

### Real-time measurement of Brix, Acid and the Brix / Acid Ratio

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#### Definition of °Brix

°Brix is a weight/weight measurement system calibrated using sucrose solution concentrations measured by a hydrometer and used to infer sweetness based on sugar content. The scale was named after Professor A.F.W. Brix who established the method in the late 19<sup>th</sup> century. The Brix scale was designed to measure the sweetness of unfermented grape juice prior to fermentation via density by means of a hydrometer. It assumed that grape juice was primarily sugar and water; therefore, other components could be ignored.

The Brix measurement is required by many food and beverage processors including producers of wine, sugar, fruit juice, soft drinks and many other industries using sweeteners and sugars in their products. The definition of Brix has evolved to mean an instrument calibrated using sucrose solutions to infer a product's sweetness. The Brix measurement is either measured directly or uses a correction for other variable substances which affect density (organic acids, ethanol or undissolved solids) to the best practice of a measurement technique.

°Brix is defined as the percentage of sucrose by weight in a solution. The Brix unit is a degree scale from 1-100. A solution that is 15°Brix is 15 percent sucrose by weight.

Traditional methods for measuring °Brix in beverages and juices is through lab and process refractometers, lab and process density meters, or flow meters. These traditional indirect methods of measuring °Brix derive measurement based on index of refraction or the density of the fluid at specific reference temperatures of 20°C.

#### Traditional Inline Brix Measurement: Common Issues.

**Inline Refractometers** use the refractive index (RI) of concentrations as the measurement technique. In juices, the RI of Brix and citric acid overlap making it impossible to differentiate them. In fact all refractometer measurements in juices require an acid correction per FDA rules. Solids in the beverage may also affect the refractive index; for example pulp in orange juice. A linear, non-logarithmic, relationship between concentration and refractive index makes a refractometer a poor choice for measuring concentrations below 1%. Additionally, a refractometer generally uses a visible source so color variations can pose measurement challenges. Process temperature variations may also affect results.

**Inline Density** meters use a fixed tube of a fixed length and orifice. Generally a pump forces process contents through the tube and back into the process pipes. Any residue on the tube narrows the tube and changes the measurement. The density tube is typically a sidestream measurement less sanitary than a mainstream device. Citric acid has a specific gravity of 1.665 so it looks like added Brix as far as density is concerned. The density of a diet beverage is close to that of water; therefore, it is difficult to tell the difference. Because density is a linear measurement technique, a color measurement is often required to supplement the density information in diet drinks. Any item which affects fluid density can affect the inferred Brix measurement. This is why CO2 compensation is often required for beverage measurements and is essential for diet measurements when using the density method.

**Inline Coriolis Mass Flow Meters** measure the velocity of a fluid through a u-shaped Coriolis flow pipe vibrating at a given frequency to derive mass

using the following formula: 
$$Q_m = \frac{K_u - I_u \omega^2}{2Kd^2} \tau$$

where  $K_u$  is the temperature dependent stiffness of the tube,  $K$  a shape-dependent factor,  $d$  the width,  $\tau$  the time lag,  $\omega$  the vibration frequency and  $I_u$  the inertia of the tube. Because the inertia of the tube depends on its contents, knowledge of the fluid density is required for the calculation of an accurate mass flow rate. Any residue in the tube looks like density to flow meters and fluctuations in process temperatures can lead to poor results. Induced frequencies from pumps and other instrument can also interfere with measurement. Mass flow cannot decipher between ingredients in a fluid and is affected by CO<sub>2</sub> concentration and other process gases.

## What is Acid?

Food acids (organic acids) are either a natural ingredient in products such as juice, vinegar, milk and wine or they are added to make flavors "sharper." They also can act as preservatives or antioxidants in products such as soda.

Common food acids include acetic acid, citric acid, phosphoric acid, tartaric acid, malic acid, fumaric acid, ascorbic acid and lactic acid. The measurement of total acids (TA) in beverages and juice is required by all producers as a key quality control indicator. Additionally, acid titrations are often used for diet beverage quality control.

Food acids are generally measured in grams per liter of titratable acidity (TA) or on the pH scale with a pH meter. Both methods are generally manual in nature and produce different results. A pH reading represents the overall strength of the acids and a titration reflects their quantity. The methods are not proportional.

### Traditional Acid Measurement: Common Issues.

Both titration and pH acid measurements are generally completed offline in a lab and can take as long 20 to 30 minutes to complete. A common issue is that lab reference measurements do not relate well to traditional inline measurements due to the fact that they are generally separate and distinct approaches. For example, inline instruments that measure diet soft drinks using density are often compared to lab titrations. These are two distinct measurement methods and they are very difficult to compare.

## VS-3000 Juice and Diet Beverage Sensor

VitalSensors' VS-3000 inline infrared sensor systems are designed to address the limitations of traditional

process instruments and laboratory techniques used to measure Brix and Acid in beverage and juice plants.

