



HAL
open science

Les propriétés rhéologiques des gels présure dépendent de la répartition des cations bivalents dans les micelles de caséine

Julien Bauland, Marie-Hélène Famelart, Fanny Guyomarc'H, Romain Jeantet, Said Bouhallab, Thomas Croguennec

► To cite this version:

Julien Bauland, Marie-Hélène Famelart, Fanny Guyomarc'H, Romain Jeantet, Said Bouhallab, et al.. Les propriétés rhéologiques des gels présure dépendent de la répartition des cations bivalents dans les micelles de caséine. IDF International Cheese Science and Technology Symposium, Jun 2021, 100% virtual edition, France. , 2021. hal-03256703

HAL Id: hal-03256703

<https://hal.inrae.fr/hal-03256703v1>

Submitted on 10 Jun 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

BAULAND J.^(1,2), FAMELART M.H.⁽¹⁾, GUYOMARC'H F.⁽¹⁾, JEANTET R.⁽¹⁾, BOUHALLAB S.⁽¹⁾ CROGUENNEC T.⁽¹⁾

(1) STLO, INRAE, Institut Agro, 35042, Rennes, France; (2) CHR-HANSEN, 2970 Horsholm, Denmark

Julien.Bauland@inrae.fr

Thomas.Croguennec@agrocampus-ouest.fr

Background

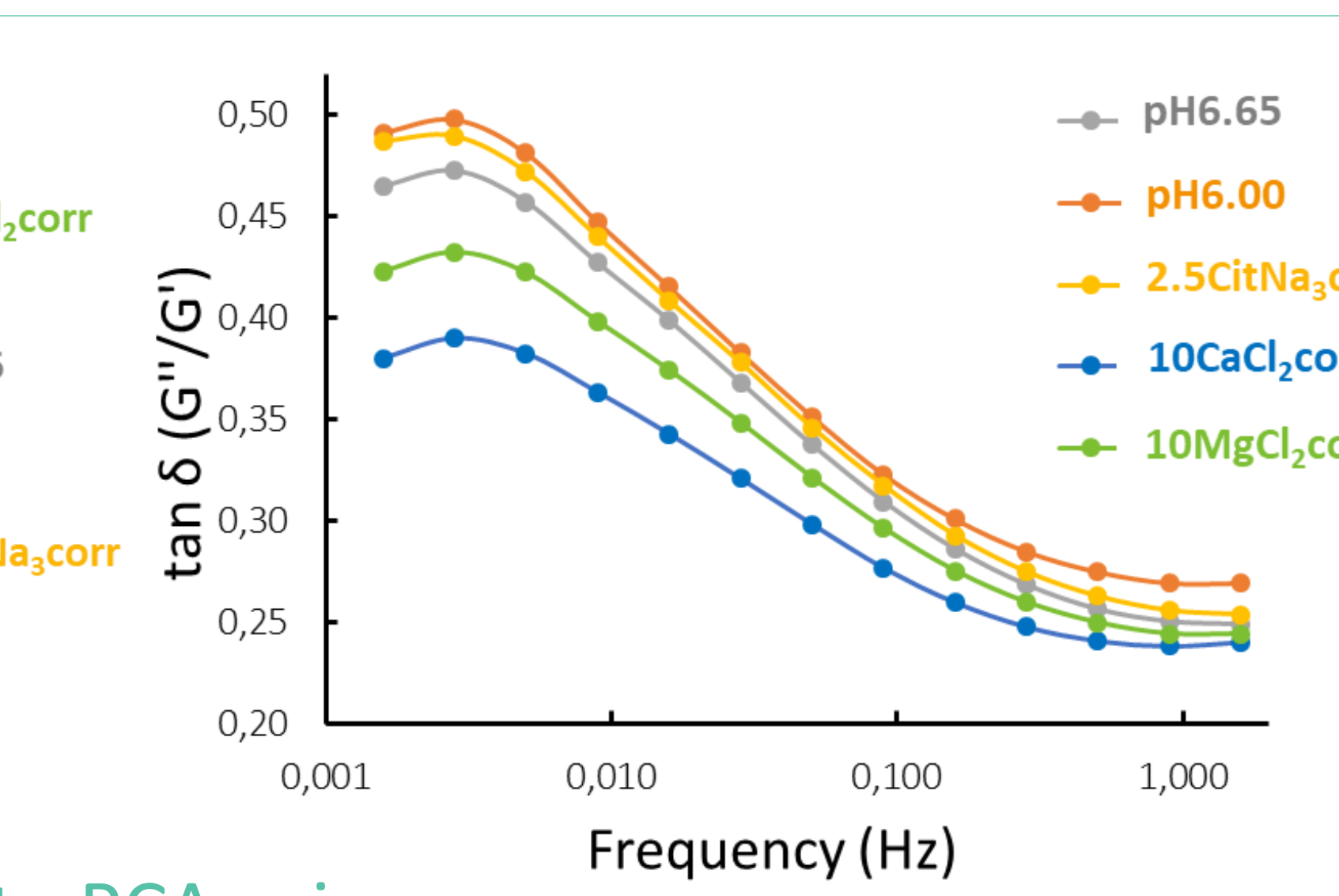
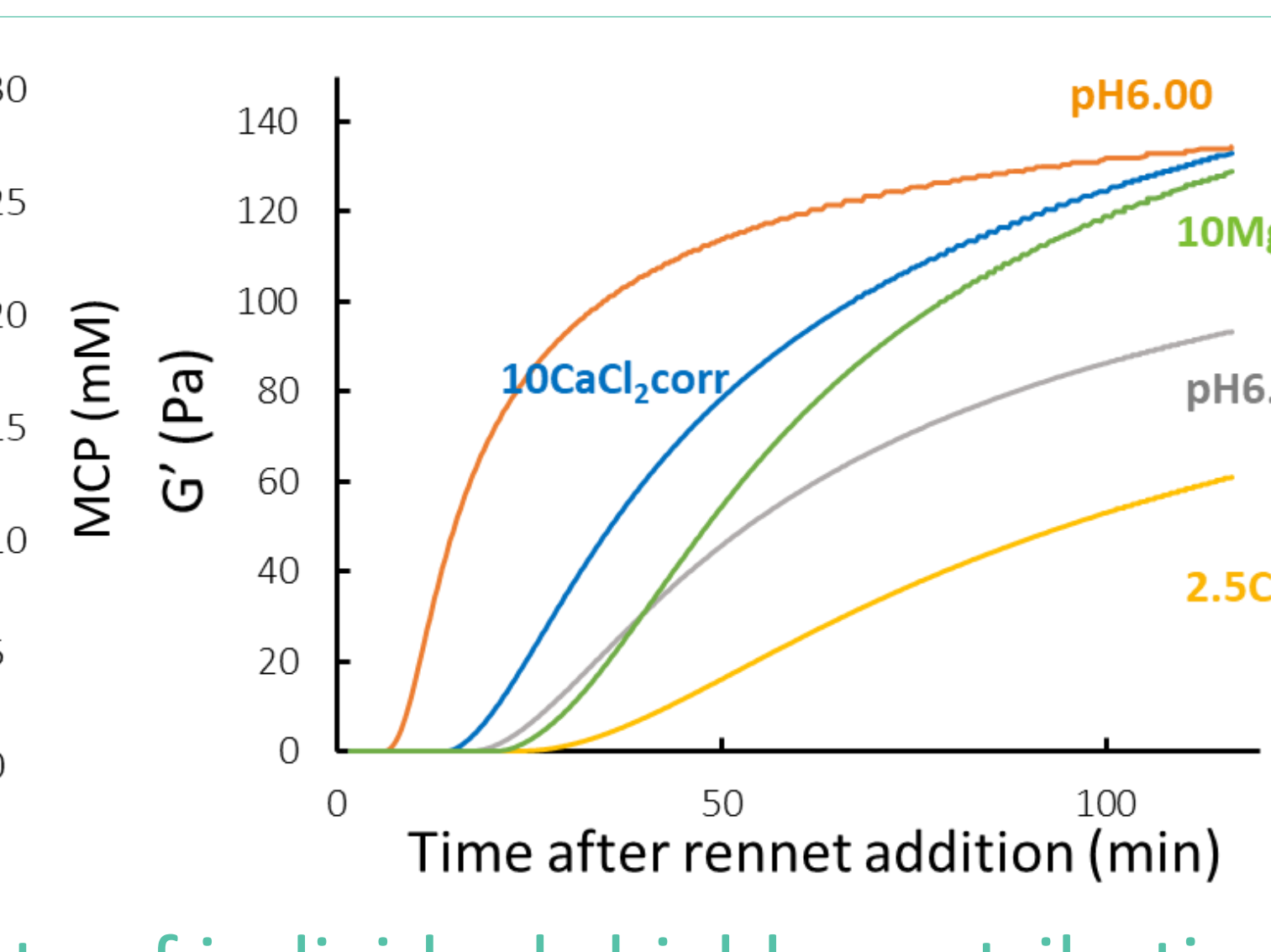
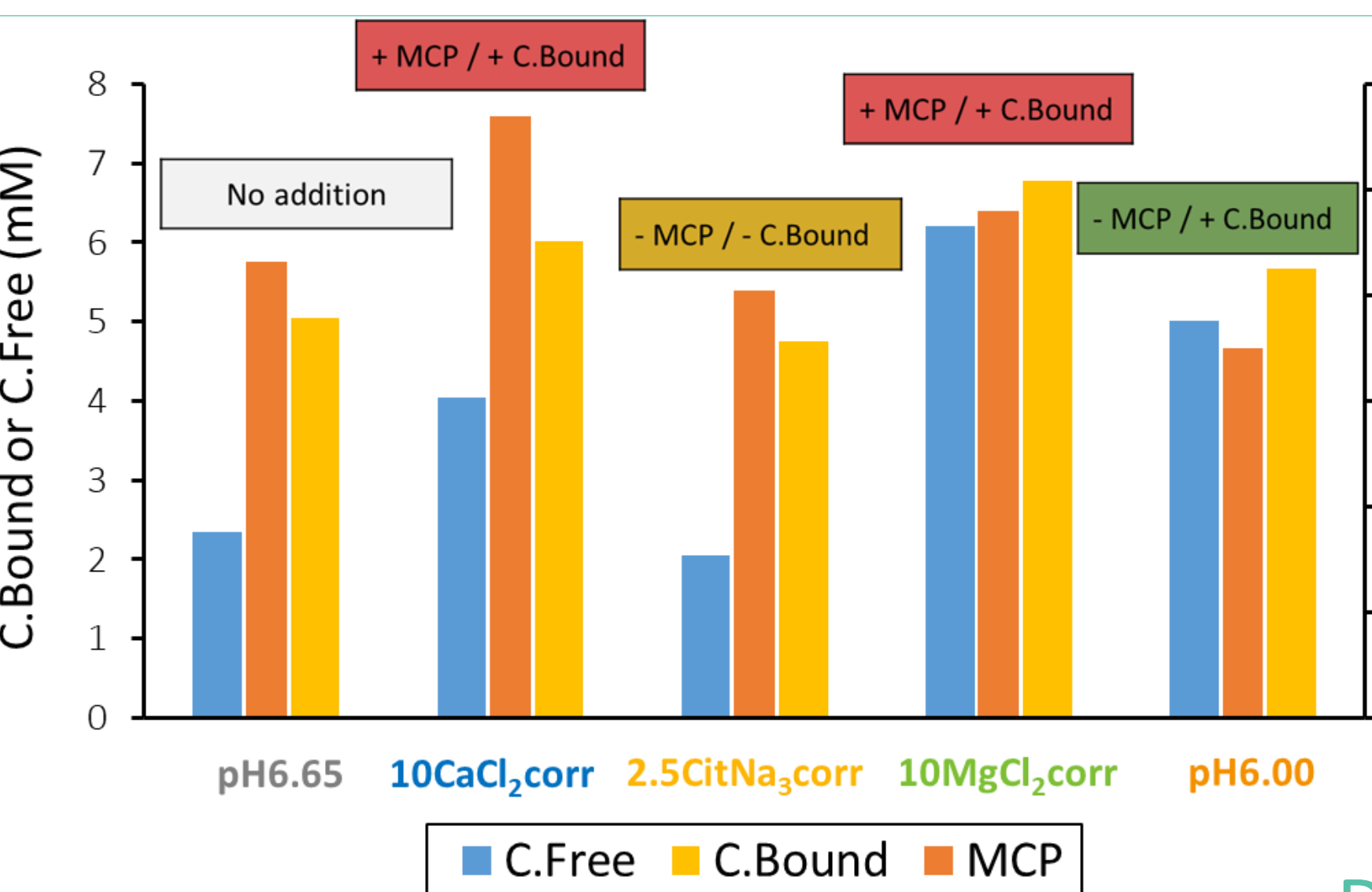
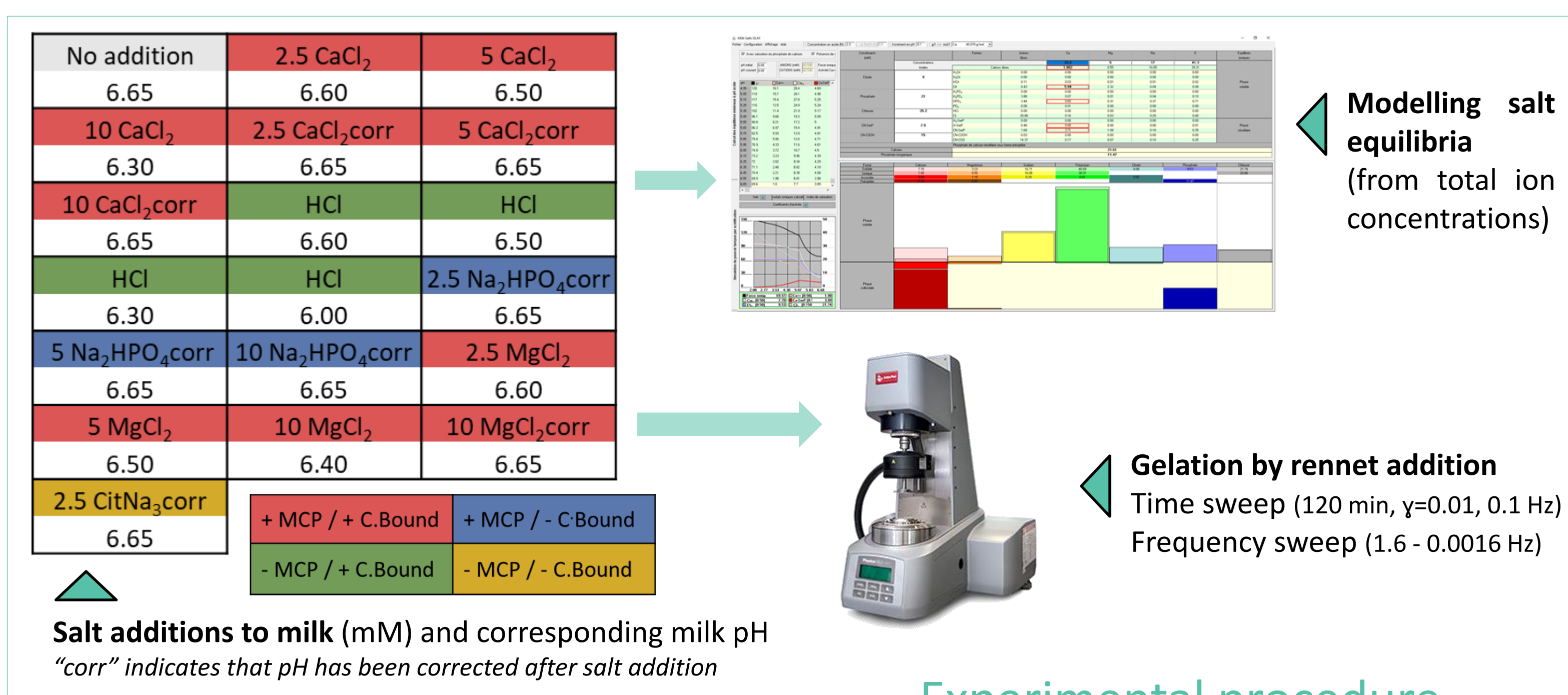
Rennet gel is a particle gel whose structure is dynamic. Its rheological properties depend on the strength and the number of bonds between particles (casein micelles) but also on their spatial distribution, i.e. their microstructure. From previous studies, it has been hypothesized that the micellar calcium phosphate (MCP) content of the casein micelles influences the gel viscoelastic character and its dynamic of rearrangements.

