Quality control and analysis for small breweries

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Introduction
Small breweries have become a growing trend in the Pacific Northwest, as well as nationwide. Small breweries lack the advantages large breweries have when it comes to quality control and analysis. It is important to promote quality beer to consumers because good beer leads to happy customers.

The objectives of this study were to modify and develop QA/QC protocols from the American Society of Brewing Chemists (ASBC) for use in classrooms and small breweries. This work focused on adapting methods for use in teaching labs for international bitterness units (IBU), standard research methods for color (SRM) and alcohol by volume (ABV) for beer.

Methods: IBU, SRM, and ABV
Each analysis contained an instrument performance check consisting of Keystone Light Beer for all measurements. All beer was decarbonated by hand, pouring back and forth around thirty times prior to analysis.

IBU: Five ml of beer were transferred and 0.5 ml of 3M HCl added with 10 ml 2,2,4-trimethyl pentane (iso-octane) and shook (320 cycles/min) for 10 minutes.

UV-Vis parameters:
- Hitachi U-3000 UV-Vis spectrophotometer
- Photometry method (fixed wavelength)
- Tungsten and Deuterium lamps used
- PMT: Auto
- Wavelength: 275nm

SRM: Each sample consisted only of beer. Samples were analyzed using the same UV-Vis parameters above with the exception of wavelength. Two were used, 410nm and 700nm. Any absorbance over 1 was diluted and re-measured.

ABV: A solution of 5% n-propanol was used for the internal standard in all assays. Calibration curve: A range of ethanol solutions from 3%-8% were used. Five ml of internal standard was mixed with 5ml of each ethanol concentration. Peak heights of ethanol to n-propanol was graphed versus ethanol concentration to produce a linear relationship.

GC w/FID parameters:
- Column: 20M Carbowax, 6 ft x 1/8 in.
- Oven Temp: 70°C to 150°C at 4°C/min
- Carrier Gas: Helium about 20 ml/min
- Injector: 200°C
- Detector: 250°C
- Sampling: 5ml of beer was mixed with 5ml of internal standard. A volume of around 1μl was injected.

Results
A sample of the data is shown in Table 1. This was based on the instrument performance check: Keystone Light and three samples of beer from a local brewery. Antion Pair was present for an Alcolyzer demo and compared the GC method of ABV analysis to the Alcolyzer ABV analysis for a select sample of beer. Figure 2 shows the two layers, organic and aqueous, from the IBU evaluation. The calibration curve used to determine the alcohol in beer is shown in Figure 2. An example of the gas chromatography read-out is shown in Figure 3.

Conclusions
All samples analyzed from the three different breweries, as well as the instrument performance check, showed consistent results after each protocol was adjusted for the equipment and technique differences. IBU required that each sample be carefully mixed otherwise an emulsion formed. Additionally, blanking with iso-octane was crucial to prevent instrumental drift. SRM was fairly straightforward. All beer had to be decarbonated or else the absorbance reading would be off. The 700nm absorbance was used as a way of checking for this.

ABV proved the most challenging. The distillation method was time consuming and produced very inconsistent results. Once the parameters of the GC were determined it provided efficient, consistent results. Although our lab does not have an Alcolyzer, the demo showed that the GC method produces accurate results, and verified the data and method.

Significance
- A protocol for each analysis type was developed and will be tested in the spring with the Instrumental Methods of Analysis Class.
- Our lab is now able to work with local breweries to provide accurate results for beer analysis.
- Working on this research allowed our lab to use the GC w/FID which had not been used for a number of years. A protocol is now provided for students to use with this instrument.
- Accurate beer analysis allows breweries to adjust their recipes which leads to happy consumers and consistent results.
- Future research includes purchasing an Alcolyzer and preparing methods for instrument use. Additionally, exploring the wine QA/QC industry.

Acknowledgments
I would like to thank the Linfield College Center for the Northwest CERC grant for funding the research and Linfield College Chemistry Department for providing this opportunity. Additional thanks go to the local brewers who donated samples for analysis.

Further information
Please contact Dr. Brian Gilbert, Linfield College, at bgilber@linfield.edu for more information.

Table 1. Sample analysis of instrument performance check and beer samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>IBU</th>
<th>SRM</th>
<th>ABV: GC</th>
<th>ABV: Alcolyzer Demo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Keystone Light (KL)</td>
<td>8.53</td>
<td>2.84</td>
<td>4.22</td>
<td>4.08</td>
</tr>
<tr>
<td>2: KL</td>
<td>8.73</td>
<td>2.89</td>
<td>4.14</td>
<td>-</td>
</tr>
<tr>
<td>3: KL</td>
<td>8.87</td>
<td>3.25</td>
<td>4.22</td>
<td>-</td>
</tr>
<tr>
<td>4: KL</td>
<td>8.65</td>
<td>3.18</td>
<td>4.58</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td>8.70</td>
<td>3.04</td>
<td>4.29</td>
<td>-</td>
</tr>
<tr>
<td>STD</td>
<td>0.143</td>
<td>0.205</td>
<td>0.197</td>
<td>-</td>
</tr>
<tr>
<td>Known</td>
<td>7.8</td>
<td>3</td>
<td>4.2</td>
<td>-</td>
</tr>
<tr>
<td>Beer 1</td>
<td>19.6</td>
<td>4.5</td>
<td>4.45</td>
<td>4.59</td>
</tr>
<tr>
<td>Beer 2</td>
<td>32.14</td>
<td>5.7</td>
<td>6.71</td>
<td>6.63</td>
</tr>
<tr>
<td>Beer 3</td>
<td>44.38</td>
<td>23.5</td>
<td>4.97</td>
<td>4.82</td>
</tr>
</tbody>
</table>

Figure 1. Aqueous layer is shown above the beer/water layer for IBU analysis.

Figure 2. Calibration curve used to determine the ethanol concentration in each beer sample for ABV.

Figure 3. Peak analysis read-out from the gas chromatography ABV determination. The ratio is used to determine the alcohol by volume in each sample.

Literature cited

Restek: Scotch on CarboBlack. B. Searchable Chromatogram Library.

Local Breweries:
- Grain Station Brew Works
- Heather Allen
- Golden Valley Brewery

Other Resources:
- Oregon Brewlab
- Anton-Paar Alcoholmeter w/ near Infrared demo

Future research includes purchasing an Alcolyzer and preparing methods for instrument use. Additionally, exploring the wine QA/QC industry.