How Good Is Your Grist?

National Homebrew Conference
June 14, 2014
Grand Rapids, Michigan

Jennifer Helber
Grain to Glass, LLC
North Kansas City, Missouri

- M.S. in Microbiology
- Established Boulevard Brewing Co.'s Quality Assurance Lab, 1999-2008
- Member of the American Society of Brewing Science; Sensory Committee
- Judge for GABF since 2006
- BJCP Judge since 2009
- Chair of Technical Subcommittee which ran a collaborative on the Manual Sieve Method

My background

More background

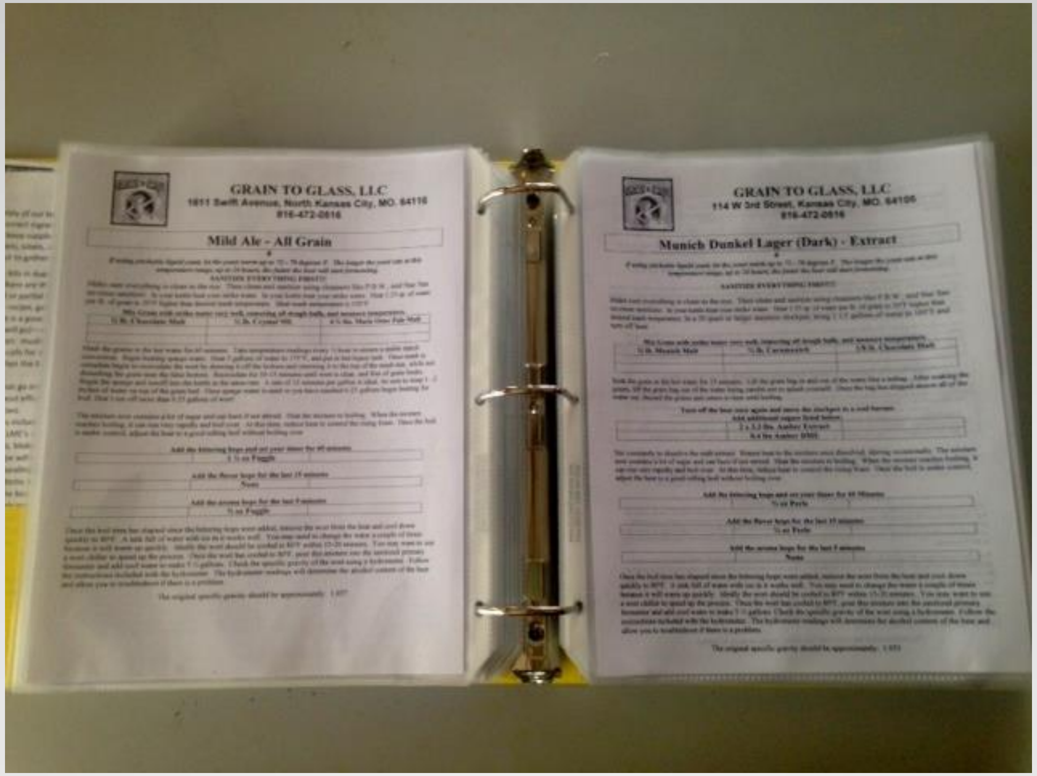
- Homebrewer since 2006
- Graduate of Siebel’s Advanced Homebrewing Course, 2009
- ZZ Hops President, 2010-2012
- Member of KC Biermeisters

- Currently, Microbiologist for the USDA, at the National Grain Center in KCMO

Owner/President of a local
Homebrew supply/Bottle Shop--
Grain to Glass, LLC
(established 2012),
in North Kansas City, Missouri

Beers and malts

We prepare recipes while homebrewers enjoy a beer!



Malting Science

Barley is Best

- It has a husk that protects the germ
- High starch-to-protein ratio
- Complete enzyme system
- Light color
- Neutral flavor

Milling: Definitions or objectives

Mill(v) to grind into a grist, flour, meal or powder

Milling ultimately is a compromise that each brewmaster reaches with a batch of grain.

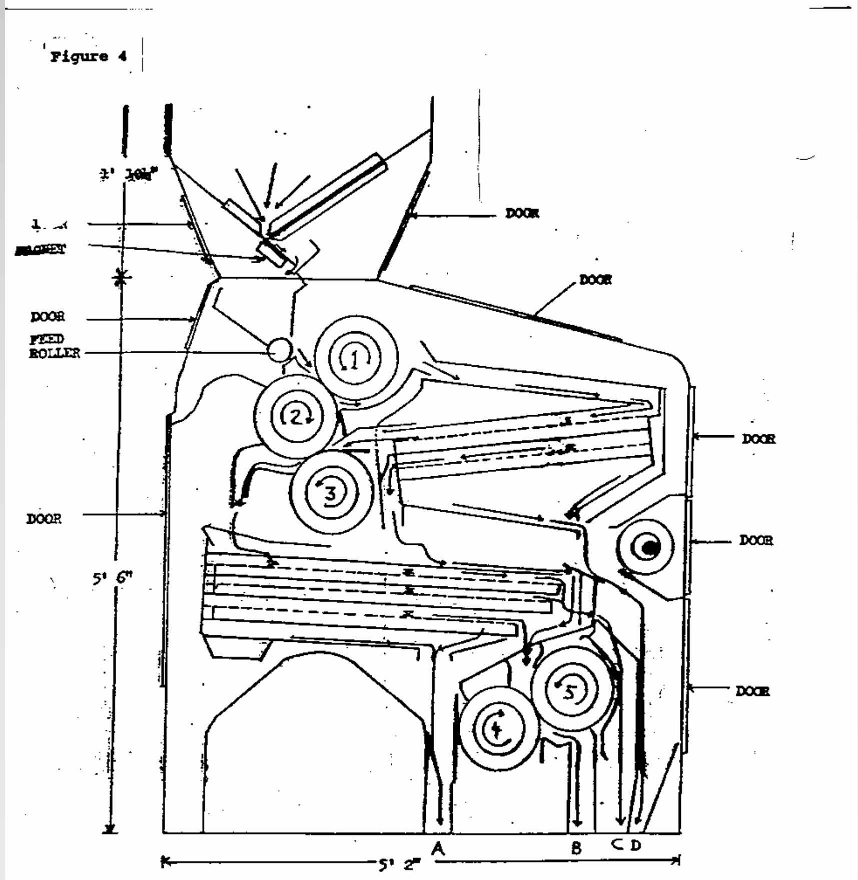
Their objectives are to find an acceptable middle ground between:

