Precision Brix Measurement: The role of digital benchtop refractometers in beverage packing

Kevin Chapman | Senior Product Manager, Xylem Analytics (**kevin.chapman@xylem.com**)
Michelle Kuzio | Product Manager, Xylem Lab (**michelle.kuzio@xylem.com**)

YSI.com/products/refractometers

Introduction

How do refractometers work?

A refractometer is an instrument designed to measure an optical constant, which is a characteristic of the material being examined. This optical constant is known as "Refractive Index" and can be used to give valuable information about the material being tested.

The fundamental definition of refractive index is based on the speed of light. Light travels at a constant speed in a vacuum (approximately 300,000 km/second), but the speed is reduced when the light passes through any other medium. The ratio of these two speeds is the refractive index of the medium.

$$n = \frac{c}{v}$$

n = refractive index of given substance
c = speed of light in a vacuum
v = speed of light in substance

When light changes speed as it passes from one medium to another, we call it "refraction". This principle can be seen clearly with the naked eye; for instance, when looking at an oarsman on the river, where an oar appears to be bent as it passes through the water.

Often refractometers measuring refractive index will convert the reading into a concentration measurement; typically, of sugar (°Brix) for food applications or other easily useable concentration scales relative to the products being measured. Although Brix, or specific gravity, is typically associated with any dissolved solids in a liquid, when dealing with high sugar matrixes, such as wine, fruit juice, or beer, the major dissolved constituent will be sugar. One degree of Brix is equal to one gram of sucrose in 100 grams of solution.

This poster will demonstrate the accuracy, precision and most importantly the applicability of using refractometer data in QA/QC operations.

Experimental

The instrument used for this evaluation was the Bellingham + Stanley RFM340-T Refractometer. There are three key features that were critical for the success of this testing.

1. A large sampling area on the prism surface allows measurement of not only homogenous fluids like juices, sodas, sauces and edible oils, but also difficult to read samples like fruit pulps.
2. Thermodynamic control system of the sample and optics. This temperature stability was achieved using a Peltier control system to ensure that the readings were only taken when the sample and optical system had reached equilibrium. Of note, refractive index is inversely proportional to the temperature of the sample. The higher the temperature, the lower the refractive index. The same sample can give two different readings simply by changing the temperature. That is why this feature is imperative to achieve the high precision and accuracy reported in the results section of this poster.
3. The instrument was calibrated using certified reference materials traceable to NIST and ICUMSA®

Table 1.RFM340-T Specifications

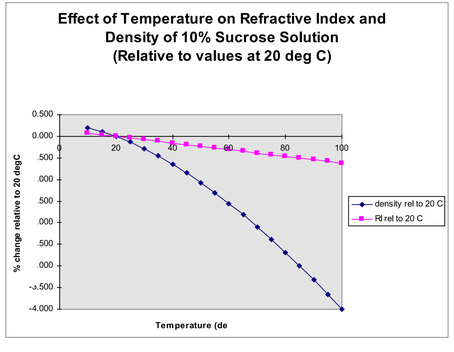
Specifications	RFM340-T
Scales	
Refractive index	1.32 – 1.58
Sugar (°Brix)	0 – 100
User-defined	100
Resolution	
Refractive index	0.000001(selectable up to 6 d.p.)
Sugar (°Brix)	0.01 / 0.001 (selectable up to 3 d.p.)
Accuracy	
Refractive index	±0.00002 (1.32 – 1.38 RI), ±0.00004 (1.38 – 1.58 RI)
Sugar (°Brix)	±0.010 (0 – 30 °Brix) ±0.030, (30 – 100 °Brix)
Precision (Reproducibility)	
Refractive Index	± 0.000005 (6 d.p.)
Sugar (°Brix)	± 0.005 (3 d.p.)
User Scale Library	20+ pre-programmed scales including HFCS (3), sugar (4), sucrose SG (3), NaCl, Butyro, Wine Must (5), Urine SG (3), PHR-MEAN and more; plus customer programmable user scales via PC.
Reading Time	Minimum 4 seconds dependent on precision required
Measuring Temperature Range	0°C or 10°C below ambient whichever is greater to 70°C
Temperature Sensor Accuracy	± 0.03 °C
Sample Temperature Stability	± 0.05 °C
Temperature Compensation Sucrose (°Brix)	5 – 80 °C
Temperature Compensation AG Fluids	5 – 40 °C
Temperature Compensation User-defined	Simple coefficient (units/ °C) or polynomial function
Temperature Stability Checks	None/delay time/repeatability/ Smart (independently selectable by Method)
Sample Illumination	Light Emitting Diode 589nm (100,000+ hours)
Prism / Dish	Artificial Sapphire / Stainless Steel 316 / PEEK (spill barrier)
Prism Seal	Silicone/Resin
Interfaces	3 x USB (A), 1 x Ethernet, RS232 via USB adaptor (optional accessory)
Power	Instrument: 24 V DC, ±5%, <2A, External PSU: 100-240V, 50-60Hz
Humidity Range	<90% RH (non-condensing)

Results

Importance of temperature stability

Although this poster is focused on refractometry, the data below demonstrates the temperature effect on not only refractometry but also densitometry. Without the stable temperature control, the data from sample to sample will shift considerably.

