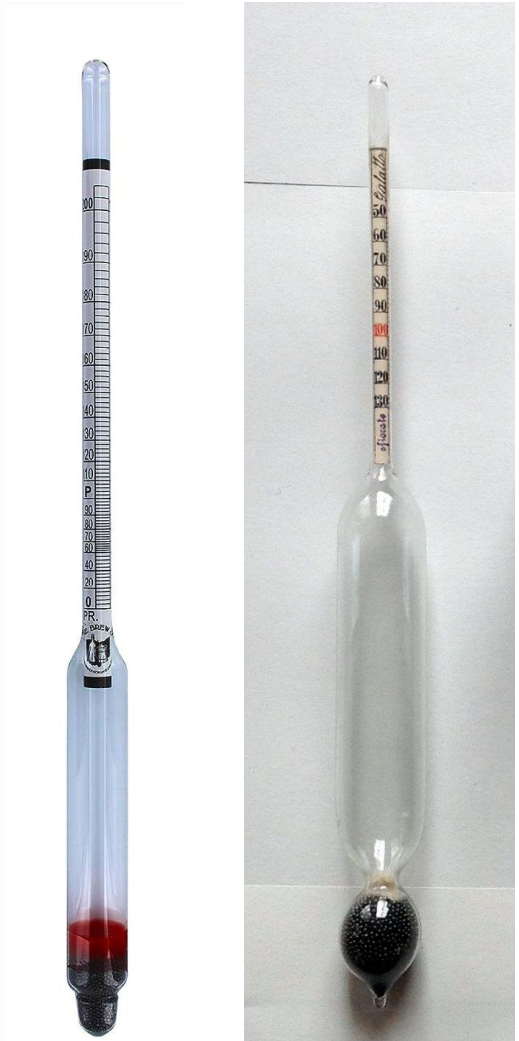
By Adam Kugler

Let's discuss the Alcohol content in our homebrews

There are many different ways to measure the alcohol content of beer. One way is to use a hydrometer or a refractometer. These are instruments that measure the relative density (or sugar content) of a liquid, and allow us to calculate the ABV based on the difference between the initial and final readings. A Pycnometer or a Distillation Apparatus are alternate alcohol measurement devices that will not be discussed here. So let's talk about hydrometers first.

Hydrometer

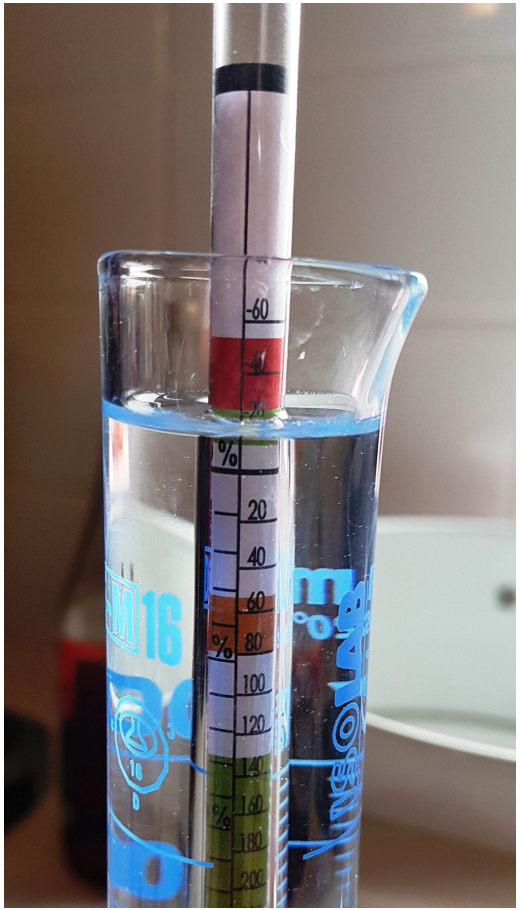
A hydrometer or lactometer (in the dairy industry) is an instrument used for measuring the density of liquids based on the concept of buoyancy. They are typically calibrated and graduated with one or more scales such as specific gravity.



A hydrometer usually consists of a sealed hollow glass tube with a wider bottom portion for buoyancy, a ballast such as lead or mercury for stability, and a narrow stem with graduations for measuring. Liquid is poured into a tall container, often a graduated cylinder, and the hydrometer is **gently** lowered into the liquid until it floats freely. The point at which the surface of the liquid touches the stem of the hydrometer correlates to relative density. Hydrometers can contain any number of scales along the stem corresponding to the density of the liquid. We care about the gravity measurement. They are also very, very delicate.

