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Microstructure Investigation of Concentrated Dairy Gels by Real-Time NMR diffusion Experiments

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Casein is the main milk protein component. It exists in milk as a suspension of large spherical particles called casein micelles. These colloidal particles can be destabilized in different ways, by addition of rennet, by slow acidification, or by combinations of both. Various parameters influenced the dynamics of the coagulation process. Depending on these conditions, the gel microstructure and its rheological properties, which are very important attributes of the product, can therefore be very different. The extent of the structural rearrangements that occur during the ageing of the fresh gel seems to be of primary importance, but although it is possible to highlight their effects, no ideal technique exists to investigate their dynamics.

In the present study, we used a time-resolved Pulsed Field Gradient NMR method to investigate how and when probe diffusion rates vary during the coagulation process of dairy protein. The self-diffusion of a small and a large poly(ethylene glycol) (PEG) were monitored during the sol-gel transition of a casein system induced by chymosin, pH changes or a combination of both. Rheological measurements revealed that the diffusion rate of the molecules studied was unaffected by the establishment of a network. However, different evolutions occurred during the gel ageing phase, depending on the size of the diffusing molecule. The diffusion of the large PEG was very sensitive to variations in the size of the casein particles and the casein aggregates constituting the network before and after gelation, respectively. In contrast, the diffusion of the small PEG was sensitive to changes in the internal structure of the colloidal matter. Scanning electron microscopy images showed that all these findings could be explained by the progressive compaction of the casein network caused by the occurrence of structural rearrangements. This study demonstrates the sensitivity of probe diffusion to structural changes in casein gels, and also the potential of PFG-NMR techniques to reveal dynamic information on evolving systems at different length scales.