Characterization of Malt Grist Fractions[1]

M. Stubits, J. Teng, and J. Pereira, *Corporate Research and Development, Anheuser-Busch Companies, Inc., St. Louis, MO 63118*

ABSTRACT

The properties of each individual fraction of a coarsely ground malt were investigated to identify the relationship between grist size, grist composition, wort run-off rate, and extract yield. Chemical composition showed that the grist could be divided into four major fractions. The coarsest fraction contained the most malt husk, the midsize fraction was mainly endosperm, the medium fine fraction contained most of the protein matrix, and the fine pan fraction was mostly starch dust. The wort run-off rate of the coarse husk fraction was slow, as was that of the fine starch dust fraction. This coarse husk fraction also contained high residual starch. Extract yield and wort run-off rate were significantly improved by reducing the grist size of the husk fraction. An optimum malt grist profile for the brewing operation is proposed based upon a distribution which maximizes the midsize grist fractions.

Key words: Malt grist size, Optimum grist profile, Sieve analysis, Wort run-off rate.

Malt grist size has a pronounced influence on lautering and extract yield. It is commonly believed that the selection of malt grist size represents a choice between a fast run-off rate with low extract yield (coarse grind) and slow run-off with high extract yield (fine grind) (4). This investigation was undertaken to determine how much the extract yield of a coarse grist could be improved without compromising the run-off rate of the wort. With this information, we have proposed an optimum grist size distribution for the brewing operation.

EXPERIMENTAL

To better understand the relationship between malt grist size, extract yield, and run-off rate, the properties of each fraction of a coarsely ground grist were investigated. Six standard U.S. sieves were chosen to characterize the size of this grist. The sieve numbers ranged from 10 to 100 and the sieve openings from 78.7 to 5.9 mils (Table I). A single batch of coarse grist was ground and separated into designated sieve fractions and the bottom pan fraction. The composition of each grist fraction was determined. Each individual grist fraction was then mashed and lautered, and the properties of the wort were measured. Afterwards, the spent grain residues were washed, dried, weighed, and analyzed.

Milling

A batch (200 lbs) of six-rowed Larker malt was ground for this study. A five-roller Bühler-Miag malt mill was adjusted for the grist distribution shown in Figure 1.

Fractionation

The entire batch of grist was separated into seven fractions by shaking portions of the grist on the six selected sieves. A Ro-Tap shaker was used for this operation.

Mashing

A 100-g sample of each malt grist fraction was mixed with 45° C water and placed in a Micromat mash bath which had been preheated to 45° C. The water/cereal ratio of each mash was 3/1. The mash was held at 45° C and agitated at 200 rpm for 67 min, then warmed to 69° C in 24 min and held at this temperature for 35 min. The mash cycle was then completed by raising the temperature of the mash to 72° C.

Lautering

At the end of the mash cycle, the weight of the mash was readjusted to 400 g by adding water, then the mash was transferred to a 1,000-ml jacketed column (72° C) for lautering. A preweighed amount of glass wool was used to support the grain bed. The mash

TABLE I
Standard U.S. Sieves

U.S. Series Designation	Sieve Opening Inches (Approx. Equivalent)
No. 10	0.0787
No. 14	0.0555
No. 18	0.0394
No. 30	0.0234
No. 60	0.0098
No. 100	0.0059
Pan	...

[1]Presented at the 50th Annual Meeting, St. Louis, MO, September 1984.

was allowed to rest for 5 min. The valve of the column was fully opened, and the volume of wort was read at 10-min intervals until the flow of wort stopped. The final volume of the collected wort was then recorded.

Sparging

The spent grain residue of each malt grist fraction was sparged with 72°C water until the wort concentration was reduced to 0.1°Plato. All fractions, except the pan fraction, were washed by sparging in the lautering column. The pan fraction was washed by repeated mixing and centrifugation because the sparge water was unable to penetrate the doughlike spent grain bed. The spent grain bed was weighed after drying overnight in a vacuum oven at 60°C.

Malt Analysis

Each malt grist fraction was analyzed for starch, protein, and fiber. Starch was determined by the glucoamylase method (6). Protein was determined according to the ASBC method (2). Fiber was determined according to the AOAC method (5).

Wort Analysis

The wort from each malt grist fraction was analyzed for extract concentration, viscosity, run-off rate, and relative volume. Extract concentration was determined according to ASBC methods (1). Viscosity was determined according to the ASBC method (3). Run-off rate was determined by plotting the amount of wort collected at each 10-min interval. Run-off rate was calculated when 95% of the final volume had been collected. Relative volume represents the total volume of wort collected as a percentage of the theoretical volume.

