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Citrus Industry changes to refractometers for sugar determination

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Introduction

For several years, fruit buyers from the various citrus markets to which South Africa exports citrus have been requesting that the testing procedure to determine sugar levels and the terminology used for sugar content of citrus fruit be standardised to correspond with market needs. Specifically, many fruit buyers use Brix refractometers, rather than hydrometers, to determine sugar content of citrus fruit. As a result of this pressure, the National Department of Agriculture (DoA) has converted export quality requirements from the traditional method of determining sugar content, i.e. by hydrometer, to a refractometer-based measurement of sugar content.

However, the two methods for determining the sugar content of citrus juice are not well correlated, and it is not possible to simply convert the result from one method of testing to the other. Therefore, this article serves to provide some insight into the two testing methods and to provide guidelines regarding the implementation of these changes in testing equipment.

In general and when correctly done, refractometer measurements of sugar content of citrus juice are about 0.5 units less than measurements done by a hydrometer (although this difference of 0.5 units does not apply to every single sample tested). Therefore, the minimum TSS (total soluble solids) specification will be amended accordingly and references to hydrometer measurements will be done away with. To this end, the DoA has adjusted the minimum TSS values downwards by 0.5 units to compensate for the switch to °Brix measurements with a refractometer.

Explanation of the two methods to determine sugar content

At the outset it is necessary to understand the fundamental differences between the two methods to determine the "sugar" content of citrus juice.

1. A hydrometer measures the specific gravity (or relative density) of **ALL** the soluble solids in a solution at a specific temperature, i.e. it measures the total of all the solids dissolved in the water and the measurement value is the sum of the total of those soluble solids, but not of sugars alone. The soluble solids include sugars, acids, salts, proteins, amino acids, etc. Total soluble solids as measured by a hydrometer is reported as % TSS.
2. A refractometer measures the refractive index of a pure sugar solution and converts this measurement to sugar concentration. When measuring the concentration of a pure sugar solution in the laboratory, then °Brix perfectly matches the actual concentration of the sugar solution. A refractometer does not take into account other dissolved solids in the solution, e.g. acids, salts, proteins, amino acids, etc. Therefore, a Brix refractometer measures the concentration of all sugars in the juice, but does not account for other soluble solids. Sugar content as measured by a refractometer is reported as °Brix.

Since specific gravity and refractive index vary according to temperature, these measurements need to be adjusted, or "corrected", to account for the temperature of the juice sample being tested relative to the temperature at which the testing equipment was designed and calibrated. In practice, this is referred to as "temperature compensation" and is applied by using tables specific to the testing equipment being used.

The two methods discussed actually measure two different physical properties of citrus juice, and since citrus juice is more complex than pure sugar solution and is composed of other soluble solids in addition to sugars, e.g. acids, salts, proteins, amino acids, etc., there will always be a discrepancy between the two testing methods which cannot simply be interconverted. This discrepancy may vary, but is, on average, about 0.5 units – refractometers will nearly always under-estimate hydrometer measurements of sugar content in citrus juice. Therefore, it becomes obvious that the two methods cannot be used interchangeably.

It is not possible to account for the other soluble solids that the hydrometer measures but the refractometer does not. Nevertheless, while a

refractometer provides a more convenient measure of sugar content in a juice sample, it also provides a better estimate of "sweetness" of the juice sample, since other soluble solids that do not impart sweetness are not measured.

Testing guidelines

Various Brix refractometers are commercially available for determining sugar content of juice samples; some are portable while others are desk-top versions, some have automatic temperature compensation features while others do not, and some are digital while others are not. Irrespective of the type of Brix refractometer used, it is imperative that a few critical principles be followed.

1. Instruments must be correctly calibrated, preferably by an accredited laboratory.
2. If a non-temperature compensating refractometer is being used, then it is imperative that the correct temperature correction table for refractometers be used (Table 1), and that the temperature correction factor be properly applied.
3. In general, the most accurate readings are obtained when the juice temperature and instrument temperature are both near 20°C.

To complicate matters further, sugar content varies from position to position within individual fruit, among individual fruit, and between fruit samples of differing fruit size. Therefore, it is imperative that a representative sample of juice be used to determine the sugar content of the batch of fruit in question, and not to simply use a few drops of juice. Furthermore, the juice sample must be thoroughly mixed before being used to make the reading.

To avoid future confusion, the different measures of sugar content in citrus juice should be referred to as:

1. **°Brix**, as measured with a temperature-compensating refractometer, or
2. **% TSS**, as measured with a hydrometer (and corrected for temperature using the appropriate temperature correction tables).

Table 1. Temperature corrections to obtain °Brix from a non-temperature correcting refractometer.

Temperature (°C)	Correction factor	Temperature (°C)	Correction factor
10.0	-0.59	20.0	0.00
10.5	-0.56	20.5	0.04
11.0	-0.53	21.0	0.07
11.5	-0.51	21.5	0.11
12.0	-0.49	22.0	0.14
12.5	-0.46	22.5	0.18
13.0	-0.42	23.0	0.21
13.5	-0.40	23.5	0.25
14.0	-0.37	24.0	0.28
14.5	-0.34	24.5	0.32
15.0	-0.30	25.0	0.36
15.5	-0.28	25.5	0.40
16.0	-0.25	26.0	0.43
16.5	-0.22	26.5	0.48
17.0	-0.19	27.0	0.52
17.5	-0.16	27.5	0.56
18.0	-0.13	28.0	0.60
18.5	-0.10	28.5	0.64
19.0	-0.06	29.0	0.68
19.5	-0.03	29.5	0.73

Note: This table applies specifically for a juice sample with a sugar content of 10 °Brix. However, for juice samples with marginally higher or lower sugar content (2 °Brix either way) the correction factor only differs at the second decimal point. Therefore it is of little practical value to include additional correction factors.