# Total Carbohydrate in Beer

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## CONCLUSIONS

1. Calibration for total carbohydrate should be made using dextrin; if dextrose is used, results should be multiplied by 0.9.
2. Of the two methods tested, Method II, the modified anthrone procedure, was more consistent than Method I, the Institute of Brewing anthrone procedure.
3. Total carbohydrate, as determined by the analytical procedures tested, is lower than calculated carbohydrate using ASBC Method BEER-6,D.

## RECOMMENDATION

1. Further work should include a comparison of Method II, the modified anthrone procedure, to the phenol-sulfuric acid procedure.

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The subcommittee was formed in 1981 to evaluate published methods for the determination of total carbohydrate in beer. This determination is becoming increasingly significant with the advent of light beers, which contain a label claim for carbohydrate and calories.

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## PROCEDURE

Two pairs of beer samples were analyzed for carbohydrate using two methods. The first sample pair consisted of Samples A and B with a low carbohydrate content. The second pair, C and D, had higher carbohydrate content.

Both of the methods tested were colorimetric methods using anthrone and sulfuric acid. The differences between the methods involved acid concentration, anthrone concentration, and length and temperature of the heating step. One of the test methods included calibrations using both dextrose (glucose) and dextrin.

Method I was the Institute of Brewing method (5) adopted by the EBC. Method II was abstracted from McCready et al (3) and Scott et al (4). Calibrations using both dextrose and dextrin were included in Method II. Paired samples were treated statistically by the Youden Unit Block design (6).

## RESULTS AND DISCUSSION

Ten collaborators submitted results. The results are presented in Table I. The results of collaborator 3 for Method II (dextrin calibration—Pair I) were outliers using Dixon's test at $P \leq 0.01$ and were excluded from the statistical analysis. Also excluded were the results of collaborator 7 for Method I, Pairs I and II.

A comparison of Method II using dextrose calibration versus

**TABLE I**
**Total Carbohydrate in Beer[a]**

| | Method I (Inst. of Brew.) | | | | Method II (Dextrose Calibration) | | | | Method II (Dextrin Calibration) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pair I | | Pair II | | Pair I | | Pair II | | Pair I | | Pair II | |
| Collaborator | A | B | C | D | A | B | C | D | A | B | C | D |
| 1 | 0.90 | 0.96 | 1.90 | 1.67 | 1.11 | 1.16 | 2.29 | 2.27 | 1.00 | 1.04 | 2.05 | 2.04 |
| 2 | 1.13 | 1.11 | 2.20 | 2.20 | 1.11 | 1.16 | 2.35 | 2.20 | 1.00 | 1.05 | 2.13 | 2.00 |
| 3 | 1.07 | 1.17 | 2.40 | 2.12 | 0.95 | 1.02 | 2.62 | 2.39 | 0.69[b] | 0.74[b] | 1.90 | 1.73 |
| 4 | 1.25 | 1.34 | 2.66 | 2.46 | 1.04 | 1.16 | 2.29 | 2.07 | 0.94 | 1.06 | 2.09 | 1.88 |
| 5 | 1.16 | 1.23 | 2.42 | 2.21 | 1.15 | 1.22 | 2.41 | 2.18 | 1.11 | 1.17 | 2.31 | 2.09 |
| 6 | 1.12 | 1.19 | 2.35 | 2.13 | 1.09 | 1.18 | 2.35 | 2.06 | 1.00 | 1.08 | 2.15 | 1.89 |
| 7 | 3.53[b] | 1.44 | 3.29[b] | 3.07 | 1.32 | 1.32 | 2.56 | 2.46 | 1.15 | 1.16 | 2.23 | 2.15 |
| 8 | 1.11 | 1.14 | 2.32 | 2.13 | 1.09 | 1.19 | 2.32 | 2.13 | 0.99 | 1.09 | 2.12 | 1.94 |
| 9 | 1.14 | 1.15 | 2.43 | 2.24 | 0.99 | 1.06 | 2.40 | 2.14 | .97 | 1.04 | 2.36 | 2.10 |
| 10 | 1.15 | 1.22 | 2.51 | 2.28 | 1.12 | 1.22 | 2.35 | 2.16 | 1.02 | 1.11 | 2.14 | 1.96 |
| Mean[c] | 1.11 | 1.17 | 2.35 | 2.16 | 1.10 | 1.17 | 2.39 | 2.21 | 1.02 | 1.09 | 2.15 | 1.98 |
| Grand Mean | 1.14 | | 2.26 | | 1.13 | | 2.30 | | 1.05 | | 2.06 | |

[a] Percent w/v.
[b] Outlier using Dixon's test at $P \leqslant 0.01$.
[c] Mean calculated excluding pairs containing outliers.