- Yield
- Separation Efficiency (Lautering)
- Quality

What’s a Mill?

Mill(n) a machine or apparatus for grinding grain

Roller Mills, 2,4, 5 or 6…



Different homebrewer mills

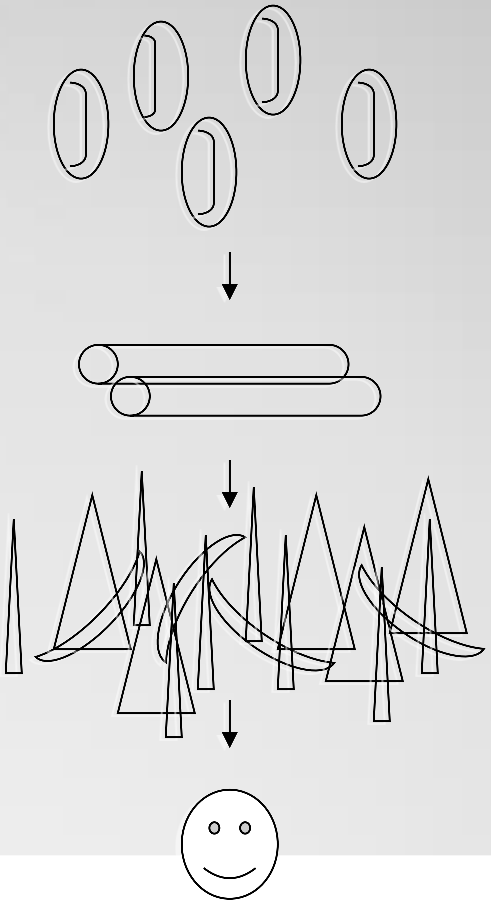
Milling: Making the most of your Grist

Grain Type/Assortment

Mill settings

Grind Profile

Brewhouse Performance



BRIESS™
MALT & INGREDIENTS Co.
All Natural Since 1876

625 S Irish Road • PO Box 229 • Chilton, WI 53014-0229 • Phone (920) 849-7711 • Fax (920) 849-4277 • www.briess.com

PRODUCT INFORMATION

Pilsen Malt WK

TYPICAL ANALYSIS

Mealy / Half / Glassy .... 98% / 2% /0%
Plump 90%
Thru 2%
Moisture 4.5%
Extract FG, Dry Basis 80.5%
Extract CG, Dry Basis 78.0%
Extract FG/CG Difference 2.0%
Protein 11.3%
S/T 37.0
Alpha Amylase 45
Diastatic Power (Lintner) 130
*Color 1.0
*°Lovibond, Series 52, ½" Cell

STORAGE AND SHELF LIFE

Best if used within 6 months from date of manufacture.
Store at temperatures of <90 °F.

KOSHER CERTIFICATION

UMK Pareve

FLAVOR

Subtle Malty, Delicately Sweet

ITEM NUMBERS AND PACKAGING OPTIONS

[illegible] .... Pilsen Malt, WK
50-pound bag
Call for # .... Pilsen Malt, WK
2,000-pound tote
Cal for # .... Pilsen Malt, WK
Bulk

CHARACTERISICS AND APPLICATIONS

- Very light colored base malt.
- Produces exceptionally clear, crisp wort.
- Pilsen Malt has a slightly lower protein level than 2-Row Brewers Malt.
- Produced from AMBA/BMBRI recommended 2-Row Malting Barley varieties.

February 2004

Equipment Needed

Recommended Sieves

- No 14………. 1.40mm opening
- No 30………. 0.600mm opening
- No 60………. 0.250mm opening
- Pan
- Cover

Balances

- Portable Balance
- Capacity Minimum 500gms
- Readability 0.1g – 1 g

Grist Profile Methods
Standard Sieve Test

This procedure is for the classification of malt grist from mill grinding by sieve analysis. The method employs a mechanical shaker for sieving a quantity of grist through standard sieves

Ro-Tap Sieve Shaker
The Rotap Testing Sieve Shaker accurately reproduces the circular and tapping motion given testing sieves in hand-sieving, but with a uniform, mechanical action assuring dependable, comparable tests.

Tyler Coarse Sieve Shaker
This low cost shaker is designed to be used in coarse testing application. Well suited for preground grist evaluation. A specially designed mechanism provides a shaking action resulting in consistent, accurate results.

