APPLICATION **NOTE**

Food – Rotational Rheometry

Preventing Herb Settlement in a Salad Dressing: The Kinexus Rotational Rheometer

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Introduction

A ready-to-use vinaigrette is a fast alternative to homemade dressings for salad preparation. Stores contain a broad variety of such products. Some of them are made not only of classical ingredients such as oil, vinegar and salt, but also contain herbs in suspension.
In addition to taste, the aesthetics of a product play a great role in selection by the customer. In the case of a sauce containing herbs, its suspension gives a first impression about product quality, long before the dressing is tasted. A vinaigrette with settled herbs doesn't look as yummy as the same one with suspended herbs.
A dressing with suspended herbs contains such thickening agents as xanthan gum or carrageenan, which give structure to the sauce. This structure is indispensable for holding the particles in the suspension and preventing them from settling.

Experimental

Rheology allows for prediction of the stability of food products by quantifying their structure. In the following, we compare the rheological signals of a fresh salad dressing with herbs to one that is expired by three years. As shown in figure 1, the herbs of the expired vinaigrette are all on the bottom of the bottle.

1 Fresh (left) and expired (right) salad dressing.

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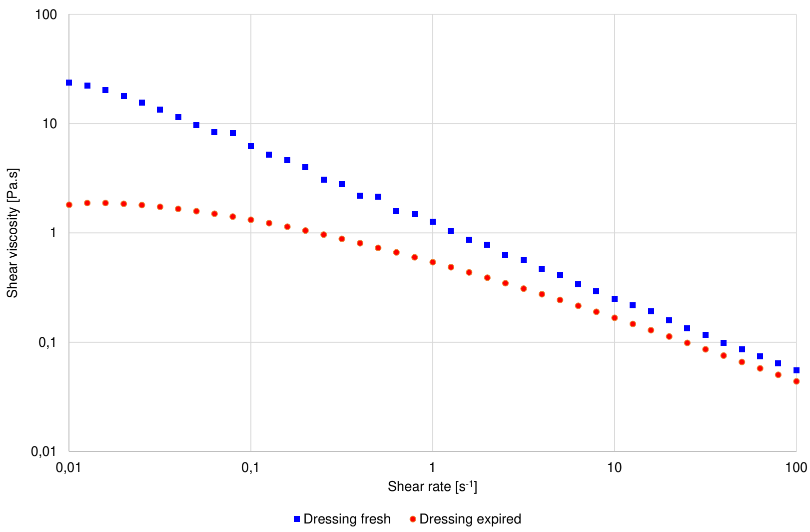
Measurement Results

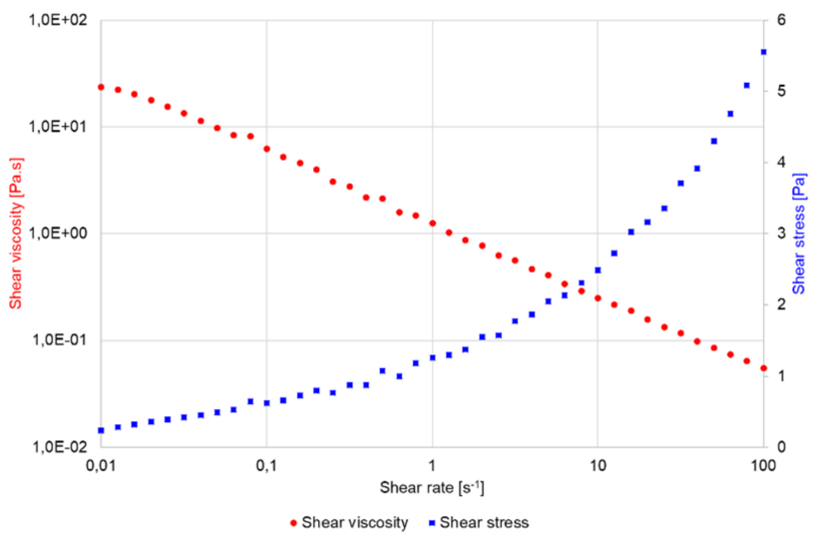
Figure 2 depicts the shear viscosity curves of the fresh and the expired salad dressings containing herbs. In the higher shear rate range, the two curves are similar and show the shear-thinning behavior of the dressings: The higher the shear rate, the lower the shear viscosity. In practice, this means that the sauce feels "more liquid" if stirred faster. However, the two products differ in the low shear rate range. While the shear viscosity of the fresh product increases with decreasing shear rates, it reaches a Newtonian plateau for the expired one. In the first case, the sample has a yield stress, i.e., requires a minimum stress before it starts flowing. This is typical for products having a structure able to inhibit sedimentation. In contrast, the expired product has no yield stress, but a zero-shear viscosity plateau, i.e., a shear viscosity at rest. Because of this absence of yield stress, the sauce will not be able to hold the particles in the suspension anymore: They will settle down.

Quantification of a Structure: The Yield Stress

Figure 3 displays the shear viscosity curve of the fresh salad dressing together with the shear stress curve. In the direction of the lower shear rates, the shear stress decreases and tends to reach a plateau. The extrapolated shear stress value in this plateau corresponds to the yield stress. It is lower than 0.2 Pa.



