Comparing the rheology and particle size of smoothies made with different blenders

RHEOLOGY AND VISCOSITY

PARTICLE SIZE

Introduction

Smoothies have been around for the best part of a century although it was not until the development, commercialization and evolution of the blender between 1920 and 1950 that home-made smoothies (in the modern sense) became possible. Their popularity was further accelerated by the health food movement of the 1960's and more recently the commercialization of dedicated smoothie makers, combined with a trend towards natural and nutritious foods [1].

In the Oxford English dictionary a smoothie is defined as 'a smooth, thick drink made with puréed fresh fruit and yogurt, ice cream, or milk'. However, their does not seem to be any fixed rules to what should go in to a smoothie with common additions being vegetables, crushed ice, nuts, seeds and extra juice or water.

What is widely accepted is that a smoothie should be as smooth and easy to consume as possible, aspects which are related to the particle size of the blended components and the viscosity of the suspension. While the viscosity of the blend can be controlled most easily by the choice of ingredients and amount of liquid used, the particle size of a given set of blended ingredients is directly dependent on the performance of the blender. This is often the main criteria that consumers will use to judge the quality of a blender – the taste test [2].

In this study, two smoothie makers have been evaluated and compared by measuring the particle (fiber) size and viscosity of two smoothie recipes prepared with the different blenders.

Figure 1 - Pictures of Blender A (left) and Blender B (right) loaded with fruit and vegetables

Materials and Methods

Two different smoothies were prepared and analysed in this study; a pink and a green smoothie with the following compositions.

Green Smoothie

100 g pineapple
100 g apple
10 g spinach
70 g water

Pink smoothie

100 g apple
30 g pineapple
10 g spinach
60 g berries
70 g water

The ingredients were blended together for 30 seconds using Blender A and B. After blending, it was clear that the smoothies were separating rather rapidly due to the buoyancy of the pulp fibers in the juice. To measure their viscosity as accurately as possible it was necessary to keep the fibers dispersed and the sample as uniform as possible during the measurement. This was achieved using a dispersion tool (or mixer) coupled to a Kinexus rotational rheometer and a standard lower cup as shown in Figure 2.

Figure 2 – Photographs showing Kinexus mixing geometry (left), green smoothie displaying separation (middle) and Kinexus with cup and mixer configuration

Furthermore, by employing a unique method for calculating shear stress and shear rate values for non-standard measuring systems such as mixers the viscosity-shear rate profiles for the two smoothies could be reported [3]. The particle size was measured using the Mastersizer 3000 coupled to a HydroSight accessory, which allowed the sample to be visualized while measuring the size of the pulp.

Findings

Particle size results for the two smoothies and two blenders are shown in Figure 3.

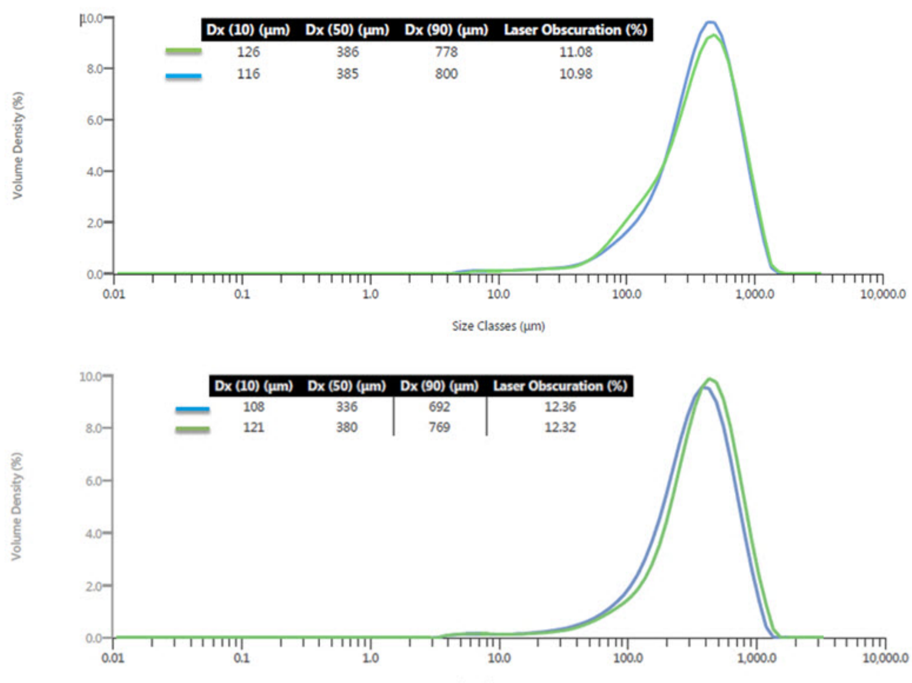


Figure 3 - Particle size results for green smoothie blends (top) and pink smoothie blends (bottom) made with Blender A (Blue) and Blender B (Green)

The green smoothie gave a very similar particle size distribution for both smoothie makers with Blender A giving a median pulp diameter of 386 µm compared with 385 µm for Blender B. For the pink smoothie the Blender A produced a slightly smoother drink with a median particle size of 336 µm compared with 380 µm for Blender B.

Figure 4 shows viscosity profiles for the different blends as a function of shear rate. Both smoothies showed shear thinning behavior, as would be expected for a complex and concentrated dispersion of this type. For the green smoothie the flow curves were almost identical, an observation that correlated with particle size results which were similar for both blenders. Particle size and size distribution are the only real variables that would be expected to affect the viscosity since the ingredients and processing conditions were the same for both blends.