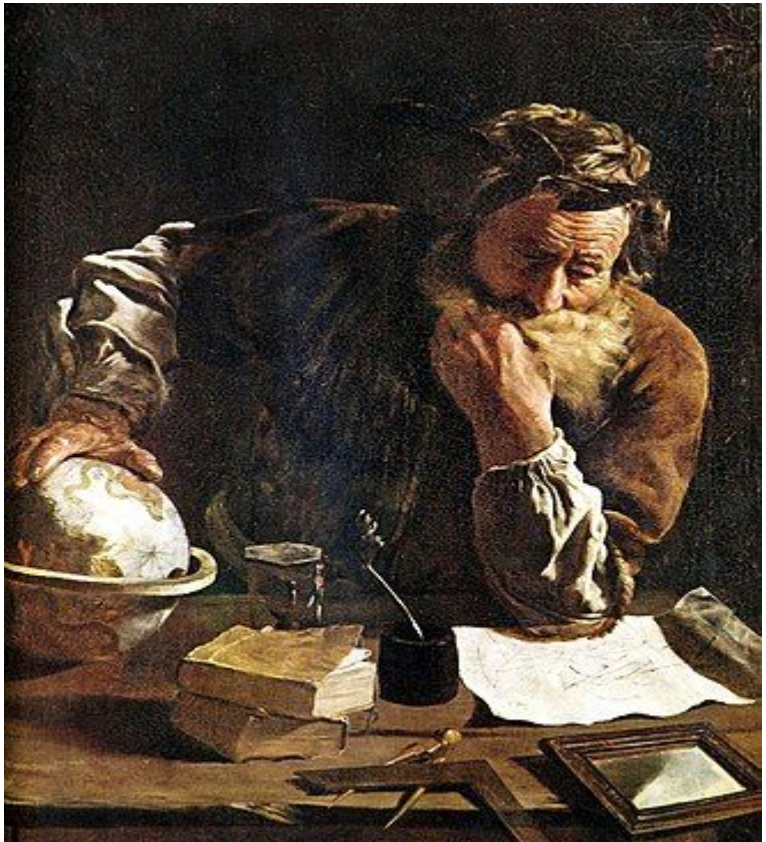
Hydrometer Reading

The hydrometer makes use of Archimedes' principle: a solid suspended in a fluid is buoyed by a force equal to the weight of the fluid displaced by the submerged part of the suspended solid. The lower the density of the fluid, the deeper a hydrometer sinks. The stem is calibrated to give a numerical reading. Your reading is displayed on the stem at the meniscus.



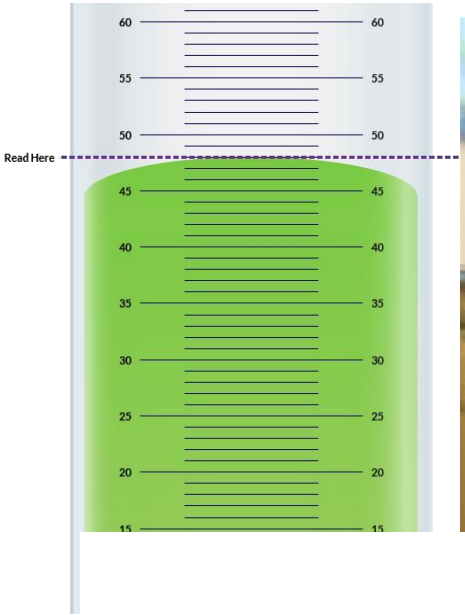
Hold up, who dat Archimedes is?

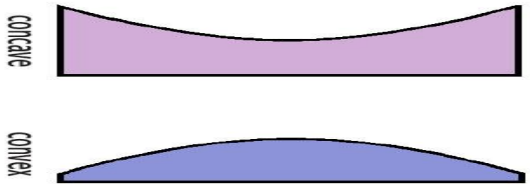
Archimedes of Syracuse (c. 287 – c. 212 BC) was an Ancient Greek mathematician, physicist, engineer, astronomer, and inventor from the ancient city of Syracuse in Sicily. Although few details of his life are known, he is regarded as one of the leading scientists in classical antiquity. Considered the greatest mathematician of ancient history, and one of the greatest of all time. Now back to the meniscus…



How To Read A Meniscus

If the liquid forms a curve, how are you expected to make an accurate measurement of the amount of liquid in a container? To read a meniscus, you first need to see what type of meniscus your liquid forms. If the meniscus is a concave meniscus, read at the lowest level of the curve. If the meniscus is convex, **take your measurement at the highest point of the curve.**





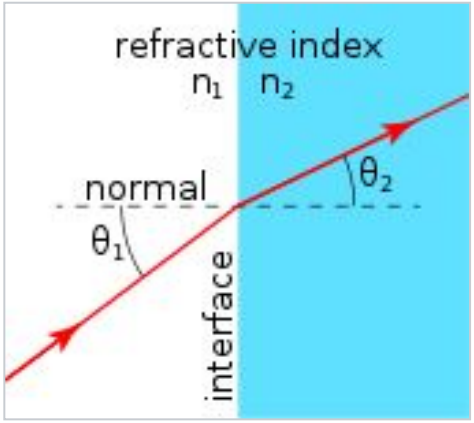
Is there another easy way to take a pre-fermentation gravity reading that doesn't involve a delicate hydrometer?

Yes. A Refractometer

A **refractometer** is a laboratory or field device for the measurement of an index of refraction (refractometry). The index of refraction is calculated from the observed refraction angle using Snell's law. For mixtures, the index of refraction then allows us to determine the concentration using mixing rules such as the Gladstone–Dale relation and Lorentz–Lorenz equation which I am not covering. Anyway...

Refraction

In optics, the **refractive index** (or **refraction index**) of an optical medium is a dimensionless number that gives the indication of the light bending ability of that medium. The refractive index determines how much the path of light is bent, or refracted, when entering a material. Thomas Young 1807. A refractometer accurately measures Brix. What is Brix?



Not those type of brix

What is Brix?

