Comparing the MEBAK Reference Method with the CDR Beerlab®

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Abstract

This study compared the MEBAK B-400.17.110 [2024-05] "Bittereinheiten" reference method and the CDR BeerLab® method (Kit REF: 301365) for the determination of bitterness units (IBU) in beer. Both methods were evaluated to determine their comparability, precision, and suitability for routine analysis across a wide range of beer samples exhibiting bitterness levels in the range of 3 – 50 IBU. Data were analyzed using various statistical approaches, including correlation analysis, Bland-Altman plots, t-tests, and calculation of the coefficient of variation. Excellent comparability was observed between both methods, with correlation coefficients indicating identical results.

In general, the mean bias was negligible, and the difference in mean results was not statistically significant. Under the tested conditions, both methods can therefore be regarded as equivalent for the determination of IBU in beer.

Furthermore, the CDR BeerLab® offers several advantages regarding speed, user-friendliness, and convenience, while maintaining accuracy and repeatability on par with the established method.

Background

The International Bitterness Unit (IBU) is a standardized scale used to quantify the bitterness of beer, which primarily originates from iso-alpha acids derived from hops. IBU values provide an objective measure, helping brewers and consumers to compare different beer styles. The bitterness of beer is a crucial quality parameter, traditionally determined for example according to the MEBAK protocol. The accurate IBU determination is an essential parameter for quality control parameter since bitterness significantly influences the sensory perception and overall balance of beer.

The CDR BeerLab® is a benchtop photometric analyzer designed to simplify and accelerate the determination of various chemical parameters in beer and wort, including International Bitterness Unit (IBU).

This study aimed to assess whether the CDR BeerLab® can provide results comparable to the established reference method, and to evaluate its reproducibility.

Samples and Methods

A total of 13 different beers covering an IBU range of 3 to 50 were analysed in triplicate using both the MEBAK reference method (B-400.17.110) and the CDR BeerLab® approach. For each beer, parallel measurements were conducted to allow for direct comparison.

While the MEBAK method is a well-established standard for IBU determination, involving solvent extraction and spectrophotometric measurement, the CDR BeerLab® uses a simplified process optimized for rapid routine screening with single-use reagent cuvettes and reduced sample and reagent volumes.

Analysis and Evaluation

To assess the performance and comparability of the two methods, the IBU values obtained for each beer sample were analysed and statistically evaluated. Both accuracy and consistency were considered by comparing mean values (mean), standard deviations (SD), and potential biases between the reference and CDR BeerLab® methods.

Reference Method

Tab. 1: Results of the reference method: IBU measurements of triple determinations (individual extractions REF IBU 1 – REF.IBU 3), mean values, and corresponding standard deviations (REF. SD).

Sample	REF. IBU 1	REF. IBU 2	REF. IBU 3	Mean	REF. SD
LBs030425	9.6	9.6	9.8	9.7	0.12
LCa260325	13.7	13.9	14.1	13.9	0.18
MOr160425	14.4	14.5	14.5	14.5	0.06
SBa030425	17.7	17.7	17.8	17.7	0.06
SAv160425	21.6	21.6	22.0	21.7	0.23
BGo260325	26.8	26.9	27.1	26.9	0.15
HEd160425	28.2	28.1	28.0	28.1	0.10
AUr030425	29.3	29.1	29.2	29.2	0.10
EUb030425	34.1	34.2	34.4	34.2	0.15
JPi260325	39.6	39.5	39.2	39.4	0.18
SIm160425	40.6	41.1	40.7	40.8	0.26
LKa030425	41.2	40.9	40.7	40.9	0.25
RDo160425	49.6	49.6	49.8	49.7	0.12

CDR BeerLab® Method

Tab. 2: Results of the CDR BeerLab® method (BL): IBU measurements of triple determinations (individual extractions BL IBU 1 – BL IBU 3), mean values, and corresponding standard deviations (BL SD).

