IWC PARIS 2008

5th International Whey Conference

Recent improvements in lactose crystallization and in drying parameters for improving quality and uses of acid whey and of related powders

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Content

- Background and Objectives

, Lactose Crystallization and Thickening

f Stickiness

„ Conclusions

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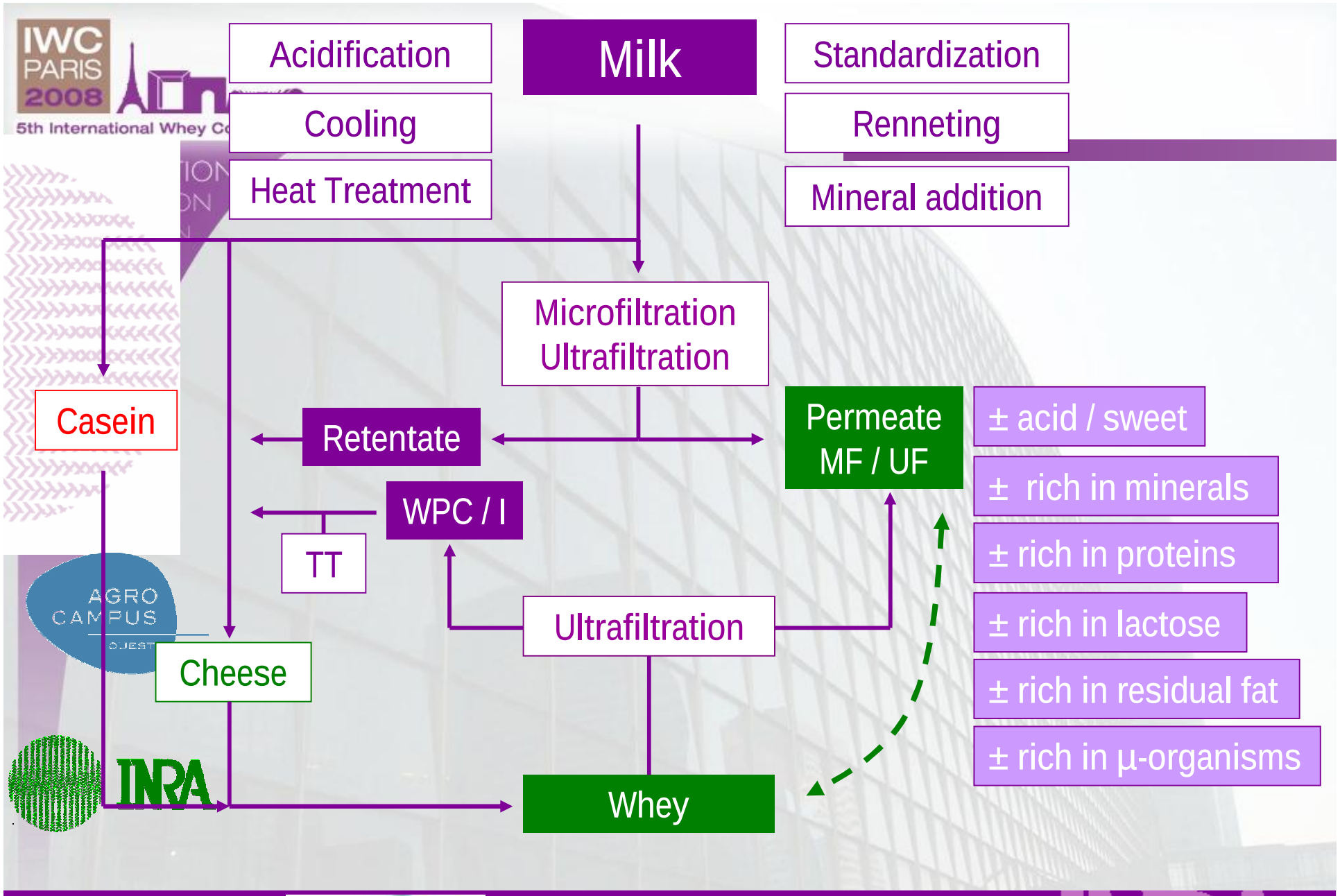
Acidification
Milk
Standardization
Cooling
Renneting
Heat Treatment
Mineral addition
Microfiltration
Ultrafiltration
Casein
Retentate
Permeate
MF / UF
± acid / sweet
± rich in minerals
WPC / I
TT
± rich in proteins
± rich in lactose
Ultrafiltration
Cheese
± rich in residual fat
± rich in µ-organisms
Whey

