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Determination of Fermentability (Final Attenuation) of Wort

Submitted on behalf of the Analysis Committee of the European Brewery Convention

Two methods for the determination of the apparent fermentability (attenuation limit) of wort, the regular fermentation as a reference method as well as a more rapid method have been collaboratively tested by members of the Analysis Committee of the European Brewery Convention to obtain repeatability (r_{95}) and reproducibility (R_{95}) values and to form an idea of the equivalence of these two procedures based on the comparison of results obtained from identical samples. In the collaborative trials the 14th EBC Standard Malt and two industrial worts were analyzed. Repeatability (r_{95}) and Reproducibility (R_{95}) values of 0.5% and 2.9% respectively at a mean level of 83.9% were obtained for laboratory wort from malt using the reference fermentation method. Using the rapid fermentation method the values were 0.9% and 2.4 % respectively at the mean level of 82.8%. The precision values for industrial wort using the reference fermentation method were $r_{95} = 0.4\%$ and $R_{95} = 2.4\%$ for mean levels of 81.3 and 82.4%, using the rapid method 0.3% and 3.5% were obtained respectively for mean levels of 80.5 and 81.7%. The reference fermentation is more precise in terms of reproducibility and yields higher results. The rapid method is recommended for guideline purposes only.

BC 3 Analysis method/ 35 wort (hot wort)

(Descriptors: Apparent fermentability, collaborative trials, reference method, rapid fermentation.

Descriptoren: Scheinbarer Vergärungsgrad, Ringanalyse, Referenzmethode, Schnellvergärung).

1 Introduction

The Analysis Committee of the European Brewery Convention decided to evaluate the reference method for the determination of fermentability (final attenuation, attenuation limit) of laboratory wort from malt and worts from commercial plants as well as a rapid method. Interlaboratory trials were organized in which 11 and 14 laboratories respectively participated. Each laboratory used its own in-house yeast.

2 Experimental

The organisation of the collaborative trial and the statistical treatment of the data were performed according to the procedures given in the International Standard ISO 5725 (1). Two trials were undertaken using a uniform design. To evaluate the equivalence of the two procedures tested statistical treatment was made according to the Paired t-Test for Differences in Means and Wilcoxon Signed Rank Test respectively (2).

The 14th Standard Malt and two industrial worts were circulated to the participating laboratories. Participants were asked to determine the fermentability of the Congress Wort made from the Standard Malt according to EBC Method 4.11 (reference method) in the version of Analytica 4th ed. (3), using in-house yeast (15 g/100 ml) and according to ASBC Wort-5 (rapid method) (4)

respectively, with the addition of 32 g/100 ml yeast and 5–7 h fermentation time. The same was done with the industrial worts (EBC Method 8.4).

3 Results and Discussion

Congress Wort (14th Standard Malt)

Results were received from 11 laboratories. The raw data, as received, are presented in Table 1. Laboratory 3 sent only one result for the rapid method, therefore it was eliminated.

In the case of the reference fermentation one set of data was identified as a straggler according to the Cochran test and another

Table 1 Laboratory Wort, Units %

Laboratory	Reference Fermentation		Rapid Fermentation	
1	82.4	82.7	76.1*	76.7*
2	84.3	84.4	82.2	82.4
3	87.0*	86.1*	83.2	—
4	84.5	84.2	83.0	82.7
5	82.4	82.2	81.5	81.0
6	85.0	84.6	82.7	81.8
7	82.7	82.7	82.3	82.2
8	85.2	84.9	83.9	83.9
9	83.9	84.0	83.1	83.7
10	83.7	83.7	83.6	83.4
11	84.9	85.0	83.3	83.1

* Straggler according to Cochran, elim.

* Outlier according to Dixon, elim.

as an outlier according to the Dixon test regarding the rapid fermentation.

The precision data are given in Table 3. The repeatability and reproducibility values are fairly similar to those obtained in the previous collaborative trial introducing the 14th Standard Malt.

