Application Notes V-243

A Rheometer with Bite – Marshmallows in the Rheometer

Klaus Oldörp, Thermo Fisher Scientific, Material Characterization, Karlsruhe, Germany

Introduction

We use many of our senses to experience our food. For a food product to be popular and therefore successful, it must meet many requirements: it has to look appealing, smell good, have a pleasant texture in the mouth - or "mouth feel" - and of course taste good. As soon as a food product is perceived as being "unpleasant" during even one of these subjective "tests," it can quickly lead to consumer rejection.

When regarding natural products like bread, meat or cheese, certain fluctuating or individual "bad" qualities are sometimes accepted, such as the smell of certain cheeses. However for industrially-produced foodstuffs, and particularly when dealing with treats such as sweets, all of the above criteria have to be met to gain consumer acceptance. No matter how good something looks or tastes, the "mouth feeling," i.e. the texture in the mouth, has to be right, otherwise the pudding will remain on the shelf in the refrigerated section and the cookies will never be purchased.

Marshmallows are another example of food where not only the flavour and sweetness, but also the "bite", is critical for enjoyment. Using a rheometer or a testing machine such as a texture analyzer, this consistency or texture can be described using objective parameters and thus making quality control or targeted improvement possible. A modern rheometer allows various options for characterising marshmallows and similar products. It also allows the viscosities of the starting materials to be measured, and the finished product can be characterized in an oscillatory test.

By combining a sensitive normal force sensor with a high-precision lift drive, the Thermo Scientific™ HAAKE™ MARS™ provides the additional option of stressing samples axially, i.e. by exerting a vertical force on them from above at a maximum of 50 N (which corresponds to a weight of 5 kg) by either pressing on or pulling the marshmallow sample. In this type of situation, the Thermo Scientific HAAKE MARS measures the axial force and position of the measurement geometry precisely while the sample is being squeezed, or the penetration of a probe into the sample is tracked.

Fig. 1: Samples M (left) and S (right) before measurement.

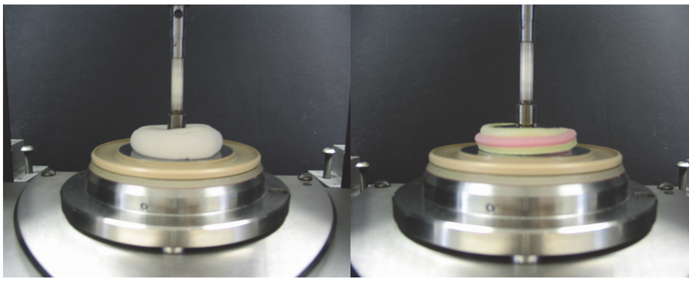

Fig. 2: Samples M (left) and S (right) during measurement.

Measurements and Results

Two products were compared during the experiment. Marshmallows (M) of about 30 mm in height and a sugar foam product (S) of about 10 mm in height. In order to compare the absolute values discs were cut from product S matching the diameter of the marshmallows and were stacked three high (Fig. 1). A 35 mm-diameter plate as used for rotational and oscillation measurements was run down to a height of 7 mm (Fig. 2) at a speed of 1 mm, and then run back up to 30 mm at 1 mm/s. This process was repeated on the samples five times in a row to simulate chewing in the mouth.

When compressing first sample M, the force increased to about 45 N before dropping again. During the following cycles the force only reached about 40 N but remained nearly constant through each cycle. A force of 50 N is required to compress sample S; the sample is thus felt to be somewhat harder. The maximum applied force decreases throughout subsequent cycles, dropping from 44 N during the second cycle to 40 N during the fifth cycle.

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The change in sample height shows clear differences between the two products. After the first compression, sample M relaxes to about 80% of its original height, while sample S only recovered to 59%. The two samples behave comparably when considering the rest of the measurement. Sample M's height is reduced by another 1.4 percentage points; that of sample S by a further 1.8 percentage points.

Interestingly, the slightly softer sample M is also more elastic and maintains nearly constant properties after the first compression. This marshmallow has a softer mouth feel and keeps its volume longer when chewed, so it probably feels like "more" in the mouth. Sample S is slightly harder and springs back much less after the first compression. In addition, sample S remained stuck on the upper geometry, which is reflected in the negative axial forces during the expansion. Sample S is thus the tackier sample, which may be one reason for the greater loss in height. Compared with the marshmallow, the sugar foam product has "more bite", that is, a little more force is required to eat it. Afterward, the product is stickier and its volume decreases faster during chewing.

