Application Note

The quality control of beer by measuring specific gravity and refractive index

Industry	Food & beverage
Instrument	Density/Specific gravity meter, Refractometer
Measurement method	Resonant frequency oscillation, Detection of critical angle of optical refraction
Standards	

1. Scope

This application note shows an example of measuring quality control items for beer using a combination of density/specific gravity meter and refractometer. Each item was calculated from specific gravity and refractive index (Refer to "7. Notes") measured by the combined system including the optional KEM RA connection kit.

- Alcohol concentration
- Real extract
- Apparent extract
- Original extract
- Apparent fermentation
- Real fermentation

2. Post-measurement procedure

After the sample in the measurement cell is drained, rinse the cell with pure water and ethanol in that order. The cell should then be dried by purging it with dry air.

3. Apparatus

Equipment	Density/Specific gravity meter
Option	RA Connecting kit

4. Reagents

Rinse liquid 1 (for washing)	Pure water
Rinse liquid 2 (for washing)	Ethanol

5. Procedure

- Calibration -

1) In the dry state of the cell, perform the calibration by air.
2) Introduce pure water into the cell and then perform the calibration with pure water.
3) Introduce ethanol into the cell, then purge with dry air.

- Preparation -

1) The sample is degassed by natural filtration twice, using a paper filter (No.5C; Advantec Toyo, Tokyo, Japan).
2) Collect the filtrate in a sample bottle.

- Measurement -

1) Introduce the pretreated sample into the cell after the cell is dry.
2) Measure the specific gravity and refractive index.
3) Rinse the cell with pure water, and then ethanol, purge the cell with dry air.

6. Example

－Parameter－

The measurement parameters are set by the customer (see the table below).

<Density/Specific gravity meter>		<Refractometer>	
Set temperature	20.00℃	Set temperature	20.00℃
Stability sense	1	Stability sense	0
Limit time	600(s)	Wait time	0(s)
Viscosity correction	OFF	Limit time	50(s)
Calibration material	air and water		

(The measurement parameters are examples for using KEM's Density/Specific gravity meter and Refractometer. They may vary depending on the model.)

－Measurement results－

Table 1 shows the results of specific gravity and refractive index measurements for the three types of beer samples, and calculation results for each control item.

Table 1 Measurement results

Beer	Density (g/cm^3)	Specific gravity (20/20℃)	Refractive index (nD)	Ref※	Alcohol Conc. (wt%)	Alcohol Conc. (vol%)	Real extract (wt%)	Original extract (°P)	Apparent extract (°P)	Real fermen-tation (%)	Apparent fermen-tation (%)
A	1.00593	1.00774	1.34112	35.727	3.89	4.96	3.76	11.32	1.98	68.1	82.5
B	1.00368	1.00548	1.33754	26.298	1.98	2.52	2.35	6.31	1.41	63.5	77.7
C	1.00624	1.00805	1.34347	41.925	5.47	6.97	4.53	14.96	2.06	71.4	86.2

※For more information about Ref, refer to "7. Notes".

7. Notes

The alcohol concentration (wt%) was calculated based on the Berglund, Ellington and Rasmussen regression equation. The other control items were calculated based on the formula described in the BCOJ (Brewery Convention of Japan) Beer Analysis Method. The calculation formulas are shown below.

- Alcohol concentration (wt%) $Al = 0.323 - 277.4 \times (SG-1) + 0.2691 \times (Ref-14.5)$
- Alcohol concentration (vol%) $Al' = Al \times d / 0.78924$
- Real extract (wt%) $Er = 0.251 + 129.8 \times (SG-1) + 0.1179 \times (Ref-14.5)$
- Original extract (°P) $P = 100 \times (2.0665 \times Al + Er) / (100 + 1.0665 \times Al)$
- Apparent extract (°P) $Ea = -460.234 + 662.649 \times SG - 202.414 \times SG^2$
- Real fermentation (%) $Fr = 100 \times 2.0665 \times Al / (2.0665 \times Al + Er)$
- Apparent fermentation (%) $Fa = 100 \times (P - Ea) / P$

SG	Specific gravity of beer (20/20°C)
d(g/cm^3)	Density of beer at 20°C
Ref	Eintauch-refraktometer (Refractometer readings with a special scale)

Ref is converted from the refractive index nD by the formula below.

(1) Case of nD ≤ 1.34274

$$Ref = 32.2421 + 2\,637.3 \times (nD - 1.3398) + 2386.57 \times (nD - 1.3398)^2 - 357849 \times (nD - 1.3398)^3$$

(2) Case of nD > 1.34274

$$Ref = 69.7677 + 2740.29 \times (nD - 1.3538) + 4356.06 \times (nD - 1.3538)^2$$

8. References

- Jean De Clerck: *Textbook of Brewing,* **vol. 2** (1958)
- BCOJ Beer Analysis Method (Rev. Ed.), *Brewery Convention of Japan,* (2013)
- V. BERGLUND,W . EMLINGTON & K. O. RASMUSSEN: über die Verwendung des Zeißschen Refraktometers bei der Malzanalyse, *Wochenschrift far Brauerei,* **51**, 233 (1934)
- Official Methods of A. O. A. C., 12th Edition, *Assoc. Official Anal. Chem.* (1975)