Rethink milk protein concentrates: a liquid solution to solid surplus

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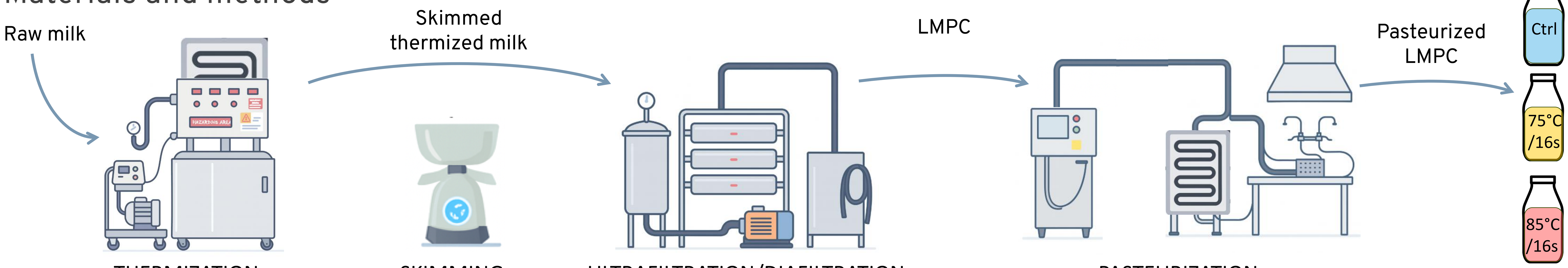
Introduction and objectives

In 2023, Canada produced over 75,000 tons of surplus non-fat dairy solids due to increasing demand for high-fat products such as cheese, butter, and cream. This study examines the valorisation of these by-products by developing liquid milk protein concentrates (LMPC) for human consumption. The goal is to understand how heat treatment following concentration impacts microbial stability, colloidal maturation, and rheology during storage, which are key factors in improving product stability over time.

Materials and methods



Results

Composition

Table 1. *Composition and physico-chemical properties of milk concentrates following different pasteurization treatments.*

	Total solids (%)	Minerals (%)	Proteins (%)	True proteins (%)	Casein ratio (%)	pH	Zeta potential (mV)	Particles size (nm)
Control	18.35 ± 0.01	1.00 ± 0.06	13.73 ± 1.99	13.64 ± 0.04	11.13 ± 0.55	6.90 ± 0.14	-26.4 ± 3.8	173.78 ± 0.35
75°C	17.81 ± 0.09	0.79 ± 0.24	13.67 ± 2.17	13.58 ± 0.03	11.79 ± 0.48*	7.00 ± 0.07	-27.2 ± 2.6	177.98 ± 10.34
85°C	17.77 ± 0.09	0.79 ± 0.36	13.77 ± 1.94	13.70 ± 0.02	12.40 ± 0.20**	6.97 ± 0.08	-27.6 ± 1.9	177.10 ± 18.52

*Asterisks indicate significant differences between the treatment and the control * p < 0.05 and ** p > 0.01*

Milk protein thermal association (RP-HPLC)