Biochemical composition of whey and derivates

Proteins	§	0 to 6 $g.L^{-1}$ ± denaturated NPN (0 to 2 $g.L^{-1}$), aa, NH_3
Minerals	§	0 to 6 $g.L^{-1}$
pH		2 to 7
Lactic acid		1 to 7 $g.L^{-1}$
Lactate		1 to 7 $g.L^{-1}$
Lactose	§	30 to 50 $g.L^{-1}$
Glucose, Galactose, etc.		1 to 5 $g.L^{-1}$
EPS, etc.		Traces
Residual fat, Phospholipides	§	Traces

Permeate and Whey

Fat residual, Phospholipides

Minerals

pH

Lactic Acid

Lactate

Proteins

± denaturated

NPN, aa, NH_3

Lactose, Glucose, Galactose, EPS, …

Processing of whey powders & derivates

Whey — TS = 5 % (w/w)



- Heat Treatment
- Whey Fractionation (MF, UF, NF, IEC, ED)
- Vacuum Evaporation

Concentrated Whey — TS = 55 % (w/w)


Lactose Crystallization

Crystallized Concentrated Whey


Spray Drying

Whey Powder — TS = 98 % (w/w)


Storage

Processing of whey powders & derivates

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Lactose Crystallization

Crystallized Concentrated Whey

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Storage

Fouling

Heat-Induced Protein Denaturation

$CaHPO_4$ Precipitation

Variability in Kinetics and Crystal Size

Extensive Thickening

Stickiness

Caking

Maillard Reactions

Loss of Solubility

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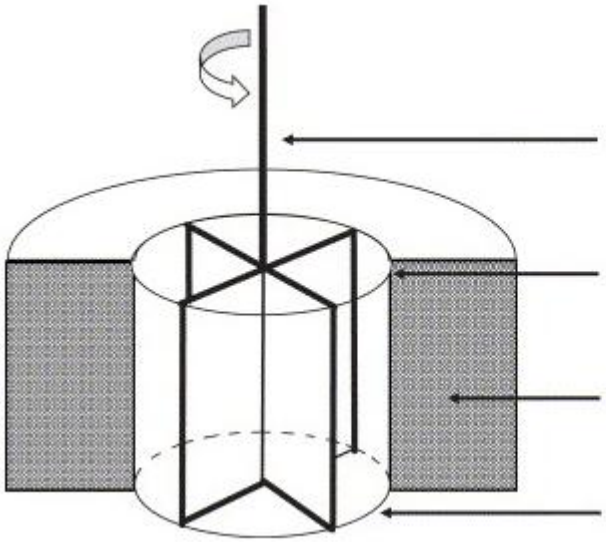
Experimental outline

AR 2000 Rheometer head



Torque = f (time)

