HORIBA Scientific

Application Note

Material Characterization of the Next Generation Sugar Substitutes

AN213

Let's begin by admitting this: sugar makes us happier; we love sweets. The sweet receptors that respond to sugar (and subsequently make us happy) on our tongue are also found in fat cells, triggering fat cells to suck up sugar for lipogenesis [1]. As research begins to link obesity and diabetes with excessive sugar consumption, the market for naturally-derived sugar substitutes or intense sweeteners has grown and is projected to continue to grow [2]. Two types of high-intensity sweeteners gaining consumer popularity have recently been submitted to the U. S. Food and Drug Administration (FDA) for GRAS (generally recognized as safe) notices, these are stevia and monk fruit [3]. Unlike other sugar substitutes that have sparked controversy over negative side-effects, these non-nutritive, non-caloric, and non-glycemic sweeteners are perceived as "all-natural." The FDA has not yet defined 'natural' but they are frequently used in drinks, beverages and as table sugar replacements.

Introduction

Stevia and monk fruit sugars are both extracted first in liquid form through hot infusion and later processed through spray or vacuum drying into powder or granule form. A consistent particle size is desired for better control of mixing, dissolution, and packing. This note does not compare the chemical compounds or safety result of the extracted steviol glycoside or mogroside V. Rather, this study focuses on the critical particle diameter of dry sugar granules as particle diameter as an indicator of:

- Flowability* – defining how much a spoon of sugar actually weighs when scooped from a jar
- Dissolution and mixing – defining consumer experience when used in drinks or baking
- Powder uniformity – defining packing and sugar weight consistency from one package to another

The size is also important since FDA has set Acceptable Daily Intake for all high-intensity sweeteners with exception of monk fruit sugar [3]. Manufacturers need to closely monitor particle size in order for end users to have better control over how much sweetener is consumed.

**(Powder flowability is a combination of various factors such as particle size, shape, surface roughness, size distribution, moisture content, or storage time, but particle size is the major indicator of powder flowability)*

Materials and Methods

Two stevia sugar samples and one monk fruit sugar were purchased and tested. To demonstrate the correlation between particle size on flow properties, a typical plastic teaspoon was used to scoop sugar samples from a jar. The physical behavior of each scoop of sugar was then visually assessed and recorded for quantifying the cohesiveness for sugar granules [4] (Table 1 below).

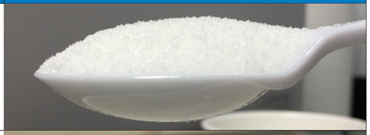
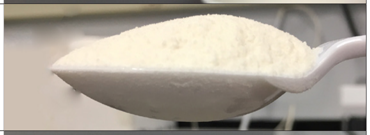
	Sample Name	Physical Property	
1	Reference white table sugar	Highly flowable.	
2	Popular brand Stevia	Dusty but flowable with a slight yellow color. Smaller angle of repose compared to store brand Stevia	
3	Store brand Stevia	Very dusty, slightly sticky, but flowable. Higher angle of repose compared to Popular brand Stevia.	
4	Monk Fruit Sugar	Electrostatic when used with plastic spoon. Particles resemble snowflakes and are noticeably lighter. Flowable.	

Table 1

Particle size data was collected by analyzing the dry powders with the LA-960 laser diffraction particle size analyzer PowderJet with the following analytical test settings:

Refractive Index: 1.54 | Imaginary (absorption): 0.001i
Feeder Speed: Auto
Nozzle Size: Medium

Results and Discussion

Each sample was assessed individually (pressure-size titration test) for an appropriate air pressure to be applied. 0.1MPa was determined to be the best air pressure for both stevia sugar dispersion and 0.2MPa for monk fruit sugar. Two averaged measurements of both Popular Brand Stevia and Store Brand Stevia are displayed below in Figure 1.

The laser diffraction analysis result shows a larger particle size distribution for the Popular Brand Stevia as it extends up to Dv90 of 487.5 µm whereas the Store Brand Stevia, under the same measurement conditions, measured smaller. Note that when stevia concentrate is extracted then processed, it tends to be very dusty (as indicated by particles < 10µm), making it harder to mix in beverages. To improve flow characteristics, patented agglomeration technology is often implemented to fuse powders to a size greater than 200 µm [5]. In this case, the laser diffraction result confirms the positive correlation between particle size and flowability and an inverse correlation between particle size and angle of repose (please see Table 1).

An averaged measurement of Monk Fruit Sugar using 0.2 MPa of air pressure is displayed in Figure 2.

