

Structuring Plant-Based Foods with Double-Network Emulsion Gels

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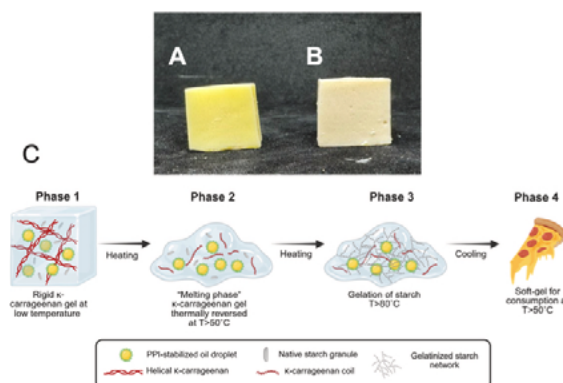
Designing plant-based foods that reproduce the temperature-dependent texture of dairy cheese and animal fat requires colloidal matrices whose mechanics can be “programmed” across cooking and eating temperatures. Here we present a double-network emulsion-gel paradigm that delivers such control and demonstrate it in two model systems: a cheese analogue and a fat analogue. In the cheese analogue, a pea-protein–stabilized oil-in-water emulsion is structured by κ -carrageenan (thermoreversible) and glutinous rice flour starch (thermo-irreversible), producing a sequential gel–sol–gel response on heating/cooling that underpins meltability and post-cooking softness. Rheological data shows a marked drop in G' between ~ 50 – 75 °C (κ -carrageenan helix-to-coil) followed by a rise on starch gelatinization, while CLSM and synchrotron-FTIR mapping resolve the transition from granular to swollen starch and the redistribution of macro-components. The gels exhibit $\geq \sim 88$ – 93% weight retention after five freeze–thaw cycles and meltability improvements (e.g., $+12$ – 116%) over commercial plant-based cheeses, with melting behaviour closer to dairy mozzarella under pizza-baking conditions.

In the fat analogue, a curdlan–konjac glucomannan (KGM) double network is thermally set in two steps (50 °C \rightarrow 85 °C) around pea-protein emulsified canola oil. The curdlan low-set gel immobilizes droplets early, while an irreversible high-set scaffold and the KGM network then reinforce structure, yielding cooking shrinkage ($57 \pm 5\%$) and springiness (0.42 ± 0.05) comparable to pork fat. There was $< 15\%$ oil/water loss over five freeze–thaw cycles, with controlled oil release during oven baking, while synchrotron-FTIR confirms protein–lipid interfacial localization and polysaccharide framework continuity.

These examples showcase double-network emulsion gels as a general strategy to tune thermal transitions, while coupling interfacial stabilization with network mechanics by pairing reversible and irreversible gelation agents and sequencing their activation. The strategy could improve the creation of clean-label, high-performance plant-based foods and other functional colloids.

Keywords:

double-network gels, emulsion gels, plant proteins, κ -carrageenan/starch, curdlan/KGM, rheology, synchrotron-FTIR



Photographs of Dairy Mozzarella and PPI- κ C-GRF emulsion gel, with a schematic representation of changes in internal structure during heating for PPI- κ C-GRF emulsion gel (Yiu et al, 2026, Food Hydrocolloids, 171, 111850)

References:

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