Controlled conditions of T°C and stirring speed / geometry

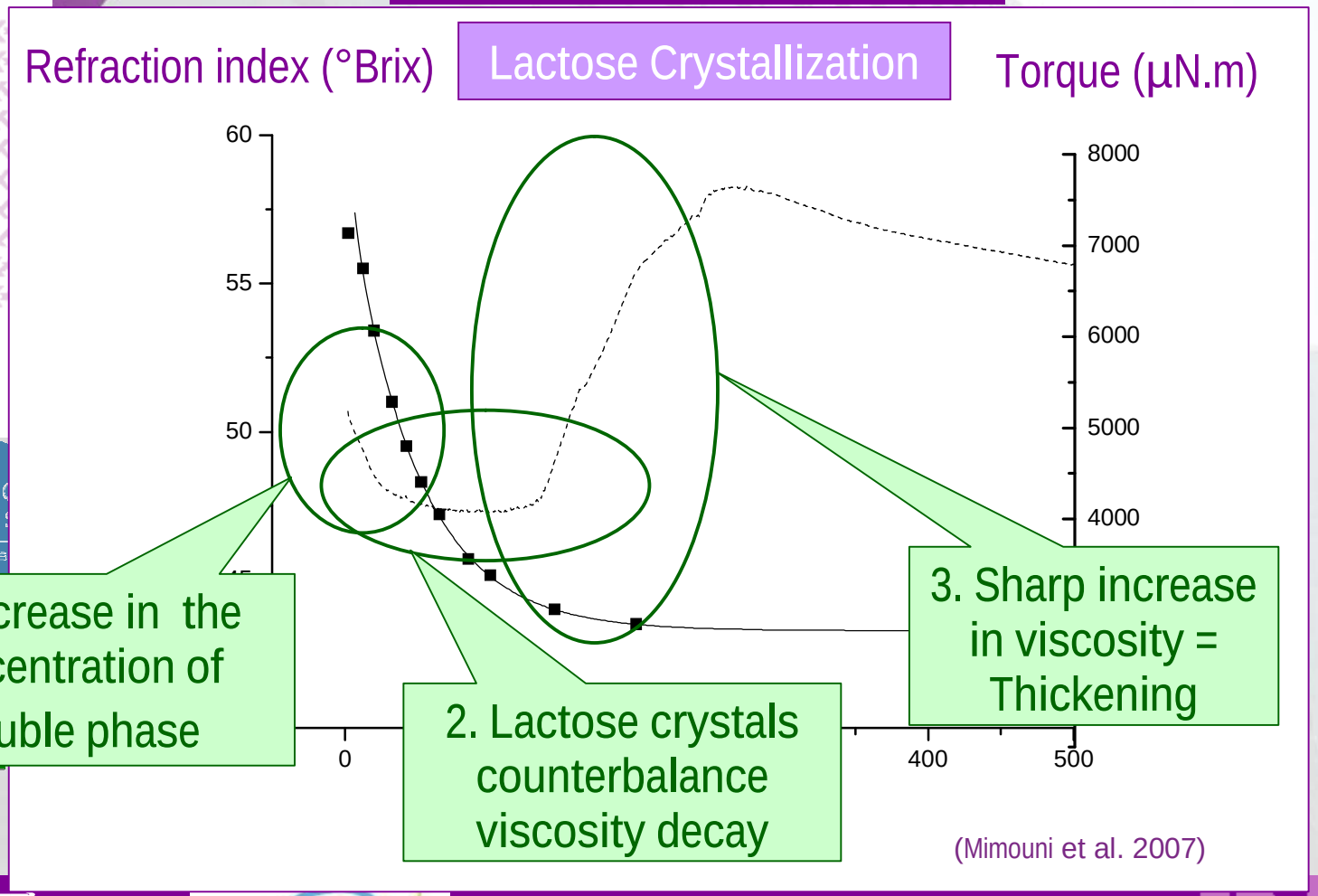
$$\text{Viscosity} = \frac{\text{Shear stress}}{\text{Rate of Shear Strain}} = \frac{k \,.\, \text{Torque}}{k' \,.\, \text{Angular Velocity}}$$

Maintained Constant

(Mandalari et al. 2007)

