APPLICATION**NOTE**

Egg Liqueur – Rosand Rotational Rheometer

About the Rheology of Egg Liqueur

Claire Straßer and Senol Gezgin

Introduction

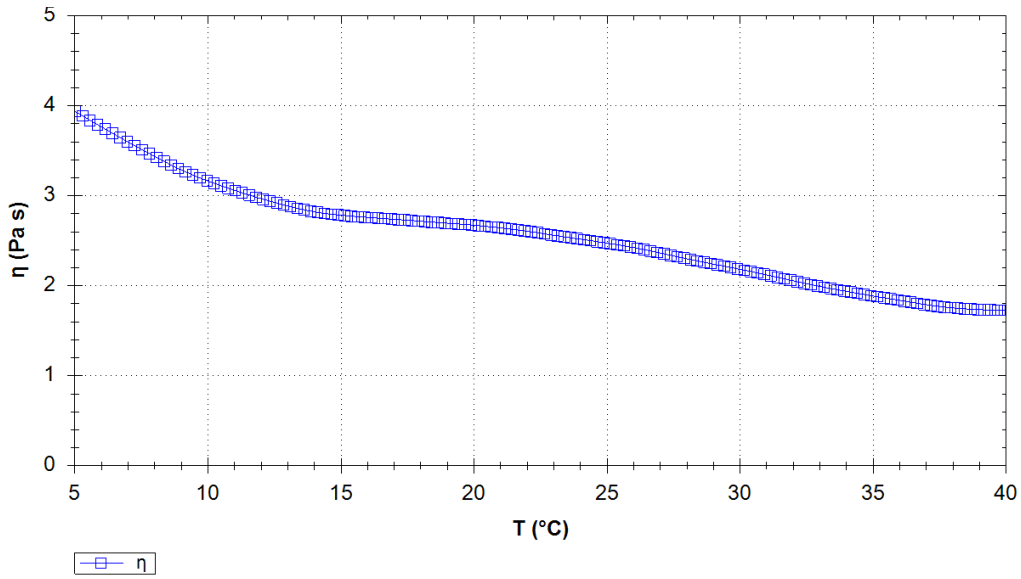
Egg liqueur is an especially popular drink at Christmas. It consists mainly of alcohol, egg yolk and sugar and should – according to common practice – be stored in a dark and cool place, if possible. But is it really okay to store egg liqueur in the refrigerator? What happens when the delicious sweet drink has already been opened and stored at room temperature? Does it change its consistency if it is kept for a longer period of time?

Rheology deals with the deformation and flow behavior of materials. The lower the viscosity, the better the material can flow, and the thinner it feels.

How Does Storage in the Fridge Affect the Viscosity of Egg Liqueur?

Temperature is one of the most important factors influencing a material's shear viscosity. The following measurement shows how storage in the fridge has an impact on the viscosity of egg liqueur in comparison to storage at (higher) room temperatures.

The shear viscosity of egg liqueur was measured during a temperature ramp between 5°C and 40°C. Figure 1 depicts the resulting curve. At 5°C, the shear viscosity is 4 Pa·s. As expected, this value decreases during increasing temperatur: It is reduced by a factor of 2 during heating from 5°C to 40°C.



1 Shear viscosity curve of egg liqueur between 5°C and 40°C (geometry: PP40 (Plate-Plate, 40-mm diameter) with solvent trap (isopropanol as solvent); gap: 1 mm; temperature program: 5°C to 40°C at 3 K/min; shear rate: 1 s^{-1})

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NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

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Long-Term Stability and Segregation: The Frequency Sweep

During storage, the egg liqueur should remain stable, i.e., homogeneous: Phase separation of the different components would affect the product quality. Information about the phase stability is gained by means of a frequency sweep.

First, an amplitude sweep is carried out in order to determine the range amplitudes that can be applied on the sample without leading to a breakdown of its structure (Figure 2). This range is called the linear visco-elastic region (LVER). As long as G´ remains constant, breakdown of the sample´s structure does not occur. For the following frequency sweep, a strain of 0.3% was selected.

Prior to the frequency sweep measurement, the egg liqueur was heated and cooled three times between 5°C and 50°C. This thermal treatment ensured that the following statement on the long-time stability is not influenced by storage in the fridge or at higher room temperatures than the 25°C employed for the measurement.