Costs

	Standard Ro-Tap Method	Standard Shaker Method	Manual Sieve Method
Ro-Tap Shaker	$1695.00		
Coarse Sieve Shaker		$1000.00	
# 14 Sieve	$29.99	$29.99	$29.99
# 30 Sieve	$29.99	$29.99	$29.99
# 60 Sieve	$29.99	$29.99	$29.99
Pan	$19.70	$19.70	$19.70
Cover	$14.95	$14.95	$14.95
Balance	$144.00	$144.00	$144.00
Total Cost	**$1963.62**	**$1268.62**	**$268.62**

Sieve analysis

Optimizing Example

Mill settings	Roller Gap top	middle	bottom	Retained 14	30	60	pan
Coarse	13.0	10.5	11.0	78	14	4	4
Normal	10.0	8.0	6.0	53	28	11	8
Fine	6.5	3.3	2.8	25	25	31	20

	Yeild	Brewhouse efficiency	Collection Time (min)
Coarse	64%	85%	96
Normal	68%	91%	94
Fine	69%	92%	143

Malt Grist by Manual Sieve Test

Subcommittee Members: J. Helber, *Chair;* J. Barr; T. Bird; M. Brynildson; S. Coon; J. Felske; M. Henion; T. Kaehler; G. Kelly; G. Kustelski; L. Larson; M. Long; T. Marti; L. Miller; E. Samp; J. Schier; A. Tveekrem; K. Villa; B. Yawney; J. Zinanti; and P. Schwarz (*ex officio*).

Keywords: Malt grind, Mill, Particle size

CONCLUSIONS

Mitteleuropäische Brautechnische Analysenkommission (MEBAK) (4) employs a mechanical test sieve shaker, such as the Tyler Ro-Tap or Pfungstädter Plansichter. However, an informal survey of brewers in the craft-brewing segment indicated that while most performed some type of grist analysis, very few utilized a mechanical test sieve shaker. Schwarz et al (5) subsequently evaluated a modification of the newly adopted official ASBC method, which employed manual sieving rather than standard mechanical shaker. Results of this preliminary ...factory ...rrent ...ve

gram. The percentage of each fraction was calculated using the weight of the individual fractions divided by the sum of all of the fractions and multiplied by 100 (3).

Statistical Analyses

Results of manual grist analysis were evaluated using the Youden unit block design (1). The data were screened for outliers using Dixon's ratio tests as described in Statistical Analysis-4 (1). Results of mechanical and manual grist analyses were compared by the paired *t*-test for differences in means as described in Statistical Analysis-5 (1). Because the mechanical test was performed only once at each laboratory, data from the mechanical test were compared with the means of the manual data for each laboratory. Outliers were not included in the calculation of means.

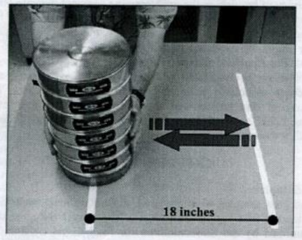
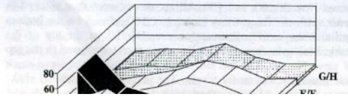


Fig. 1. Representation of the manual analysis of malt grist using U.S. test sieves. The sieve stack and receiving pan are shaken back and forth on a smooth flat surface, traveling 18 in. (45.7 cm) before the direction is reversed.

TABLE I
Characteristics of Standard U.S. Sieves

	Opening[a]		
U.S. Sieve	Microns	Inches	Grist Fractions[b]
No. 10	2,000	0.0787	Husksb held
No. 14	1,410	0.0555	Husks held
No. 18	1,000	0.0394	Husks held
No. 30	594	0.0234	Coarse grits held
No. 60	250	0.0098	Fine grits held
No. 100	150	0.0059	Ordinary flour held
Pan	...	...	Fine flour

[a] Information from (5).
[b] Information from (4).



RESULTS AND DISCUSSION

The size of the opening and characteristics of particles retained for each sieve used are shown in Table I. Mills used in this study were selected to provide a range of malt grist particle-size

TABLE II
Summary Data[a] (% w/w) for Malt Grist Analysis[b] by Manual Sieve Test

Fraction/Sample	Mean	Maximum	Minimum	Standard Deviation
Grist retained on U.S. No. 10				
A	24.4	31.2	20.5	3.1
B	27.6	52.8	20.4	9.4
C	62.4	64.5	60.5	1.2
D	61.9	64.1	58.7	1.6
E	3.4	3.9	2.8	0.4
F	4.2	5.6	3.2	0.8
G	18.7	22.5	16.3	2.1
H	17.7	20.7	15.0	1.8
Grist retained on U.S. No. 14				
A	38.4	42.3	35.6	2.0
B	36.3	40.9	17.3	6.8
C	17.9	19.4	16.6	0.8
D	18.6	19.6	17.0	0.9
E	11.0	12.2	9.3	1.0
F	11.0	12.3	9.1	1.0
G	25.8	27.6	23.3	1.3
H	19.2	20.2	17.6	1.0
Grist retained on U.S. No. 18				
A	15.0	18.7	11.9	1.8
B	14.8	18.5	11.7	1.8
C	6.5	7.5	6.0	0.4
D	6.6	8.0	6.1	0.5
E	18.0	19.4	16.9	0.9
F	17.8	19.5	16.6	1.1
G	28.1	31.1	27.0	1.5
H	14.7	16.3	13.6	0.8
Grist retained on U.S. No. 30				
A	9.9	10.7	8.3	0.8
B	9.4	10.6	7.3	1.1
C	5.4	5.8	5.0	0.3
D	5.4	5.9	4.9	0.4
E	30.0	31.9	28.3	1.3
F	29.6	30.9	28.0	1.0
G	18.6	23.3	14.8	2.4
H	16.1	17.6	14.7	1.0
Grist retained on U.S. No. 60				
A	7.5	8.4	6.9	0.5
B	7.3	8.7	6.4	0.7
C	4.2	4.4	3.9	0.1
D	4.2	4.5	3.9	0.2
E	22.8	24.2	22.1	0.7
F	22.4	23.4	20.8	0.8
G	6.8	7.2	6.5	0.3
H	18.5	19.4	17.5	0.6
Grist retained on U.S. No. 100				
A	2.2	2.4	2.0	0.1
B	2.1	2.5	1.9	0.2
C	1.3	1.7	1.1	0.2
D	1.3	1.6	1.2	0.1
E	6.6	7.8	5.6	0.6
F	7.1	7.9	6.2	0.6
G	1.1	1.4	1.0	0.1
H	7.1	8.3	6.3	0.7
Grist through U.S. No. 100				