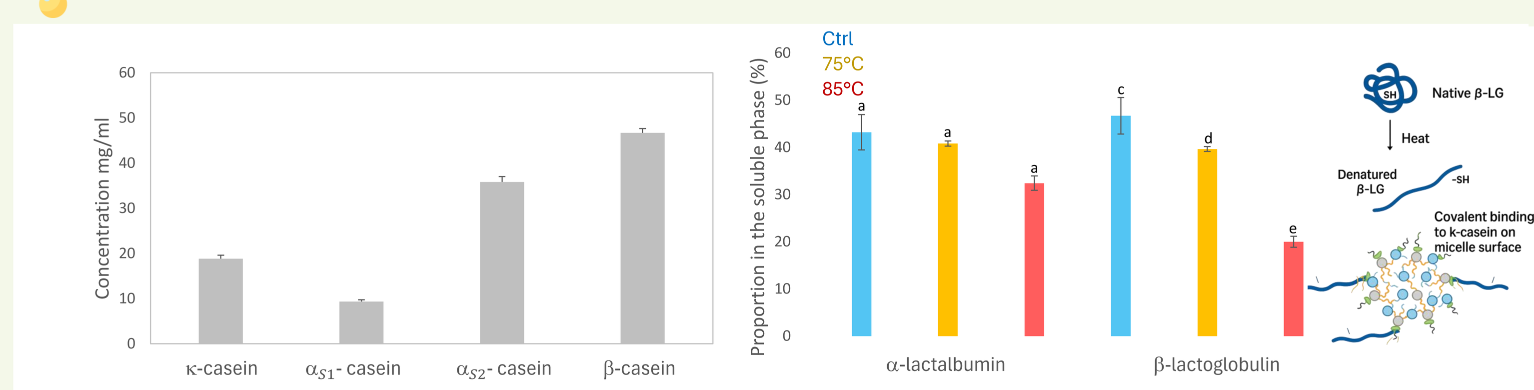


Figure 1. *Pasteurization promotes whey protein associations with caseins:* ***A)*** *total caseins in LMPC and* ***B)*** *soluble whey proteins in LMPC (after centrifugation at 100,000 × g for 4 hours at 20°C). Different letters indicate significant differences between treatments<0.05).*

Microbial stability

Table 2. *Microbial composition of LMPC (log_{10} UFC/mL).*

	Total flora	Psychrotrophs	Enterobacteria	Yeast and molds
Control	4.66 ± 1.08	6.09 ± 1.22	3.67 ± 1.88	5.83 ± 1.42
75°C	< 1 d.l	< 1 d.l	< 1 d.l	< 1 d.l
85°C	< 1 d.l	< 1 d.l	< 1 d.l	< 1 d.l

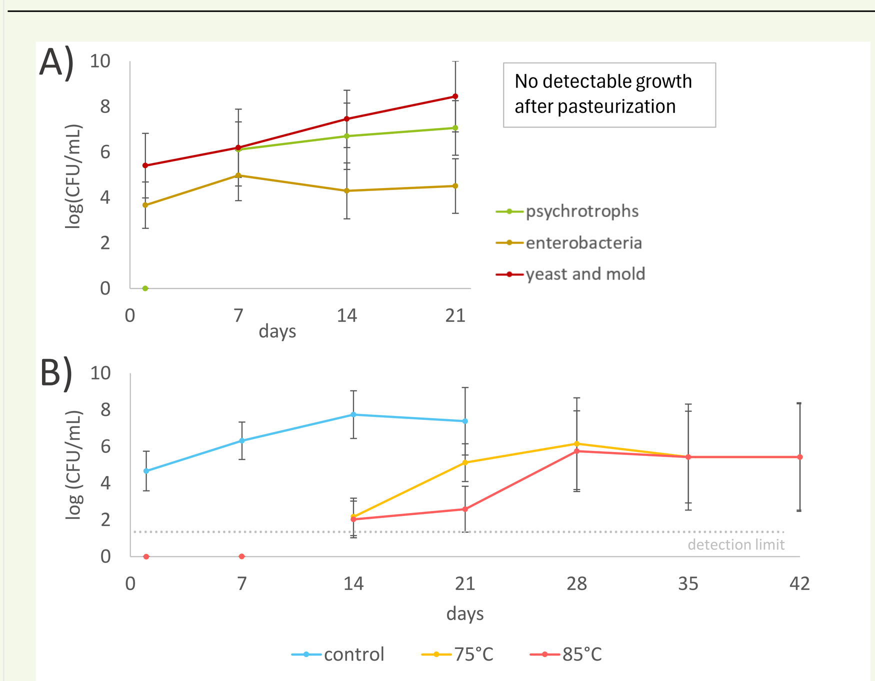
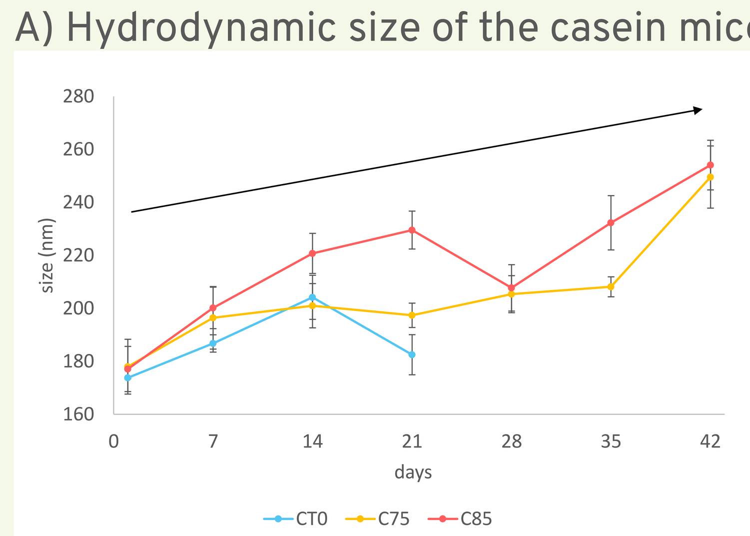


