RHEOLASER MASTER

Milk Coagulation Analysis
Optimize Ingredients and Process

INTRODUCTION

Several recent studies have shown that milk coagulation ability is widely influenced by genetics, feed, seasonal conditions, pollutants, etc. Low milk quality considerably decreases the yield of cheese (loss of proteins by loose gel network). Rheolaser MASTER uses a non-contact method, called Diffusing Wave Spectroscopy, which is perfectly adapted to study milk under real conditions (T, rennet addition, etc.). It detects gel formation and determines accurately the gel time and gel properties.

Sensitive **Accurate** **Multi sample**

HOW IT WORKS

Rheolaser Master is based on Diffusing Wave Spectroscopy (DWS), a multiple light scattering technique. Light is backscattered by scatterers in the sample. The microstructure motion inside the sample (droplets, crystallites, etc.), creates an interference pattern (Speckle Image). Variation of this image in time is directly related to the mobility of the scatterers. (Figure 1). The faster the Speckle Image changes in time, the higher the mobility of the microstructure.

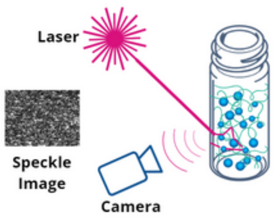

Figure 1. Schematical representation of the measurement set-up.

By a mathematical treatment, Mean Square Displacement (MSD) curves are obtained (Figure 2), which contain the viscoelastic information. Short straight lines (red curve) indicate the liquid behavior of the sample, whereas curves with a plateau, the so-called elastic plateau (pink curve), indicate gel-like or solid-like behavior.

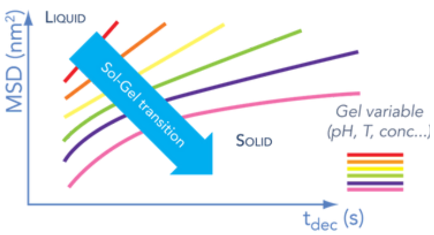

Figure 2. Typical result of MSD curves during a gelation experiment.

RESULTS AND DISCUSSION

Milk coagulation was studied under various conditions, such as rennet concentration, milk pH, pasteurization, and temperature treatment. All results are represented as Elasticity Index (EI), which is the reverse of the MSD height at the elastic plateau. The higher the index value, the stronger the milk gel is formed. Figure 3 shows a typical evolution of the EI as a function of time, calculated from the MSD curves of Figure 1. Several steps can be observed during milk coagulation by rennet addition. In the first minutes (1), the enzyme activity is low, and the rheological properties such as elasticity and viscosity did not change significantly. Number (2) indicates the flocculation of the casein micelles, which is the first step in milk gel network formation. Number (3) indicates the coagulation formation until the maximum elasticity is given at EI max (4). After that point, syneresis took place (5) which is indicated by a decrease in the Elasticity Index.

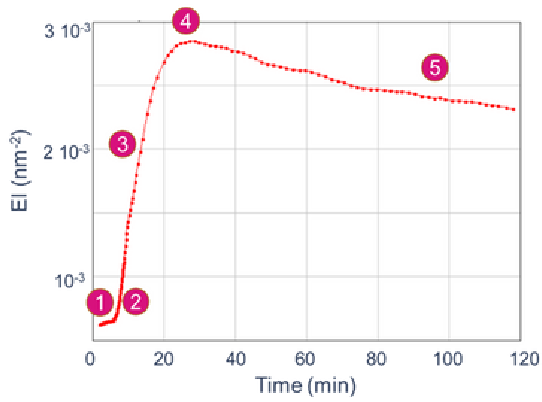

Figure 3. Typical curve of Elasticity Index during milk coagulation indicating the five characteristic steps of the reaction.

Impact of pasteurization temperature

Figure 4 shows the evolution of the EI as a function of time pasteurized milk at 70°C (red) and at 80°C (blue). The EI of the red curve increases after 20 minutes, clearly showing a gel formation due to the rennet activity. The blue curve shows only a slight continuous increase due to flocculation. It is known that too high a pasteurization temperature significantly decreases the coagulation ability. Thus, Rheolaser Master can indicate if the milk is still able to form milk gel by rennet addition.