GRIST

A. BY STANDARD SIEVE TEST

This procedure is for the classification of malt grist from mill grindings by sieve analysis. The method employs a mechanical shaker for sieving a quantity of grist through six standard sieves.

Apparatus

(a) *Mechanical sieving device*, designed for use with 8-in.-diameter standard testing sieves. See **Malt-4, Standardization of Malt Setting**, *Sieving ground malt* for types of mechanical sieving devices available.
(b) *Standard test sieves*, 8-in. diameter, Nos. 10, 14, 18, 30, 60, 100, a cover, and bottom pan, or equivalent.
(c) *Brush*, for cleaning the sieves.
(d) *Rubber balls*, 5/8-in diameter, Screwballs (Sefar Filtration, Kansas City, MO, or equivalent).
(e) *Dark paper*.
(f) *Analytical balance*, accurate to 0.1 g.
(g) *Timer*.

Method

Place three rubber balls on each of the U.S. standard test sieves Nos. 30, 60, and 100. Stack all six sieves in order with sieve No. 10 on top and sieve No. 100 on the bottom. Place the bottom pan under sieve No. 100. Obtain a sample of ground malt for analysis and reduce it to 100- to130-g by splitting or dividing. A "Jones-type" riffle sample splitter or divider is described in **Malt-1** and is useful for dividing malt grist. Place the 100–130 g sample of malt grist on the top of sieve No. 10, cover, and mechanically sieve for 5 min. Empty each individual sieve and the bottom pan onto dark paper and brush each one clean. Weigh the fractions, and record the net weight of the individual fractions to the nearest tenth of a gram.

Calculation

Calculate the percentage of malt grist retained for each fraction by dividing the weight of each fraction by the sum of the fraction weights and multiply by 100.

$$\%_x = \frac{W_x}{W_t} \times 100 \quad or \quad \frac{W_p}{W_t} \times 100$$

in which

x = screen 10, 14, 18, 30, 60, or 100
p = pan
$\%x$ = percent of malt grist for the fraction
W_x = weight of individual fraction retained on sieve No. x (in g)
W_p = weight of material passed through to the bottom pan (in g)
$W_t = W_{10} + W_{14} + W_{18} + W_{30} + W_{60} + W_{100} + W_p$ = sum of all fractions retained and passed through to the bottom pan (in g).

Report the percentage of malt grist retained for each fraction to the nearest tenth of a percent.

Example

$W_{10} = 21.8$ g
$W_{14} = 41.4$ g
$W_{18} = 16.6$ g
$W_{30} = 10.9$ g
$W_{60} = 6.9$ g
$W_{100} = 8.0$ g
$W_p = 4.3$ g

$$\begin{aligned} W_t(\text{g}) &= W_{10} + W_{14} + W_{18} + W_{30} + W_{60} + W_{100} + W_p \\ &= 21.8 + 41.4 + 16.6 + 10.9 + 6.9 + 8.0 + 4.3 \\ &= 109.9 \end{aligned}$$

$$\begin{aligned} \%_{10} &= \frac{21.8}{109.9} \times 100 \\ &= 19.8 \end{aligned}$$

$$\begin{aligned} \%_p &= \frac{4.3}{109.9} \times 100 \\ &= 3.9 \end{aligned}$$

Precision

Based on a collaborative study (1), repeatability and reproducibility coefficients of variation of 0.7–8.4% and 2.7–20.6%, respectively, can be expected for malt ground and passed through sieves 10–100. For malt grist retained on and passed through sieve No. 100, reproducibility coefficients of variation ranged from 6.8 to 15.2% and 11.0 to 20.6%, respectively, because of low mean values.

References

1. American Society of Brewing Chemists. Report of Subcommittee on Malt Grind by Standard Sieve Test. *Journal* 58:184, 2000.
2. Briggs, D. E., Hough, J. S., Stevens, R., and Young, T. W. Preparation of the grist. Pages 304-319 in: *Malting and Brewing Science*, 2nd ed. Vol. 1. Chapman and Hall, London, 1981.
3. Mitteleuropaische Brautechnische Analysenkommission. *Brautechnischen Analysenmethoden*, Band II. MEBAK, Freising-Weihenstephan, Germany, 1979.
4. Stubitis, M., Tang, J., and Pereira, J. Characterization of malt grist fraction. *J. Am. Soc. Brew. Chem.* 44:12, 1986.