Figure 2. *Pasteurization controls LMPC microbial growth:* ***A)*** *microbial counts in the untreated control, and* ***B)*** *evolution of total flora in unpasteurized (blue) and pasteurized LMPC samples at 75°C (yellow) and 85°C (red).*

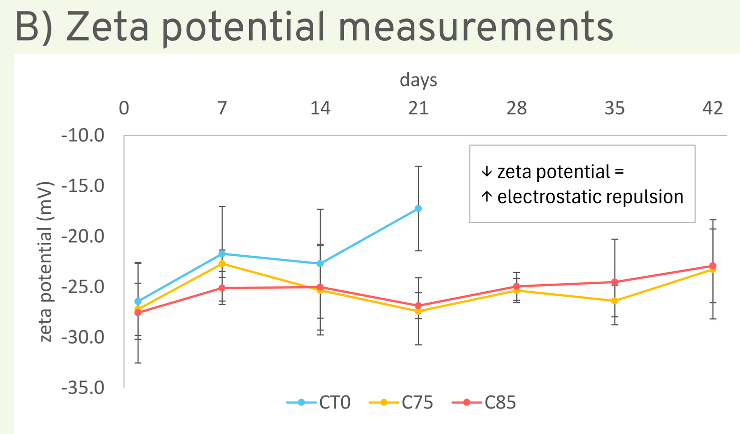
Colloidal stability

A) Hydrodynamic size of the casein micelles



→ Laser diffusion measurements show gradual ↑ hydrodynamic size = ↑ casein micelle swelling