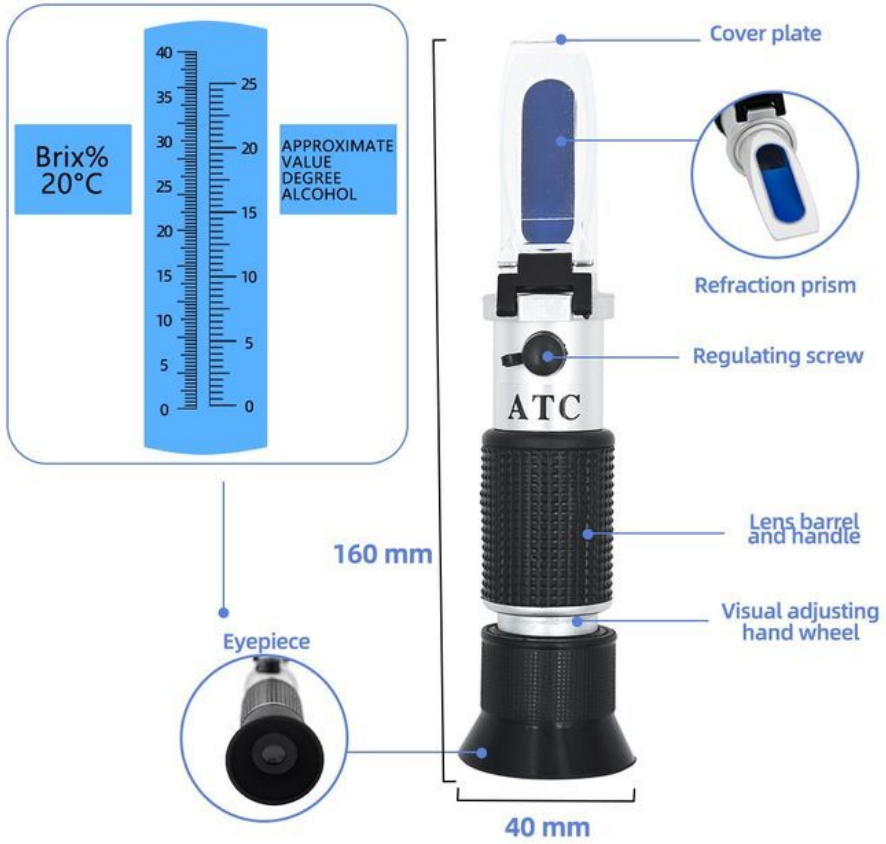
Brix is a measure of the concentration of dissolved solids, most noticeably sugars, in a solution. The “Brix” portion of the measurement is derived from the name of the German scientist, Anton Brix, who developed a standard scale in the early 19th century for measuring the amount of sugar in a liquid.

20% Brix refers to a solution which has 20 grams of sugar dissolved in 100 milliliters of water. In the wine industry, Brix measurements are taken of the must or grape juice to determine the sugar content prior to fermentation.

This is important because the higher the sugar level, the higher the potential alcohol content of the resulting wine. Therefore, a 20% Brix sugar content would indicate a substantial sugar content, and could potentially produce a wine with a higher alcoholic content. Brix is easily measured with a refractometer.

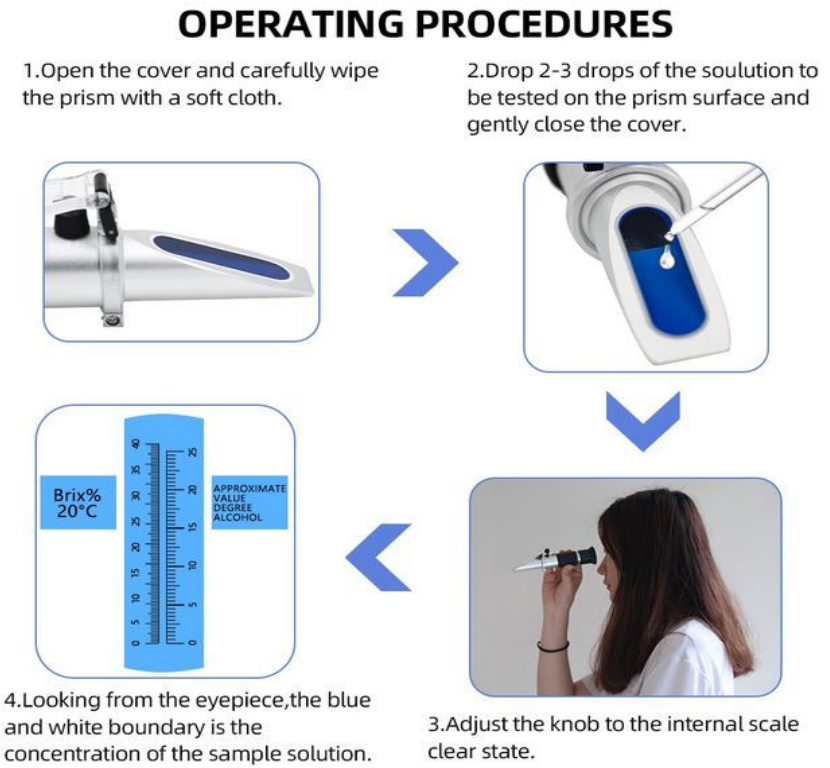
Refractometers in brewing

A sugar refractometer is an instrument used to measure the amount of sugar in a solution. It does this by using **light refraction**, or the bending of light. When light passes through a solution, different sugar levels will cause light to bend at different angles. This angle is then read and converted into the sugar concentration of the sample.



