Rheological Characterization of Ice Cream

Relevant for: MCR, DSO, PTD, Food, Ice Cream, Temperature Sweep (TS), Oscillation Thermo-Rheometry (OTR)

A temperature dependent rheological characterization of ice cream samples was carried out. A correlation between rheological data and the sensorial impression is given. The temperature dependent rheological behavior of ice cream is an important property for the final product. For example an ice cream should have a low rigidity at low temperatures for a good scoopability, but on the other hand it should have creaminess for a good mouth feeling after melting at higher temperatures. Whereas in the intermediate range during the melting a consumer does not like to have a feeling of too much coldness. The measurements were conducted using an Anton Paar MCR rheometer.

1 Introduction

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2 Sample

Standard vanilla ice cream with two different processing methods were used: Freezer and ULTICE.

3 Experimental Setup

The measurements were conducted using an Anton Paar MCR rheometer with the Direct Strain Oscillation (DSO) option, the Peltier temperature control unit PTD, a 25 mm profiled inset and a profiled parallel-plate measuring system PP25-P (Ø 25 mm). The gap size was 2 or 3 mm. Special care has to be taken for the sample preparation. Disks with a diameter of 25 mm have been prepared and placed into the rheometer which was set at -20 °C.

Due to extended structures in ice cream and the stiff consistency of the ice cream at low temperatures a parallel-plate measuring system was used. In order to prevent slip profiled geometries were used.

The Advanced Peltier System PTD which eliminates any significant temperature gradients throughout the sample was used for setting the temperature.

Oscillatory tests are used to measure the ice cream samples since oscillatory tests give the additional information on the elastic behavior of the sample, i.e. it can be distinguished between viscous (G'') and elastic (G') properties.

Temperature Sweep (TS) or Oscillatory Thermo Rheology (OTR) on ice cream:

Presetting: Constant angular frequency $\omega = 10\ s^{-1}$, Constant strain $\gamma = 0.02$ %. Temperature ramp T = 20 °C to +10 °C, Heating rate 0.5 K per minute.

4 Results and Discussion

Figure 1 shows the results of a TS at the two different processed ice creams. Three different regions can be distinguished:

1. T < -10 °C:

The ice crystal microstructure is dominating the rheological behavior. The level of the storage modulus G' and the loss modulus G'' corresponds to the rigidity and scoopability of the ice cream.

2. -10 °C < T < 0 °C:

The ice crystals are melting. The steeper the slope of G' and G'' the faster the melting, i.e. a more pronounced sensorial impression of coldness.

3. T > 0 °C:

All ice crystals are molten. Only dispersed air bubbles and the fat phase are influencing the rheological behavior. G'' correlates to the sensorial impression of creaminess. The higher the loss modulus the creamier the sensorial impression of the ice cream is felt by the consumer.

Figure 1 shows that the ULTICE sample has a better scoopability, a less pronounced impression of coldness and a higher creaminess compared to the freezer sample.

In Figure 2 the importance of a good temperature control is indicated. The same ice cream sample was measured with the PTD system and with an open system in which only the bottom plate was temperature controlled by a Peltier plate. As can be seen the values of G' and G'' are much lower measured without the hood compared to the measurements with PTD system indicating a higher average temperature in the sample. In addition the rather large temperature gradients in the sample for such a system lead to more smoothed G' and G'' curves in which the details of the melting process are not observable to the extend which is needed to correlate the rheological behavior with the important properties of the ice cream.

5 Summary

The results show that a temperature dependent characterization of ice cream samples reveals detailed information on the scoopability and the creaminess as well as the coldness a consumer feels during the melting process. If the experimental setup prevails an precise temperature with small temperature gradients within the ice cream samples, the rheological data can be correlated directly to the mechanical behavior and the sensorial impression of the samples. The proposed test can therefore serve as a tool for improving and assuring the quality of ice cream products.

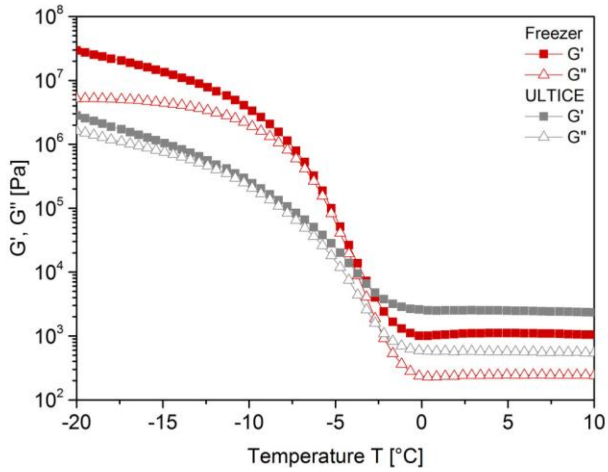

Figure 1: Temperature Sweep (TS) of an ice cream with different processing conditions

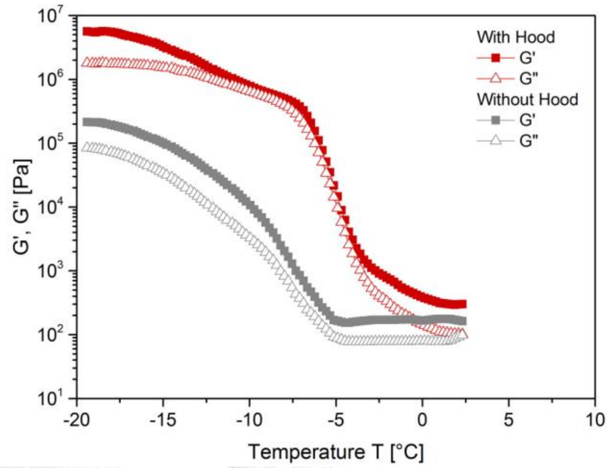

Figure 2: Temperature Sweeps (TS) of an ice cream with the PTD (With Hood) and a conventional Peltier system (Without Hood)

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