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Set and stirred acid milk gels through chemical or bacterial acidification

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Introduction

It is well known that acid gels made with a bacterial culture or glucono-δ-lactone (GDL) and at different incubation temperatures have different rheological properties and microstructures. Acidification through fermentation leads to gels with large void spaces. Increasing the incubation temperature leads to a higher pH of gelation and more mineralised gel particles. The aim of this study was to compare the rheological properties of stirred acid gels made with GDL at 20°C or a bacterial culture at 38°C, where extreme microstructures were expected.

Materials & Methods

Reconstituted milk at 140 g.kg^{-1} dry matter was heat-treated 90°C for 10 min. Non ropy *Lactobacillus bulgaricus* (LB340, 0.002 unit.L^{-1}) and *Streptococcus thermophilus* (TA060, 0.02 unit.L^{-1}) at 38°C for 12 h or GDL at 19.6 g.kg^{-1} for 20 h were added to reach pH 4.4. The set gels were then forced under compressed air through tube ended with a mesh (350-400 µm holes) and the stirring was completed in a home food processor for 10 s at 300 rpm. Stirred gels were characterised by low amplitude dynamic oscillation during 20 h at 4°C, creep measurements, viscosity at 64 s^{-1} and pH during 28 days of storage at 4°C

Results & Discussion

Set gels

Fig.1 shows the formation of the 2 set gels: chemical gels had a lower gelation pH (5.07) than bacterial gels (5.32), no max in tan δ while a max in tan δ for bacterial gels occured at pH 4.98 and lower $G'_{pH4.6}$ and tan $\delta_{pH4.6}$.

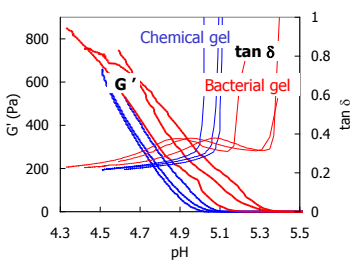


Fig.1. Viscoelastic properties of heat treated milk during acidification with GDL at 20°C or a bacterial culture at 38°C (coaxial cylinder - 0.1% strain - 1 Hz)

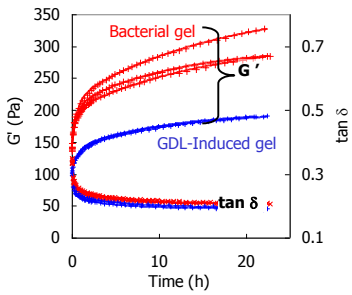


Fig.2. Rebodying of the gels at pH 4.4 with time after stirring (cone-plate-4°C-0.1% strain-0.16 Hz)

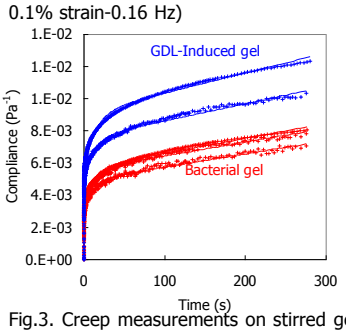
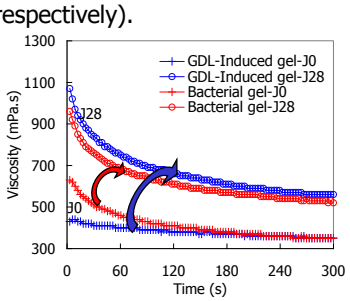


Fig.3. Creep measurements on stirred gel just after stirring (cone-plate-4°C). Four creep measurements of 5 min each at σ=0.3-1 Pa

Stirred gels

Fig.2 shows an increased G' and solid behavior of the bacterial gel after stirring, demonstating the higher rebodying capacity of these gels compared to chemical gels: pieces of gel resetted into a gel with increased G' and solid behavior. Stirred gels behaved with an instantaneous and a retarded compliance and a final flow (Fig.3). Bacterial gel had higher compliances and viscosity than chemical gel on the day of stirring (Fig.3-4). Viscosity increased during the 28 days of storage, but viscosity of chemical gels increased more than that of bacterial gels, with same pH values at 28 days (4.12 and 4.18, respectively).

Fig.4. Viscosity of stirred gel (cone-plate - 4°C - 64 s^{-1}) at J0 (the day of stirring) and at J28 (stored for 28 days at 4°C)



Conclusions

Acidification with bacteria at 38°C led to different gelation kinetics with a higher gelation pH and slightly stronger set gel with more mineralised, more charged particles and with less casein dissociation and more heterogeneity in pH than with chemical addition at 20°C, due to the higher gelation pH. Stirring can allow the particles in bacterial gels to re-organise, by increasing the homogeneity in pH. This could explain their greater ability for rebodying on stirring, compared to chemical gels. Indeed, stirred acid gels showed high rebodying properties during short (20 h) and long (28 days) storage time. During storage at 4°C for 28 days, viscosity of stirred gels extensively increased, but the viscosity of chemical gels increased more extensively than that of bacterial gels. As chemical gels were formed at a lower temperature, hydrophobic interactions can be of less significance in their building, leading to gels more able to re-organise at 4°C than bacterial gels formed at 38°C. Rebodying of stirred gels can be explained by changes in structure and properties of particles inside the gel, leading to different or more interactions between the pieces of gels.