Thixotropy of Ketchup

Ketchup is a popular condiment used throughout the world. Ketchup, after agitation, must regain its structure quickly in order to cling to foods such as fries and hot dogs. Ketchup manufacturers often use a rheometer in the product design and improvement phases for product quality control purposes. Using the Anton Paar Modular Compact Rheometer (MCR) 302e at Ebatco, the flow properties of ketchup can be examined through thixotropy.

Shear-thinning, or thixotropy, is an important property of ketchup that affects consumer satisfaction. In simple terms, ketchup is a thixotropic material because it becomes less viscous when it is subjected to shear stress and becomes more viscous when that stressor is removed. Typically, testing the thixotropy of ketchup consists of three phases that mimic the sample-in a bottle at rest, being squeezed from a bottle, and recovering after being dispensed.

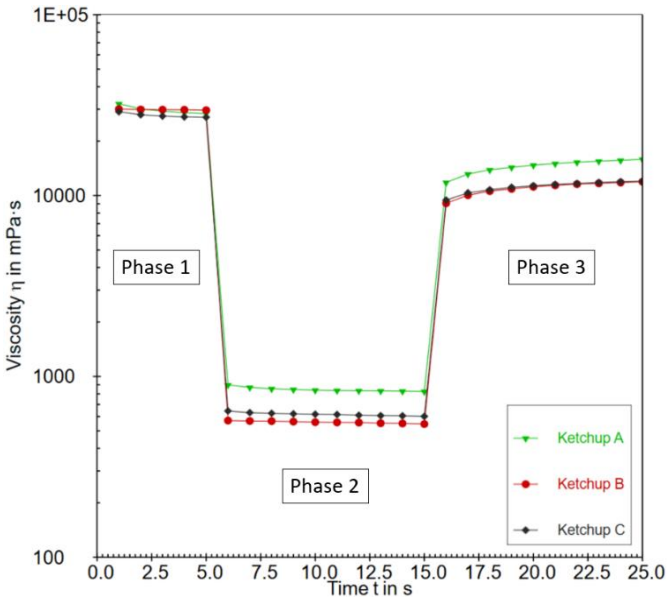

Figure 1. Thixotropic results of ketchup samples.

Thixotropy tests were conducted on three ketchup samples (referred to as Ketchup A, B, and C) using a 25 mm parallel plate and 25 mm base plate at a fixed temperature of 24 ºC. Figure 1 depicts the ketchups' progression during the three phases of testing. Phase 1 represents the ketchup at rest, Phase 2 is the ketchup being subjected to a high shear rate, and Phase 3 is the recovery of ketchup as it returns to a resting state. Table 1 shows the structure recovery characteristics of all three ketchup samples. Among the three ketchup samples tested, Ketchup A had the highest viscosity during Phase 2 and most recovery during Phase 3. Further, Ketchup A has the largest initial recovery of 41.6% and was also the fastest to reach 45% total recovery (in less than 2 seconds).

Table 1 Comparison of Structural Recovery of Ketchup

Analysis	Ketchup A	Ketchup B	Ketchup C
Initial Structure Recovery (%)	41.60	30.60	34.80
Time for 45% Recovery (s)	1.37	57.71	12.39

Another important aspect of the flow properties of ketchup is the yield point. The yield point is the lowest shear-stress value above which a material will behave like a fluid. Figure 2 illustrates the shear rate vs. shear stress measurement results obtained on the ketchup samples at 24 ºC. The yield points can be determined using the data shown in Figure 2 as well as the Casson standard equation. The respective yield stress of each sample was as follows: 37.10 Pa for Ketchup A, 29.02 Pa for Ketchup B, and 21.88 Pa for Ketchup C. Ketchup C had a much lower yield stress than the other two samples, suggesting that Ketchup C loses its structure more readily and begins to flow with less force applied.

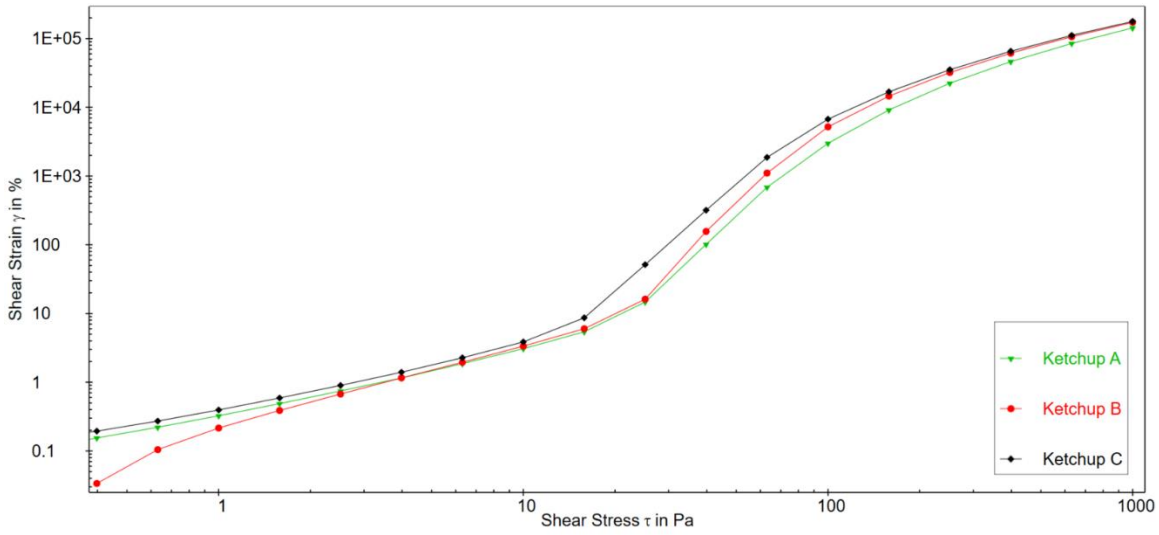

Figure 2. Flow curve of ketchup samples.

In summary, Ketchup A had the highest yield stress, Phase 2 viscosity, and fastest recovery of all three ketchups samples. Ketchup B had the second highest yield stress, lowest Phase 2 viscosity, and slowest recovery time. Ketchup C had the lowest yield stress, middle Phase 2 viscosity, and middle recovery time. Overall, the results indicate, with some differences, all three ketchup products behave with the same relative thixotropic pattern. Were these samples the ketchups from a manufacturing line, the results would elucidate the degrees of quality variations among batches.

Ketchup may be manufactured differently throughout the world, but all ketchups require thixotropic characteristics. Knowing, measuring, and controlling the thixotropic properties of ketchup is important for maintaining the consistency, quality, and consumer experience. While thixotropic properties may vary from brand to brand, rheology readily serves as a crucial tool in measuring and monitoring those properties for desired product quality and best-possible customer satisfaction.