Summary

In addition to the classical measuring modes rotation and oscillation, modern rheometers with a lift drive with precise position control and a sensitive normal force sensor such as the Thermo Scientific HAAKE MARS rheometer offer the option of squeezing and pulling samples in the axial direction. Tests were carried out on marshmallow samples which allow conclusions to be drawn about the texture of these sweets during chewing. Both the force for compressing the sample and its elastic recovery were determined.
With this application, range of measurement capabilities which can be used on the HAAKE MARS has been expanded, providing users with a cost-effective solution for characterizing its samples with an additional method. How soft or elastic the perfect marshmallow should be and whether a certain stickiness is part of its enjoyment when eating it is up to the consumer to decide. Using a modern rheometer and a simple method can always ensure that the desired quality is always consistently produced.

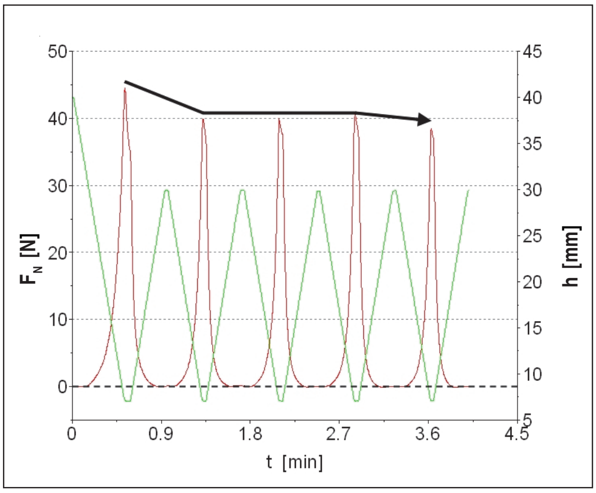

Fig. 3: History of axial force exerted on sample M when exposed to multiple compression to 7 mm. On the initial loading the force rises to approximately 45 N. After that, the maximum force remains more or less constant at about 40 N. When the sample is allowed to decompress, the axial force returns to 0 N.

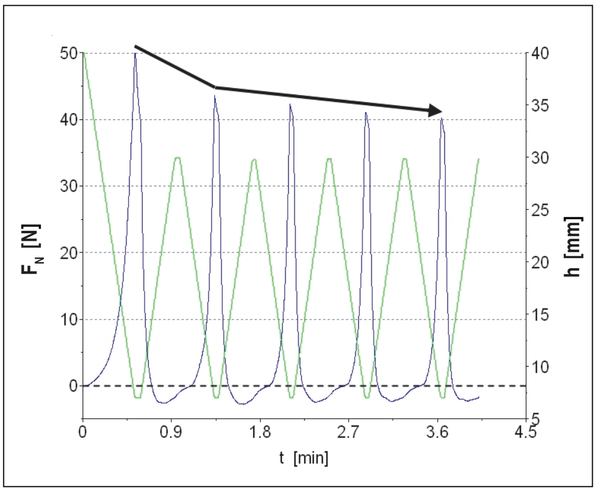

Fig. 4: History of axial force on sample S at multiple compressing to 7 mm. On the initial loading the force rises to approximately 50 N. After that, the maximum force of 44 N decreases in stages to 40 N. After the sample relaxed the axial force returns to negative values, i.e. the outer side of the sample becomes sticky under pressure.

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Material Characterization

Benelux
Tel. +31 (0) 76 579 55 55
info.mc.nl@thermofisher.com

China
Tel. +86 (21) 68 65 45 88
info.mc.china@thermofisher.com

France
Tel. +33 (0) 1 60 92 48 00
info.mc.fr@thermofisher.com

India
Tel. +91 (22) 27 78 11 01
info.mc.in@thermofisher.com

Japan
Tel. +81 (45) 453-9167
info.mc.jp@thermofisher.com

United Kingdom
Tel. +44 (0) 1785 82 52 00
info.mc.uk@thermofisher.com

USA
Tel. +1 866 537 0811
info.mc.us@thermofisher.com

International/Germany
Dieselstr. 4
76227 Karlsruhe
Tel. +49 (0) 721 4 09 44 44
info.mc.de@thermofisher.com

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