Spent Grain Analysis

The spent grain residue of each malt grist fraction was analyzed for starch, fiber, and protein. The first three components were determined as described under Malt Analysis.

RESULTS

The results of this investigation are summarized in Table II. Examination of these data indicated that the seven fractions can be meaningfully consolidated into four fractions, each having a unique composition. The combined 10 and 14 fraction or "husk fraction" has the highest fiber content. The combined 18 and 30 fraction or "endosperm fraction" is high in starch content and low in fiber content. The combined 60 and 100 fraction or "protein matrix" is highest in protein and lowest in starch content. The pan fraction or "starch dust" is highest in starch content and lowest in fiber. Table III summarizes the relative composition of these four fractions.

Characteristics of the wort from each of the four fractions are shown in Table IV. The husk fraction exhibited the lowest extract and slow run-off. The endosperm fraction is high in extract concentration and fastest in run-off. The protein matrix has fast run-off and low extract concentration. The starch dust fraction is slowest in run-off but highest in extract concentration.

Table V summarizes the spent grain analysis of each of the four fractions. The husk spent grain fraction contains the highest percentage of fiber and residual starch. The endosperm spent grain is high in protein but low in fiber. The protein matrix spent grain is low in protein and starch yet high in fiber. The highest percentage of protein and lowest percentage of fiber are found in the starch dust spent grain.

DISCUSSION

From these experimental results we may infer that the lautering run-off is much influenced by the radically different structures of the spent grains derived from various grist fractions. In the case of the husk fraction, the unexpectedly slow run-off is caused by the large fibrous husk structure, which absorbs and retains much wort in the mash. Scanning electron micrographs (Figure 2) of these husks reveal porous and spongelike morphology. For a very different reason, the lautering run-off of the starch dust fraction is very slow. The extremely fine proteinaceous spent grain particles

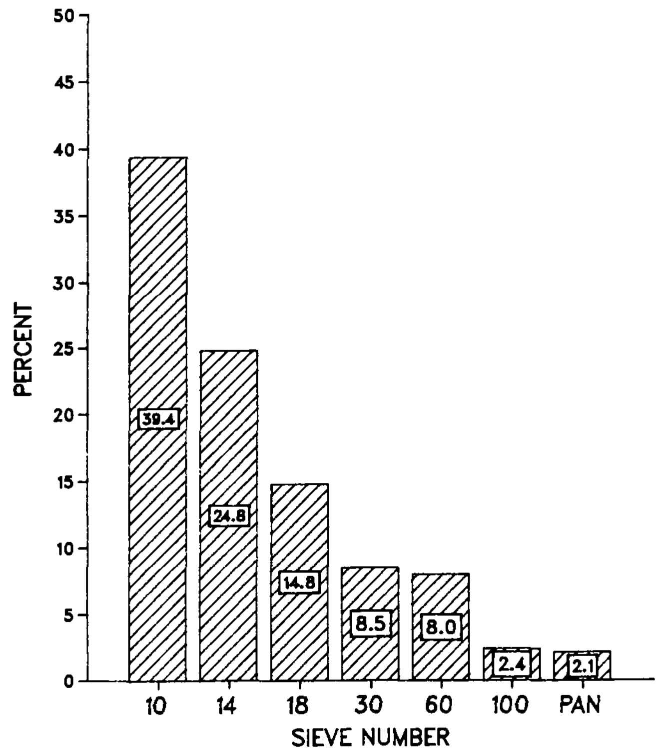

Fig. 1. Particle size distribution of coarse grist.

TABLE II
Properties of Malt Grist Fractions

	Malt Analyses			Spent Grain Analyses			Wort Analyses			
Sieve Number	Starch (%)	Protein (%)	Fiber (%)	Starch (%)	Protein (%)	Fiber (%)	°Plato (g ext/100 g soln)	Viscosity (rel)	Run-Off Rate (ml/min)	Relative Volume (%)
10	50.09	11.99	7.10	9.60	20.73	23.26	16.60	2.07	0.55	38.06
14	56.05	13.83	4.12	9.84	30.93	13.54	19.13	2.60	0.88	53.35
18	63.36	11.56	3.50	8.14	36.90	12.98	20.90	2.62	2.98	72.90
30	54.93	13.38	3.71	4.89	35.58	14.04	20.42	2.50	4.44	69.35
60	47.14	15.36	5.19	3.92	33.34	15.15	19.83	2.44	3.07	62.58
100	49.35	17.73	4.29	5.60	35.70	12.47	20.09	2.41	2.33	53.87
Pan	69.89	11.82	1.93	6.53	42.02	9.90	21.71	2.54	0.52	36.77

agglomerate into a dense doughlike mass that restricts the wort flow.