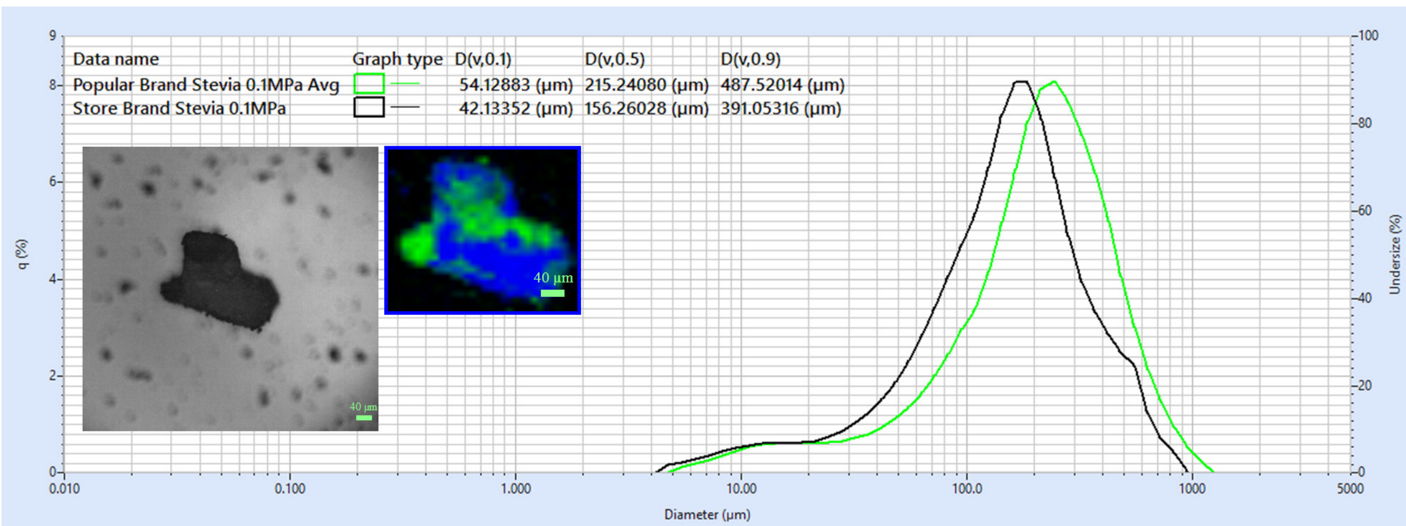


Figure 1: The particle size distribution of a popular brand stevia against a store brand stevia sugar along with example particle images

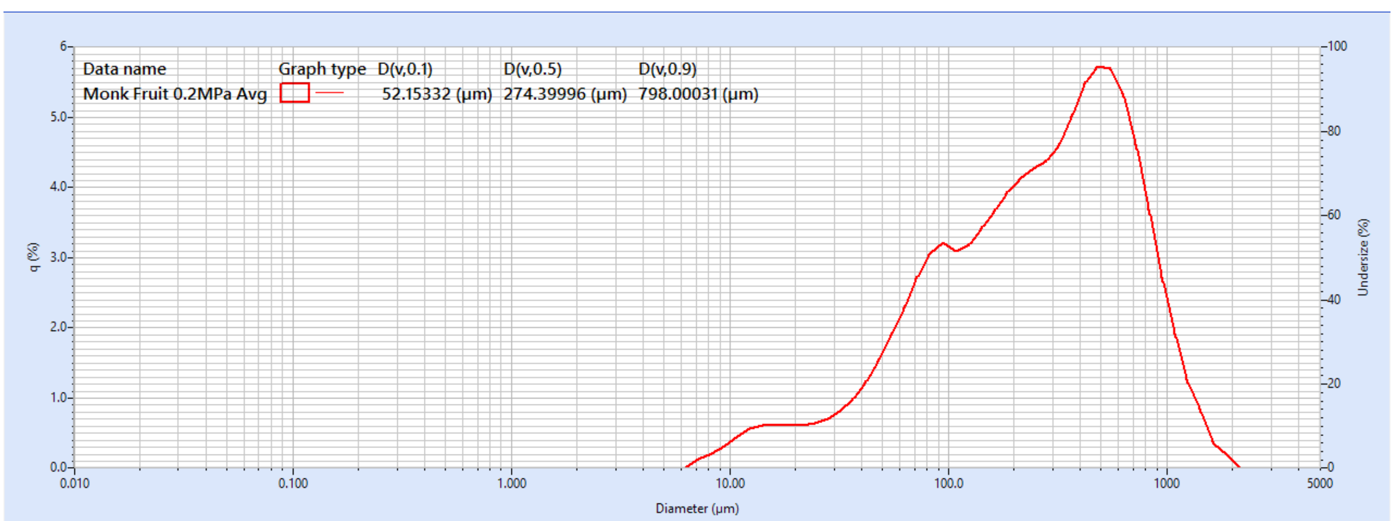


Figure 2: The particle size distribution of well-dispersed monk fruit sugar (0.2MPa air pressure) mimics the particle size of white table sugar

Monk Fruit Sugar exhibits a greater inter-particle attraction (likely due to its particle morphology and higher inter-particle forces) and requires higher pressure to disperse.

Overall, monk fruit sugar is larger in particle size (with Dv50 of 274 µm, mimicking the typical size of white table sugar) and wider in particle size distribution. This physical attribute makes monk fruit sugar an excellent alternative for baking as it offers similar "body" or bulk as regular table sugar.

Summary

Material characterization of the next generation "all natural" sugar substitutes is a combination of particle size, shape, surface roughness, size distribution, moisture content, and storage time. The laser diffraction technique offers manufacturers a single quick measurement of size. This data can be used to predict powder flowability, dissolution, and separation. In this note, we have shown that particle size is the most accurate predictor of granular material flowability, with decreasing particle size indicating lower flowability.

References

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