2 Shear viscosity curves of fresh (blue) and expired salad dressings (red). Geometry cup and bob 25 mm, gap 9.15 min, temperature 25°C.



3 Fresh dressing. Shear viscosity (red) and shear stress (blue). Geometry cup and bob 25 mm, gap 9.15 min, temperature 25°C.

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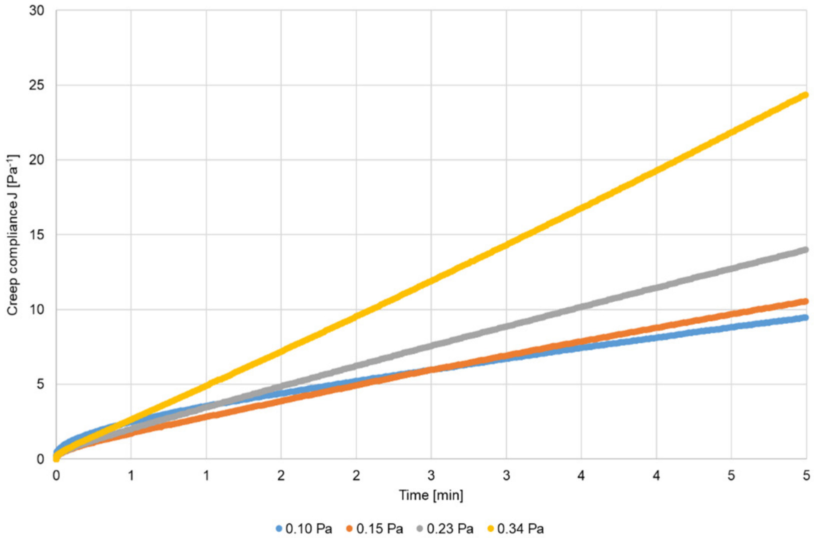
The yield stress can also be determined by a creep test. For that, 5-minute creep measurements were repeated on the same loading, using a starting stress of 0.01 Pa and followed by tests with stresses increasing by a factor of 1.5. The temperature of the test was 25°C. Figure 4 depicts the resulting curves of such a test on the fresh salad dressing. At 0.10 Pa and 0.15 Pa, the curves overlay and tend to reach a plateau. The applied stress doesn't lead to any flowing. At higher shear stress, the compliance increases with the shear stress. The yield stress is determined as a value between 0.15 Pa (no flowing) and 0.23 Pa (first shear stress segment where flowing is detected). This accords well to the value detected above.

Prediction of Stability and Shelf Life: The Frequency Sweep

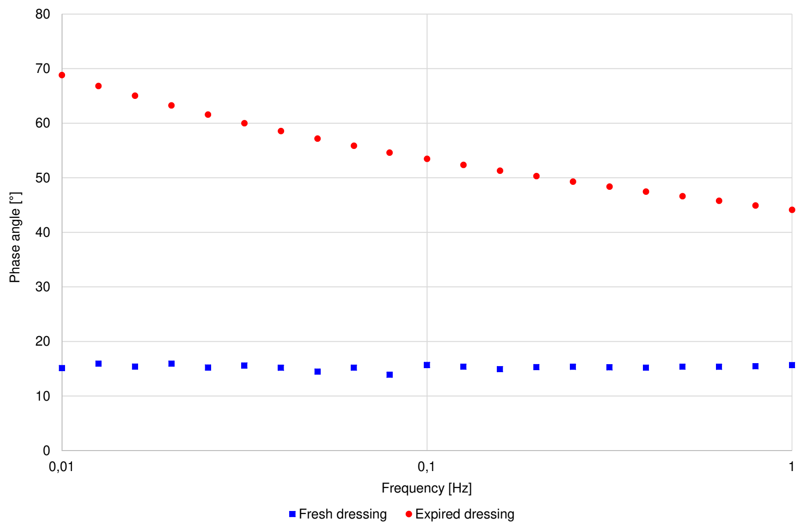
The stability of an emulsion or a suspension can also be investigated by the signals resulting from a frequency sweep, and particularly from the phase angle. Figure 5 displays the phase angle curves of both salad dressings during frequency sweep at 25°C. An increase in the phase angle toward lower frequencies indicates instability (expired sample, red curve).



4 Fresh dressing. Creep test at different shear shear stresses.
Geometry: cup and bob 25 mm, gap: 9.15 mm, temperature: 25°C, incremental increase of shear stress).

Creep Test and Compliance

During a creep test, a constant shear stress is applied and the resulting variations of shear strain are measured.
The compliance J [Pa^{-1}] is defined as:
J = Measured strain [%]/Applied stress [Pa]



5 Phase angle measured during a frequency sweep of fresh (blue) and expired (red) salad dressings.
Geometry: cup and bob 25 mm, gap: 9.15 mm, temperature: 25°C, incremental increase of shear stress.

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Conclusion

The stability of a suspension is closely related to the existence of a yield stress, which can be predicted by rotational or oscillation tests. The shape of the shear viscosity curve toward lower shear rates (rotation test) as well as the shape of the phase angle in the frequency sweep toward the low frequencies (oscillation test) indicate whether a yield stress is present or not.

The yield stress can be determined by the minimum shear stress in a shear viscosity curve, by the phase angle in a frequency sweep, or by a creep test.

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