The cheese that won't melt

Reimagining dairy gels for the future of food.

The dairy industry is constantly looking for innovative and sustainable products to meet consumer demands. Heat- and acid-induced milk gels have a unique characteristic: they do not melt or flow when cooked or fried. This makes them ideal as a non-melting cheese - a desirable feature in products like grilled foods or meat alternatives where structural integrity during heating is essential.

Despite their potential, little is known about how processing conditions, especially acidification temperature and milk composition, impact their structure and textural properties. To bridge this knowledge gap, the Gelcook project systematically investigated how milk gels are formed under direct acidification at elevated temperatures (≥60 °C) and how the composition of milk and thermal history influence their functional properties. Furthermore, the changes in gel structure caused by cooking have been elucidated. The research has been summarized in four scientific papers that provide new insights with clear industrial applications.

Acidification temperature

A key finding was that acidification temperature significantly influenced gelation kinetics and internal protein bonding. As temperature increased from 60 to 90 °C, the proportion of calcium bonds rose sharply resulting in more compact structure and more firm and elastic gels, offering new strategies to tune the mechanical properties of the gels. To better understand the internal structure of the gels, Low-Field NMR analysis was used to analyze water mobility. Results confirmed that higher acidification temperatures led to more compact and dense protein networks, aligning with the observed changes in texture.

Type of milk and protein concentration

The type and concentration of proteins in the milk also played a critical role in gel formation. Buffalo milk, with its naturally higher casein content, produced firmer, drier, and denser gels compared to cow milk. Similarly, increasing the casein content in cow milk or altering the whey or casein protein levels affected gel texture, with higher whey content leading to softer, moister gels. This illustrates that protein type and content are a

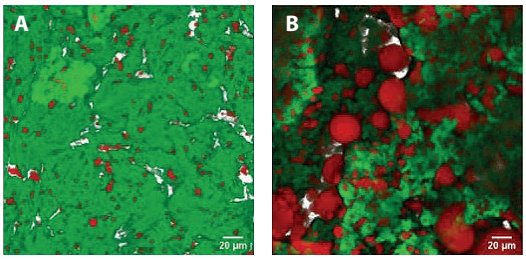

Figure 1. CLSM images depicting the microstructure of cow heat and acid induced gels, to show the differences in the porosity. Green reveals the protein network and red the fat droplets (A) 3% milk fat 0 min heating time show a very compact protein structure with small fat droplets, whereas (B) 4.5% 6 min heating time shows in open protein structure network filled with large (>20 mm) fat globules. (Published in International Dairy Journal, 129, 2022, https://doi.org/10.1016/j.idairyj.2021.105299.)

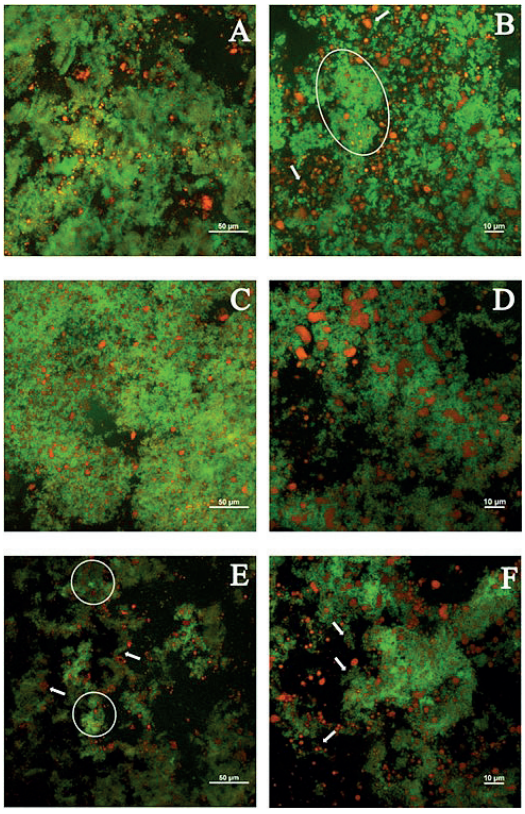

Figure 2. Confocal laser scanning microscopy images at 40x (left) and 100x (right) of heat and acid induced gels showing the effects of changing the casein:whey ratio 7.33 (A and B), 4.55 (C and D), and 0.85 (E and F) on protein network in green and fat droplets in red. (Published Food Structure, 37, 2023, 100341, https://doi.org/10.1016/j.foostr.2023.100341.)

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powerful lever for tailoring product functionality in this type of product.

Cookability
Further testing showed that cooking softened the gels, but interestingly, only gels acidified at higher temperatures absorbed water when cooked in salted water. This ability to hold moisture after processing is particularly valuable in developing juicy, meat-like textures in alternative protein products.

How can the industry benefit from this research?
A better understanding of the factors influencing texture and cookability of the gels was achieved by determining the relationship between composition, gel formation, protein interactions, and protein ratio of heat and acid-induced milk gels. Overall, this study provides the dairy and food processing industries with new tools to tailor the structure and behavior of milk gels, opening pathways for the development of innovative, functional, and heat-stable cheese, especially to be used as meat alternatives or novel cheese formats. ●

PROJEKTINFO

Title: GELCOOK - Elucidating the mechanism of formation of cookable milk gels

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Project period: 01/10/2020 - 31/06/20234

Objective: To understand the mechanism behind the formation of heat and acid-induced cow milk gels, as influenced by the acidification process and composition of milk, and how these can be used to control the texture and cooking stability.

PROJECTS RELATED TO THE DANISH DAIRY RESEARCH FOUNDATION