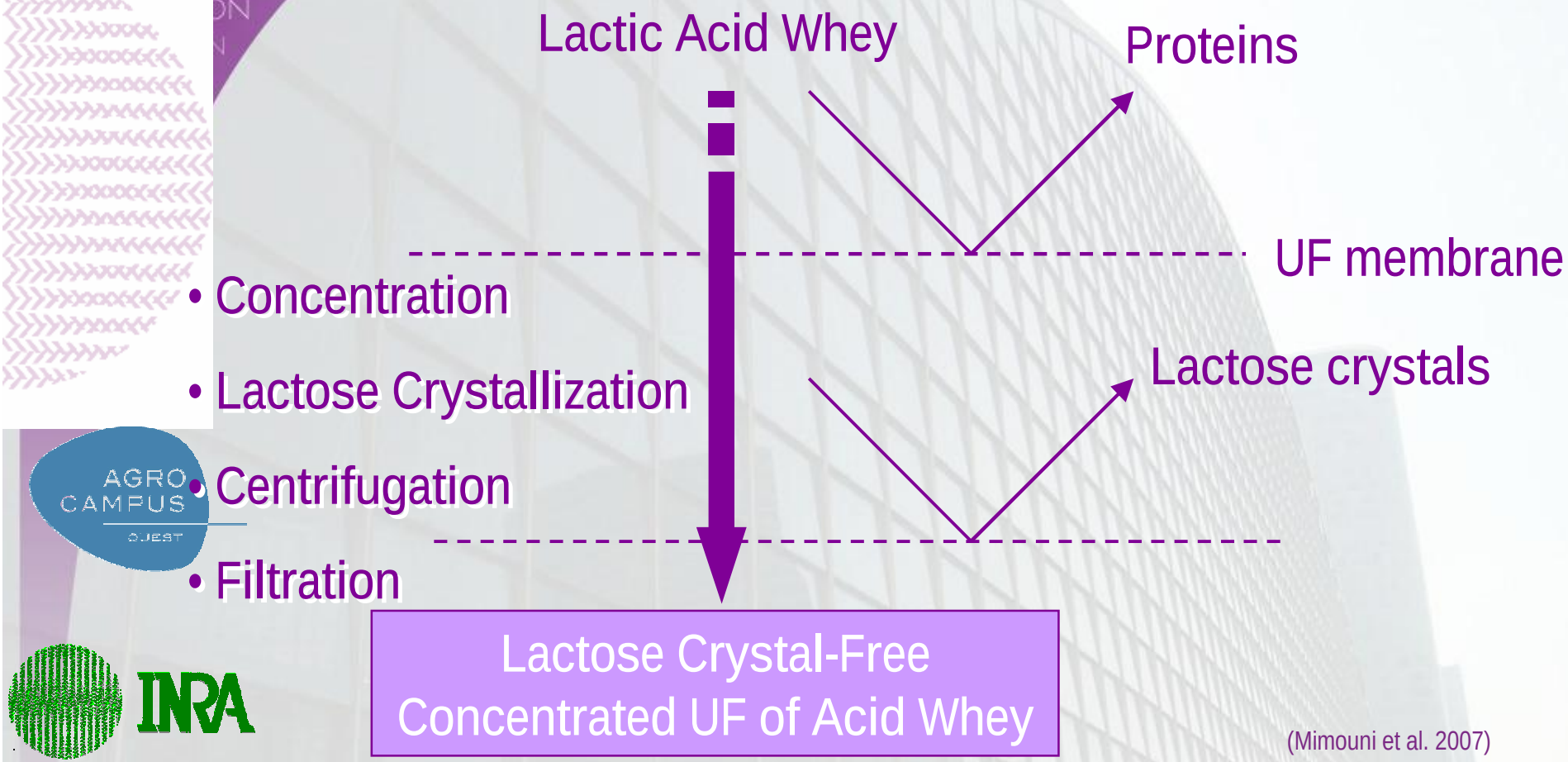
Thickening at lab scale

Concentrated Acid Whey



(Mimouni et al. 2007)

