HORIBA Scientific

# Application Note

## Particle Characterization of Powdered Sugar

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**Sugar (sucrose) is naturally present in fruits and vegetables in various concentrations. Among all plants, sugar canes and sugar beets contain the highest amount of sucrose, 12-14% and 16-18% respectively. Extraction of sugar involves two part operations: processing sugar canes and beets into raw sugar and processing raw sugar into refined sugar [1] such as milled, screened, liquid, invert, and brown sugars (Figure 1). In this note, the focus will be on the characterization of powdered sugar using high-throughput laser diffraction technique.**

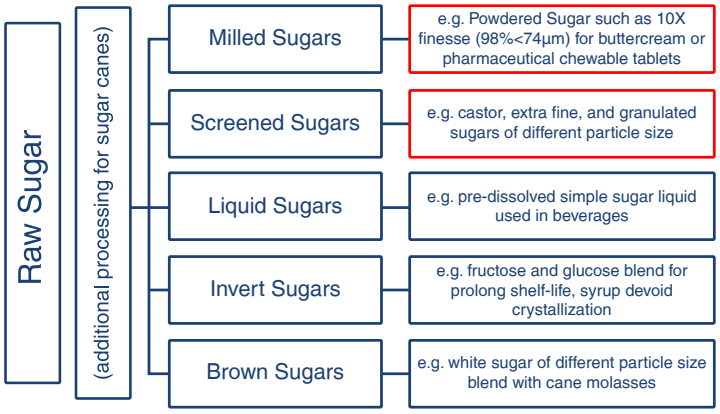


***Figure 1. Raw sugar is refined to different sugar ranges for various applications. Milled and screened sugars (boxed in red) can be readily measured and optimized with the LA-960V2 laser diffraction particle size analyzer.***

## Quality Control of Sugar

Quality control is an essential part of the sugar production. Sugar particle size specifications affect product dissolution rate, flowability, dust generation, and directly affects applications such as the spread of cookie dough or compaction strength of a chewable tablet. Traditionally, sugar manufacturers have chosen to use sieving analysis due to its low initial cost and its seemingly simple operating procedure. Sieve shakers vibrate and cause sample to pass through a series of sieve meshes stacked on top of each other until the narrowest dimension of a particle falls through (Figure 2).

***Figure 2. A rectangular shaped sugar crystal compared to the square aperture of the sieve opening***

The sieve technique, however, has inherent disadvantages:

- Low repeatability and reproducibility – up to 30% difference from sieve to sieve
- Long measurement, maintenance, and cleaning time
- Poor performance for fine particles – especially for particles < 44 µm (325 mesh)
- Cross sample contamination
- Low automation

Powdered sugar is milled from white granulated sugar crystals to various degrees of fineness. 6X, 10X, and silk sugars are most commonly seen [2]:

- 6X – defined as 93.5% < 200 mesh (74 µm)
- 10X – defined as 98% < 200 mesh (74 µm)
- Silk Sugar – defined as 97% < 20.5 µm

Finely milled powdered sugars have a higher surface area, which leads to a higher tendency for moisture absorption and clumping. 3-5% of anti-caking agent is often added to help maintain product flowability and even then, some clumping is expected. For this reason, laser diffraction technique is preferred because of its powerful but adjustable air dispersion ability. Laser diffraction technique offers users a quick feedback mechanism to monitor and course-correct the milling process. Ultimately, a desired powdered sugar product has a narrow particle size distribution to minimize particle separation and to maximize sugar dissolution when mixing in a temperature sensitive setting (e.g. buttercream icing).

## Materials and Methods

A commercially available 10X Powdered Sugar was purchased and tested. To measure powdered sugar at its un-agglomerated state, some sort of energy assistance for particle dispersion is required. To determine an appropriate dispersion power, 10X Powdered Sugar is set to be measured three repeats each at 0.01 MPa (≈0 Bar), 0.1 MPa (1 Bar), 0.2 MPa (2 Bar), 0.3 MPa (3 Bar) and 0.4 MPa (4 Bar). Each analysis was set for three seconds each. In doing so, two important parameters can be observed:

1. Sample repeatability indicating particle separation.
2. The effect of air pressure on size.

## Results and Discussion

The particle size distribution of 10X powdered sugar measured well within manufacturing milling criteria (defined as 98% < 200 mesh (74 µm)). 98% of the particles were smaller than 64.8 µm with a Dv10 of 7.32 µm, Dv50 of 14.9 µm, and Dv90 of 34.8 µm. The result also showed that at 0.3 MPa (3 Bar) of air pressure, excellent repeatability and a narrow Gaussian distribution was observed. This suggests that at 0.3 MPa, neither measuring unrepresentative sample aliquot nor milling particle by attrition were done:

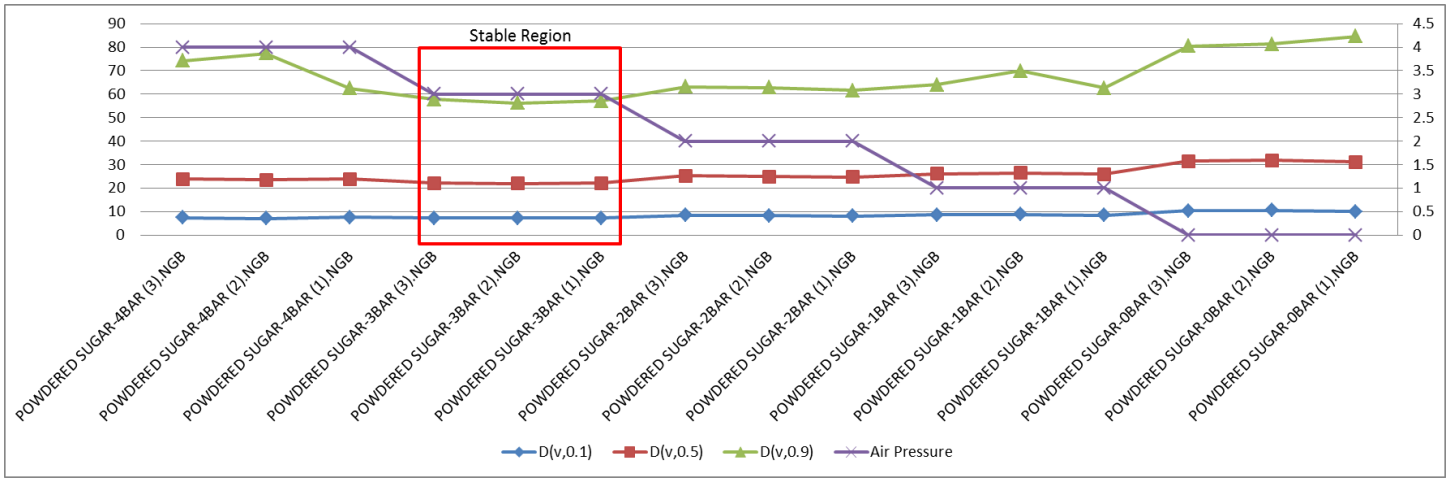


***Figure 3. Pressure-Size Titration Test where (1) repeatability and (2) the effect of air pressure from 0-0.4 MPa on powdered sugar was observed. 0.3 MPa of air was deemed to be most appropriate.***

The three measurements at 0.3 MPa were then averaged and displayed below (Figure 4):

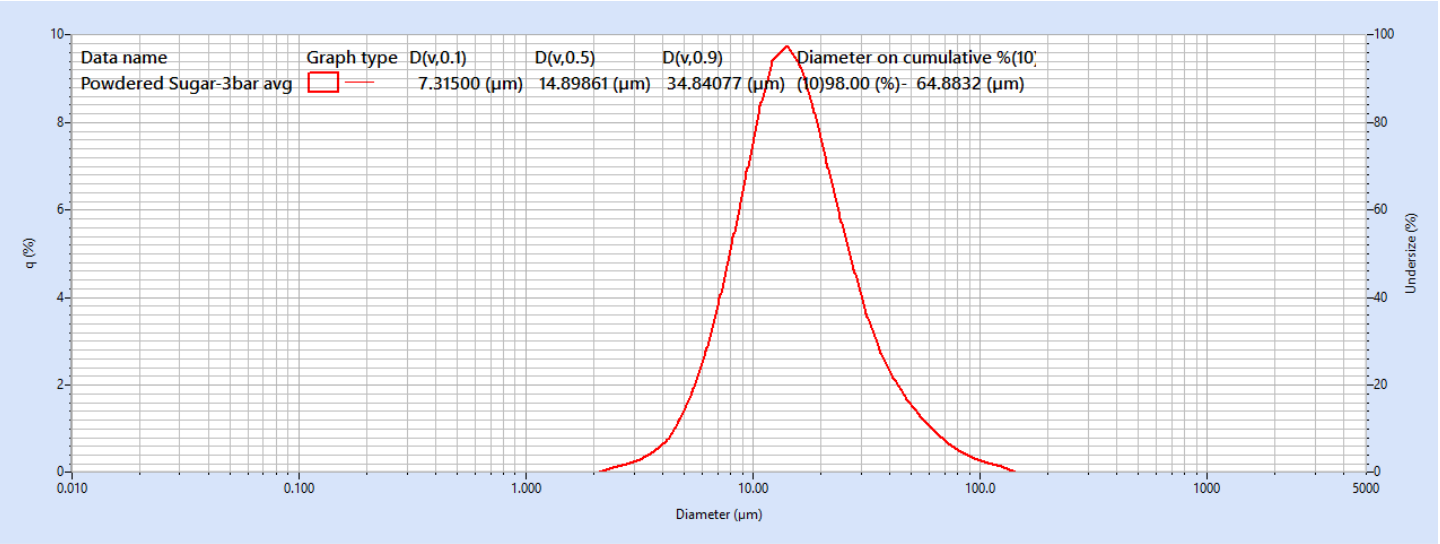


***Figure 4. The particle size distribution of 10X powdered sugar dispersed at 0.3 MPa of air pressure.***

## Summary

Particle size of sugar products is an important measure of sample flow properties and application. In this study, the LA-960V2's ability to rapidly analyze particle separation and the particle size of powdered sugar at its de-agglomerated state was demonstrated. Laser diffraction has been proven as an effective replacement of sieves and ensures greater milling efficiency from pilot to production size alike.

## References

1. https://www.crystalsugar.com/sugar-processing/

2. http://www.hmicronpowder.com/industries/food/sugar