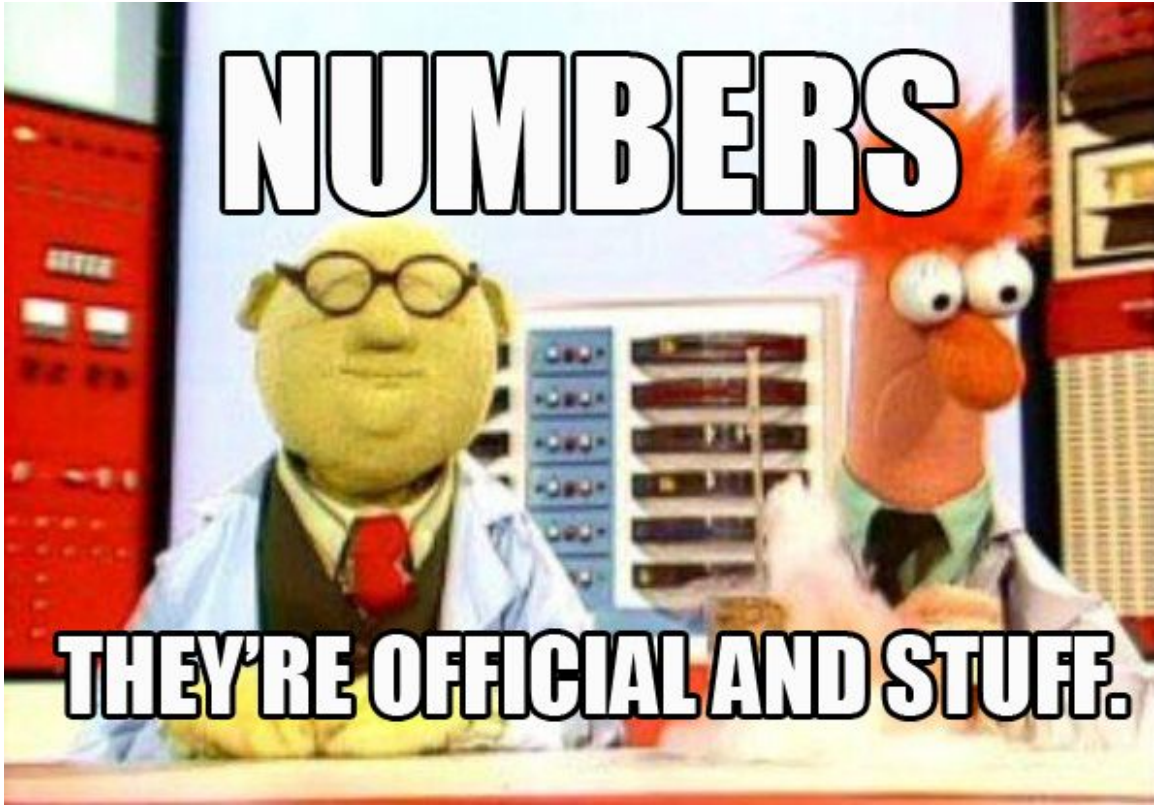
Use

With a refractometer, one drop of a liquid sample is placed on a glass or plastic prism, and a beam of light is then directed onto the sample. The amount of light that is deflected is then used to determine the refractive index of the sample, which in turn is used to calculate the concentration of the dissolved solids.



Brix (°Bx)	Plato	SG
0.0	0.0	1000
1.0	1.0	1004
2.0	2.1	1008
3.0	3.1	1012
4.0	4.2	1016
5.0	5.2	1020
6.0	6.2	1025
7.0	7.3	1029
8.0	8.3	1033
9.0	9.4	1037
10.0	10.4	1042
11.0	11.4	1046
12.0	12.5	1050
13.0	13.5	1055
14.0	14.6	1059
15.0	15.6	1064
16.0	16.6	1068
17.0	17.7	1073
18.0	18.7	1077
19.0	19.8	1082
20.0	20.8	1087
21.0	21.8	1091
22.0	22.9	1096
23.0	23.9	1101
24.0	25.0	1106
25.0	26.0	110
26.0	27.0	1115
27.0	28.1	1120