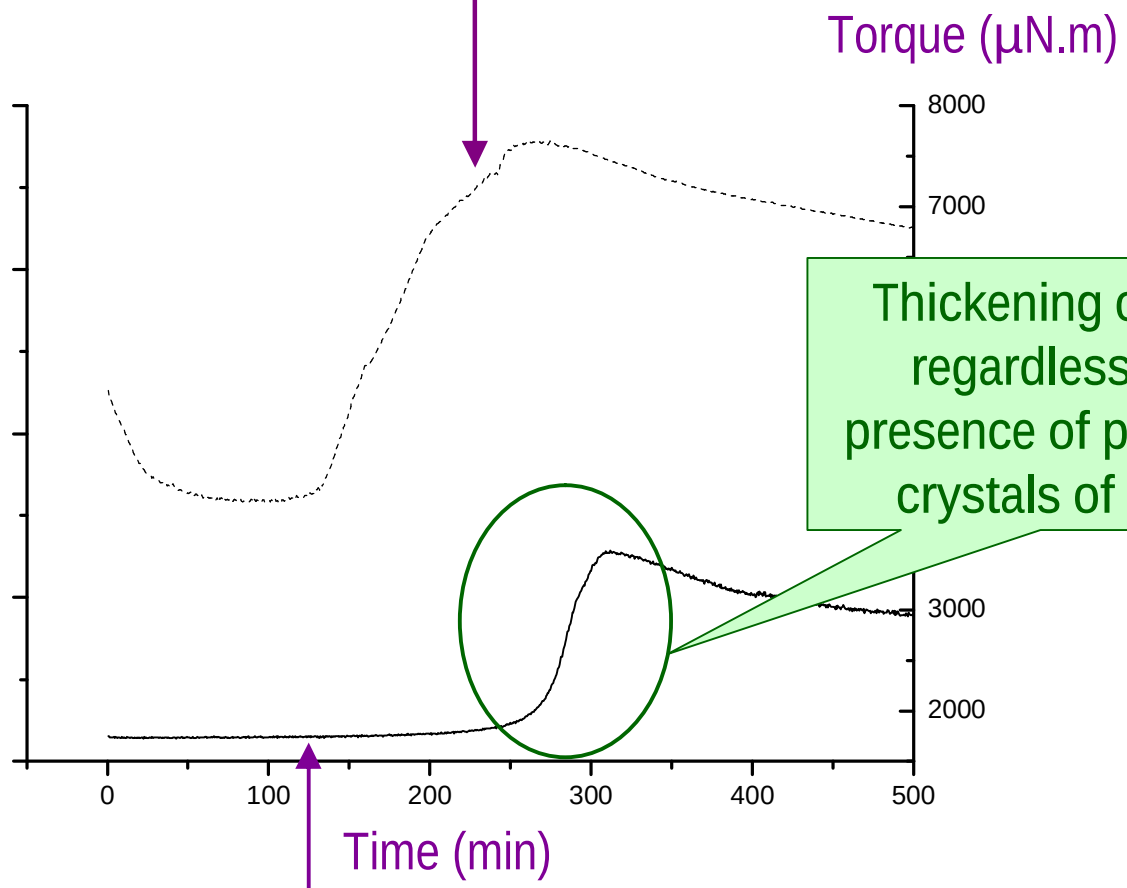
Separation of proteins and lactose crystals from concentrated whey



