HORIBA Scientific

Application Note

Predicting Whiskey Shelf Stability with Particle Size Distribution

AN228

PREDICTING WHISKEY SHELF STABILITY WITH PARTICLE SIZE DISTRIBUTION

Introduction

The COVID-19 pandemic has likely made many people into liquor connoisseurs and subsequently experts on color, mouthfeel, and taste profiles. In this note, the particle science behind these determining factors will be thoroughly examined and explained.

Whiskey is an alcoholic beverage made from a fermented mash of grains such as barley, corn, rye, and wheat where the grain mixture defines its characteristics. During fermentation, a secondary reaction produced by yeast called congener is formed. Congener is one of the key contributors to how one perceives the quality of the whiskey. For example, esters present in congener lends bourbon whiskey a sweet, fruity smell. Likewise, excess esters can lead to an unpleasant smell that reminds one of industrial chemicals (similar to super glue). Esters and alcohol can form large agglomerates [1], causing degradation in color and taste. After fermentation, whiskey then undergoes distillation and is transferred into charred oak casks where maturation occurs. In this step, the flavor profile deepens intensely as wood-derived components further modify the congeners [2] for two or more years. Studies indicate that the presence of particulate structures is reduced in average size in matured distillates due to the dissolution of wood components [1].

The final act before bottling is chill filtration where the temperature is lowered in order to agglomerate particles for better filter efficiency. Since each barrel ages differently, the same filtration method cannot be applied. A heavily rectified method will remove the desirable flavor and color. In contrast, an under filtered whiskey is muddy and may precipitate. Therefore, careful control of the particulates in whiskey is an important step. Inadequate monitoring of particle size impedes the final product stability, consistency, quality, and price.

Materials and Method

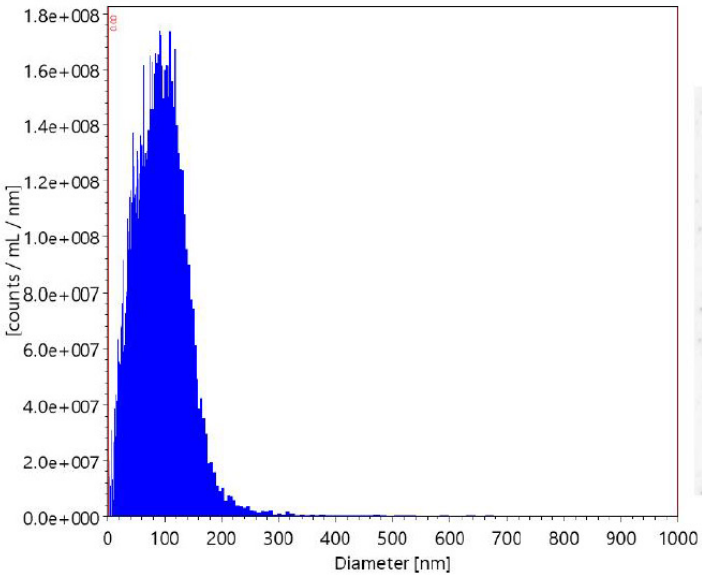
Four Roses Bourbon was acquired commercially. (Bourbon is whiskey made from over 51% corn grain and aged in oak barrels.) Measurements were carried out at ambient laboratory temperature using the ViewSizer 3000 multispectral nanoparticle tracking analyzer (NTA). The ViewSizer 3000 tracks particle Brownian motion and offers particle counting and sizing of polydisperse sample.

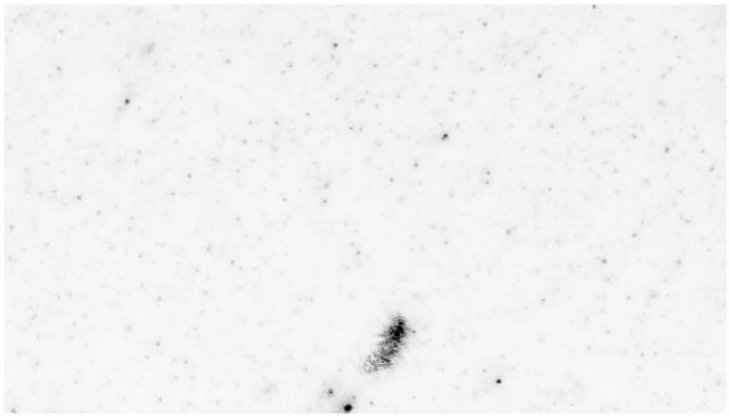
The measurements were recorded with the following parameters: frame rate: 30 frames/sec; exposure: 15 msec; gain: 30; blue laser power: 70 mW; green laser power: 12 mW; and red laser power: 8 mW; temperature control: active, 22°C. 25 short videos were collected with 5 seconds of stirring between each video to ensure completely independent sets of particles in each video.

Prior to analyzing the sample, the sample cuvette, insert, and stir bar were thoroughly cleaned with water and ethanol. Approximately 400 microliters of neat Four Roses Bourbon were pipetted into the cuvette for an initial assessment using the video preview function. A high concentration of particles were observed colliding and consequently restricted tracking of each individual particle. The sample was therefore diluted 100x with water and again, 400uL of the diluted bourbon was pipetted into the cuvette. The data was then recorded as per the settings described above.

Results

The particle size distribution and a captured image for Four Roses Bourbon are shown below. The result exhibits a single, narrow peak distribution with only a few larger particulates tailing towards the coarse end. This distribution profile lessened the effect of Ostwald ripening where the formation of inhomogeneous structures occurs. The average particle size is 97 nanometers with a concentration of 1.9×10^{10} particles/mL. The analysis is an indicator of smoother mouthfeel and a predictor for longer shelf stability.





References

[1] Piggott, J.R., et al. “Flavour Development in Whisky Maturation.” Developments in Food Science, Elsevier, 2 Sept. 2007, www.sciencedirect.com/science/article/pii/S016745010680261X.

[2] Carrithers AD; Brown MJ; Rashed MZ; Islam S; Velev OD; Williams SJ; “Multiscale Self-Assembly of Distinctive Weblike Structures from Evaporated Drops of Dilute American Whiskeys.” *ACS Nano*, U.S. National Library of Medicine, pubmed.ncbi.nlm.nih.gov/32208622/.