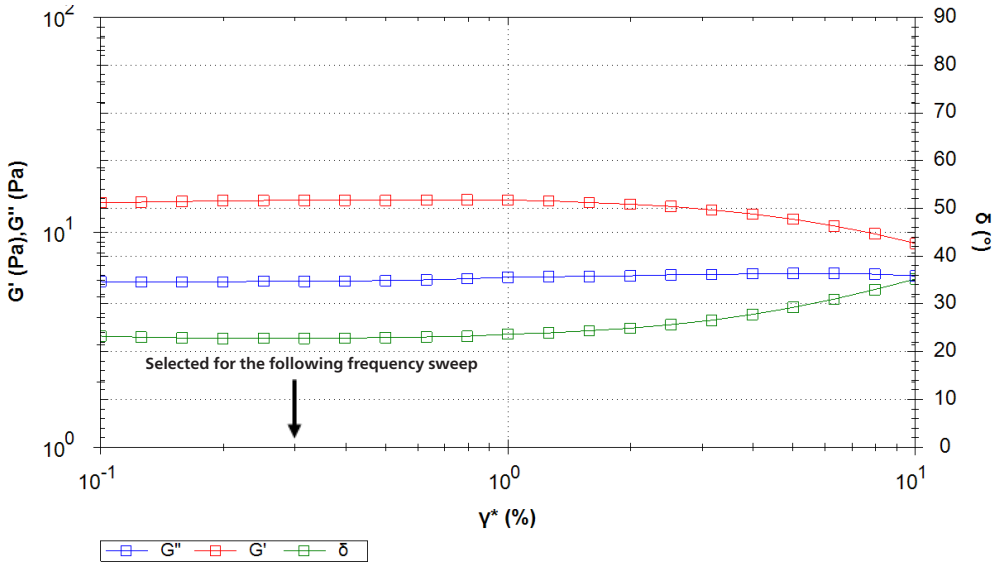
Some Definitions:

G*: Complex shear modulus (stiffness)

G': Storage shear modulus, elastic contribution to G*

G": Loss shear modulus, viscous contribution to G*

δ: Phase angle (δ = G"/G'), relative measure for the viscous and elastic properties of a visco-elastic material. It ranges from 0° for a fully elastic material to 90° for a fully viscous material.



2 Amplitude sweep for the determination of the LVER (geometry: PP40 (Plate-Plate, 40-mm diameter) with solvent trap (isopropanol as solvent); gap: 1 mm; temperature: 25°C; frequency: 1 Hz; amplitude: 0.1 to 10%)

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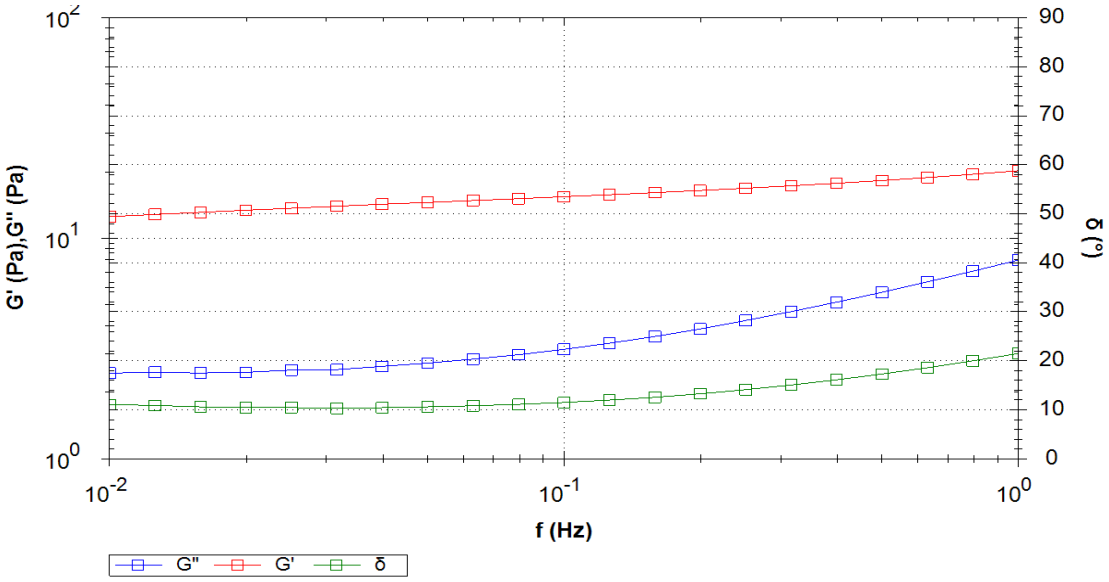
The frequency sweep applied on the egg liqueur (Figure 3) shows that the elastic shear modulus G´ is higher than the viscous shear modulus G´´ over the entire frequency range measured, also in diretion of the lower frequencies. This means this egg liqueur is a visco-elastic solid!

The "solid-like" properties dominate the "liquid-like" properties. This solid-like behavior in the low frequency range (corresponding to long time scales) is an indication that the product is stable under rest conditions and that no phase separation occurs.



3 Frequenxcy sweep off egg liqueur (geometry: PP40 (Plate-Plate, 40-mm diameter) with solvent trap (isopropanol as solvent); gap: 1 mm; temperature: 25°C; amplitude: 0.3%; frequency: 1 to 0.01 Hz)

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