Name(s)

Mark A. Swerdlow

Project Number

J1538

Project Title

Can You Tell How Much Sugar Is in Your Drink by How Much It Bends Light?

Abstract

Objectives/Goals

My objective was to determine the effect of sugar concentration on the index of refraction (IOR) of sugar solutions. My hypothesis was that IOR increases enough with increasing concentrations of sugar to differentiate a diet soft drink from a regular (sugar) soft drink.

Methods/Materials

I placed a cylindrical tank with its axis parallel to the ground, filled it half way with liquid, and mounted a laser on a metal arm that rotated around its center. To vary the angle of incidence at the air-liquid boundary, I rotated metal arm. I photographed the path of the laser using a digital camera and loaded the photos into iPhoto. I used a digital protractor to measure the angles of incidence and refraction; I used Excel to plot sine of the angle of incidence on the Y axis and sine of the angle of refraction on the X axis. I calculated IOR as the slope of the best fit line through the origin. Experimental variables were the IORs of 10%, 20%, or 30% sugar solutions, Diet Sprite, or regular (10.7% sugar) Sprite. The control was the IOR of water. I assessed reproducibility by making 8 repeated measurements of 3 photos.

Results

Overall, 95 photos were suitable for analysis. The standard deviation was $< 0.1°$ for the offset between the water and camera levels and $0.2°$ to $0.3°$ for the angles of incidence and refraction. There was a strong linear correlation between the sines of the angles of incidence and refraction ($R^2 > 0.98$). The IOR increased with increasing concentrations of sugar from 1.335 for water to 1.357, 1.372, and 1.397 for 10%, 20%, and 30% solutions, respectively ($F = 8.5$, $p < .0001$ by ANOVA). The IOR was less for Diet Sprite than for regular Sprite (1.329 vs. 1.363, $p = .03$).

Conclusions/Discussion

The IOR increases 1% to 2% for each 10% increase in sugar concentration up to 30%. The IORs of Diet regular Sprite are close to those of water and 10% sugar solutions, respectively. Using a series of measurements, this method is accurate enough to detect about a 10% change in concentration of sugar and to determine if a soft drink is diet.

Summary Statement

The index of refraction increases with increasing concentration of sugar in water; this property can be used to distinguish a diet soft drink from a regular (sugar) soft drink.

Help Received

Father showed me how to do statistical tests. Mother helped assemble display. Henry McGilton modified digital protractor program (Protractor) to store measured angles.