Effect of heat treatment on the formation of acid milk gel: a kinetic study using rheology and confocal microscopy

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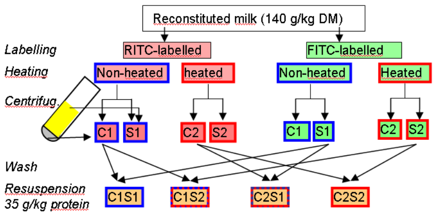
Introduction

In the manufacture of yoghurts, the extensive heat-treatment of milk at 80-95°C for several minutes has been shown to increase the pH of gelation and the final elastic modulus of the gel. These changes correlate well with the formation of micelle-bound (MC) and serum (SC) heat-induced whey protein/κ-casein complexes. The objective of this study was to investigate the specific contributions of the heat-induced complexes and the casein micelles to the formation of acid milk gels using a highly relevant labelling procedure for CLSM, and rheology.

Materials & Methods



Systems acidified by GDL addition at 35°C

Monitored on an inverted microscope (Nikon) with a 60x oil-immersion objective

- FITC λ_{exc}= 488 nm - λ_{em}= 515 ± 15 nm
- RITC λ_{exc}= 543 nm - λ_{em}= 590 ± 25 nm
- Observations at 30 µm depth

Monitored by low amplitude dynamic oscillation method (AR2000, TA Instruments)

- t_{gel} defined as the time when G'>1 Pa.
- Neither the presence nor the nature of the fluorescent probes nor the labeled phase modified the acid gelation as measured by rheology (preliminary results)
- 2 repetitions of the complete sample preparation and gelation performed

Results & Discussion

- Comparison C1S1/C2S2 systems confirms the literature on the effect of heat-treatment on acid gelation of milk : ➚ pHgel; ➚ dG'/dpH; ➚ G'; ➚ solid-like behaviour; tanδmax present; ➚ pore diameter; ➚ visible connectivity (Fig1 and Table1)
- When MC or SC was present (C1S2 and C2S1) behaviour similar to heated milk system (C2S2): same pH_{gel}, G', tanδ and microstructure
- FITC-labelled SC visible in C1S2 and C2S2. super-imposable with RITC-labelled casein micelles ➔ co-location of SC and micelles

Table 1. Mean values for pH of gelation, pH at the local maximum of tanδ and G' and tanδ at pH 4.5

	pH_{gel}	$pH_{max\ tan\delta}$	$G'_{pH\ 4,5}$ (Pa)	$tan\delta_{pH\ 4,5}$
C1S1	4.86[a]	-	26[a]	0.343[a]
C1S2	5.11[b]	4.90[a]	363[b]	0.294[b]
C2S1	5.24[b]	4.93[a]	293[b]	0.287[b]
C2S2	5.22[b]	4.92[a]	421[b]	0270[b]

Means with different superscripts in column differ significantly ($P < 0.05$)

- Values of pH_{gel} confirmed by CLSM: 5.0 (C1S2-C2S1-C2S2) - 4.8 (C1S1) (Fig.2)
- No evidence of any particular sequence in the aggregation of casein micelles or heat-induced SC, meaning simultaneous aggregation (Fig.2)
- When FITC-labelled SC were present (C2S2 and C1S2), resulting overlay images are orange (red+green) as compared to C1S1 - C2S1 without SC (red)

Fig.1: Development of the elastic modulus and tanδ of milk systems during acidification. Right hand side images show the final microstructure of systems at pH 4.6.Scale bar is 10 µm.

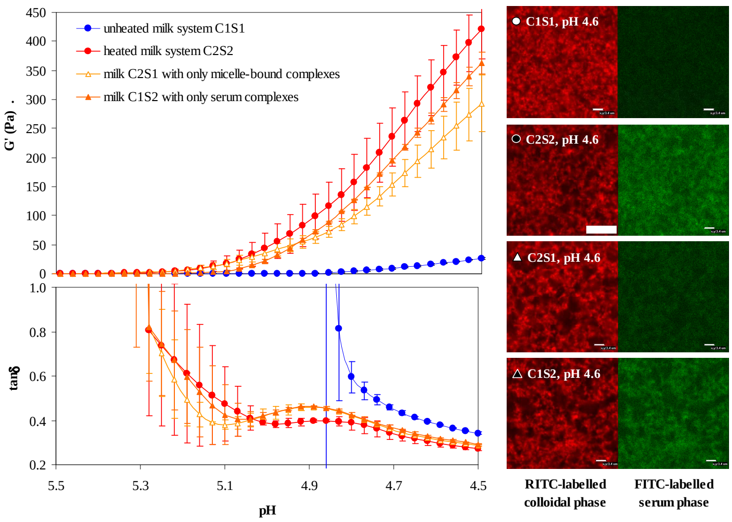
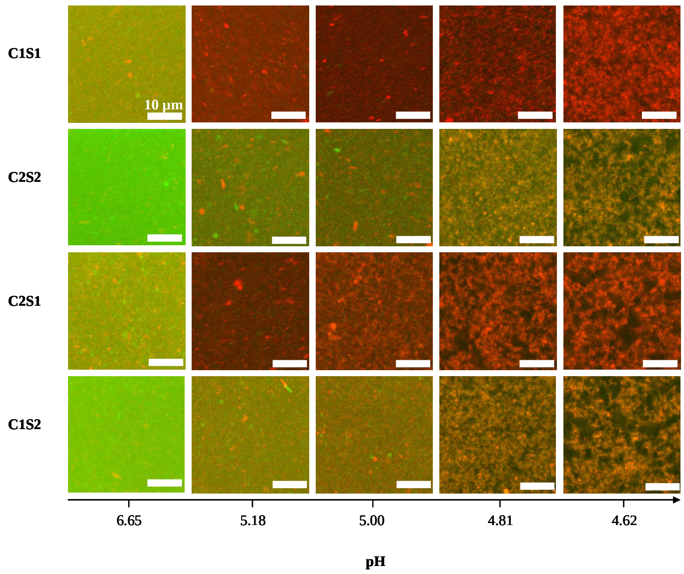


Fig.2: FITC/RITC overlay images of the systems (RITC on colloidal components in red and FITC fixed on soluble components in green)



Conclusions

Confirmation that the heat-induced complexes were responsible for the earlier destabilisation of milk system at pH ~5.2 and for enhanced G'

Heat-induced complexes located in the serum or the colloidal phase or both
➔ same rheological and microstructural changes of acid gels
+ co-location of SC and casein micelles in the gels

➔ ***suggested that SC interacted with the casein micelles before gelation***
Possibly C1S2 = C2S1 = C2S2 at the gel time

Casein micelles = the building material of the gel with SC attached to their surface

➔ ***SC provide casein micelles with new gelation functionality***

Dairy Science and Technology Week 2009 - 20-24 april 2009 - Rennes - France

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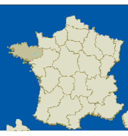
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