Rotational Viscosity Testing of Dairy Products with ViscoQC

The consistency of dairy products is directly related to the acceptance of the final product by consumers. This application report shows how simple viscosity measurements of e.g. yoghurt with ViscoQC 100/300 help you to ensure perfect food quality.

1 Introduction

The viscosity is used to evaluate the raw materials, the type and characteristics of ingredients as well as the production process of dairy products.

Depending on composition, condition or process to which the food may be subjected to, it can show Newtonian or non-Newtonian behavior.

Moreover, the type of milk (e.g. fat content or milk protein casein) has a determining influence on the viscosity of dairy products.

1.1 Keywords

Viscosity of yoghurt, milk, cream, dairy products, quality control, rotational viscometer, determination of viscosity, dynamic viscosity, digital viscometer

2 Experiment

The viscosity of yoghurt with fruit pieces was determined with the rotational viscometers ViscoQC 100/300 – R (Table 1).

Sample	Yoghurt	
Instrument	ViscoQC 100 - R	ViscoQC 300 - R
Measurement type	Single-point	Multi-point
Spindle	V73 (full immersion)	
Temperature	Room temperature (approx. 23 °C)	

Table 1: Configuration and measurement conditions during viscosity testing of yoghurt.

As the viscosity of yoghurt is very sensitive to shear stress, a vane spindle was used for the test. A big advantage of vane spindles is that they do not destroy the sample's structure when immersed in comparison to e.g. cylindrical measuring systems. Besides, slippage of the sample is reduced.

The yoghurt was left at room temperature over night to reach ambient temperature as otherwise the temperature will change during the measurement which has a big impact on viscosity. The temperature of the sample was measured using a Pt 100 sensor.

2.1 Test Procedure

Single-point viscosity determinations using ViscoQC 100 are perfectly suited for quick quality control checks of dairy products.

ViscoQC 300 is the best choice for multi-point analysis at different speeds to study the flow behavior.

For determining the yield point with the vane technique, graph functionality, step-programming and analysis functionality, the optional software package V-Curve was activated on the stand-alone ViscoQC 300.

ViscoQC 300 supports the optional lab execution software AP Connect, which allows fully automatic collection, storage and distribution of data.

2.2 Test Conditions

The sample should be disturbed as little as possible prior to inserting the vane spindle. For that reason yoghurt was measured in its cup.

Single-point test: The viscosity at 10 rpm was determined with ViscoQC 100 using the "Stop at Time (@t)" mode with a target time of 30 s.

Speed-dependent test: A linear speed ramp from 1 rpm to 10 rpm with 5 measurement points was performed using ViscoQC 300. The measurement point duration was set to 30 s for the speed scan (SpS).

Yield point test: A yield stress method (YiS) was programmed on ViscoQC 300 + V-Curve as described as follows:

- Zeroing: was set active with a "Zero speed" of 0.1 rpm. During Zeroing the Torque was set to 0 %. This is important as during immersion of the vane spindle some torque has possibly been applied to the sample. This could already falsify the yield stress determination.

- The “Run speed” was set to 0.1 rpm. A speed to measure within 10 % to 100 % torque must be selected (max. 5 rpm). The selected speed will influence the yield point value.
- The “Torque Reduction” is set to 100 %. This will cause the test to stop as soon as no torque increase is detectable anymore.
- The “Overtime” was set to 20 s. An overtime enables monitoring of the flow behavior after the yield point.

Time-dependent test:

The viscosity change was observed over 10 min measurement time using the measurement mode “Stop at Time (@t)” with multipoint data collection. Every 10 s a measurement point was recorded and the speed was set to 3 rpm.

3 Results and Discussion

The single-point viscosity value of yoghurt determined with ViscoQC 100 is shown in Table 2. The viscosity of yoghurt specifies e.g. if it is drinkable or spoonable. Moreover, the viscosity is influenced by concentration, composition and pre-treatment of milk, starter culture and incubation temperature.

