Brix

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For other uses, see Brix (disambiguation).

Degrees Brix (symbol °Bx) is the sugar content of an aqueous solution. One degree Brix is 1 gram of sucrose in 100 grams of solution and represents the strength of the solution as percentage by mass. If the solution contains dissolved solids other than pure sucrose, then the °Bx only approximates the dissolved solid content. The °Bx is traditionally used in the wine, sugar, carbonated beverage, fruit juice, and honey industries.

Comparable scales for indicating sucrose content are the degree Plato (°P), which is widely used by the brewing industry, and the degree Balling, which is the oldest of the three systems and therefore mostly found in older textbooks, but also still in use in some parts of the world.[1]

A sucrose solution with an apparent specific gravity (20°/20 °C) of 1.040 would be 9.99325 °Bx or 9.99359 °P while the representative sugar body, the International Commission for Uniform Methods of Sugar Analysis (ICUMSA), which favors the use of mass fraction, would report the solution strength as 9.99249%. Because the differences between the systems are of little practical significance (the differences are less than the precision of the instruments) and wide historical use of the Brix unit, modern instruments calculate mass fraction using ICUMSA official formulas but report the result as °Bx.

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Background [edit]

In the early 1800s, Karl Balling, followed by Adolf Brix, and finally the *Normal-Commissions* under Fritz Plato, prepared pure sucrose solutions of known strength, measured their specific gravities and prepared tables of percent sucrose by mass vs. measured specific gravity. Balling measured specific gravity to 3 decimal places, Brix to 5, and the Normal-Eichungs Kommission to 6 with the goal of the Commission being to correct errors in the 5th and 6th decimal place in the Brix table.

Equipped with one of these tables, a brewer wishing to know how much sugar was in his wort could measure its specific gravity and enter that specific gravity into the Plato table to obtain °Plato, which is the concentration of sucrose by percentage mass. Similarly, a vintner could enter the specific gravity of his must into the Brix table to obtain the °Bx, which is the concentration of sucrose by percent mass. It is important to point out that neither wort nor must is a solution of pure sucrose in pure water. Many other compounds are dissolved as well but these are either sugars, which behave very similarly to sucrose with respect to specific gravity as a function of concentration, or compounds which are present in small amounts (minerals, hop acids in wort, tannins, acids in must). In any case, even if °Bx are not representative of the exact amount of sugar in a must or fruit juice they can be used for comparison of relative sugar content.

Measurement [edit]

As specific gravity was the basis for the Balling, Brix and Plato tables, dissolved sugar content was originally estimated by measurement of specific gravity using a hydrometer or pycnometer. In modern times, hydrometers are still widely used, but where greater accuracy is required, an electronic oscillating U-tube meter may be employed. Whichever means are used, the analyst enters the tables with specific gravity and takes out (using interpolation if necessary) the sugar content in percent by mass. If the analyst uses the Plato tables (maintained by the American Society of Brewing Chemists[2]) he or she reports in °P. If using the Brix table (the current version of which is maintained by NIST and can be found on their website),[3] he or she reports in °Bx. If using the ICUMSA tables,[4] he or she would report in mass fraction (m.f.). It is not, typically, actually necessary to consult tables as the tabulated °Bx or °P value can be printed directly on the hydrometer scale next to the tabulated value of specific gravity or stored in the memory of the electronic U-tube meter or calculated from polynomial fits to the tabulated data. Both ICUMSA and ASBC have published suitable polynomials; in fact, the ICUMSA tables are calculated from the polynomials. The opposite is true with the ASBC polynomial. Also note that the tables in use today are not those published by Brix or Plato. Those workers measured true specific gravity reference to water at 4 °C using, respectively, 17.5 °C and 20 °C, as the temperature at which the density of a sucrose solution be measured. Both NBS and ASBC converted to apparent specific gravity at 20 °C/20 °C. The ICUMSA tables are based on more recent measurements on sucrose, fructose, glucose and invert sugar, and they tabulate true density and weight in air at 20 °C against mass fraction.

Dissolution of sucrose and other sugars in water changes not only its specific gravity but its optical properties in particular its refractive index and the extent to which it rotates the plane of linearly polarized light. The refractive index, nD, for sucrose solutions of various percentage by mass has been measured and tables of nD vs. °Bx published. As with the hydrometer, it is possible to use these tables to calibrate a refractometer so that it reads directly in °Bx. Calibration is usually based on the ICUMSA tables,[5] but the user of an electronic refractometer should verify this.