(Mimouni et al. 2007)

Rheology

Concentrated Acid Whey

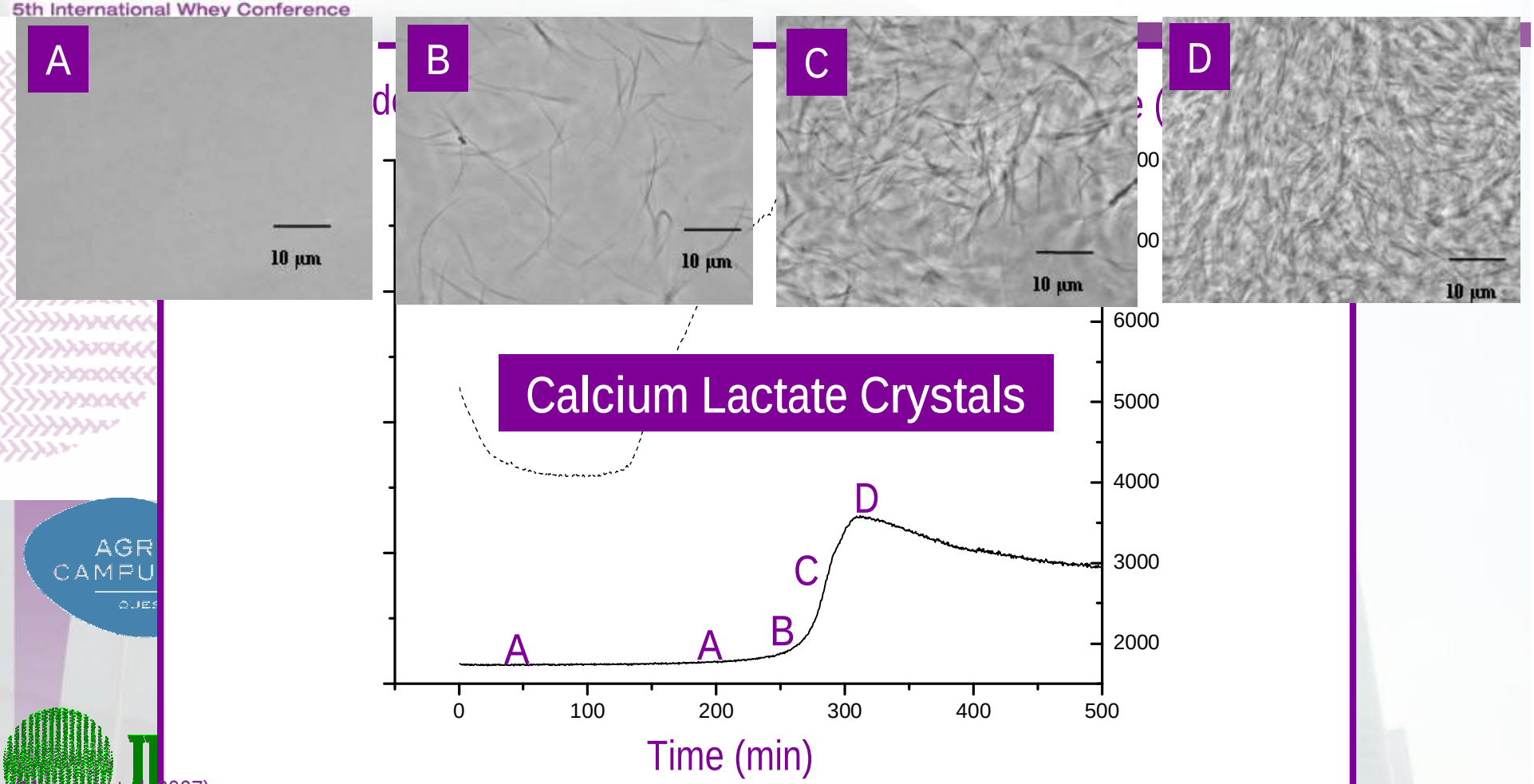


Thickening occurred regardless of the presence of proteins or crystals of lactose

Lactose Crystal-Free Concentrated UF of Acid Whey

(Mimouni et al. 2007)

Structure

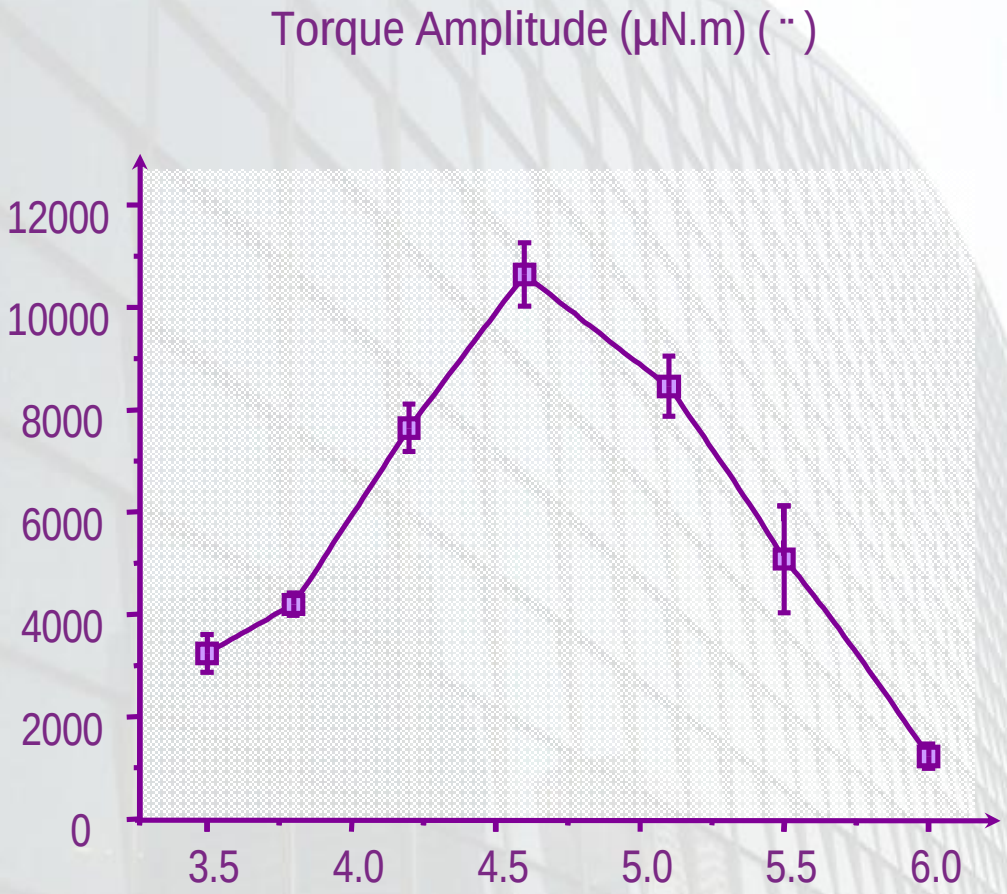


(Wijnhoven et al. 2007)

Viscosity of particle suspensions:

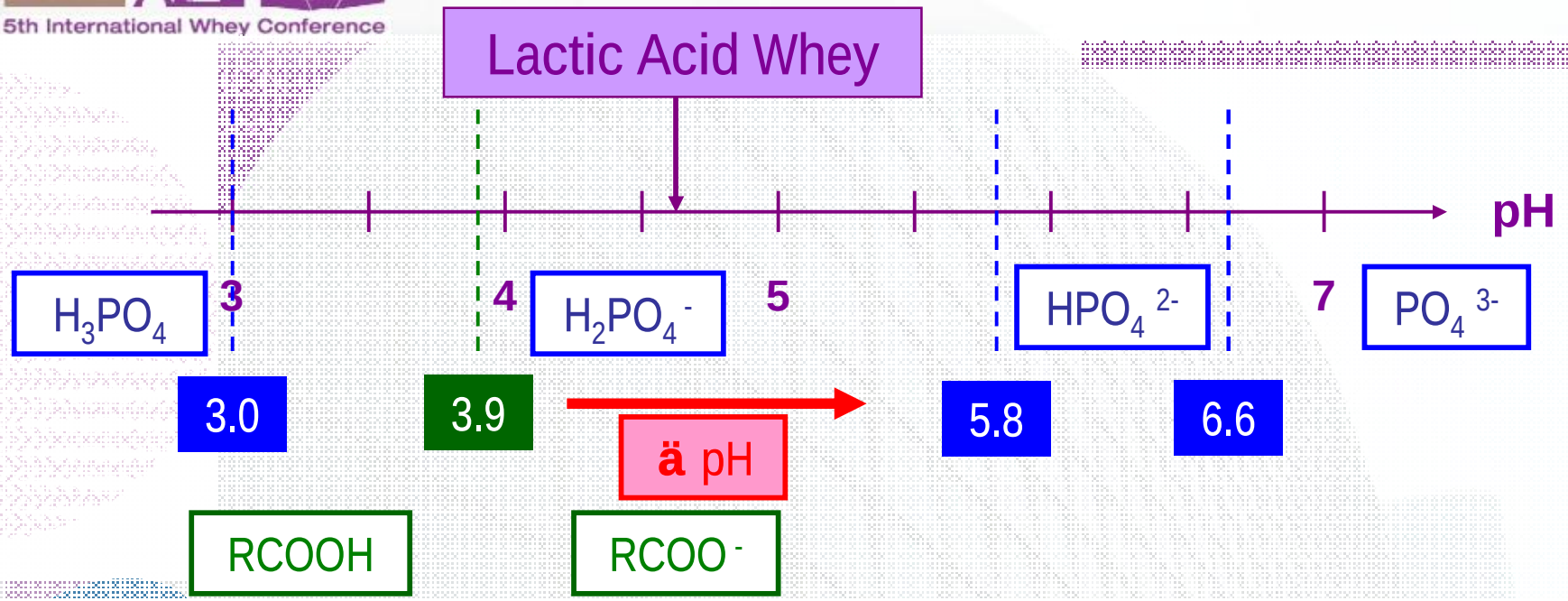
- increases with volume fraction of particles (*Petrie, 1999)*
- <u>strongly</u> increases with the particle aspect ratio (i.e. elongation) *(Pabst, 2006)*

Influence of pH



(Mimouni et al. 2007)

Influence of pH



Anions	Association constant with Ca^{2+} ($L.mol^{-1}$)
$RCOO^-$	15
$H_2PO_4^-$	11
HPO_4^{2-}	642
PO_4^{3-}	$2.88.10^6$

(Holt et al.,1981)

(Mimouni et al. 2007)

Influence of Ph Example

pH	Phosphate concentration (g.100 g^{-1} H_2O)	
	0	1.5
3.5	5.0 ± 1.5	4.4 ± 0.5
5.1	60.4 ± 0.9	40.2 ± 4.1
6.1	64.7 ± 2.4	25.0 ± 4.7

Torque amplitude (ΔF, 10^{-4} N.m) of calcium lactate supersaturated solutions ([Ca] = 1.34 g.100 g^{-1} of H_2O), at different pH, during stirring at 120 rad.s^{-1} and 20°C, with and without phosphate ions.

(Mimouni et al. 2007)

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Integration of T_g

ð Acid lactic whey / permeate, mono & disaccharides, polyols, hydrolyzed compounds, minerals

Low T_g

Low T_g / ö Stickiness

ø Inlet q & Flow rate

ø Outlet air q & AH

ø q Droplet & Powder

T_g Lactic acid = - 60°C

T_g Lactose = + 90°C

Materials

B I O N O V

Pilot workshop : Research and development for evaporation / drying

«MSD type» drying tower 80 kg of water evaporated per hour

Spray drying

ð [Acid lactic whey] at » 55% TS, at » 80% crystallized lactose

	Inlet q°C	Outlet q°C	AH $g.kg^{-1}DA$	[C] $kg.h^{-1}$	Powder $kg.h^{-1}$	€ / ton Water	€ / ton Powder
[ALW]	233	89	41	258	185	78.5	61.6
[ALW]	155	75	26	129	92	99.9	78.5