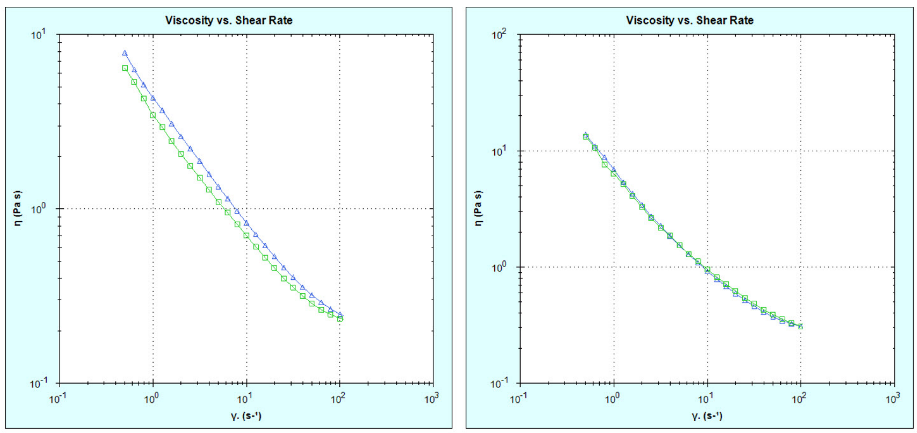
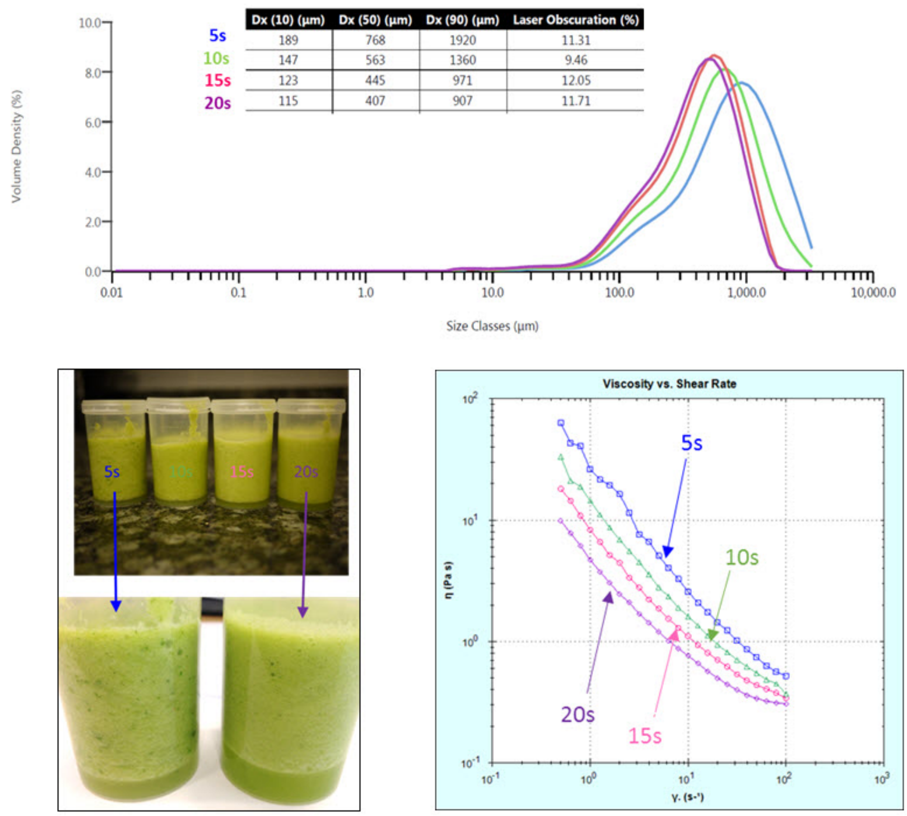


Figure 4 – Viscosity vs shear rate curves for the green smoothie blend (left) and pink smoothie blends (right) made with Blender A (Blue) and Blender B (Green)

For the pink smoothie, Blender A produced a smoothie that was slightly higher in viscosity than that produced with Blender B. This is likely due to the difference in measured pulp size for the two blenders, with the smoothie from Blender A having a larger ratio of smaller particles. What the HydroSight revealed was that in addition to the larger pulp fibers being present there was also a large number of micro-bubbles present, which will most likely contribute to viscosity and texture also and needs to be considered [2].

Finally, using just Blender B, the differences in viscosity and particle size as a function of blending time were evaluated as shown in Figure 5. Increasing the blending time resulted in a reduction in particle size (and most likely an increase in the amount of free water) which corresponded with a decrease in viscosity. After 5 seconds of blending, the smoothies were extremely lumpy requiring greater force to mix and resulting in a higher measured viscosity.



	Dx (10) (µm)	Dx (50) (µm)	Dx (90) (µm)	Laser Obscuration (%)
5s	189	768	1920	11.31
10s	147	563	1360	9.46
15s	123	445	971	12.05
20s	115	407	907	11.71

Figure 5 – Particle size and viscosity data for the green smoothie measured after different blending times using Blender B

Conclusions

Two smoothie makers were evaluated and compared by measuring the particle (fiber) size and viscosity of two different smoothie recipes. There was very little difference between the two blenders in terms of the measured particle size distribution and viscosity of the blends. Where viscosity differences were observed a difference in particle size was also found, suggesting a causal relationship.

References

1. *The History of Smoothies: What Every Serious Smoothie Maker Should Know – Ryan Carmody*
2. *Blending with the boss – Applied science and recipes*
3. *JJ Duffy, AJ Hill, SH Murphy; Simple method for determining stress and strain constants for non-standard measuring systems on a rotational rheometer , Appl. Rheol. 25:4 (2015) 42670*

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