

► THE PRACTITIONER'S TOOL KIT

Brix and Salinity Refractometers: Great Inspection Tools

Editor's Note: The National Environmental Health Association (NEHA) strives to provide relevant and useful information for environmental health practitioners. In a recent membership survey, we heard your request for information in the *Journal* that is more applicable to your daily work. We listened and are pleased to feature this column from a cadre of environmental health luminaries with over 300 years of combined experience in the environmental health field. This group will share their tricks of the trade to help you create a tool kit of resources for your daily work.

The conclusions of this column are those of the authors and do not necessarily represent the official position of NEHA, nor does it imply endorsement of any products, services, or resources mentioned.

Introduction

A colleague wrote the following in a recent email: "Today they threw out nine 5-gallon containers of kimchi fermenting at room temperature. The sanitarian threw bleach on it, and my client is beside herself as she is a small business and sells it for \$10 per quart." Unfortunately, this example is not an isolated incident—it happens all too frequently and could have been easily avoided by a simple check of the pH and salinity.

Barring the lack of knowledge about the intrinsic and extrinsic parameters of food that affect microbial growth, water activity (a_w ; Food and Drug Administration [FDA], 2014), and acidity and alkalinity (pH) are often overlooked in routine inspections, water activity more so than pH. We tend to use temperature as the only or throwback measurement, thereby missing important parameters in keeping food safe. Somehow we never truly embraced Chapter 1-19 and 20: Time/Temperature Control for Safety Food in the 2022 *Food Code*, where a_w and pH are well-defined [FDA, 2023]. For those of us who work in food production, a_w is detailed and regularly used in 21 C.F.R. 113.10, 113.40 (i), 113.81(f), and 113.100 (a)(6).

When these two food safety control parameters were first introduced into the *Food Code* in 1993, one of us made a presentation extolling their virtues in disease prevention and how to evaluate and measure them in the field. Much to our surprise, a rejoinder came from a government source, stating that these parameters were meant only as a reference. We wondered why it was in the *Food Code* if that was the case. Since then, we have relied on a_w and pH in evaluating ethnic foods that do not rely on more common methods of preparation and holding. We also learned that most health departments have neither invested in water activity and pH field monitoring instrumentation nor provided adequate training on food microbiology for environmental health professionals who conduct retail food inspections. We even wrote about it in a previous column to raise awareness (Balsamo et al., 2024).

Unlike thermometry, field instrumentation for measuring a_w and pH has limited options and is rather pricey due to its complexity. This statement is particularly true for a_w measurement systems. Therefore, we tried to find a suitable and reasonably priced alternative to provide some needed field testing under lim-

ited conditions. Although not perfect, refractometry, both Brix ("Bx) and salinity/specific gravity can provide rapid analyses for foods fermented, cured, and preserved in sugar or brine solutions to ensure safe handling, presentation, and storage.

The Brix scale measures the concentration of dissolved sugar by mass in a liquid and was developed in the 19th century by Adolf Ferdinand Wenceslaus Brix, a German mathematician and engineer. It is widely used in winemaking, brewing, and food industries to determine crop maturity and potential alcohol content. Gabriel (2008) showed that we can estimate a_w from pH and Brix values of some food products.

The Refractometer and Its Uses

A refractometer is an optical instrument that measures the refractive index of a substance (Photo 1). The refractive index is essentially the degree to which light changes direction when passing through that substance. By determining this value, one can derive the concentration of solutes in a solution, most commonly sugars and salts in the food industry.

Brix measures the total amount of dissolved solids (primarily sugars) in a liquid using light refraction, while a_w measures the "free" or unbound water available in a product for microbial growth. Salinity measurements are basically the same, but it is important to note that they are inversely related to degrees Brix. As Brix (1 degree Brix equals 1% sucrose) and salinity (measured in mg or ppt) increase, a_w decreases.

While Brix, salinity, and a_w are used to evaluate food quality and shelf stability, they serve

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Photo 1: Brix (top) and salinity/specific gravity (bottom) refractometers. Photo courtesy of Dr. Robert Powitz.

different primary purposes. Although a high Brix number ($^{\circ}\text{Bx} > 65\text{--}70$) usually brings a_w down to a safer level, you cannot use Brix as a direct substitute for a_w when validating food safety or determining shelf stability. We can, however, determine if foods pose a reasonable risk of foodborne illness by taking Brix and salinity measurements, along with the pH of some foods we encounter and a bit of research. Had these measurements been done with the kimchi mentioned at the beginning of this column, a two-millennia history of preparation would have verified its safety, and we could have avoided creating a lack of trust, embarrassment, and economic loss.

We were introduced early in our careers to refractometers as a means of detecting adulteration. The refractometer was used to detect discrepancies in the expected refractive index of pure products. Any deviation from that number would result in further investigation. We primarily used refractometry on milk, honey, and beverages, particularly cider. We also used our refractometer to measure salinity and moisture content on products such as cheeses, pickles, and some dried fruits to determine storage conditions that prevent mold growth and ensure product longevity.

A third and probably the most important application for the refractometer is assessing food quality. It is not uncommon for institutions to procure food from resale and food liquidators, usually overstock items and salvage, including short-dated, close-out, or surplus inventory. Checking ripeness of vegetables and fruits by measuring crop juices in degrees Brix and comparing their refractive index to the Brix Index Food Quality Chart (www.transpacmarine.com/static/pdf/research/ag-chemistry/BrixChart.pdf). The chart provides readings to rate foods as poor, average, good, and excellent. When used along with plate-waste studies in correctional and other custodial care facilities, we are able to ensure that residents are receiving and consuming foods that are palatable and ensure proper nutrition. We routinely use our refractometers for that purpose.

Field Application: Sampling

There are two major types of refractometers: analog and digital. Analog refractometers are less expensive, do not need batteries, and are ideal for field use. Our refractometers are analog for degrees Brix and salinity. They are designed so that the solution being measured should be at room temperature, ideally at 25°C (77°F). Measurement is easily done, since the sample is only a few drops on the refractometer's prism. Calibration is important. To calibrate refractometers, start by adding 2–3 drops of distilled or deionized water to the refractometer prism. Close the lid to avoid bubbles and hold the instrument horizontally toward a light source. Read the horizontal line at the "0" mark. The horizontal line is a shadow at the angle where inner reflection occurs on the measurement scale. If needed, adjust the calibration screw located on top of the unit to 0 on the display.

After calibration, open the plastic cover and make sure the evaporation coating on

the front of the refractometer is clean and dry. Place 2–3 drops of the solution to be tested on the refractometer and squeeze the cover gently to evenly distribute the solution. Place the glass toward a source of light and read the value on the horizontal line through the eyepiece/viewfinder. To make sure that you are getting an accurate result, repeat these steps two or three times. On completion, clean the unit and stow it in its case. The case generally comes with a screwdriver to adjust calibration and a small pipette for applying distilled water and samples. That is all there is to it—fast, easy, and accurate.

Bottom Line

Both the Brix and salinity refractometers are essential adjuncts to our field instrument kit. They are inexpensive, rugged, and ideal for screening foods that are questionable in quality, preparation, service, and storage. And they are particularly helpful when used in concert with pH determination in estimating a_w . 🌸

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Did You Know?

September is National Food Safety Education Month. Every year, an estimated 1 in 6 people in the U.S. get sick from a foodborne disease. Check out our food safety resources at www.neha.org/food-safety_2. You can learn about the credentials, courses, and study materials we offer to strengthen your skills. You can also find numerous resources, including our allergen poster developed by our Food Safety Committee.