2nd Topic of discussion: Inaccuracy of scale



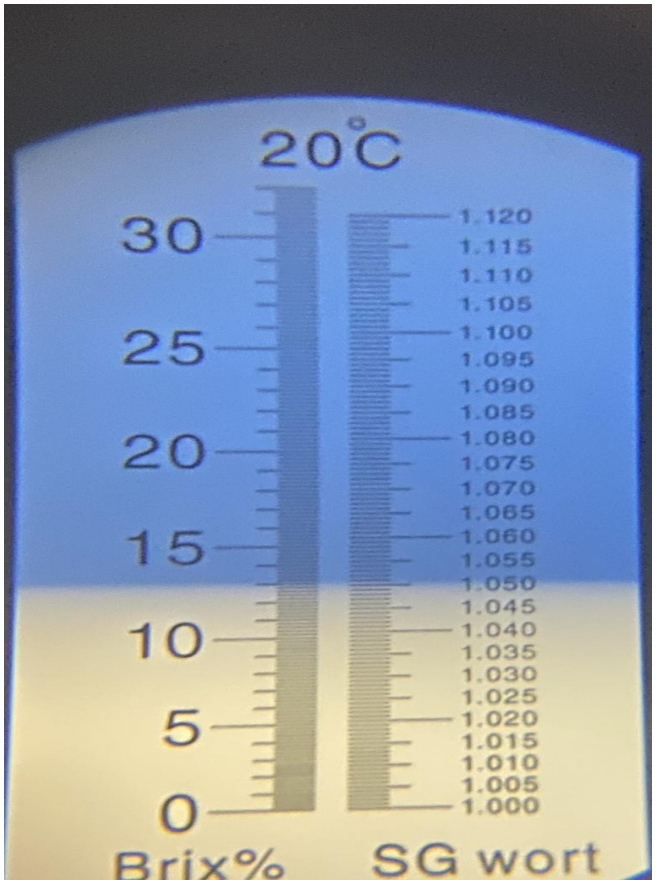
Gravity Reading of my Festbeer

Brix to Specific Gravity Calculator:

Brix: 13

UPDATE

Specific Gravity: 1.0526



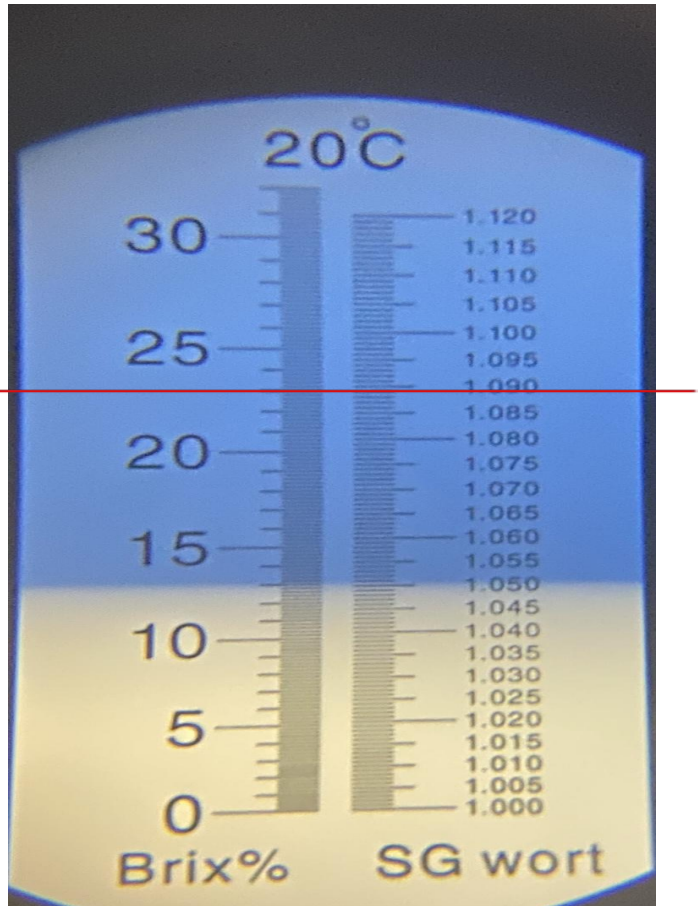
Higher gravity reading
(red line is 23 brix)

Brix to Specific Gravity Calculator:

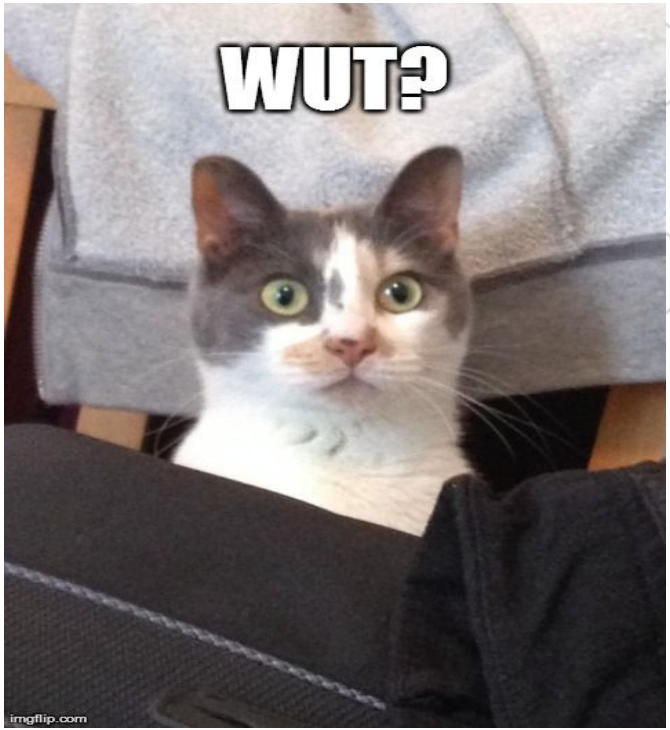
Brix: 23

UPDATE

Specific Gravity: 1.0965



WTF?