B) Zeta potential measurements

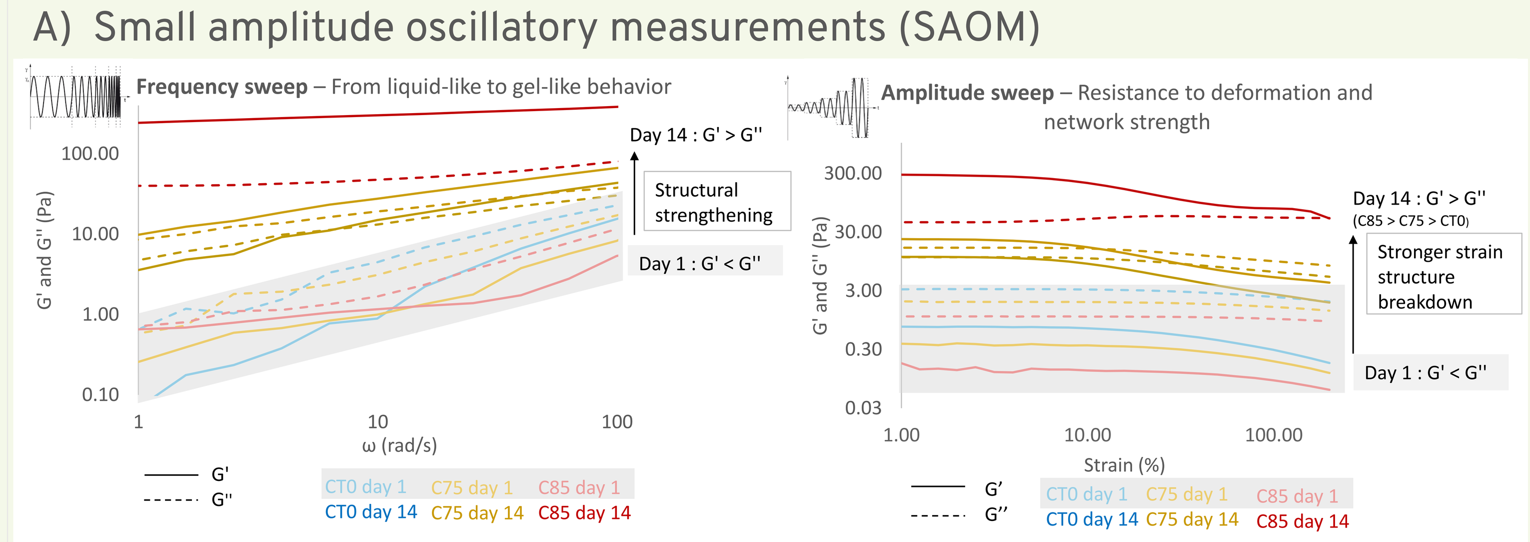


→ Storage significantly affected the zeta potential, suggesting progressive micellar surface rearrangement due to whey protein aggregation.

Figure 3. *Pasteurization alters LMPC colloidal properties during storage:* ***A)*** *particle size (DLS) shifts, and* ***B)*** *zeta potential changes reveal evolving surface charge and stability.*

Rheological structuration

A) Small amplitude oscillatory measurements (SAOM)