The repeatability (r_{95}) of the reference fermentation is better than that of the rapid method, the reproducibility (R_{95}) is equivalent. The reference method gives a higher attenuation limit from a statistical point of view.

Therefore it was decided to perform a second test analyzing worts from a commercial plant using a longer fermentation time from five to seven hours in the rapid test.

Table 2 Industrial Wort, Units %

Wort A				
Laboratory	Reference Fermentation		Rapid Fermentation	
1	81.7	–	81.1	–
2	80.3	80.3	78.0*	78.4*
3	82.5	82.7	82.8	82.9
4	81.3	81.1	79.5	79.5
5	81.6	81.5	81.1	81.0
6	81.9	81.8	81.8	81.7
7	80.5	–	80.4	80.4
8	81.3	81.2	79.6	79.5
9	81.9	81.9	81.2	81.2
10	81.0	80.9	79.4	79.6
11	81.6	81.7	81.5	81.4
12	79.8	79.7	79.0	79.0
13	80.1*	80.6*	79.2	79.0
14	81.4	81.4	80.2	80.4
	* Outlier according to Cochran, elim.		* Straggler according to Cochran, elim.	
Wort B				
Laboratory	Reference Fermentation		Rapid Fermentation	
1	83.1	–	82.7	–
2	80.3	80.6	79.7	80.1
3	83.4	83.9	84.2	84.1
4	82.7	83.3	80.8	81.2
5	83.1	83.0	82.4	82.3
6	83.1	82.8	81.8	82.1
7	82.3	82.3	81.8	81.8
8	82.5	82.5	80.8	80.7
9	83.3	83.3	82.8	82.7
10	82.2	82.0	81.6	81.5
11	82.6	82.8	82.6	82.6
12	81.0	81.0	80.0	79.9
13	81.4	81.7	79.8*	80.7*
14	82.7	82.9	81.6	81.9
	* Outlier according to Cochran, elim.			

Table 3 Summary of Precision Data, Units %

Reference Fermentation				
Sample	No Laboratories	Mean	r_{95}	R_{95}
Laboratory Wort	10	83.9	0.5	2.9
Industrial Wort A	11	81.3	0.2	2.2
Industrial Wort B	13	82.4	0.5	2.7
Rapid Fermentation				
Sample	No Laboratories	Mean	r_{95}	R_{95}
Laboratory Wort	9	82.8	0.9	2.4
Industrial Wort A	12	80.5	0.2	3.4
Industrial Wort B	12	81.7	0.4	3.5

Industrial Wort

Results were received from 14 laboratories and are presented in Table 2.

Laboratory 1 sent one result for each sample only, so it was eliminated. Laboratory 7 reported only one result for wort A using the reference method and was therefore eliminated. Evaluating the data of the reference fermentation of wort A, one set was identified as an outlier according to the Cochran test and another as a straggler, these results were not included in the statistical evaluation. The sets of the rapid fermentation of wort B showed one outlier according to the Cochran test and was omitted.

The precision data are given in Table 3.

The repeatability of both methods, the reference fermentation as well as the rapid fermentation, is similar, the reproducibility of the reference fermentation is better.

Despite the two hours longer fermentation time (7 hours instead of 5 hours) the attenuation limit using the rapid method was still lower compared to that of the reference method within about 24 hours.

4 Conclusion

The results of these collaborative trials showed that the repeatability and reproducibility values for the determination of the attenuation limit of laboratory wort from malt and industrial worts respectively using the reference fermentation method within about 24 hours are at an acceptable level, especially in view of the fact that each laboratory used its own in-house yeast.

The rapid method (fermentation time 5 hours and 7 hours respectively) had the tendency to give worse precision values and resulted in lower attenuation limits. This is probably due to the different yeast strains used and their different fermentation power which are obviously relevant for shorter fermentation times.

From the results of these trials the Analysis Committee of the European Brewery Convention decided to recommend the rapid method for guideline purposes.