	Yoghurt
Speed [rpm]	10
Torque [%]	49.6
Viscosity [mPa·s]	26536

Table 2: Average viscosity value of yoghurt at 10 rpm (n = 5). Measurements performed with ViscoQC 100 – R and spindle V73 (full immersion).

By determining the viscosity at different speeds with ViscoQC 300 the flow behavior of dairy products can be analyzed (Figure 1). At low speeds the viscosity at rest (e.g. in the yoghurt cup) and at high speeds the viscosity during process/application (e.g. during stirring/swallowing) can be measured. Yoghurt has a shear-thinning flow behavior, which means that the viscosity decreases when a force is applied by e.g. stirring.

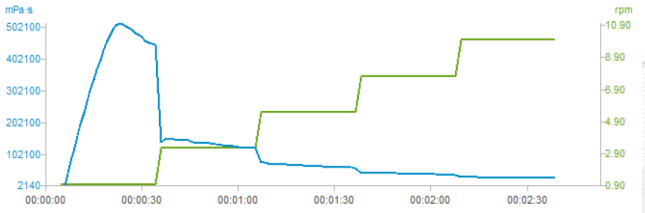

Figure 1: *Online graph of yoghurt to visualize the flow behavior of the sample*. Only if V-Curve is activated on ViscoQC 300.

To determine the yield point with the vane technique, the sample is sheared at a constant low speed and the resulting torque or shear stress is measured. If no torque increase is detectable anymore, the sample starts to flow. The maximum shear stress measured is called the static yield point and can be detected through a peak in a graph (Figure 2).

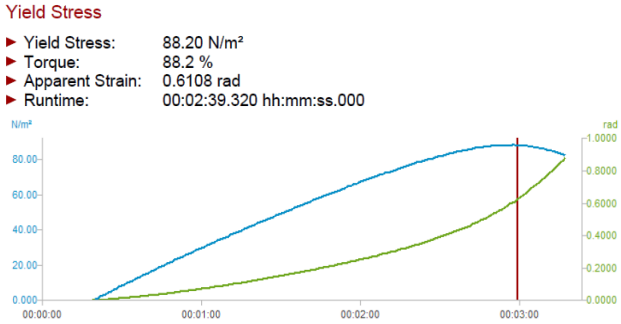

Figure 2: *Yield stress measurement of yoghurt with the measurement method “Yield stress (YiS)” using vane spindles. Only if V-Curve is activated on ViscoQC 300.*

By analyzing the viscosity over a defined measurement time it could be nicely demonstrated that the yoghurt has a time-dependent shear-thinning behavior (Figure 3). Yoghurt is non-thixotropic, what means that the viscosity will not fully regenerate to its initial state after e.g. pumping.

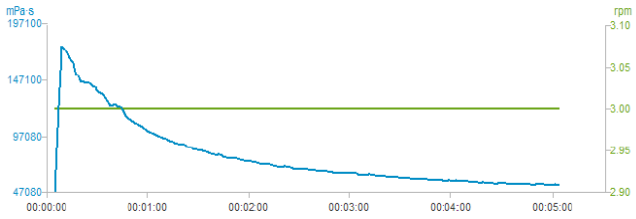

Figure 3: *Time-dependent behavior of yoghurt*.

4 Summary

The measurements showed that ViscoQC 100 and ViscoQC 300 are perfectly suited for viscosity determinations of dairy products either for single-point/multi-point or yield point measurements.

The instrument torque model (L/R/H) and measuring system has to be chosen according to the consistency of the sample. For samples like yoghurt and cream vane spindles can be used to minimize structural changes of the sample during immersion of the spindle and to avoid slipping effects. For measuring low-viscosity dairy products like milk ViscoQC – L with DG26 is needed.

To be able to measure the yield point with the vane technique, the V-Curve software package must be activated on ViscoQC 300.

If you have further questions regarding this application report, please contact your local Anton Paar representative.

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