METHODS

Cleaning All samples were cleaned on a Carter Dockage Tester and only grain between 5 and 7/64" was used.

Barley Mill Ground barley was prepared with a Labconco Burr mill that was adjusted so that only 35% of the grist remained on a 525 µm sieve after 3 min of shaking and tapping.

Kernel Weight The number of kernels in a 20 g aliquot of each sample was counted electronically and the '1000 kernel weight' was calculated.

Plumpness Samples were sized on a Eureka-Niagra Barley Grader and the percentage of the seeds retained on a 6/64" screen was determined.

Barley Color The brightness of the grains was measured using an Agtron M45-D analyzer.

Barley Moisture Content (Barley 5B) Five g of ground sample was dried for 3 h at 104°C. The percentage of weight loss that occurred during this drying was calculated.

Barley Protein Content Total nitrogen values were obtained using an automated Dumas combustion procedure with a LECO FP-528 analyzer. Nitrogen values were converted to protein percentages by multiplication by 6.25.

Malting Conditions 170 g (db) aliquots of barley were processed in Joe White micro-malters. Samples were hydrated to 47% moisture via a 32 h steep at 19°C: 8 h wet, 8 h air, 5 h wet, 5 h air, 2 h wet, 2 h air, 2 h wet. (Larger barleys, > 42 mg/kernel, received a continuous, wet pre-steep (16°C) of between 1 and 3 h). The samples were germinated for 48 h (18°C), 24 h (17°C), and 24 h (16°C), with moisture adjustment to 47% at 0, 24, and 48 h. The samples received 4 full turns every 2 h. The germinated grain was kilned for 24h as follows: 49°C, 10 h; 54°C, 4 h; 60°C, 3 h; 68°C, 2 h; and 85°C, 3 h, with 30 min. ramps between stages. All stages received 40% total flow, with 0% recirculation for stages 1-3, 50% for stage 4, and 75% for stage 5.

Malt Mill Fine-grind malts were prepared with a Miag laboratory cone mill that was adjusted so that 10% of the grist remained on a 525 µm sieve after 3 min of shaking, with tapping. Malts to be used for moisture, protein and amylolytic activity analyses were ground in a Labconco Burr mill (see Barley Mill).

Malt Moisture Content Determined by Malt 3 (Methods of Analysis of the ASBC, 8th ed, 1992) See Barley Moisture Content.

Malt Protein Content See Barley Protein Content.

Malt Extract Samples were extracted using the Malt-4 procedure (Methods of Analysis of the ASBC, 8th ed, 1992), except that all weights and volumes specified for the method were halved. The specific gravity of the filtrate was measured with an Anton Parr DMA5000 density meter. The density data were used to calculate the amount of soluble material present in the filtrate, and thus the percentage that was extracted from the malt.

Wort Color was determined on a Skalar SAN plus analyzer by measuring the absorbance at 430nm and dividing by a factor determined by collaborative testing.

Wort Clarity was assessed by visual inspection.

β-Glucan Levels were determined on a Skalar SAN plus analyzer by using the Wort-18 fluorescence flow injection analysis method with calcofluor as the fluorescent agent (Methods of Analysis of the ASBC, 8th ed, 1992).

Free Amino Nitrogen Levels were determined on a Skalar SAN plus analyzer using an automated version of the Wort-12 protocol (Methods of Analysis of the ASBC, 8th ed, 1992).

Soluble (Wort) Protein Levels were determined on a Skalar SAN plus analyzer using the Wort-17 UV-spectrophotometric method (Methods of Analysis of the ASBC, 8th ed, 1992).

S/T Ratio was calculated as Soluble Protein / Total Malt Protein

Diastatic Power Values were determined on a Skalar SAN plus analyzer by the automated ferricyanide procedure Malt-6C (Methods of Analysis of the ASBC, 8th ed, 1992).

α-Amylase activities were measured on a Skalar SAN plus analyzer by heating the extract to 73°C to inactivate any β-amylase present. The remaining (α-amylase) activity was measured as described for Diastatic Power Values.

Viscosities were measured on an Anton Paar AMVn rolling ball viscometer. Relative viscosities were reported: flow time of mash extract over the flow time of distilled water.

Turbidities were determined in Nephelometric Turbidity Units (NTU) on a Hach Model 18900 Ratio Turbidimeter.

Quality Scores were calculated by using a modification of the method of Clancy and Ullrich (Cereal Chem. 65:428-430, 1988). The criteria used to quantify individual quality factors are listed in Table A1.

Overall Rank Values were ordered from low to high based on their Quality Scores. A rank of '1' was assigned to the sample with the best quality score.

Quality Score Parameters for 2- and 6-rowed barleys

Quality parameter	2-rowed condition	Adjunct score	6-rowed condition	Adjunct score	2-rowed condition	All Malt score
Kernel Weight	> 42.0	5	> 32.0	5	> 42.0	5
(mg)	40.1-42.0	4	30.1-32.0	4	40.1-42.0	4
	38.1-40.0	2	28.1-30.0	2	38.1-40.0	2
	< 38.0	0	< 28.0	0	< 38.0	0
on 6/64 "	> 90.0	5	> 80.0	5	>90.0	5
(%)	85.0-89.9	3	73.0-79.9	3	85.0-89.9	3
	< 85.0	0	< 73.0	0	< 85.0	0
Malt Extract	> 81.0	10	> 79.0	10	> 81.5	10
(% db)	79.4-81.0	7	78.2-78.9	7	80.0-81.0	5
	78.0-79.4	4	77.7-78.2	4	79.5-80.0	3
	<78.0	0	< 77.7	0	<79.5	0
Wort Clarity	= 3	0	= 3	0	= 3	0
3=hazy	= 2	1	= 2	1	= 2	1
2=slightly hazy	= 1	2	= 1	2	= 1	2
1=clear						
Barley Protein	> 13.5	0	> 14.0	0	> 11.5	0
(% db)	13.0-13.5	5	13.5-13.9	5	10.5-11.5	5
	11.0-13.0	10	11.5-13.5	10	9.8-10.5	10
	< 11.0	5	< 11.5	5	< 9.8	5
Wort Protein	> 6.0	0	> 6.0	0	> 4.7	0
(% db)	5.6-6.0	3	5.7-6.0	3	4.5-4.7	3
	4.4-5.6	7	5.2-5.7	7	4.1-4.5	7
	4.0-4.4	3	4.8-5.2	3	3.9-4.1	3
	< 4.0	0	< 4.8	0	< 3.9	0
S/T (Soluble/Total	>47	0	>47	0	>45	0
Protein, % db)	40-47	5	42-47	5	43-45	3
	< 40	0	< 42	0	39-43	5
					<39	3
DP (Diastatic	>120	7	>140	7	>120	0
Power, ° ASBC)	100-120	4	120-140	4	115-120	3
	< 100	0	< 120	0	100-115	7
					95-100	3
					<95	0
Alpha-amylase	>50	7	>50	7	>75	2
(20° DU)	40-50	4	40-50	4	65-75	5
	< 40	0	< 40	0	< 65	0
Beta-glucan	< 100	7	<120	7	< 100	7
(ppm)	100-150	3	120 - 170	3	100-150	3
	> 150	0	> 170	0	> 150	0
Free Amino Nitrogen	>190	5	>200	5	>200	0
	180 - 190	3	190 - 200	3	180 - 200	3
	< 180	0	< 190	0	150-180	7
					130-150	3
					<130	0
		70 max		70 max		70 max