The benefits include:

- Direct, 24x7 inline measurement of ingredients using Beer-Lamberts Law for real-time Brix/Sugars and Organic Acids (Total Acid) measurement using one compact sensor
- Real-time Brix/Acid ratio
- Real-time measurement 17 times per second; ideal for blending and instantaneous control data
- Measures instantaneous product transition
- Sensor is not affected by temperature, pressure, flow, density or color,
- Solid-state device with no moving parts and requires no routine maintenance. No pumps or side-streams pipes required: sanitary measurement
- Brix measurements match lab reference methods
- Acid measurements match lab titration methods

## VS-3000 Principle of Operation

VS-3000 sensors are mid infrared optical sensors with no moving parts designed for years of trouble free service. Each VS-3000 sensor can measure up to three concentrations and temperature in real-time. Concentrations are measured through the use of specific optical filters at specific mid-infrared wavelengths. As a result, direct ingredient measurement of Acid and Brix/Sugar molecules is possible. Sensor materials are 316L stainless steel, an ultra-hard synthetic sapphire crystal and virgin PEEK.

## VS-3000 Technology in Action

Chart 1 shows VS-3000 real-time acid data in g/L from a soft drink plant for sugared and diet soft drinks. VS-3000 acid correlation to lab reference samples is excellent, an R<sup>2</sup> of .9947 allowing for blending control. Product transitions in the data can be seen clearly. The .008 w/w% resolution of the VS-3000 sensors allows for clear product differentiation without the use of other lab tests. Real-time acid data saves man months of lab time and testing; as well as leading to a higher quality product and plant optimization.

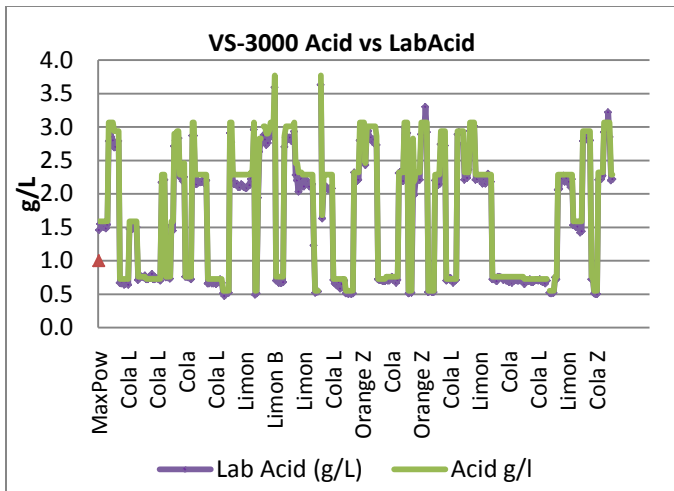


Chart 1

Chart 2 shows VS-3000 real-time Brix data for sugared and diet soft drinks versus lab refractometer samples over a three month period. The correlation is excellent with an  $R^2$  of .9947. Product transitions are clear and readings instantaneous helping to optimize plant production. .01°Brix resolution.

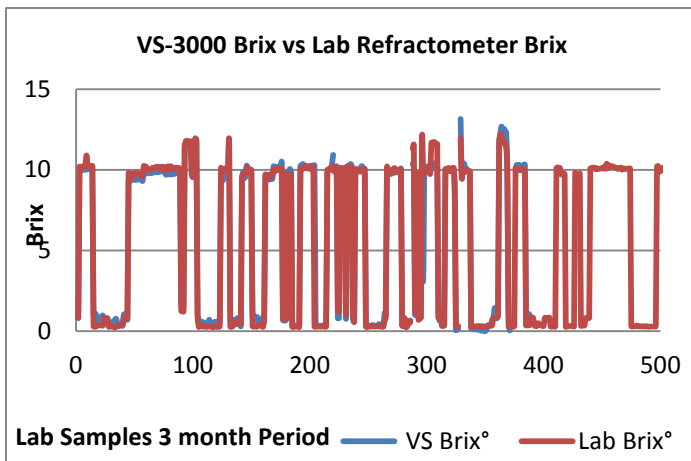


Chart 2

## Benefits

VS-3000 infrared optical sensors yield highly accurate real-time results of Brix/Sugars and Acids in soft drinks, juices, syrup, fruit products. The VS-3000 have low cost of ownership and can measure up to three concentrations, temperature and product transitions.

VS-3000 sensors have the capability to measure ingredients directly. Measurements are not inferred or calculated from index of refraction, density, or color. Designed for reliability, the sensors have no

moving parts and require no routine maintenance. As a result of the real-time Brix and Acid measurements the Brix/Acid ratio can be calculated automatically and in real-time.

## References

“The Soft Drink Companion, A Technical Handbook” by Maurice Shachman

“High Fructose Corn Syrup 42 and 55” by International Society of Beverage Technologists, 1994, 1999

“Determining Brix/Acid ratios with a two-component infrared analyzer” Paul Wilks in American Laboratory 1986

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