2000, rev. 2009

B. BY MANUAL SIEVE TEST

This procedure is for the classification of malt grist from mill grindings by sieve analysis. The method employs manual shaking of U.S. standard test sieves for sieving a quantity of grist through four standard sieves.

doi: 10.1094/ASBCMOA-Malt-15

Apparatus

(a) *U.S. standard test sieves*, 8-in. diameter, Nos. 10, 30, 60, 100, a cover, and bottom pan, or equivalent.
(b) *Brush*, for cleaning the sieves.
(c) *Rubber balls*, 5/8-in. diameter, Screwballs (Sefar Filtration, Kansas City, MO, or equivalent).

Method

Place three rubber balls on each of the U.S. standard test sieves Nos. 30, 60, and 100. Stack all four sieves, Nos. 10, 30, 60, and 100 in order with sieve No. 10 on top and sieve No. 100 on the bottom. Place the bottom pan under sieve No. 100. Obtain a sample of ground malt for analysis and reduce it to 100–130 g by splitting or dividing. A "Jones-type" riffle sample splitter or divider is described in **Malt-1** and is useful for dividing malt grist. Place the 100- to 130-g sample of malt grist on the top of sieve No. 10, cover, and sieve for 3 min, sliding along a smooth surface for 18 in. per 0.5 sec, and then reverse the direction (total cycle time 1.0 sec). After each 15-sec interval, tap the pan and sieve stack sharply against a flat surface (see Note 1). Empty and brush clean each individual sieve and the bottom pan onto dark-colored paper. Weigh and record the net weight of the individual fractions to the nearest 0.1 g.

the sum of all of the fraction weights and multiply by 100.

$$\%_x = \frac{W_x}{W_t} \times 100$$

in which

$\%_x$ = percent of malt grist for each fraction

W_x = weight of individual fraction retained on sieve No. x (in g)

W_p = weight of material passed through to the bottom pan (in g)

W_t = sum of all fractions retained and passed through to the bottom pan (in g)

Report the percentage of malt grist retained for each fraction to the nearest one-tenth of a percent.

ple

= 21.8 g
= 78.9 g
= 6.9 g
= 8.0 g
= 4.3 g

$$g) = W_{10} + W_{30} + W_{60} + W_{100} + W_p$$
$$= 21.8 + 78.9 + 6.9 + 8.0 + 4.3$$
$$= 109.9$$

$$= \frac{21.8}{109.9} \times 100$$
$$= 19.8$$

$$= \frac{4.3}{109.9} \times 100$$
$$= 3.9$$

ion

collaborative tests (1) repeatability and reprolity coefficients of variation for all sieve fractions from 1.1 to 12.7% and 1.8 to 17.2%, respec-

Dark-colored paper is useful for ease of visual- when emptying and brushing grist from the pans.

2. To mimic the mechanical shaker and effectively move fines to the lower pans, the tapping motion must produce a loud bang.

References

1. American Society of Brewing Chemists. Report of Subcommittee on Malt Grist by Manual Sieve Test. *Journal* 61:246, 2003.
2. Schwarz, P., Barr, J., Joyce, M., Power, J., and Horsley, R. *J. Am. Soc. Brew. Chem.* 60:10-13, 2003.