Sample	BL IBU 1	BL IBU 2	BL IBU 3	Mean	BL SD
LBs030425	9.7	9.4	9.9	9.7	0.25
LCa260325	13.7	13.7	13.9	13.8	0.12
MOr160425	14.8	14.8	14.6	14.7	0.12
SBa030425	17.2	17.3	17.3	17.3	0.06
SAv160425	22.0	22.4	21.7	22.0	0.35
BGo260325	27.0	26.7	27.7	27.1	0.51
HEd160425	27.5	27.6	28.1	27.7	0.32
AUr030425	29.5	29.3	29.3	29.4	0.12
EUb030425	33.7	33.4	34.4	33.8	0.51
JPi260325	39.4	39.1	39.4	39.3	0.17
SIm160425	39.7	39.8	40.1	39.9	0.21
LKa030425	40.1	40.3	40.6	40.3	0.25
RDo160425	49.1	49.6	49.2	49.3	0.26

Comparison of Reference Method and CDR BeerLab®

Correlation between both methods

The difference between the IBU values determined with the CDR BeerLab® and the reference method is minimal (as shown in Table 3). The results show an exceptionally high correlation between the two methods, as indicated by the coefficient of determination ($R^2 = 0.9993$) (Fig.1). Additionally, a Pearson correlation analysis was performed to evaluate the linear relationship between the two methods, yielding a correlation coefficient of $R = 0.9997$. These values indicate a strong positive linear association and demonstrate that the CDR BeerLab® method provides IBU values that are nearly identical to those obtained with the reference method. Together, these findings confirm the equivalence, reliability, and consistency of the CDR BeerLab® method for the determination of bitterness in beer samples.

Tab. 3: Comparison of mean IBU values obtained with the reference method (REF. IBU) and the CDR BeerLab® method (BL IBU), including the difference (Δ) between both methods.

Sample	REF. IBU	BL IBU	Difference (Δ)
LCa260325	9.7	9.7	0.00
BGo260325	13.9	13.8	0.12
JPi260325	14.5	14.7	-0.27
LBs030425	17.7	17.3	0.5
SBa030425	21.7	22.0	-0.3
AUr030425	26.9	27.1	-0.3
EUb030425	28.1	27.7	0.4
LKa030425	29.2	29.4	-0.2
MOr160425	34.2	33.8	0.4
SAv160425	39.4	39.3	0.1
HEd160425	40.8	39.9	0.9
SIm160425	40.9	40.3	0.6
RDo160425	49.7	49.3	0.4

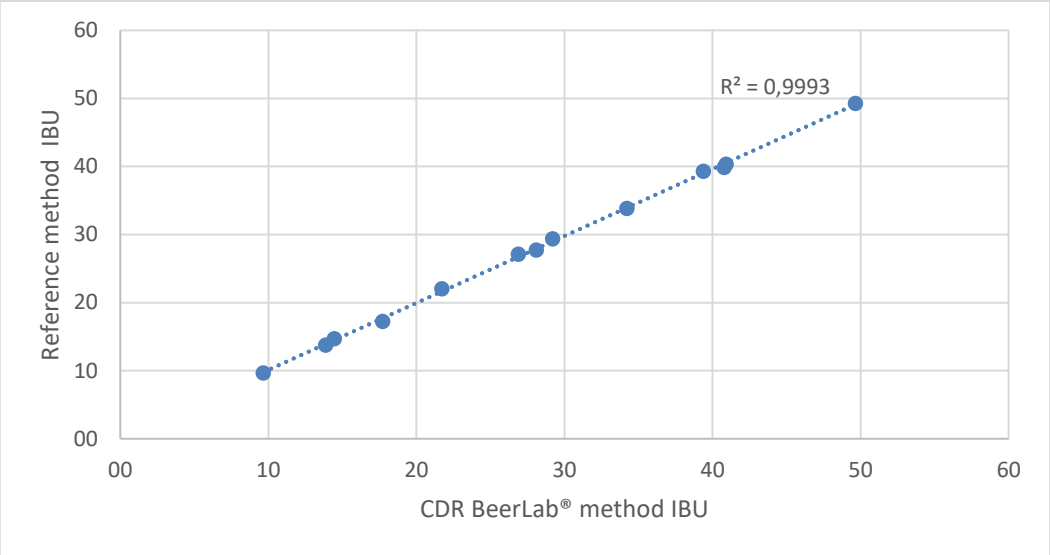

Fig. 1: Correlation of mean IBU values obtained with the reference method and the CDR BeerLab® method.

