Rheological Tests on Milk Drinks

Relevant for: Milk drinks, amplitude sweep, yield point, viscosity

Thickened milk drinks may be easier to swallow, especially if they retain their higher viscosity under high shear conditions; i.e. during swallowing. With rheometers like the MCR 92 we can measure this behavior. Here, the rheological behavior of four milk drinks is tested.

1 Introdcution

By adding a thickening agent to low-viscosity fluids, such as low-viscosity milk products, a weak gel structure is formed. The gel structure makes the fluid more viscous, which makes swallowing easier. With rheometers like the MCR 92 we can measure this behavior.

2 Experimental Setup

2.1 Samples

Three milk drinks (peach, vanilla and chocolate milk) containing thickening agents were tested and compared with normal milk, which has a fat content of 3.5 %. Two of the samples, vanilla and peach milk, and contained locust-bean gum. The chocolate milk contained carrageenan.

2.2 Instrument

All measurements were performed with an Anton Paar MCR 92 with the double-gap measuring system DG26.7. This measuring system is more sensitive to lower torques due to its larger shear area. The temperature was controlled by using an air-cooled C-PTD Peltier temperature device.

2.3 Test Conditions and Settings

The measurements were performed at 20 °C. Two different tests were carried out.

For each sample, the flow behavior was determined in rotation with a viscosity curve. A pre-shear interval without data collection was made at a shear rate of 1000 s^{-1} for a duration of 5 s in order to prepare the sample for the measurement. The measurement interval was made with a logarithmic shear rate ramp from 1000 to 0.1 s^{-1} and a logarithmic measuring-point duration ramp from 1 to 10 s.

Two samples, vanilla and peach milk, were also tested in oscillation with an amplitude sweep. The amplitude sweep was carried out at a constant frequency with increasing deformation from γ = 0.1 to 100 %. The frequency (angular frequency) was preset at ω = 10 rad/s. The range in which storage modulus G' and loss modulus G" do not change at the applied deformation is called the linear viscoelastic range (LVE range). In this range, the structure of the sample is stable. The amplitude sweep can provide initial information about the structure of the sample. If the storage modulus G' is higher than the loss modulus G", the sample is said to have gel-like character. A sample with G" > G' is said to be predominantly liquid or viscous. The structural strength of a material can be expressed by the level of G'.

3 Results and Discussion

The peach milk drink shows the highest viscosity values over the whole measurement range (Figure 1). This means that this sample should be relatively easy to swallow, because the viscosity also stays high at higher shear rates; i.e., when swallowing.

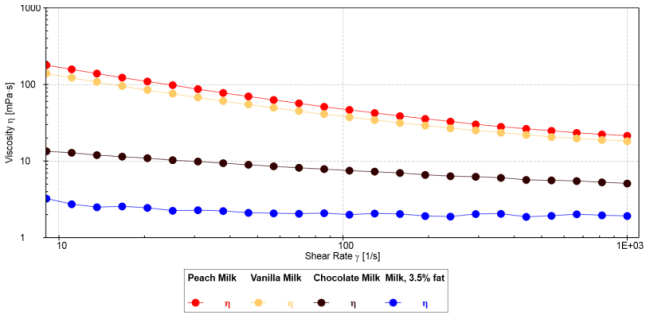

Figure 1: Viscosity curves of the four investigated milk drinks

The vanilla milk shows very similar behavior. Its viscosity is only slightly lower than that of the peach milk. This is possibly due to the same thickening agent. The peach milk also contains fruit puree, which contributes to higher viscosity values. The chocolate drink shows overall lower viscosity. All the three samples show a shear-thinning behavior. This means that the viscosity decreases at higher shear rates, i.e., when swallowing. The pure milk without thickening agent shows the lowest viscosity (Table 1).

Sample	Shear rate 10 s^{-1} [mPas]	Shear rate 150 s^{-1} [mPas]
Peach	169	39.8
Vanilla	131	32.3
Chocolate	13.2	7.10
Pure milk	2.90	2.00

Table 1: Viscosity values at 10 s^{-1} and 150 s^{-1}

The peach and vanilla milk contain enough thickening agent to form a gel-like structure at rest. This can be seen in the amplitude sweeps (Figure 2). At low deformations, G' > G''. This means the sample forms a gel that is not destroyed until a higher deformation is reached.

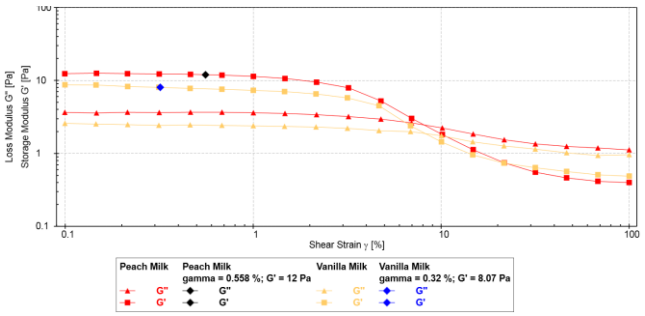

Figure 2: Amplitude sweeps of peach and vanilla milk

4 Summary

For many foods, tuning the rheological behavior can lead to improved customer acceptance. For example, thickened fluids may be easier to eat and drink.

For measuring the viscosity of a sample under different shear conditions, the MCR 92 provides highly reliable results.

For food manufacturers interested in quality control as well as research and development of new products, the MCR 92 with its high-precision encoder and highly dynamic EC motor offers a much wider application range than conventional spring-type viscometers with their limited torque and speed range.

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