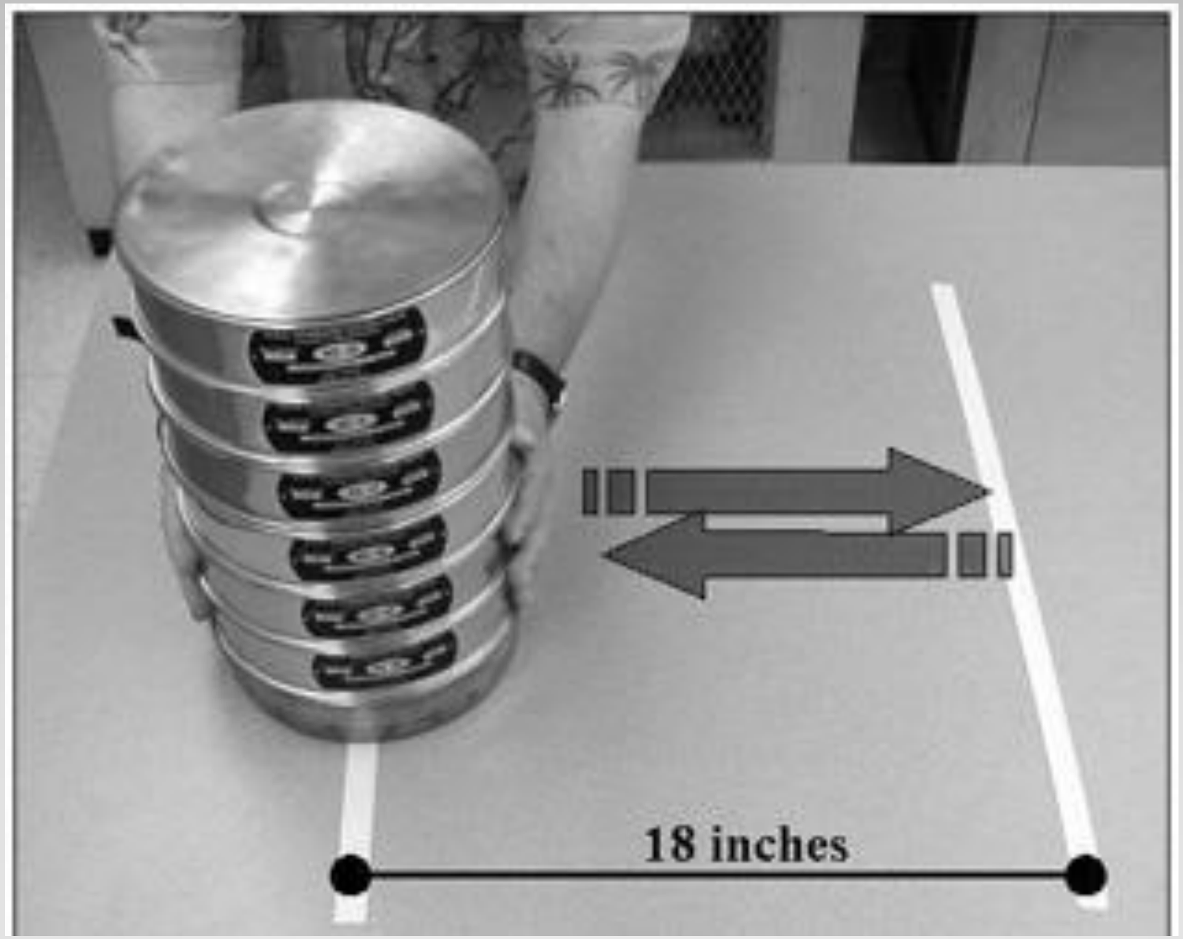
2003, rev. 2009

Video illustrating technique for manual sieve analysis

- **TABLE I**
- **Characteristics of Standard U.S. Sieves**
- **U.S. Sieve Microns Grist Fractions**
- No. 10 Husks held
- No. 14 Husks held
- No. 18 Husks held
- No. 30 Coarse grits held
- No. 60 Fine grits held
- No. 100 Ordinary flour held
- Pan … … Fine flour

- Individual grist samples weighing between 100 and 130 g
- 8-in.-diameter U.S. Standard test sieves nos. 10, 30, 60, 100 and a receiving pan.
- The top sieve was covered and the sieve stack was manually shaken for 3 min back and forth on a smooth flat surface
- Traveling 18 in. (45.7 cm), and then reversing the direction in a cycle of 1 sec
- After each 15-sec interval, the pan and sieve stack were sharply tapped
- The individual fractions were then weighed and the weights were recorded to the nearest one-tenth of a gram

Manual Method



Manual Sieve Method

How it's done--

Grist weighed from each sieve

Homebrew Club Exercise

ZZ Hops and KC Biermeisters

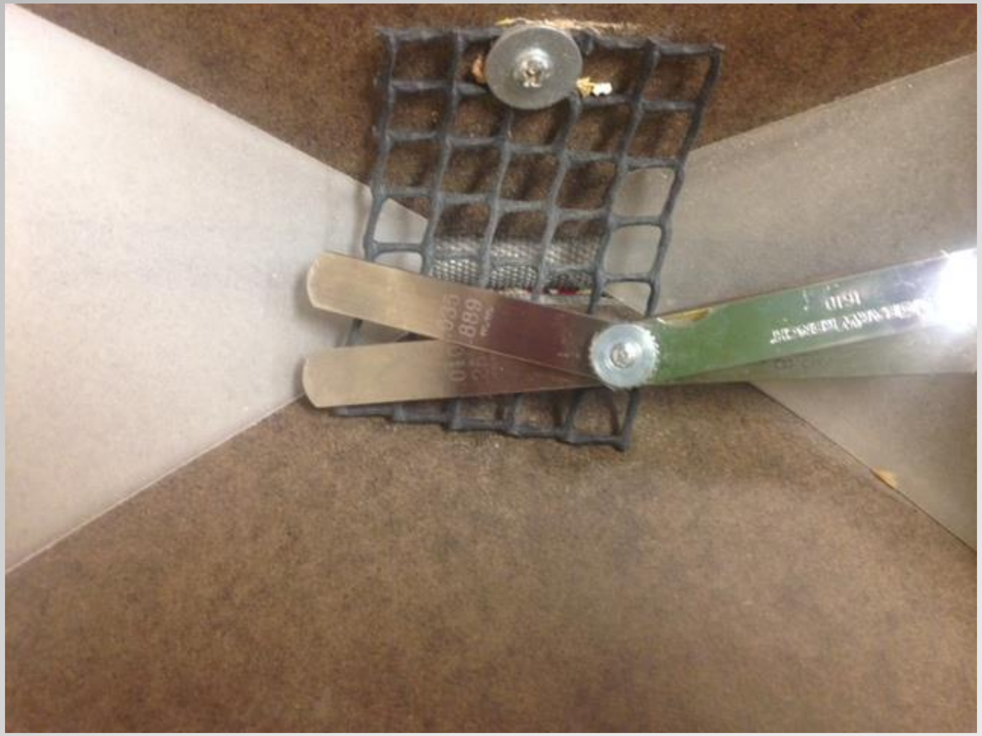
Shake it!

ZZ Hops Teamwork, 2012

Weighing Sieve Results

	Brewer A	%	Brewer B	%	Brewer C	%	Brewer D	%
10	49.1	49.1	30.6	30.6	48.0	48	62.5	62.5
30	**40.4**	40.4	**54.8**	54.8	**47.2**	47.2	**33.5**	33.5
60	6.1	6.1	12.5	12.5	2.3	2.3	2.5	2.5
100	1.1	1.1	0.6	0.6	0.3	0.3	1.0	1
pan	2.6	2.6	1.3	1.3	1.7	1.7	0.5	0.5
total	99.3	99.3	99.8	99.8	99.5	99.5	100	100
	Monster 2	%	Monster 3	%	Schmidling	%	Barley Crusher	

KC Biermeisters sieve results



Compare Sieve Results with Gap Width

If your mill results are too coarse or too fine, adjust the gap between the rollers.