Evaluation of Method Agreement and Consistency

The Bland-Altman plot is a widely used statistical method for evaluating the agreement between two quantitative measurement techniques. This is accomplished by plotting the difference between the two methods against their average for each sample. In this plot, the mean difference (bias) provides an estimate of any systematic discrepancy between both methods, while the spread of the differences illustrates random variation (Fig. 2). Additionally, the Bland-Altman plot includes limits of agreement (LoA), often calculated as the mean difference ±1.96 times the standard deviation of the differences, which represent the range within which 95% of the differences between methods are expected to fall. These 95% confidence intervals allow for an assessment of whether the two methods can be used interchangeably. This approach enables a detailed evaluation of the consistency and potential bias between both techniques across the range of tested samples.

Tab. 4: Summary of mean IBU values determined by both methods and the averages (for each sample) used for Bland-Altman analysis.

Sample	REF.IBU	BL IBU	**Mean**
LBs030425	9.7	9.7	9.7
LCa260325	13.8	13.8	13.8
MOr160425	14.5	14.7	14.6
SBa030425	17.7	17.3	17.5
SAv160425	21.7	22.0	21.9
BGo260325	26.9	27.1	27.0
HEd160425	28.1	27.7	27.9
AUr030425	29.2	29.4	29.3
EUb030425	34.2	33.8	34.0
JPi260325	39.4	39.3	39.4
SIm160425	40.8	39.9	40.3
LKa030425	40.9	40.3	40.6
RDo160425	49.7	49.3	49.5

The respective Bland-Altman plot illustrates the agreement between the reference method and the CDR BeerLab® method graphically by plotting the differences in IBU values versus the average values for each beer sample. The plot includes the average bias as well as the upper and lower limits of agreement.

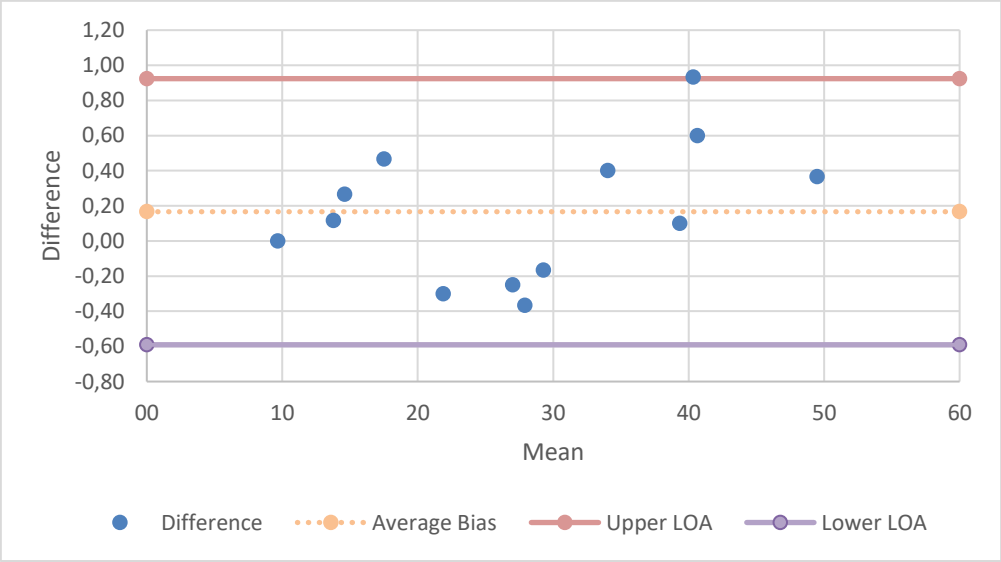

Fig. 2: Bland-Altman-Plot illustrating the differences in IBU values between the reference method and the CDR BeerLab® method plotted against the average of both methods.

The Bland-Altman analysis revealed an average bias of 0.17 IBU with a standard deviation of 0.39, indicating that, overall, the two methods show very similar results, with the reference method tending to give slightly higher values than the CDR BeerLab® method.

The 95% limits of agreement extended from −0.59 (Lower LoA) to 0.92 (Upper LoA) IBU. With the exception of one sample, all differences were within a relatively narrow range between −0.40 and 0.60 IBU, reflecting good agreement for the majority of measurements.

One sample exhibited a difference of 0.93 IBU, marginally exceeding the upper limit of agreement. This might indicate a potential outlier or an unusual deviation for this specific sample. There is no dependence of the differences on the absolute IBU values; however, it is evident that four samples in the range of 20 to 30 IBU exhibited negative differences between −0.2 and −0.4 IBU, which is below the mean bias resulting in an asymmetrical pattern of differences around the mean bias in the plot. The observed asymmetry suggests that systematic factors may be influencing the agreement in certain IBU ranges and indicates that the observed variability is not random but may reflect method-specific biases in particular intervals of the measurement spectrum. Overall, the results demonstrate that the IBU values determined by the CDR BeerLab® and MEBAK methods show minimal systematic differences and only a narrow range of variability, thereby confirming a high level of agreement between the two approaches.

