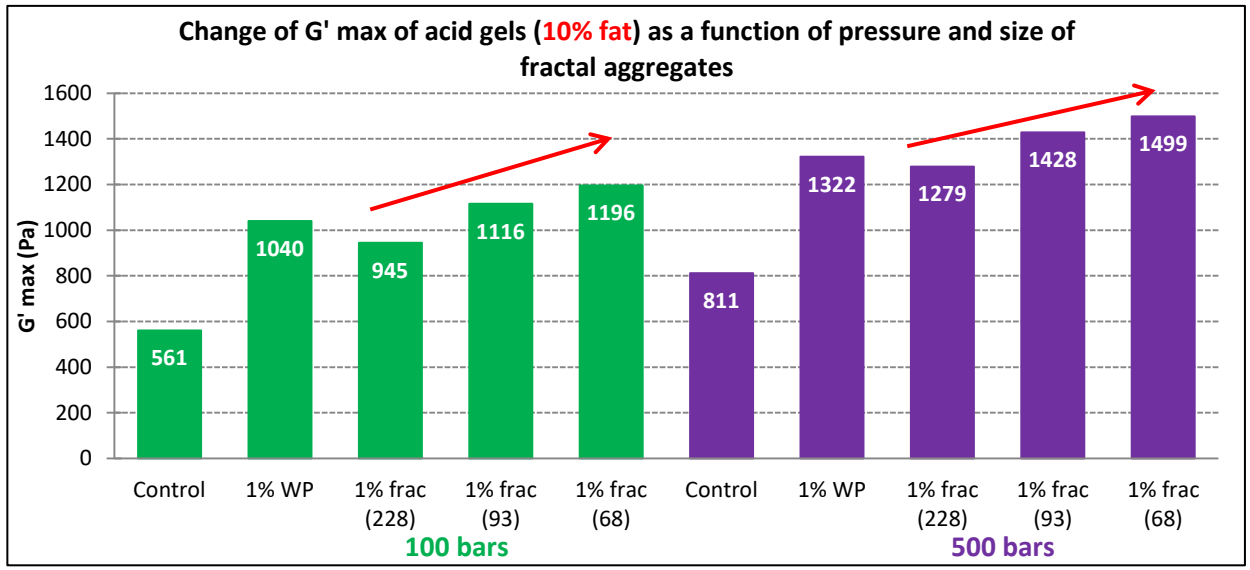
Constant concentration (1%) but variable fractal size



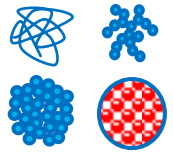
Milk with **10%** fat (**100** or **500** bars)

228 nm 93 nm 68 nm

Constant concentration (1%) but variable fractal size



Conclusions

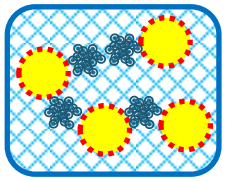


- Difficult to control the interface by addition of aggregates in dairy systems where caseins are predominant (80%) → **ability of caseins to adsorb preferentially on fat droplets**
- Size of fat droplets is dependent on the homogenization pressure (no impact of the type of aggregates → **interface is saturated by caseins**)

- **Fractal aggregates**: better results at high pressure and with small aggregates even at 3.5% fat
- **Microgel** and **mixed aggregates**: protein enrichment, no modification of texture with increasing concentration

→ Modulation of the texture (firmness, syneresis, protein network) by the impact of aggregates in the continuous phase

→ Impact of small fractals on the interface?



Perspectives

- Complete the experiments with small fractal aggregates: interfacial composition, TEM of emulsions...

- Investigate how systems are formed/structured:
  - Differences between fractal/mixed aggregates/microgels

  - Study interface/continuous phase **interactions**

Thank you for your attention

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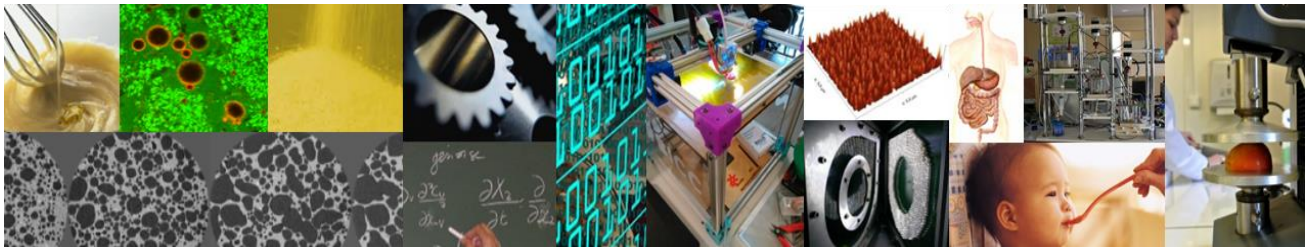

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