Figure 1



The data presented is for 4 types of samples, distilled water, sucrose solutions, lemon syrup and cola syrup. Each sample was prepared for measurement in order to achieve the best possible measurement outcome, particularly in relation to sample homogeneity. For beverages, the most important factor when applying sample to the instrument is degassing, as any entrapped air or CO_2 in the sample will come out of solution as it hits the atemperated prism, forming a layer of bubbles that will prevent good measurement.

General techniques considered for sample preparation;

- Degassing
- Filtering
- Stirring
- Blending
- Centrifuging
- Clarifying

Distilled Water

Distilled Water – 30s stabilization period

Application	°Brix	Prism °C	Quality
1	0.00	20.0	100
2	0.00	20.0	100
3	0.00	20.0	100
4	0.00	20.0	100
5	0.00	20.0	100
6	0.00	20.0	100
7	0.00	20.0	100
8	0.00	20.0	100
9	0.00	20.0	100
10	0.00	20.0	100

12.5 °Brix Sucrose Solution

12.50 °Brix – 30s stabilization period

Application	°Brix	Prism °C	Quality
1	12.50	20.0	100
2	12.50	20.0	100
3	12.50	20.0	100
4	12.50	20.0	100
5	12.50	20.0	100
6	12.50	20.0	100
7	12.50	20.0	100
8	12.50	20.0	100
9	12.50	20.0	100
10	12.50	20.0	100

50 °Brix Sucrose Solution

50.00 °Brix – 30s stabilization period

Application	°Brix	Prism °C	Quality
1	50.01	20.0	92
2	50.01	20.0	92
3	50.02	20.0	92
4	50.01	20.0	92
5	50.02	20.0	92
6	49.99	20.0	92
7	50.00	20.0	92
8	50.01	20.0	92
9	50.00	20.0	92
10	49.99	20.0	92

60 °Brix Sucrose Solution

60.00 °Brix – 30s stabilization period

Application	°Brix	Prism °C	Quality
1	60.00	20.0	92
2	60.00	20.0	92
3	60.00	20.0	92
4	60.00	20.0	92
5	60.00	20.0	92
6	60.00	20.0	92
7	60.00	20.0	92
8	60.00	20.0	92
9	60.00	20.0	92
10	59.99	20.0	92

Lemon syrup

Lemon Syrup – 60s stabilization period

Application	°Brix	Prism °C	Quality
1	54.37	20.0	93
2	54.38	20.0	93
3	54.38	20.0	93
4	54.37	20.0	93
5	54.36	20.0	93
6	54.37	20.0	93
7	54.36	20.0	93
8	54.36	20.0	93
9	54.37	20.0	93
10	54.38	20.0	93

Cola syrup

Cola Syrup – 60s stabilization period

Application	°Brix	Prism °C	Quality
1	53.79	20.0	93
2	53.79	20.0	93
3	53.79	20.0	93
4	53.79	20.0	93
5	53.79	20.0	93
6	53.79	20.0	93
7	53.80	20.0	91
8	53.80	20.0	92
9	53.79	20.0	93
10	53.80	20.0	93

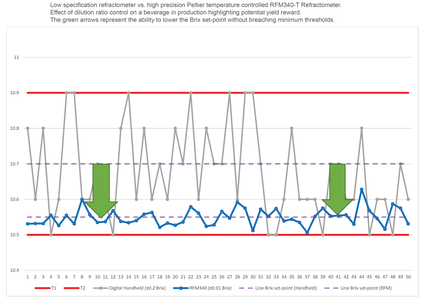
Conclusion

Quality Control (QC) and Quality Assurance (QA)

Reliable Brix measurements during the preparative stages of beverage production such as component dosing or concentrate dilution operations (QC) and final product compliance testing (QA) is critical.

It can be seen that with good laboratory practise, Brix results may easily be achieved to two decimal places and it is this that benefits beverage producers as once reliable, or more importantly, reproducible measurements are achieved, it is possible to adjust process to within a fraction of the lower Brix specification of the product being packaged without running any risk of crossing its critical threshold.

To put it simply, this means higher company profits may be achieved as a result of extended concentrate yields due to tighter control within production.



© 2025 Xylem, Inc. XA00366 0225 | ICUMSA® is a trademark of ICUMSA Ltd. and Verlag Dr. Albert Bartens KG