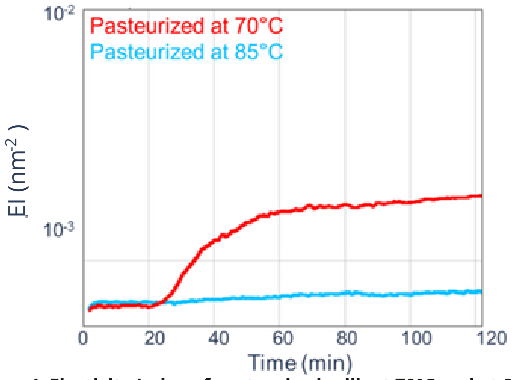

Figure 4. Elasticity Index of pasteurized milk at 70°C and at 85°C (33°C, no CaCl2 addition, 20 mL/L).

Impact of coagulation temperature

In Figure 6 we can compare the evolution of EI of the same milk gel preparation (rennet concentration, pH, no CaCl2) performed at three different temperatures. The enzymatic reaction is fastest at the highest temperature (38°C, green) and decreased with decreasing temperature. The maximum EI is approximately the same for all temperatures but delayed in time, with decreasing temperatures.

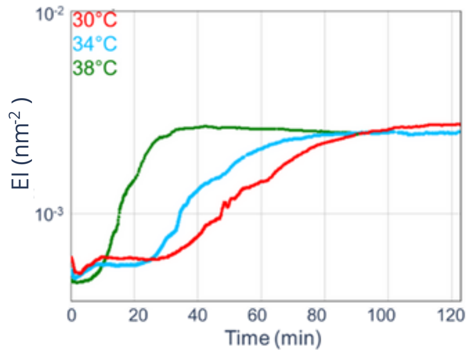

Figure 6. Elasticity Index of pasteurized milk (70°C) and rennet addition at different temperatures (no CaCl2 addition, 20 mL/L, pH 6.8).

Impact of Pasteurization

Figure 5 shows the evolution of the EI of pasteurized milk at 70°C (blue) and raw milk (red). Both kinds of milk form a gel at approximately the same time, but the subsequent evolution is different. The pasteurized milk showed the formation of a stronger gel (EI max) and delayed syneresis (decrease of EI), whereas the raw milk formed a less strong gel and a pronounced syneresis.

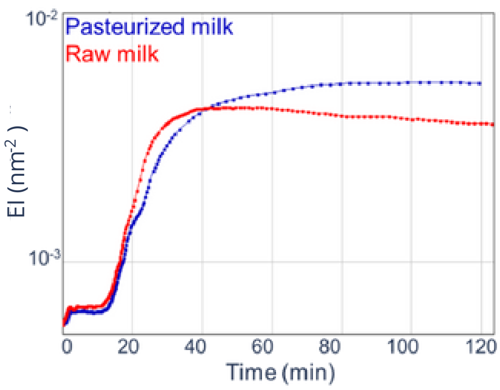

Figure 5. Elasticity Index of pasteurized milk (70°C) and raw milk (33°C, no CaCl2 addition, 20 mL/L).

Impact of Rennet Concentration

Many recipes use different concentrations of rennet, which leads to different gel formation kinetics. In Figure 7, three different rennet concentrations are shown, whereas the other parameters were kept constant (T, initial pH, no CaCl2). The EI increased first with higher rennet addition (38 mL/L, green) and was delayed for lower rennet concentrations. Gel strength was not influenced by the rennet concentration.

