Breaking Strength of Chocolate

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Chocolate appeals to all of our senses. We see the colour and the glossy surface of the bar, we smell the elusive flavours, we weigh it in our hands and feel how it melts, we hear it break and sense its resistance, and savour the taste. With so much "sensuality", it is easy to forget how quickly the pleasure can be destroyed, if even just one of these properties is not as we expect it or are accustomed to.

Even unconsciously, the breaking behaviour of chocolate plays an important role in influencing the consumer's impression. Chocolate experts can even evaluate the quality of a sample by breaking off a piece.

Rheology plays an important role in several steps of chocolate production. The liquid chocolate formulation and the fats used can be characterized by their viscosities, yield stresses and solidification behaviours. These parameters are important for quality control and processing, and can be determined using rotational or oscillation measurements.

Sensory properties as experienced during the melting process, or "mouth feeling", can be described with the viscosity curves and the yield stress. However, these rheological parameters contain no information about the breaking strength of the final chocolate bar – and therefore a new method and new equipment are necessary to assess the resistance to break.

The Thermo Scientific™ HAAKE™ MARS™ rheometer, manufactured by Thermo Fisher, features a highly sensitive normal force sensor and a very precise lift motor which allows the customer to apply controlled axial forces to the sample, pushing or pulling it, and to analyze its axial deformation.

For example, with a new measuring geometry (Fig.3), chocolate bars can be positioned on the rheometer and submitted to an increasing axial force until they break. This measuring geometry [1] consists of two parallel support bars which can be mounted onto a base plate in a variable distance from 1 to 7 cm. The sample lies on these bars and a user-defined piston can be lowered onto the sample, making possible bending, breaking and penetration tests.

Fig. 1: Thermo Scientific HAAKE MARS Rheometer.

The bending geometry was used to investigate the breaking behaviour of small bars of milk and dark chocolate. The distance of the support bars was fixed at 5 cm. The piston was cylindrical with a diameter of 6 mm. The piston was lowered at a rate of 1.3 mm/min.

The comparison of the results in Fig. 2 shows a much greater deformation prior to breakage for the dark chocolate – it is more elastic than the milk chocolate. The normal force increases quickly and then falls to zero almost immediately (blue curve). This behaviour is typical for hard and brittle samples.

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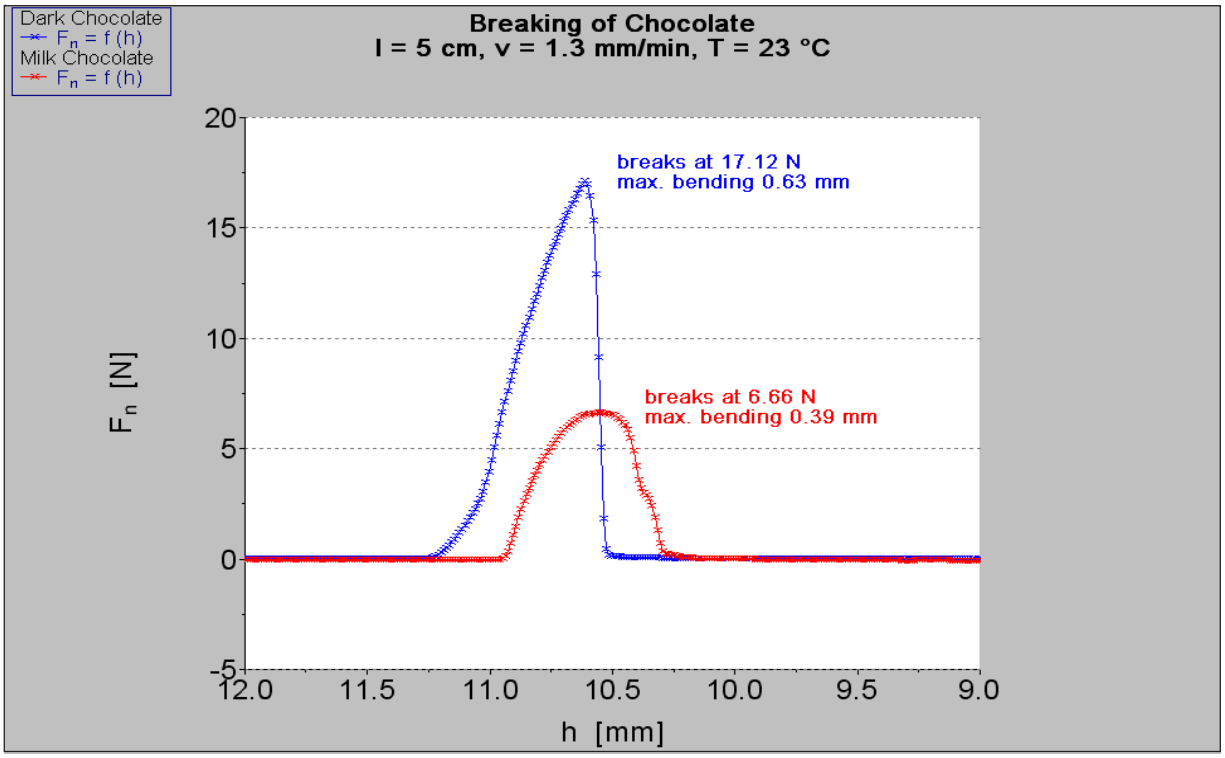

Fig. 2: Breakage curves of half bitter (blue) and a milk (red) chocolate bars.

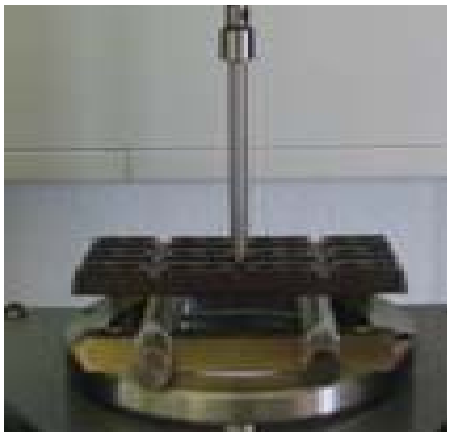

Fig. 3: Breaking test on a chocolate bar on the HAAKE MARS using the new bending geometry.

The milk chocolate is much "softer", which can be seen in the moderate increase in the normal force (red curve). Only a third of the normal force required for the dark chocolate is needed to break the milk chocolate bar. The bar breaks in two steps: first it cracks to about the middle of its thickness before breaking completely.

Using the bending geometry for the HAAKE MARS rheometer, it was possible to characterize two types of chocolate with respect to their breaking behaviour. The axial deformation, the necessary normal force for breakage and the shape of the force/deformation curves can be used as evaluation parameters. With the same method, different formulations of a certain chocolate type may be analyzed for an efficient product development, or the quality of different production lots can be controlled.
Unlike subjective sensory tests which depend on the test person, the described method provides objective and reproducible results, independent of the analyst.
This accessory significantly broadens the application range of the HAAKE MARS rheometer. The determination of additional relevant product properties can be performed on the same instrument used for the analysis of flow and viscoelastic behaviour of the samples - which is much more cost efficient than the purchase of a second specific instrument. The geometry for bending and breaking tests is just one example of the wide range of application-specific accessories available for the HAAKE MARS.

Reference

[1] Thermo Scientific Product Information P014 "Sample fixturefor banding and breaking tests for Thermo Scientific rheometer" Cornelia Küchenmeister and Klaus Oldörp

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