Strategy

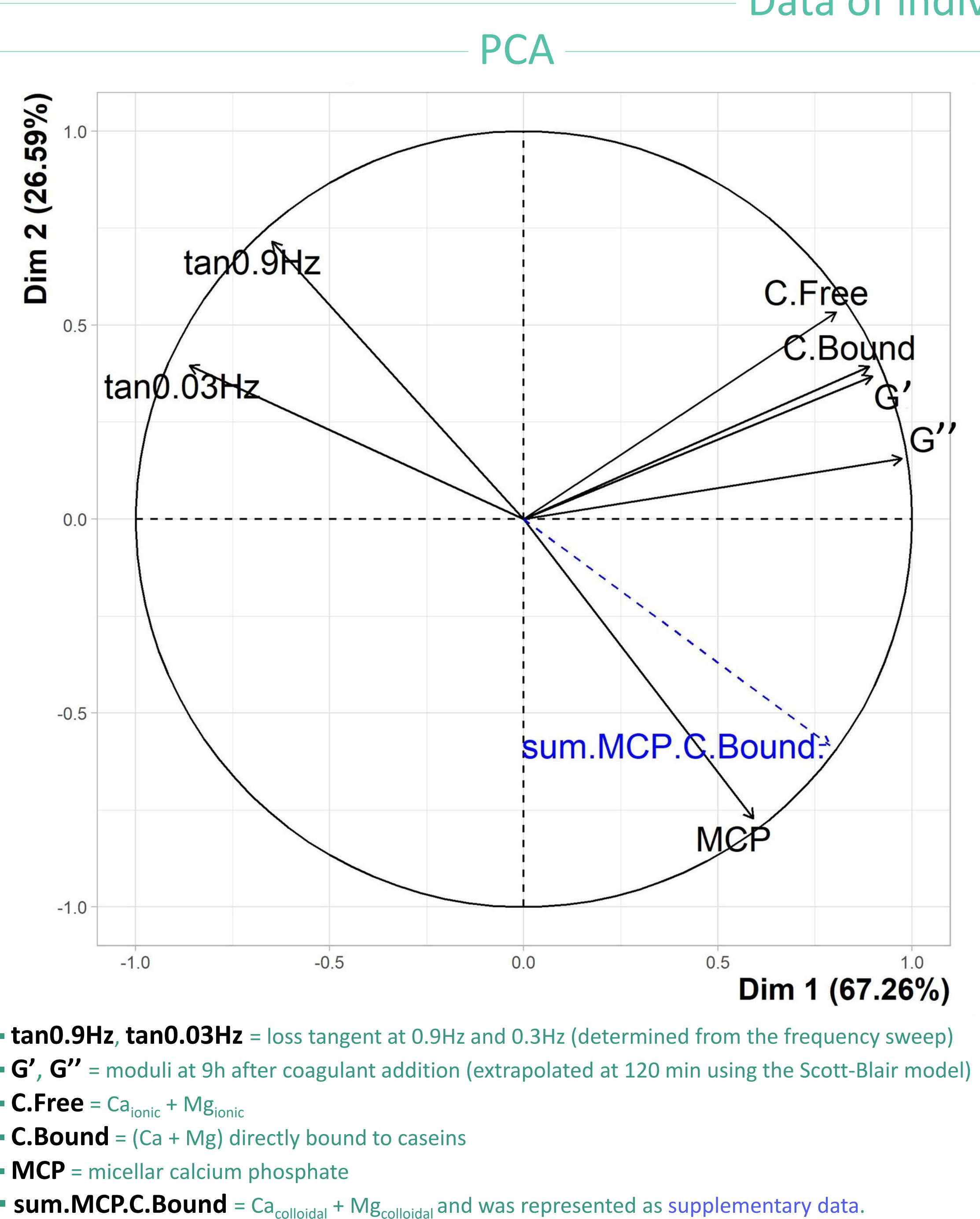
19 samples were prepared by adding different salts (CaCl₂, MgCl₂, Na₂HPO₄, CitNa₃) to milk or by varying the milk pH. Samples were gelled by rennet addition at 30°C and gel properties were assessed by small angle shear oscillatory rheology using a Couette geometry. A frequency sweep was initiated 120 min after rennet addition. Detailed mineral distribution was obtained by modelling salt equilibria from total ion concentrations using the Milk Salts GLM software [1].

Results

Low MCP content would result in more viscous gels that quickly rearrange, but this has been observed in a limited number of conditions. Divalent cations (Ca²⁺ and Mg²⁺) also exist as free (C.Free) or as directly bound to casein residues (C.Bound), but they are seldom considered. **In this study, milk samples with various mineral composition were analyzed to determine how the mineral partition affects the rheological properties of rennet gels.**