Check with feeler gauges.

Periodically check the gap on your mill.

Optimizing Example

Mill settings	top	10	30	60	100	pan
Coarse	0.055	78	14	4	1	4
Normal	0.045	53	28	11	2	8
Fine	0.025	22	23	30	5	20

The method employs manual shaking of U.S. standard test sieves for sieving a quantity of grist through four standard sieves.

Post-sieve analysis

Malting barley methods used to measure quality

At the Grain Research Laboratory, unless otherwise specified, analytical results for barley and malt are reported on a dry weight basis. The ASBC methods cited are those of the *American Society of Brewing Chemists*, Ninth Edition, (2009).

List of western Canadian malting barley methods and tests

α-Amylase activity

α-Amylase activity is determined using ASBC method MALT 7B automated to run on a Skalar segmented flow analyser, using ASBC dextrinized starch as the substrate, and calibrated with standards that have been determined by method ASBC Malt 7A.

β-Glucan content

β-Glucan content is determined in malt extract by Skalar segmented flow analysis using Calcofluor staining of soluble, high molecular weight β-glucan (ASBC Wort-18).

Diastatic power

Diastatic power is determined on a Skalar segemented flow analyzer, using an automated neocuproin assay for reducing sugars, which is calibrated using malt standards analysed using the official ferricyanide reducing sugar method, (ASBC Malt 6A).

Dockage and assortment

Dockage - Dockage-free barley is obtained by passing an uncleaned sample through a Carter Dockage Tester arranged as described in the Canadian Grain Commission's Official Grain Grading Guide for dockage determination. This involves passing the barley over a no. 6 riddle, no. 6 and no. 5 Buckwheat sieves. Material retained above the no. 5 sieve is considered to be dockage-free.

Assortment - All samples are passed through a Carter Dockage Tester equipped with a no. 6 riddle to remove foreign material and two slotted sieves to sort the barley. Heavy Grade barley is the material retained on a 6/64" (2.38 mm) x 3/4" slotted sieve. Intermediate Grade is barley that passes through the

Fine-grind and coarse-grind Extracts

Extracts are prepared using an Industrial Equipment Corporation (IEC) mash bath and the Congress mashing procedure from 45°C to 70°C. Specific gravities are determined at 20°C with an Anton Paar DMA 5000 digital density meter (ASBC Malt-4).

Free amino nitrogen is determined on the fine extract according to the official ASBC method Wort-12, automated to run on a Skalar segmented flow analyzer.

Germination energy

Germination energy is determined by placing 100 kernels of barley on two layers of Whatman No. 1 filter paper, in a 9.0 cm diameter petri dish, and adding 4.0 ml of purified water. Samples are controlled at 20 degrees Celcius and 90% relative humidity in a germination chamber. Germinated kernels are removed after 24 and 48 hours and a final count is made at 72 hours (ASBC Barley 3C, IOB, and EBC procedure).

Kolbach index (Ratio S/T)

Kolbach index is calculated from the formula, (% Soluble protein/% Malt protein) x 100.

Micromalting

Malts are prepared using an Automatic Phoenix Micromalting System designed to handle twenty-four 500 g samples of barley per run.

Malt mills

Barley Malt Quality Methods

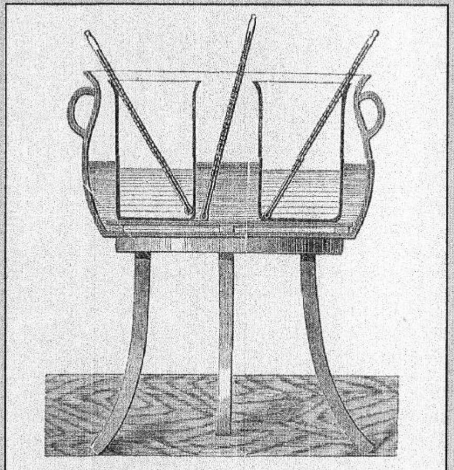


Abb. 44. Wasserbad zum Maischen.

Windisch, 1895

Also need to consider that many standard methods are old!

- Extract (Congress Mash), origins are in late 1800's
  - Original intent was only to determine maximum theoretical extract.
  - However, Congress wort is now used for all standard wort analyses.
    - Non-ideal mash conditions.
- Origins of ASBC alpha-amylase and DP methods is prior to 1920

How will these differ in a "Congress Wort"?

- Named for the standardized process instituted by the European Brewing Congress (EBC) in 1875.
- A standard weight of finely ground malt is multi-infusion mashed over a period of nearly 2 hours.
- The mash is filtered thru a paper filter for a period of 1 hour and the specific gravity is measured. The % Extract, Fine Grind, As-Is is calculated from the ASBC Table for Extract Determination in Malt.