Sugars also have known infrared absorption spectra and this has made it possible to develop instruments for measuring sugar concentration using NIR (Near Infra Red) and FT-IR (Fourier Transform Infrared Spectrometry) techniques. In the former case, in-line instruments are available which allow constant monitoring of sugar content in sugar refineries, beverage plants, wineries, etc. As with any other instruments, NIR and FT-IR instruments can be calibrated against pure sucrose solutions and thus report in °Bx, but there are other possibilities with these technologies, as they have the potential to distinguish between sugars and interfering substances.

Tables [edit]

Approximate values of °Bx can be computed from $231.61 \times (S - 0.9977)$, where S is the apparent specific gravity of the solution at 20 °C/20 °C. More accurate values are available from °Bx = (((182.4601*S -775.6821)*S +1262.7794)*S -669.5622), derived from the NBS table with S as above. This should not be used above S = 1.17874 (40 °Bx). RMS disagreement between the polynomial and the NBS table is 0.0009 °Bx. The Plato scale can be approximated by the Lincoln Equation °P = (463-205*S)*(S-1) or values obtained with high accuracy with respect to the ASBC table from the ASBC polynomial °P = (((135.997*S - 630.272)*S + 1111.14)*S - 616.868).

The difference between the °Bx and °P as calculated from the respective polynomials is: °P - °Bx = (((-2.81615*S +8.79724)*S - 9.1626)*S +3.18213). The difference is generally less than ±0.0005 °Bx or °P with the exception being for weak solutions. As 0 °Bx is approached °P tend towards as much as 0.002 °P higher than the °Bx calculated for the same specific gravity. Disagreements of this order of magnitude can be expected as the NBS and the ASBC used slightly different values for the density of air and pure water in their calculations for converting to apparent specific gravity. It should be clear from these comments that Plato and Brix are, for all but the most exacting applications, the same. Note: all polynomials in this article are in a format that can be pasted directly into a spreadsheet.

When a refractometer is used, the Brix value can be obtained from the polynomial fit to the

ICUMSA table: Bx = (((((11758.74*nD -88885.21)*nD + 270177.93)*nD - 413145.80)*nD + 318417.95)*nD -99127.4536) where nD is the refractive index, measured at the wavelength of the sodium D line (589.3 nm) at 20 °C. Temperature is very important as refractive index changes dramatically with temperature. Many refractometers have built in "Automatic Temperature Compensation" (ATC) which is based on knowledge of the way the refractive index of sucrose changes. For example, the refractive index of a sucrose solution of strength less than 10 °Bx is such that a 1 °C change in temperature would cause the Brix reading to shift by about 0.06 °Bx. Beer, conversely, exhibits a change with temperature about three times this much. It is important, therefore, that users of refractometers either make sure the sample and prism of the instrument are both at very close to 20 °C or, if that is difficult to ensure, readings should be taken at 2 temperatures separated by a few degrees, the change per degree noted and the final recorded value referenced to 20 °C using the Bx vs. Temp slope information.

Usage [edit]

See also: Ripeness in viticulture

The three scales are often used interchangeably since the differences are minor.

- Brix is primarily used in fruit juice, wine making, carbonated beverage industry, starch and the sugar industry.
- Plato is primarily used in brewing.
- Balling appears on older saccharimeters and is still used in the South African wine industry and in some breweries.

Brix is used in the food industry for measuring the approximate amount of sugars in fruits, vegetables, juices, wine, soft drinks and in the starch and sugar manufacturing industry. Different countries use the scales in different industries: In brewing, the UK uses specific gravity X 1000; Europe uses Plato degrees; and the US use a mix of specific gravity, degrees Brix, degrees Baumé, and degrees Plato. For fruit juices, 1.0 degree Brix is denoted as 1.0% sugar by mass. This usually correlates well with perceived sweetness.

Modern optical Brix meters are divided into two categories. In the first are the Abbe-based instruments in which a drop of the sample solution is placed on a prism; the result is observed through an eyepiece. The critical angle (the angle beyond which light is totally reflected back into the sample) is a function of the refractive index and the operator detects this critical angle by noting where a dark-bright boundary falls on an engraved scale. The scale can be calibrated in Brix or refractive index. Often the prism mount contains a thermometer which can be used to correct to 20 °C in situations where measurement cannot be made at exactly that temperature. These instruments are available in bench and handheld versions.