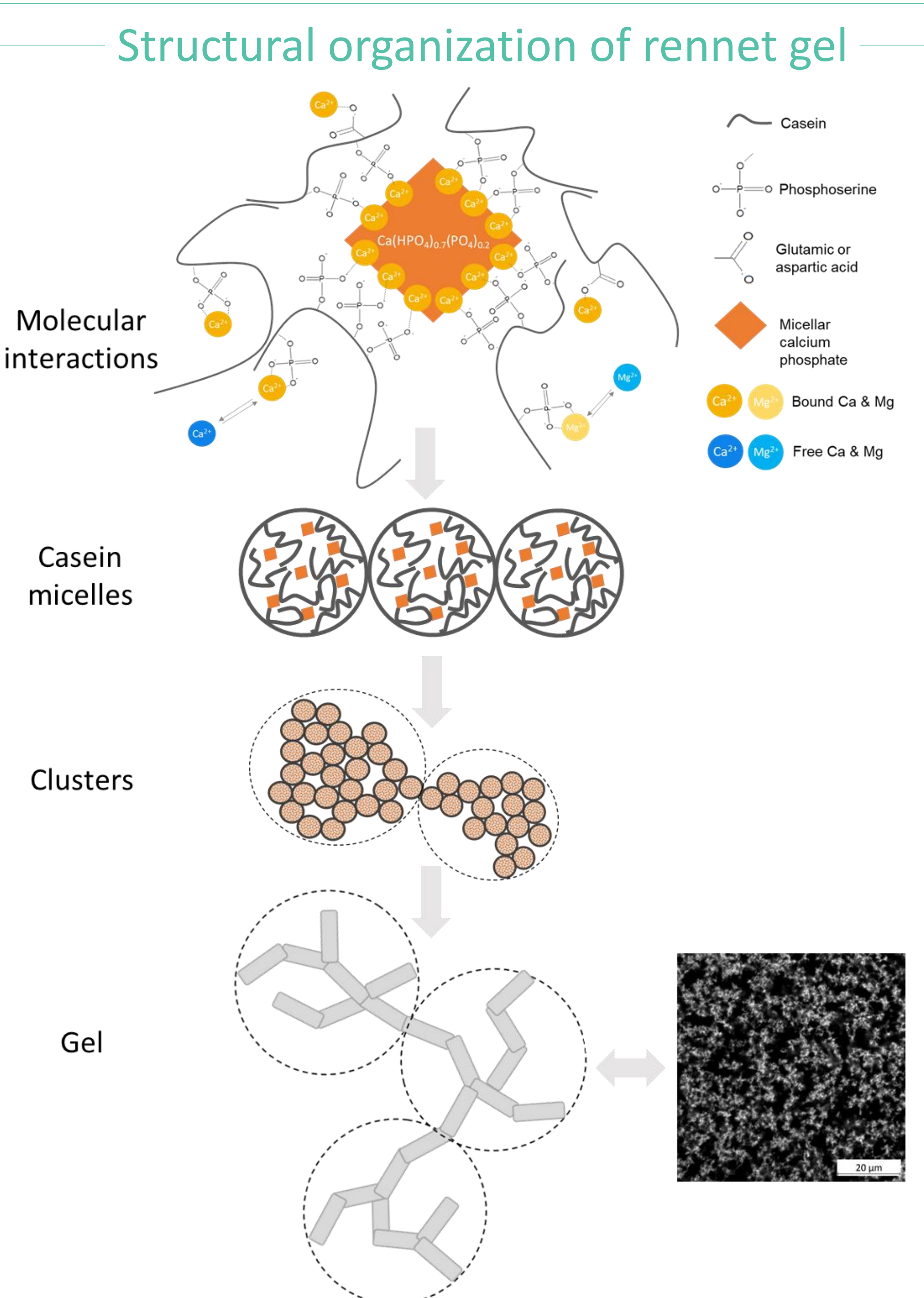
To reveal potential correlations between mineral distribution and rheological properties, the data set was simplified using principal component analysis (PCA).



It has been suggested that the value of the moduli (G' and G'') depends on the number of bonds between casein micelles [2]. The correlation between C.Free, C.Bound, G' and G'' suggests that the direct binding of cations to caseins reduces electrostatic repulsions between casein micelles and promotes the creation of inter-micelle bonds. The MCP content was not correlated to the absolute value of the moduli but was anticorrelated to their ratio, the tan δ . Thus, the viscoelastic character of the gel depends on intra-micellar interactions that are enhanced by the presence of MCP.

It is not self evident through which mechanism and at which scale MCP affects the gel dynamics. We formulated 2 hypothesis:

- Bonds between MCP and caseins could directly participate to the gel rheological properties. Increased MCP content would increase the number of bonds with high relaxation time, giving the gel a more elastic character (decrease of tan δ).
- MCP could also affect the casein micelle mechanical properties (hardness). Harder or softer elementary particles could lead to different aptitudes to rearrangement and cluster shapes, leading to different gel structures.



[1] Mekmene, O., Y. Le Graët, and F. Gaucheron. 2009. A model for predicting salt equilibria in milk and mineral-enriched milks. Food Chem.

[2] Horne, D.S., and J.A. Lucey. 2017. Rennet-Induced Coagulation of Milk. Elsevier Inc.