Congress Mash

100 grams of milled malt —
Sample B on left
Sample D on right

300 mL strike water at 120F; held for 60 minutes (stirring every 15 minutes)

Temperature increased to 160F over 60 minutes (stirring every 15 minutes)

At the end of 2 hours, samples filtered through coffee filters

Specific Gravity checks

Kitchen Congress Wort, using an induction hotplate

Finer vs Coarser

Sieve 30	Sieve 30
54.8 %	33.5 %
1.072 SG	1.065 SG

Coarser grind exposes less of the endosperm—

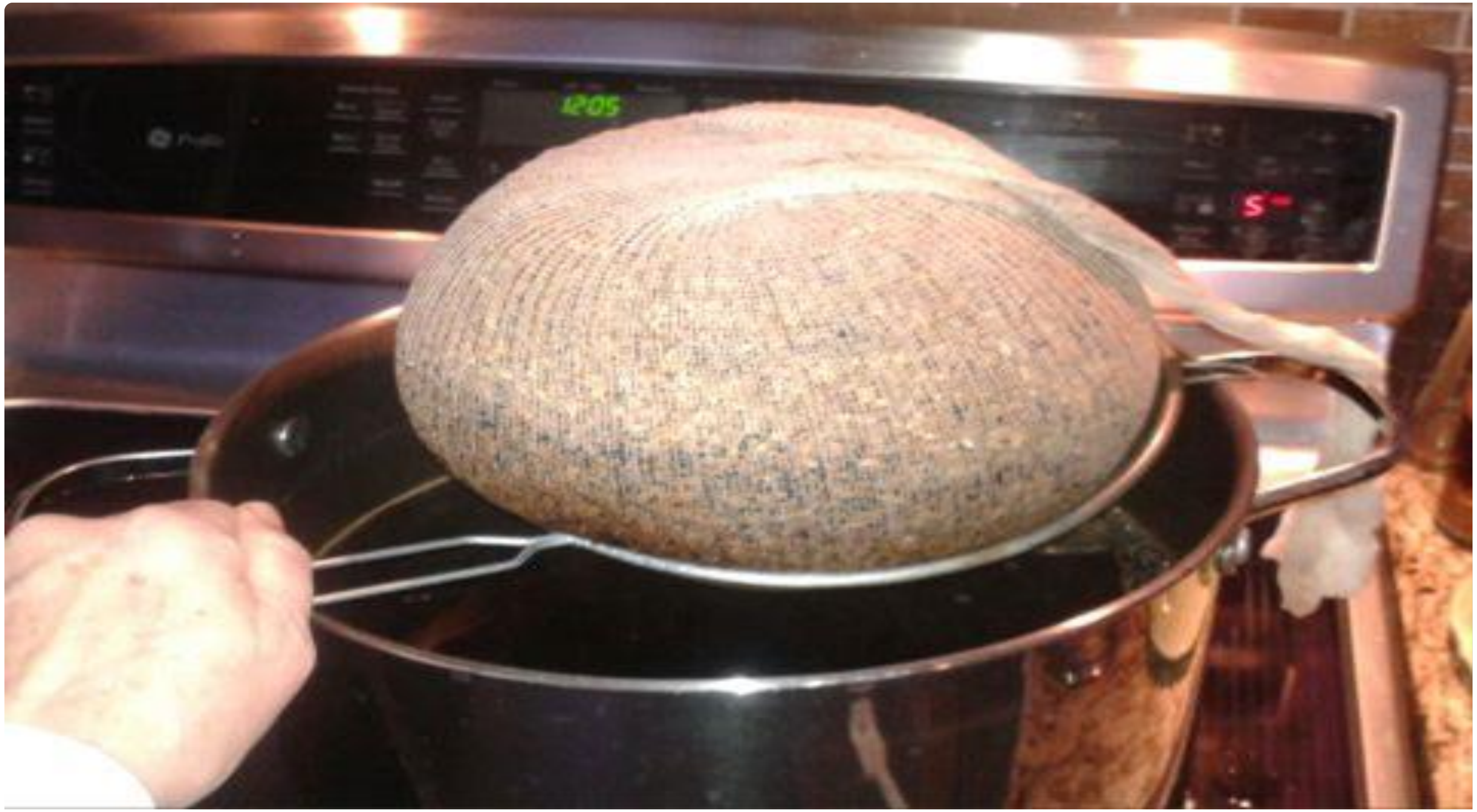
Less contact with heated water—

Less enzyme activation—

Less conversion to sugar

Sieves are something a good homebrew supply shop should have!

Not only to check customers' mills, but their own!



Proper grind is important not only to all-grain brewing, but also to partial-mash brewing

When malt is a major part of a recipe, the coarseness of the grind is important

Summary

- Milling consistently is important in making consistent beers
- Optimizing mill settings is beneficial in achieving efficient extraction of sugars and avoiding stuck mashes

- Efficient extraction from proper mill settings saves on malt bill and makeup additions of DME to achieve desired target Original Gravity

- Adjustable mills should be periodically checked; gap setting can be measured with feeler gauges—and compared with sieve results

Summary

References

- Schwarz, P., Barr, J.., Joyce, M., Power, J. and Horsley, R.
  J. Am. Soc. Brew.Chem. 60:10-13 (2002)
- Helber, J., Barr, J., Bird, T., Brynildson, M., Coon, S., Felske, J. Henion, M. Kaehler, T. Kelly, G., Kutelski, L., Larson, L., Long, M., Marti, T., Miller, L., Samp, E., Schier, J., Tveekrem, A., Villa, K., Yawney, B., Zinanti, J., and Schwarz, P.
  J. Am. Soc. Brew. Chem. 61:246 *(*2003)
- Methods of Analysis, Malt-15, American Society of Brewing Chemists, 2009
- Practical Milling for the Craft Brewer, Briess presentation for the Craft Brewers’ Conference, Bob Hansen, 2007

THANKS, AND COME SEE!