Based on these inferences, we made the following lautering predictions. First, that the wort run-off rate for the total grist (unfractionated) would be dominated by the husk, which is 75% of the spent grain material. Second, that the extract yield of this coarse grist could be significantly improved by reducing the size of the 10-mesh fraction, which has a much greater amount of residual starch than the other fractions. Third, that this reduction in grist size would improve lautering because the resultant finer husk particles would retain less wort. Additional experiments were run to test the validity of these predictions.

In the first experiment, all seven grist fractions were combined, mashed, and filtered as described in the experimental section. It was found that the flow rate of the wort from this grist was almost identical to the flow rate of the wort from the husk fraction. Because the composition of this fraction is the same as that of the original brewhouse grist, this finding supports the prediction that the run-off of the coarse brewhouse grist is dominated by the run-off rate of the wort from the husk fraction (Table VI).

Second, the coarse 10-mesh fraction was reground so that the husk particles were now retained on the 60-mesh sieve, then the seven grist fractions were recombined, mashed, and filtered. The extract yield of this grist was 3% higher than that of the original coarse grist. It was also found that the run-off rate of the wort from this grist was three times as fast as the run-off rate of the wort from the original grist. These findings support the prediction that both brewhouse yield and wort run-off rate could be improved by reducing the amount of the coarse husk fraction.