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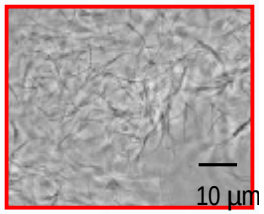
Conclusions

Origin of thickening is due to the formation of calcium lactate crystals

Concentrated lactic acid wheys are likely to thicken because of:

High [Ca] ⊕ High [Lactate] ⊕ pH ~ 4.5 ⇒



Origin of stickiness during spray drying is due to the low T_g value of lactic acid (- 60°C)

To improve the quality of the lactic acid whey powder

ð Modify the calcium lactate supersaturation à (pH; Phosphate; Citrate; TS; Temperature)

ð Modify the spray drying parameters à (æ [C] flow rate, inlet and outlet air q, outlet air AH)

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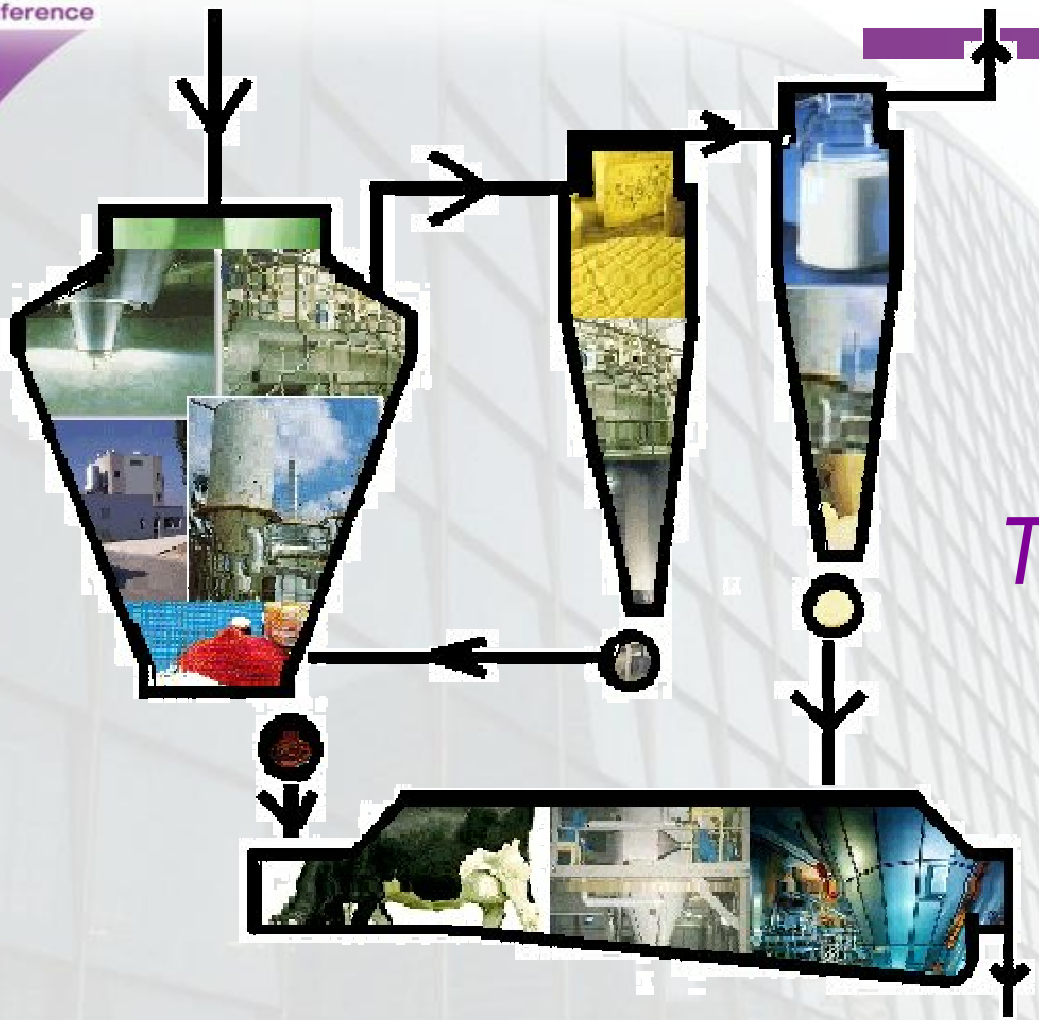

MERCI

THANK YOU

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