B) Viscoelastic model parameters

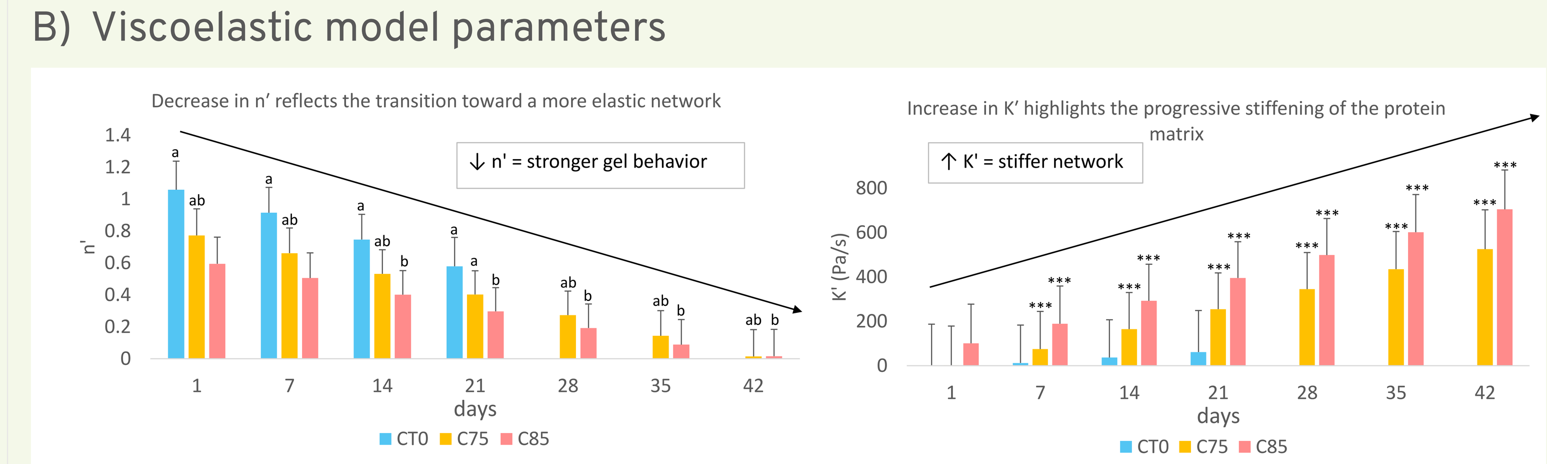
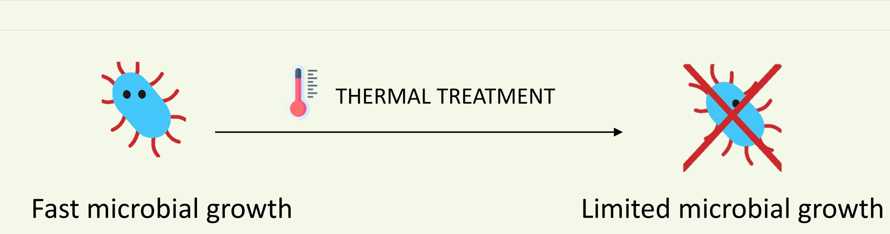
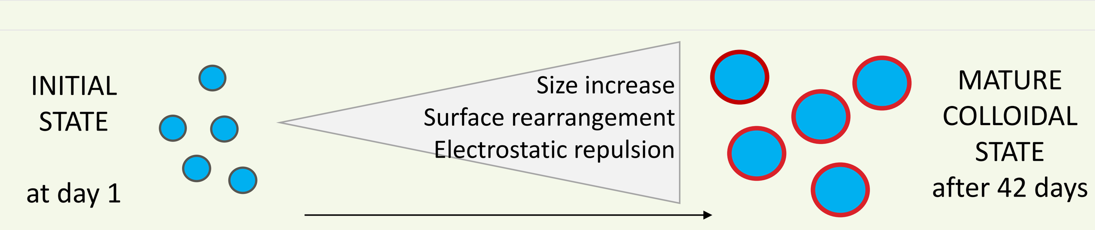
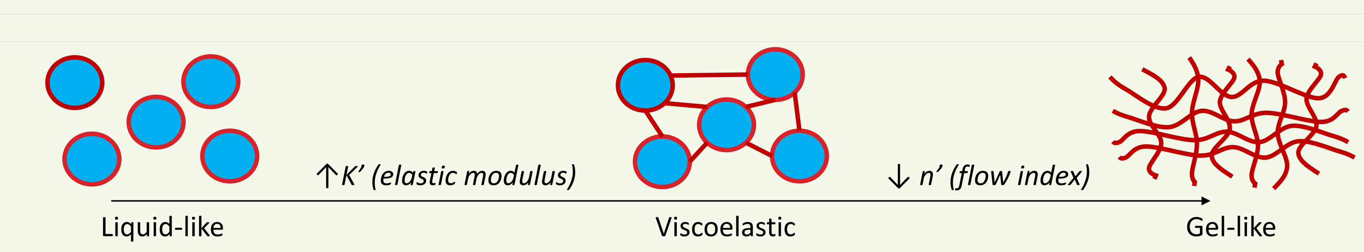


Figure 4. *Heat treatments strengthen gels and stiffen the protein network during storage:* ***A)*** *SAOM (frequency and amplitude sweeps) show the liquid-to-gel transition, and* ***B)*** *power-law parameters reveal progressive elastic reinforcement.*
Different letters indicate significant differences between treatments at a given day (p < 0.05)
*Asterisks indicate significant differences compared with day 1 of the same treatment (*** p < 0.001)*







Conclusion

Thermal processing not only ensured microbial stability but also guided the natural structuring of liquid milk protein concentrates during storage. Over time, the system evolved from a dispersed liquid to a cohesive protein network, illustrating the synergy between microbial stability, colloidal maturation, and rheological strengthening. Work is underway to control and reverse heat-induced protein networks, enabling tunable LMPC functionality.

References

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Corredig et al., 2019
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