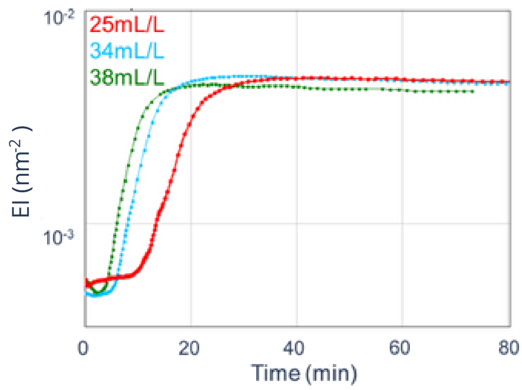

Figure 7. Elasticity Index of pasteurized milk (70°C) and different rennet concentration (34°C, no CaCl2 addition, pH 6.4).

Impact of Rennet Concentration

Some recipes require the addition of CaCl2, mainly after pasteurization. Figure 8 shows the Elasticity Index with (red) and without (green) CaCl2 addition. The gelation time was slightly longer without CaCl2 addition. More significantly, the gel strength was higher with CaCl2 addition, as the calcium ions work to reinforce the gel network.

Rheolaser Master can also be used to study the influence of protein enrichment. Figure 9 shows two recipes with the same conditions (T, pH, rennet concentration, CaCl2), but with (green) or without (red) protein enrichment. The kinetic was slower for the preparation with additional protein content due to lower diffusion coefficients and lower enzyme activity. The milk gel strength was not affected by the protein addition.

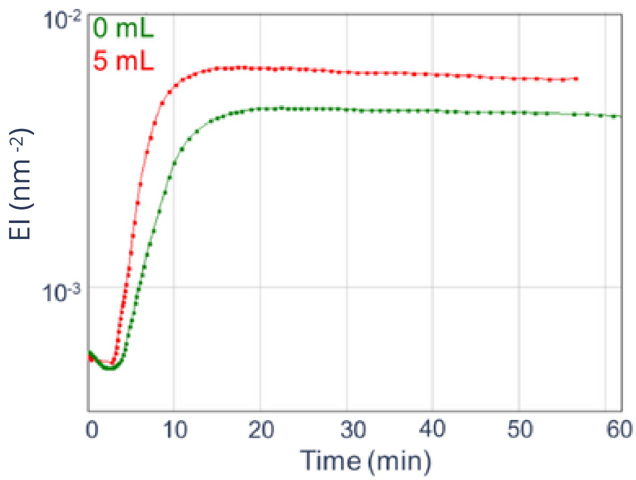

Figure 8. Elasticity Index of pasteurized milk (70°C) and different CaCl2 additions (34°C, 30 mL/L, pH 6.4).

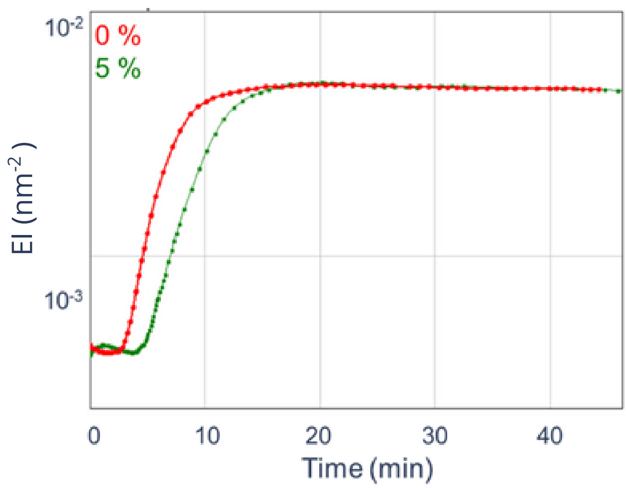

Figure 9. Evolution of Elasticity Index (EI) of 4 sol-gel reactions at 20°C.

CONCLUSION

Rheolaser Master using passive microrheology is a powerful tool for cheese milk gel characterization. The non-destructive and non-invasive optical method is perfectly adapted to study different cheese preparations. Key parameters, such as flocculation time and coagulation time, which are crucial for cheese fabrication can be determined in a precise way, while also determining the influence of milk processing, rennet quantity, and other typical factors which affect the gelation time and the gel strength. Milk coagulation ability can therefore be perfectly studied.