Digital refractometers also find the critical angle, but the light path is entirely internal to the prism. A drop of sample is placed on its surface, so the critical light beam never penetrates the sample. This makes it easier to read turbid samples. The light/dark boundary, whose position is proportional to the critical angle, is sensed by a CCD array. These meters are also available in bench top (laboratory) and portable (pocket) versions. These are the easiest to use of all the methods for estimating Brix and can be used on location with minimal training. A drop of distilled water is placed on the prism to calibrate them; the distilled water is then replaced by a drop of juice from the fruit being measured. This ability to easily measure Brix in the field makes it possible to determine ideal harvesting times of fruit and vegetables so that products arrive at the consumers in a perfect state or are ideal for subsequent processing steps such as vinification.

Due to higher accuracy and the ability to couple it with other measuring techniques (%CO2 and %alcohol), most soft drink companies and breweries use an oscillating U-tube density meter. Refractometers are still commonly used for fruit juice.

Brix and Actual Dissolved Solids Content [edit]

When a sugar solution is measured by refractometer or density meter, the °Bx or °P value obtained by entry into the appropriate table only represents the amount of dry solids dissolved in the sample if the dry solids are exclusively sucrose. This is seldom the case. Grape juice (must), for example, contains little sucrose but does contain glucose, fructose, acids and other substances. In such cases, the °Bx value clearly cannot be equated with the sucrose content, but it may represent a good approximation to the total sugar content. For example, an 11.0% by mass D-Glucose ("grape sugar") solution measured 10.9 °Bx using a hand held instrument.[citation needed] For these reasons, the sugar content of a solution obtained by use of refractometry with the ICUMSA table is often reported as "Refractometric Dry Substance" (RDS)[6] which could be thought of as an equivalent sucrose content. Where it is desirable to know the actual dry solids content, empirical correction formulas can be developed based on calibrations with solutions similar to those being tested. For example, in sugar refining, dissolved solids can be accurately estimated from refractive index measurement corrected by an optical rotation (polarization) measurement.

Alcohol has a higher refractive index (1.361) than water (1.333). As a consequence, a refractometer measurement made on a sugar solution once fermentation has begun will result in a reading substantially higher than the actual solids content. Thus, an operator must be certain that the sample he is testing has not begun to ferment. Brix or Plato measurements based on specific gravity are also affected by fermentation, but in the opposite direction; as ethanol is less dense than water, an ethanol/sugar/water solution gives a Brix or Plato reading which is artificially low.

References [edit]

1. ^ Hough, J.S., D. E. Briggs, R. Stevens and T. W. Young, "Malting and Brewing Science, Vol 2 Hopped Wort and Beer", Chapman & Hall, London,1971
2. ^ "ASBC Methods of Analysis", ASBC; St. Paul Table 1: Extract in Wort and Beer
3. ^ Bates, Frederick (1 May 1942). "Polarimetry, Saccharimetry and the Sugars. Table 114: Brix, apparent density, apparent specific gravity, and grams of sucrose per 100 ml of sugar solutions" (PDF). *http://www.boulder.nist.gov/div838/publications.html*. Retrieved 10 January 2014.
4. ^ "ICUMSA Methods Book" op. cit. Specification and Standard SPS-4 Densimitry and Tables: Sucrose - Official; Glucose, Fructose and Invert Sugars - Official
5. ^ "ICUMSA Methods Book", op. cit.; Specification and Standard SPS-3 Refractometry and Tables - Official; Tables A-F
6. ^ "ICUMSA Methods Book, op. cit. Method GS4/3/8-13 (2009) "The Determination of Refractometric Dry Substance (RDS %) of Molasses - Accepted and Very Pure Syrups (Liquid Sugars), Thick Juice and Run-off Syrups - Official",

Further reading [edit]

- Boulton, Roger; Vernon Singleton; Linda Bisson; Ralph Kunkee (1996). *Principles and Practices of Winemaking*. Chapman & Hall. ISBN 0-412-06411-1
- Rene Martinez VitalSensors Technologies LLC. "VS1000B Series In-Line Brix Sensors for the Beverage Industry" (PDF).— Martinez describes the theory and practice of measuring brix on-line in beverages.
- Examples of combined laboratory systems for measuring Brix and CO2 in soft drinks and Plato, CO2, % alcohol, pH, and colour in beer simultaneously. Also in-line versions of these instruments are available.

External links [edit]

- Brix vs relative density
- Brix to Specific Gravity Table
- Brix, Specific Gravity & Sugar Conversions
- Brix, Plato, Balling, Specific gravity

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