23 Brix is showing a gravity reading of 1.089 on refractometer and conversion calculator shows 1.096. How can this be?

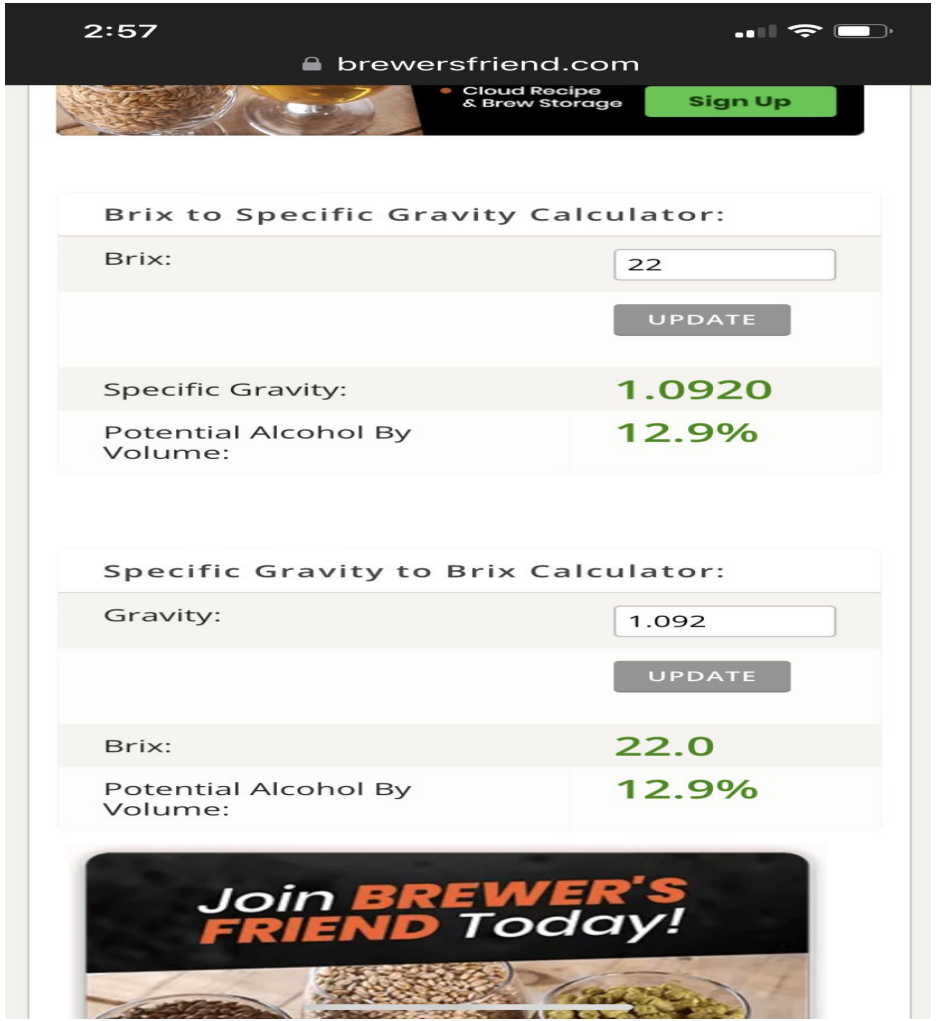
Simple. The SG scale is wrong. Only use Brix. A refractometer is incapable of measuring SG. It's an approximation, and in this case especially, it's pretty far off.

Instead of using that SG scale, use a conversion tool like this, which is way more accurate when done properly, both for OG and FG:

https://www.brewersfriend.com/refractometer-calculator/

Brix Conversion Calculator

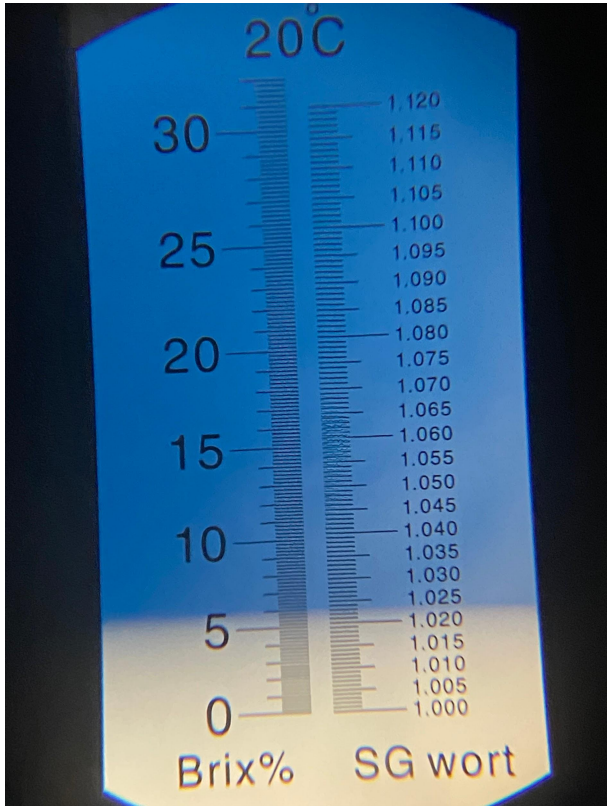
This calculator converts Brix to Specific Gravity and Specific Gravity to Brix. Some hydrometers have only one or the other, which is where this calculator comes in. Computes potential alcohol by volume (for use in dry wines). The Plato and Balling scale are very close to the Brix scale and can be used here interchangeably. The higher the number, the more sugar is in solution. Ultimately this translates into a higher alcohol volume in the finished product. Wine makers typically use Brix. Beer brewers go by Plato in the professional world, and Specific Gravity in the home brewing world.



What does this mean?