**TABLE II**
**Statistical Summary of Results**

| Method | Pair | No. of Labs | Grand Mean[a] | Laboratory Error | | | c.v.[d] | Calc. F[b] | Critical F[e] |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Within[b] | Between[b] | Combined[c] | | | |
| I (Inst. of Brewing) | I (A,B) | 9 | 1.141 | 0.028 | 0.094 | 0.098 | 8.6 | 24.4 | 6.029 |
| | II (C,D) | 9 | 2.257 | 0.055 | 0.205 | 0.212 | 9.4 | 28.6 | 6.029 |
| II (Dextrose Calibration | I (A,B) | 10 | 1.133 | 0.024 | 0.089 | 0.092 | 8.1 | 28.5 | 5.351 |
| | II (C,D) | 10 | 2.300 | 0.057 | 0.108 | 0.122 | 5.3 | 8.3 | 5.351 |
| II (Dextrin Calibration) | I (A,B) | 9 | 1.054 | 0.024 | 0.054 | 0.059 | 5.6 | 11.4 | 6.029 |
| | II (C,D) | 10 | 2.063 | 0.056 | 0.115 | 0.128 | 6.2 | 9.6 | 5.351 |

[a] Grand mean = GM = $(\bar{A} + \bar{B})/2$ or $(\bar{C} + \bar{D})/2$.
[b] Calculated per Youden and Steiner (6).
[c] Combined-laboratory error ($S_c$) calculated from within-laboratory error ($S_r$) and between-laboratory error ($S_b$); $S_c = \sqrt{S_r^2 + S_b^2}$.
[d] Coefficient of variation = 100 ($S_c$/GM).
[e] Critical F from tables of F distribution at $P = \leqslant 0.01$.

**TABLE III**
**Analytical Data Used to Calculate Carbohydrate in Beer**

| | Sample | | | |
|---|---|---|---|---|
| | A | B | C | D |
| Specific gravity | 1.00129 | 1.00155 | 1.00500 | 1.00431 |
| Real extract (% w/v) | 1.69 | 1.77 | 2.73 | 2.54 |
| Protein (% w/v) | 0.25 | 0.25 | 0.21 | 0.21 |
| Ash (% w/v) | 0.07 | 0.07 | 0.07 | 0.07 |

**TABLE IV**
**Calculated Versus Measured Carbohydrate in Beer[a]**

| Samples | Calculated Carbohydrate | Measured Carbohydrate | |
|---|---|---|---|
| | | Dextrose Calibration | Dextrin Calibration |
| A | 1.37 | 1.11 | 1.02 |
| B | 1.45 | 1.17 | 1.09 |
| C | 2.46 | 2.37 | 2.15 |
| D | 2.27 | 2.19 | 1.98 |

[a] Percent, w/v.

dextrin calibration shows that the dextrin calibrations resulted in lower values for carbohydrate. This is to be expected, based on the molecular formula of dextrin $(C_6H_{10}O_5)_n$ versus dextrose $(C_6H_{12}O_6)$. Upon the acid hydrolysis occurring during the analysis, one molecule of water is added to each dextrin subunit to form each molecule of dextrose. Because a given weight of dextrin contains more subunits than the same weight of dextrose, dextrin gives a larger response on a weight basis. The theoretical relationship is:

$$\text{dextrose} \times 0.9 = \text{dextrin}.$$

As the residual carbohydrate in American beers is primarily dextrin, this theoretical relationship should apply. Experimentally, comparing the dextrin results of Method II with the average dextrose results of Methods I and II, factors for Samples A through D were calculated as 0.92, 0.93, 0.91, and 0.90. Because the experimental data are in agreement with the theoretical calculation, it is appropriate to either use dextrin for calibration or apply the 0.9 correction factor if dextrose is used. This is not taken into account in the Institute of Brewing method.

As indicated in Table II, Method II yielded results that were slightly less variable than those of Method I. This is reflected in the lower between- and combined-error terms and in lower coefficient of variation values for Method II. In addition, although not indicated in Table I, if Dixon's outlier test is applied at $P \leqslant 0.05$, Method I would have four sample pairs classified as outliers, whereas Method II would have only one outlier for the dextrose calibration and one for the dextrin calibration. This may indicate that Method II is easier to follow.

Apart from evaluating methods for the determination of total

carbohydrate, a second objective of the subcommittee was to compare the carbohydrate values obtained with the ASBC formula for calculated carbohydrate, BEER-6,D (1). To make this calculation, each of the collaborators was requested to determine the specific gravity and real extract of the four samples. Protein and ash determinations were made at the chairman's laboratory only. The average specific gravity, real extract, and the protein and ash data are given in Table III for each of the four samples. The data in Table III were used to calculate carbohydrate content according to ASBC BEER-6,D; the results, expressed on a w/v basis, are given in Table IV. Also included are the average measured carbohydrate contents of the four samples using dextrose calibration by Methods I and II and dextrin calibration by Method II. The calculation procedure overestimates the actual carbohydrate present in beer as measured by the anthrone procedures.

Several collaborators have suggested that a phenol-sulfuric acid procedure, as reported by Dubois et al (2), may offer advantages over the methods tested this year. The primary advantages of the phenol-sulfuric acid procedure are reagent stability and elimination of the heating step. A comparison of the phenol-sulfuric acid procedure and anthrone Method II is planned for next year.

## LITERATURE CITED

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