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Cheeseology – A Rheological Study of Cheese

The production of cheese dates back to 8,000 BCE and has an important role to play in many cultural dishes. Cheese comes in a wide variety of forms, ranging from soft, spreadable cheeses to hard, crumbly cheeses and everything in between. The extended gel structures and consistency in cheese are inherently unique to the cheese variety. Furthermore, this structure changes dynamically when refrigerated, heated, or left in ambient conditions. Mouth-feel, or texture, is a crucial and highly debated characteristic of cheese, and the molecular structure that dictates this property relies heavily on temperature. A rheometer, which shows how materials flow when subjected to stress, can be used to correlate quantifiable material properties to the user experience.

Ebatco is equipped with an Anton Paar MCR 302e Rheometer, with a Plate & Hood Electrical Temperature Device and several testing geometries for different types of materials and testing plans. Oscillatory rheology tests were performed on different types of cheeses to investigate their elastic and viscous behavior. Stress amplitude sweeps were selected to assess the structural integrity of the cheese under stress, and temperature sweeps were used to determine phase transition temperatures and property changes with temperature. Amplitude sweeps were conducted first to determine the Linear Viscoelastic Region (LVER), or the range of stresses that maintain the storage modulus, G' , and the loss modulus, G'' , at nearly constant values. The storage modulus can be thought of as a solid-like, or elastic, component, and the loss modulus can be thought of as a liquid-like, or viscous, component. Figure 1 provides an overlay of results from the amplitude sweep test for three types of cheeses at room temperature.

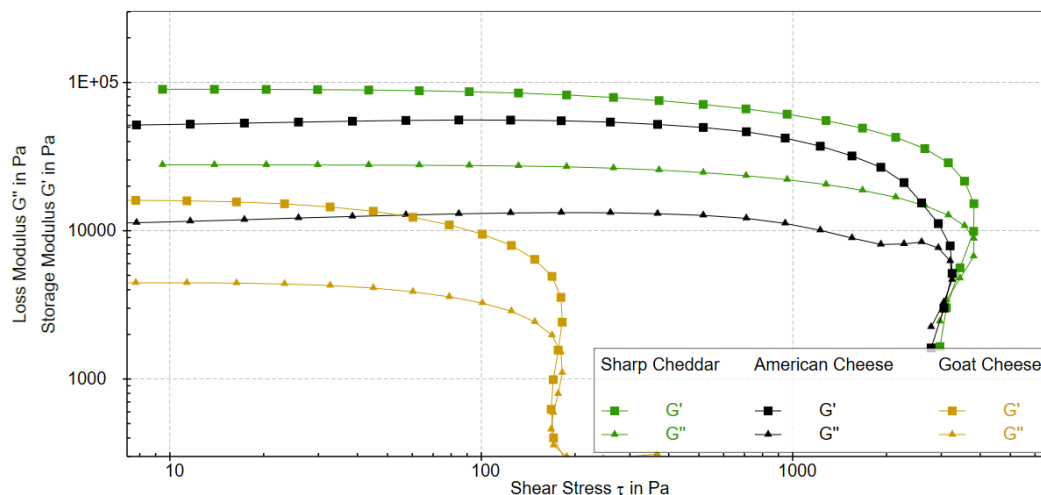


Figure 1. Strain amplitude sweeps for Sharp Cheddar, American, and Spreadable Goat Cheeses.



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The breakdown stress is the stress at which the LVER plateau and the microstructure can no longer be maintained. The Spreadable Goat Cheese has the smallest LVER plateau and lowest breakdown stress of the tested cheeses, indicating it requires the lowest force to begin spreading, as expected for a spreadable cheese. By comparing the breakdown stresses between cheeses, the other two types will require a force more than 20 times greater to spread. The Sharp Cheddar has the highest storage modulus, which is consistent with the expected higher hardness and stiffness, and the lowest storage modulus for the Spreadable Goat Cheese is consistent with observed softness and flexibility when handling.

The temperature sweep results for two comparable cheeses, American and Sharp Cheddar Cheese, are shown in Figure 2. The point where $G' = G''$ for Sharp Cheddar at 56.5 °C indicates a melting transition. The American Cheese has a slow and steady decrease in G' and G'' , but there is no melting transition over the studied temperature range. The temperature stability of the American Cheese will allow it to soften over a hot burger patty without it melting and falling off. The temperature stability over a wide temperature range makes assembling foods like hamburgers and hot sandwiches easier and more consistent. The mouth-feel and texture will also be noticeably different, since G' is significantly lower for the Sharp Cheddar than the American Cheese at body temperature.

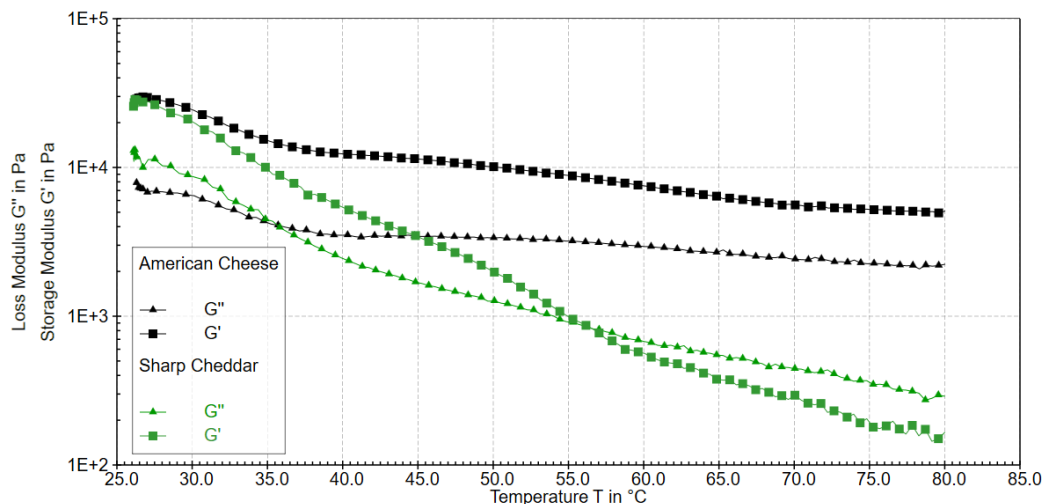


Figure 2. Temperature sweeps for Sharp Cheddar and American Cheeses.

User experience can be difficult to predict, but utilizing scientific methods to uncover quantitative relationships is an important step in product development, mass production, and quality control for food products. This rheological study has shown such relationships between spreadability and breakdown stress, hot food assembly and temperature stability, as well as mouth-feel and temperature-dependent properties. Rheology, among many other techniques at Ebatco, can be used to develop your product to have a more consistent and optimized user experience.