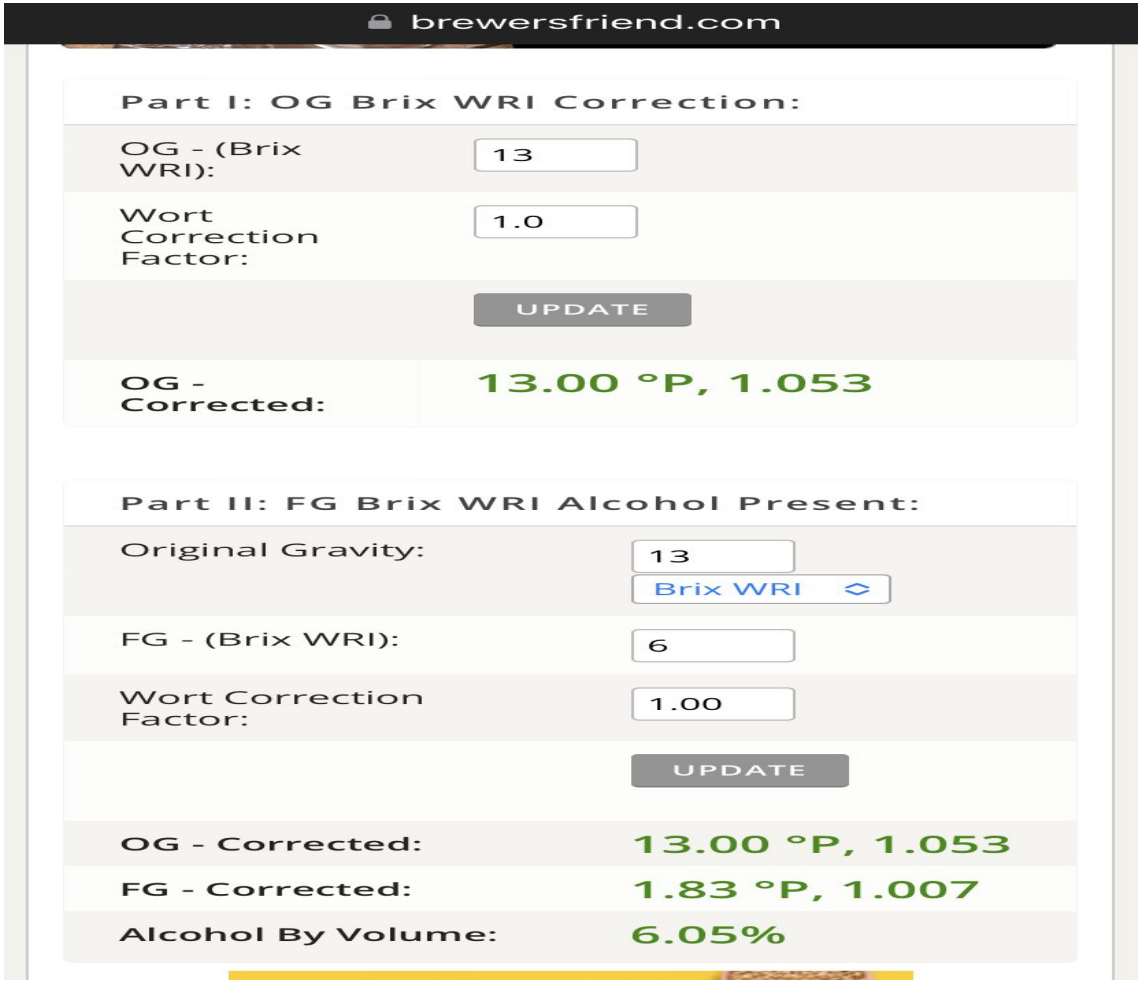
For Average strength beers the gravity reading on a refractometer is fine, but on higher gravity beers you may want to use the brix scale and convert it for better alcohol by volume accuracy.

3rd topic: refractometer post fermentation



Refractometer reading post fermentation

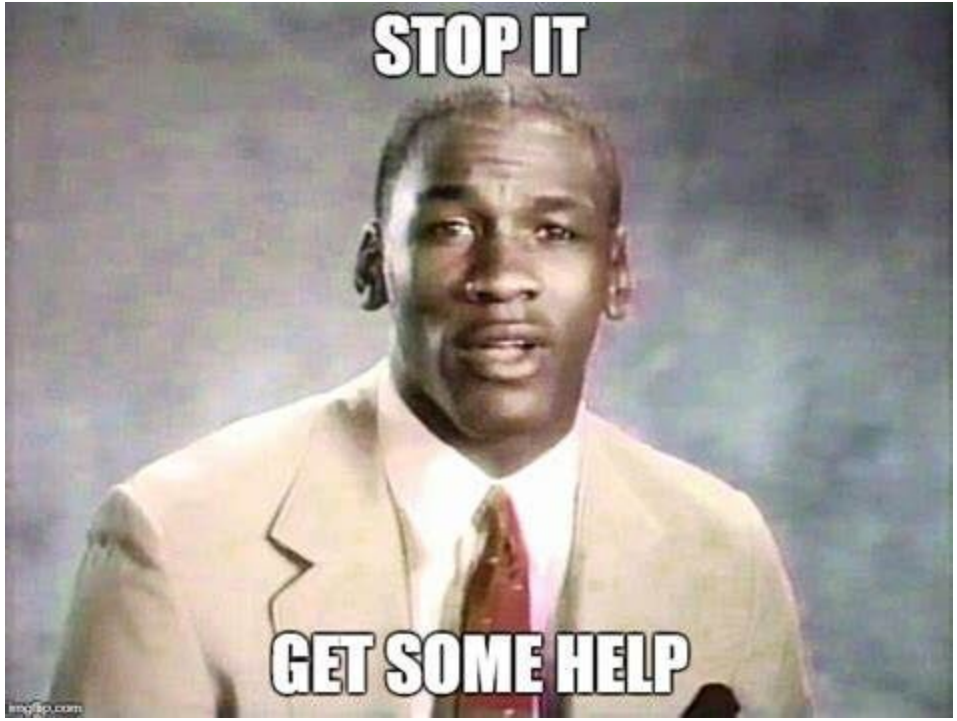
I historically have only used Refractometers prior to fermentation. Once fermentation had started, I was instructed that refractometer readings may be inaccurate due to the now presence of alcohol. I USED TO think A hydrometer was the preferred tool for measuring gravity readings after fermentation had begun. I am not so sure now. **You can use a conversion calculator to use a refractometer post fermentation and I tried it out yesterday.**



