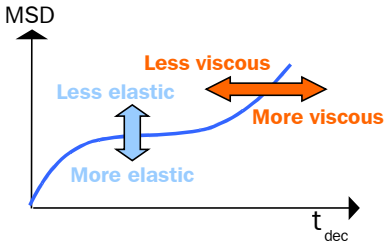
Viscoelastic characterization of cheese thanks to microrheology

Application
Food

Objective
Analyze the microrheology of cheese after two different processes and control the final quality of the product.

Device
RHEOLASER® LAB

Reminder about Mean Square Displacement



MSD curves are the signature of the product's microrheology. It reflects the visco-elastic behaviour of a sample.
By acquiring MSD curves at different ageing times for a same sample, it is therefore possible to identify the evolution of both viscosity, elasticity, and microstructural properties of a given product.

Introduction

Rheology of food stuff, such as cheese, salad dressing, butter… is a key parameter that must be controlled during and after the manufacturing process. Indeed viscoelastic behavior drives several end use properties like flow during a process, spreadability , shape stability, physical stability…
Microrheology enables to easily and deeply characterize these properties by measuring the viscosity and the elasticity of samples at rest, versus ageing time thanks to a non contact measurement, without the limitations of classical rheology (sampling issues due to the strong structure, weak structures not to be broken, …).

In this example, a same cheese was analyzed before and after a given process (for instance homogenization). The goal is to determine if the viscoelasticity is affected by the process.

Raw data: Particle Mean Square Displacement (MSD)

In microrheology, particles probe the viscoelastic behavior of the sample. Thus, particle Mean square displacement curve is the signature of the product rheology.

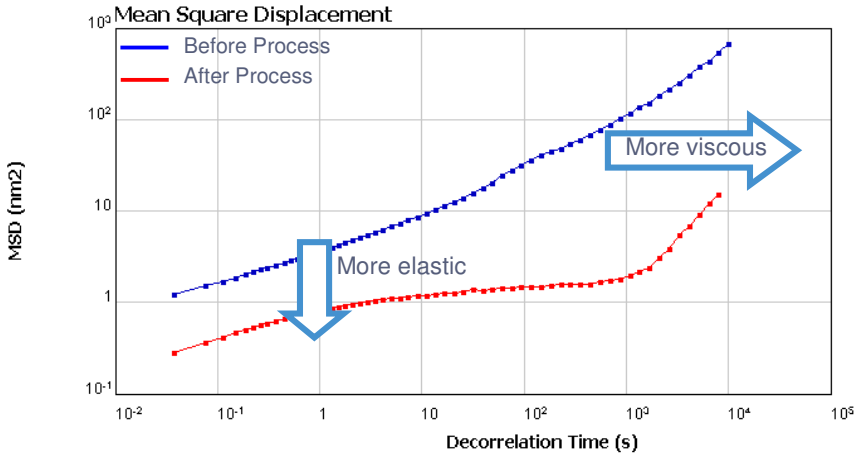


Figure 1. Mean Square Displacement of the cheese after the 2 distinct processes.

As we can see in the above graph, the MSD curve of the product before the process grows linearly with time which means that the viscosity dominates over elasticity.

After the process the MSD curve shows a plateau formation up to 10^3 s (=10^{-3} Hz) meaning a strong elastic behavior. After 10^3 s (Relaxation time t_R) the MSD curve increases, corresponding to the viscous behavior.

The macroscopic viscosity after the process is higher than before the process as the curve shifts to the right.

Characterization of the 2 samples

The user can easily compare the viscoelastic characteristics of the 2 samples by computing various parameters. These computations (see Figure 2) are available just by a one-click feature in the software, allowing a quick comparison of various samples.

Cheese before process			Cheese after process		
Visco-elastic Factors			**Visco-elastic Factors**		
Elasticity Factor :	2.28E-1	nm⁻²	Elasticity Factor :	1.1E0	nm⁻²
Viscosity Factor :	1.26E1	nm⁻².s	Viscosity Factor :	5.47E2	nm⁻².
Visco-elastic Moduli at 1Hz			**Visco-elastic Moduli at 1Hz**		
Elastic Modulus :	6.92E2	Pa	Elastic Modulus :	3.35E3	Pa
Viscous Modulus :	4.36E2	Pa	Viscous Modulus :	1.3E3	Pa
Moduli ratio :	6.3E-1		Moduli ratio :	3.88E-1	
Generalized Maxwell			**Generalized Maxwell**		
Elasticity :	1.17E3	Pa	Elasticity :	6.38E3	Pa
Relaxation Time :	1.47E1	s	Relaxation Time :	1.23E3	s
Macroscopic viscosity :	1.71E4	Pa.s	Macroscopic viscosity :	7.88E6	Pa.s

Figure 2. Comparison of the 2 samples using various parameters.

In that case, the user can observe that:

- Elasticity is stronger after the process (Elasticity Factor after the process is 5.5 times greater than before, so is the elastic modulus G') ;
- Viscous modulus G'' is greater after the process than before ;
- Macroscopic viscosity is way greater after the process than before (more than 400 times greater) ;
- Relaxation time is a lot longer after the process (1230 seconds vs. 15 seconds).

Note:
The relaxation time t_R is the characteristic time for which a sample moves from a solid-like behavior to a liquid-like behavior. It is linked both to elasticity and viscosity.

A complete characterization (viscoelastic spectrum versus frequency, between 10^{-4} Hz and 10 Hz) is also possible, with just one acquisition for each sample (Figure 3).

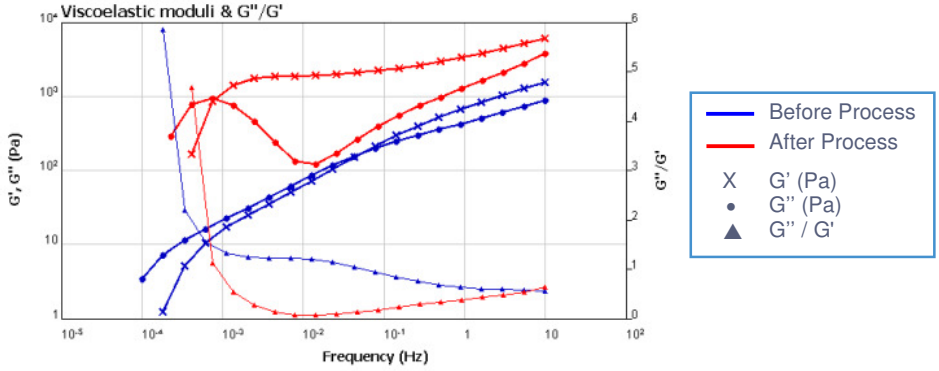


Figure 3. Viscoelastic spectrum and ratio of G''/G' for the 2 samples.

As seen previously the cheese before the process is less consistent than after. The sample before the process is viscoelastic (G''/G' is near 1) whereas after the process the elasticity dominates (G''/G' <1) . It behaves as a solid.

Summary

The differences in the rheological behaviors of this product before or after a given step of the process (homogenization) are important, and reflects the importance of this stage during the production of the cheese.
Rheolaser® LAB can fully and easily characterize the viscoelasticity of food stuff. Measurement is done thanks a non-contact method which enables to analyze the sample at rest, on the very same sample versus ageing time and over a large frequency range.