5 Zusammenfassung

Hagen, W., und Schwarz, H.: Bestimmung der Gärfähigkeit (Endvergärungsgrad) von Würze — Monatsschrift für Brauwissenschaft 52, Nr. 5/6, 94 – 96, 1999

BC 3 Chemisch-technische Brauereibetriebskontrolle/ 35 Würze (Ausschlag- bzw. Anstellwürze)

Zwei Verfahren zur Bestimmung des scheinbaren Vergärungsgrades (Endvergärungsgrad) von Würze, nämlich die Regelgärung als Referenzmethode sowie ein schnelleres Verfahren, wurden von Mitgliedern des Analysekomitees der European Brewery Convention in einem Ringversuch geprüft, um Werte für die Wiederholbarkeit (r_{95}) und Reproduzierbarkeit (R_{95}) zu gewinnen und auf der Grundlage eines Vergleiches der an identischen Proben gewonnenen Werte ein Bild von der Gleichwertigkeit dieser beiden Verfahren zu erhalten. In den Ringversuchen wurden das 14. Standardmalz EBC und zwei industrielle Bierwürzen analysiert. Für die Wiederholbarkeit (r_{95}) und Reproduzierbarkeit (R_{95}) wurden für Laborwürze aus Malz beim Referenz-Gärverfahren Werte von 0,5% bzw. 2,9% bei einem Mittelwert von 83,9% ermittelt. Bei der Schnellvergärung betragen die Werte 0,9% bzw. 2,4% bei einem mittleren Füllstand von 82,8%. Die Genauigkeit für industrielle Bierwürze betragen beim Referenz-Gärverfahren $r_{95} = 0,4\%$ und $R_{95} = 2,4\%$ für mittlere Füllstände von 81,3 und 82,4%, beim Schnellverfahren wurden 0,3% bzw. 3,5% für mittlere Füllstände von 80,5 und 81,7% erreicht. Das Referenz-Gärverfahren ist genauer im Hinblick auf die Reproduzierbarkeit und bringt höhere Ergebnisse. Das Schnellverfahren wird nur zu Orientierungszwecken empfohlen.

Hagen, W., et Schwarz, H.: Détermination de la fermentescibilité (atténuation limite) du moût — Monatsschrift für Brauwissenschaft 52, No 5/6, 94 – 96, 1999

BC 3 Contrôles de la qualité physico-chimique en brasserie/ 35 moût (moût fin cuisson, moût à l'entonnement)

Deux méthodes pour la détermination de la fermentescibilité apparente (atténuation limite) du moût, la fermentation classique en tant que

méthode de référence ainsi qu'une méthode plus rapide ont été testées par les membres du Comité des Analyses de la European Brewery Convention pour obtenir les valeurs de répétabilité (r_{95}) et de reproductibilité (R_{95}) et de se faire une idée sur l'équivalence de ces deux méthodes d'analyses basées sur la comparaison des résultats d'échantillons identiques. Dans le test inter-laboratoire on a analysé le malt standard No 14 de l'EBC et deux moûts industriels. La répétabilité (r_{95}) et la reproductibilité (R_{95}) présentaient des valeurs de 0,5% et de 2,9% respectivement avec un niveau moyen de 83,9% obtenu sur le moût de malt en appliquant la méthode de référence par fermentation. En utilisant la méthode rapide de fermentation, les valeurs étaient de 0,9% et de 2,4% respectivement avec un niveau moyen de 82,8%. Les valeurs de précision pour les moûts industriels, utilisant la méthode de référence par fermentation, étaient de $r_{95} = 0,4\%$ et de $R_{95} = 2,4\%$ avec des niveaux moyens de 81,3 et 82,4%. En utilisant la méthode rapide on a obtenu 0,3% et 3,5% respectivement avec des niveaux moyens de 80,5 et 81,7%. La méthode de référence par fermentation est plus précise au niveau de la reproductibilité et produit des valeurs plus élevées. La méthode rapide est recommandée uniquement pour des tests d'orientation.

6 References

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4. Methods of Analysis of the American Society of Brewing Chemists, 8th edition, 1992. The Society, St. Paul, Minnesota.