Hydrometer reading 1.007ish

This is the same number the calculator from previous slide came up with

4th Topic



Now that we have pre and post fermentation gravity readings, how do we determine alcohol content ? (standard equation)

$$ABV = (OG - FG) * 131.25$$

How do you calculate gravity in beer? The basic formula used by most homebrewers is pretty simple: **ABV = (OG – FG) * 131.25**. ABV = alcohol by volume, OG = original gravity, and FG = final gravity. So, using this formula with beer having an OG of 1.055 and a FG of 1.015, your ABV would be 5.25%.

Theinstituteofbeer.com

Standard Equation

Alcohol By Volume ABV Calculator

This calculator determines the ABV of your beer based on the gravity change before and after fermentation. If you took an original gravity reading (or had estimated OG), and also took a final gravity (FG) reading prior to adding priming sugar at bottling you can find out your batch's alcohol by volume ABV.

Be sure to also check out our Hydrometer Temperature Adjustment Calculator, and Brix Converter.

Alcohol By Volume Calculator:

Gravity Unit:	(•) SG (1.xxx) ( ) Plato °P
Original Gravity (OG):	1.053
Final Gravity (FG):	1.007
Equation:	(•) Standard ( ) Alternate *(see below for more information)*
	UPDATE
Alcohol By Volume:	**6.04%**

Alternate Equation

Alcohol By Volume ABV Calculator

This calculator determines the ABV of your beer based on the gravity change before and after fermentation. If you took an original gravity reading (or had estimated OG), and also took a final gravity (FG) reading prior to adding priming sugar at bottling you can find out your batch's alcohol by volume ABV.

Be sure to also check out our Hydrometer Temperature Adjustment Calculator, and Brix Converter.

Alcohol By Volume Calculator:

Gravity Unit:	(•) SG (1.xxx) ( ) Plato °P
Original Gravity (OG):	1.053
Final Gravity (FG):	1.007
Equation:	( ) Standard (•) Alternate *(see below for more information)*
	UPDATE
Alcohol By Volume:	**6.15%**

High Gravity Standard Equation

Alcohol By Volume Calculator:

Gravity Unit:	◉ SG (1.xxx) ○ Plato °P
Original Gravity (OG):	1.110
Final Gravity (FG):	1.015
Equation:	◉ Standard ○ Alternate *(see below for more information)*
	UPDATE
Alcohol By Volume:	**12.47%**

High Gravity alternate equation

Alcohol By Volume Calculator:

Gravity Unit:	(●) SG (1.xxx) ( ) Plato °P
Original Gravity (OG):	1.110
Final Gravity (FG):	1.015
Equation:	( ) Standard (●) Alternate *(see below for more information)*
	UPDATE
Alcohol By Volume:	13.89%

Alternate Formula

A more complex equation which attempts to provide greater accuracy at higher gravities is:

ABV =(76.08 * (og-fg) / (1.775-og)) * (fg / 0.794)

The alternate equation reports a higher ABV for higher gravity beers. This equation is just a different take on it. Scientists rarely agree when it comes to equations. There will probably be another equation for ABV down the road.

The complex formula, and variations on it come from *Ritchie Products Ltd, (Zymurgy, Summer 1995, vol. 18, no. 2) -Michael L. Hall's article Brew by the Numbers: Add Up What's in Your Beer, and Designing Great Beers by Daniels.*

Why is there a difference in calculations?

1. The relationship between the change in gravity, and the change in ABV is not linear. All these equations are approximations.
2. Some calculators round internally as they go. The Brewer's Friend calculator rounds only at the very end, which means significant digits are kept along the way (making it more true to the equation).
3. Other online calculators should be close to one of the two equations reported by the Brewer's Friend ABV Calculator. If not, they are doing their own thing which warrants inquiry.

Which equation should I use?

Most of us probably use the basic equation. I know I do on beers under 8 % ABV. If you don't like math, go with the basic equation.

If you are really into math and numbers and sciencey stuff, and want to brew a lot of high gravity beers, or prefer Daniels over Papazian, use the advanced equation.

Either way, they are close for beers below 6% ABV. The difference does get larger as the gravity increases.

In conclusion

Accurately knowing the alcohol content of your homebrews can help you and your friends make educated decisions on consumption.

Cheers!

THE END

Any questions?