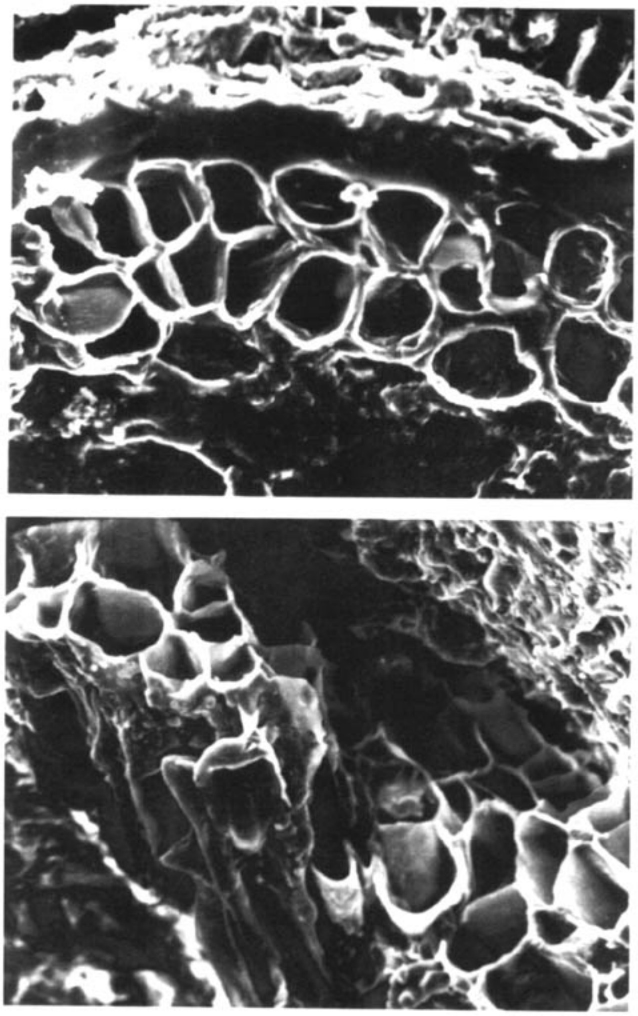

Fig. 2. *Scanning electron micrographs reveal morphology of malt husk fraction.*

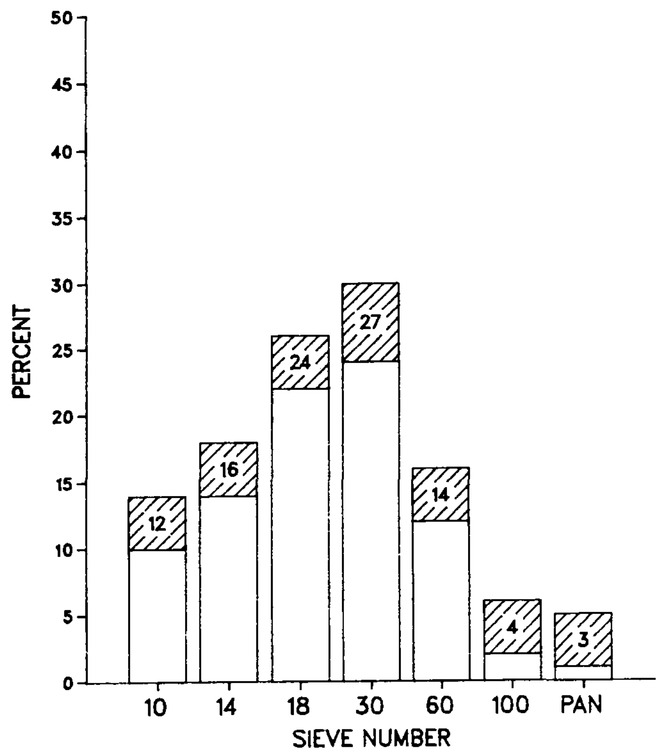

Fig. 3. Sieve analysis of optimum malt grist particle size distribution.

TABLE III
Composition of Malt Grist Fractions

Combined Fractions	Grist Classification	Starch (%)	Protein (%)	Fiber (%)
10 + 14	Husk	52.38 (2)[a]	12.69 (3)	5.95 (4)
18 + 30	Endosperm	60.27 (3)	12.24 (2)	3.58 (2)
60 + 100	Protein matrix	47.70 (1)	15.90 (4)	4.98 (3)
Pan	Starch dust	69.89 (4)	11.82 (1)	1.93 (1)

[a](1) Lowest, (2) low, (3) high, and (4) highest.

TABLE IV
Properties of Wort from Malt Grist Fractions

Combined Grist Fractions	Grist Classification	°Plato (g Ext/100 g Soln)	Viscosity (cS)	Run-Off Rate (ml/min)	Relative Volume (%)
10 + 14	Husk	17.58 (1)[a]	2.27 (1)	0.67 (2)	44.05 (2)
18 + 30	Endosperm	20.70 (3)	2.52 (3)	3.51 (4)	71.56 (4)
60 + 100	Protein matrix	19.86 (2)	2.42 (2)	2.89 (3)	60.56 (3)
Pan	Starch dust	21.70 (4)	2.54 (4)	0.52 (1)	36.77 (1)

[a](1) Lowest, (2) low, (3) high, and (4) highest.

TABLE V
Composition of Spent Grain Residues

Grist Classification	Starch (%)	Protein (%)	Fiber (%)
Husk	9.60 (4)[a]	24.66 (1)	19.51 (4)
Endosperm	6.62 (3)	36.43 (3)	13.35 (2)
Protein matrix	4.31 (1)	33.88 (2)	14.49 (3)
Starch dust	6.53 (2)	42.02 (4)	9.91 (1)

[a](1) Lowest, (2) low, (3) high, and (4) highest.

TABLE VI
Effect of Husk Fraction on Total Grist

Grist	Run-Off Rate (ml/min)	Extract Yield (%)
Husk fraction	0.67	70.70
Total grist	0.75	74.78
#10 Fraction reground	2.93	77.76
% Improvement	291%	3.0

CONCLUSION

This investigation concludes that, from the viewpoints of favorable extract yield and good lautering run-off, grist should be ground to have a bell shaped particle size distribution (Figure 3). Most of the grist should fall between the 18- and 60-mesh sieves.

The malt mills have been carefully adjusted to reduce the husk fraction without producing excessive "dust." This new grist profile has resulted in significant improvement in extract yield without increase in run-off time.

LITERATURE CITED

1. American Society of Brewing Chemists. Methods of Analysis, 7th ed. Malt-2 and 3. The Society: St. Paul, MN, 1976.
2. American Society of Brewing Chemists. Methods of Analysis, 7th ed. Malt-8. The Society: St. Paul, MN, 1976.
3. American Society of Brewing Chemists. Methods of Analysis, 7th ed. Wort-13. The Society: St. Paul, MN, 1976.
4. Briggs, D. E., Hough, J. S., Stevens, R., and Young, T. W. Page 309 in: Malting and Brewing Science. Vol. 1. 2nd ed. Chapman Hall: London, 1981.
5. Association of Official Analytical Chemists. Page 132 in: Official Methods of Analysis. 13th ed. W. Horwitz, ed. Crude Fiber 7.061. AOAC: Washington, DC, 1980.
6. Thivend, P., Mercier, C., and Builbot, A. Methods in Carbohydrate Chemistry. Vol. 6. R. L. Whistler, ed. Academic Press, Inc.: New York, 1972.

[Received September 12, 1984]