Differences in Means and Variances between Methods

A paired t-test was conducted to assess whether there was a statistically significant difference between the mean values obtained by the two methods. With a p-value of 0.12, which is greater than the conventional significance threshold of 0.05, this indicates that the difference between both methods is insignificant. Thus, no systematic differences are observed under the conditions tested.

Additionally, an F-test was performed to compare the variances of the two methods. The resulting p-value of 0.92 demonstrates that there is no statistically significant difference

in variability between the methods. A p-value close to 1 indicates a very high probability that any observed difference in variance is random rather than a true difference. This demonstrates that the variability in repeated measurements for both methods is statistically indistinguishable, further supporting the conclusion that both methods exhibit comparable levels of precision.

In summary, while the paired t-test evaluates whether the average values from both methods differ significantly, the F-test assesses whether their variabilities are similar. The results of both tests confirm that the CDR BeerLab® and the reference method are not only comparable in accuracy but also in precision.

Comparison of Repeatability

As a measure of precision, the coefficient of variation (CoV) was determined for each sample allowing for a direct comparison of the repeatability between the two methods.

Tab. 5: Coefficients of variation (CoV) for each beer sample and the mean CoV for both methods.

Sample	REF.IBU	BL IBU
LBs030425	1.19	2.60
LCa260325	1.26	0.84
MOr160425	0.40	0.78
SBa030425	0.33	0.33
SAv160425	1.06	1.59
BGo260325	0.57	1.89
HEd160425	0.36	1.16
AUr030425	0.34	0.39
EUb030425	0.45	1.52
JPi260325	0.46	0.44
SIm160425	0.65	0.52
LKa030425	0.61	0.62
RDo160425	0.23	0.54
CoV	0.61	1.02

The mean CoV was 0.61% for the reference method and 1.02% for the CDR BeerLab® method. These very low CoV values indicate excellent repeatability for both methods.

Summary of Statistical Analysis

- Exceptionally strong linear relationship ($R = 0.9997$; $R^2 = 0.9993$) between both methods for samples from 3 to 50 IBU.
- The Bland-Altman analysis demonstrated a minimal average bias and narrow limits of agreement, indicating a high level of concordance between the CDR BeerLab® and the reference method.
- No significant difference in mean values ($p = 0.12$) was found, indicating statistical equivalence.
- Excellent precision (Coefficient of Variation): Both methods produced very low mean CoV (reference: 0.61%, CDR BeerLab®: 1.02%), reflecting comparable repeatability between methods with no significant difference in variance ($p = 0.92$).

Handling

During the tests, the CDR BeerLab® analyzer proved to be straightforward to operate and could be used immediately after connecting it to the mains power supply, although a short warm-up period was required before starting measurements. The pre-set test routines can be selected via the touchscreen menu, with clear on-screen instructions guiding users step by step through the analysis procedures. Only minimal training was required for operation. However, additional laboratory equipment, such as a benchtop centrifuge and a laboratory shaker, was necessary for sample preparation. The use of an ultrasonic bath was also found to be beneficial for optimal degassing of beer samples. Measurement results could be obtained either using the built-in printer or conveniently exported to a computer via USB memory stick. No routine maintenance is required for the device, and performing software updates proved to be uncomplicated.

Conclusion

The comparative study demonstrated that the CDR BeerLab® method provides results for IBU determination in beer that are statistically equivalent with those from the reference method. The CDR BeerLab® instrument is easy to use with minimal training and provides results more rapidly than traditional laboratory-based methods. The CDR BeerLab® method uses approximately 20 times less chemical reagents compared to the reference method, which not only minimizes the environmental impact but also significantly reduces the hazard potential, particularly in relation to isooctane — a substance classified as toxic and hazardous to the aquatic environment. However, due to small sample and reagent volumes, pipetting accuracy remains a key requirement, when using the CDR BeerLab® system. Notably, both analytical systems are suitable for routine laboratory use, and either can be selected for reliable IBU measurements in a brewery setting.