Influence of Variety Blending on Analysis of Malt Quality[1]

CHARLES W. BAKER[2], *North Dakota State University, Fargo, ND 58102*

ABSTRACT

Varietal quality differentiation was unaffected by substituting variety blend for average data. The effect of blending the same variety, grown at different locations, before malting and analysis, was examined. Eleven varieties grown at seven locations were malted individually (n = 77) and after blending by variety (n = 11). Sample size and blending time were determined by analyzing these influences on anticipated average barley protein values. The overall quality profile of each variety blend was statistically equal to that observed after averaging the data of each variety over the seven sites of growth. The significant difference between blend and average α-amylase values was meaningless, as the order of blend and average absolute values was identical. Specific varietal quality parameters observed at specific locations of growth were significantly different from those of the variety blends. However, this difference was lost during varietal averaging and/or blending. Thus, blending single varieties before malting produced the same malt data as averaging the quality data of the individual malts.

Key words: *Analysis, Blending, Quality, Variety.*

The barley and malt quality testing program at North Dakota State University is composed of barley prediction and micromalt series of analyses (8). Advancement of experimental selections through the different stages of the barley variety development program has been reviewed (8). The utility and indispensability of barley prediction testing have been illustrated by statistical analyses (3).

The original micromalting procedure (6) has been modified (3,4) to increase efficiency and save labor time. Although updated, the number of experimental samples micromalted and analyzed average two to three times the number of experimental varieties. For example, the 807 experimental samples analyzed from the 1975 crop represented only 362 different varieties. The variety development program was expanded in 1974 to include six- and two-row varieties. To allow equal emphasis, variety blending was suggested as a means of testing more cultivars without appreciably increasing total sample number. Unpublished blending data[3] indicated that blending the same variety of barley or malt of different protein levels resulted in varietal malt data not significantly different from the average variety data.

The present study was undertaken to more completely define the variables that would affect variety blending in the micromalting phase of quality testing. The lack of a significant difference between malt quality data determined from individual barley varieties blended before malting and analysis and that obtained after averaging would streamline the program considerably. The statistical evaluation of this approach is presented.

EXPERIMENTAL

General Methods

Barley color was measured instrumentally (7) with a Gardner Digital Difference Meter Model XL-10 (Gardner Laboratory, Inc., Bethesda, Md.). Color was reported as the Gardner L value.

Kernel assortment was determined by a modification (3) of the standard ASBC Malt-2 method (1). Results were reported as per cent plump and thin kernels and as the single-value plumpness score, a weighted summation of overall kernel plumpness (3).

Methods for determination of the moisture content of unmalted barley and kilned malt have been described (3).

All coarsely and finely ground malt samples were prepared on a Miag Malt Mill (Buhler-Miag, Inc., Minneapolis, Minn.) standardized according to the ASBC Approved Method Malt-4 (1).

Worts were prepared by the ASBC Approved Method Malt-4 (1). Malt recovery, soluble protein (N × 6.25), and the ratio of soluble to total protein were determined by standard ASBC methods (1). Barley and malt total protein (N × 6.25), fine grind extract, and fine-coarse grind extract difference were determined by modified ASBC procedures (3). Malt diastatic power and α-amylase were determined by the automated procedure described by Banasik (4) on infusions prepared by the standard ASBC Malt-6 method (1). All results were reported on a dry basis.

Preparation of Samples

The cultivars (*Hordeum vulgare* L.) Dickson, Klages, Beacon, Shabet, Vanguard, Georgie, Multum, Bonanza, ND-231, Manker, and Karl were grown in drill strips at the seven experiment branch stations (Carrington dry and irrigated land, Dickinson, Fargo, Langdon, Minot, and Williston) in North Dakota in 1975. Lightweight dockage was removed from each deawned sample with a Clipper Fan Mill (A. T. Ferrell & Co., Saginaw, Mich.), using sieve nos. 7 and 13. The fan vent was approximately three-fourths open.

Each variety blend was prepared by mixing 100 g of the same variety from each location of growth. Blending was done in a MacLellan Batch Mixer (Anglo American Mill Corp., Owensboro, Ky.) for 1 min. Any foreign materials and damaged kernels remaining in the 77 single-variety and 11 variety-blend samples were removed by hand.

Each cleaned single-variety and variety-blend sample (80 *g*, dry basis) was malted by the procedure described by Banasik *et al.* (6). Kilning was achieved by a two-stage process (9). Each single variety was malted in March, 1976, while blends were malted in June, 1976. Average malt quality data were calculated for each variety from the corresponding individual station data by standard procedures.

RESULTS AND DISCUSSION

The effects of sample size and blending time on variety blending were assessed by examining their influences on the average barley protein anticipated after mixing two variety pairs (different locations of growth) of widely different levels of barley protein. The differences in barley protein between the two samples of variety "R" and the two of variety "L" were 3.61 and 4.48%, respectively. The anticipated averages of barley protein of varieties R and L were 14.66 and 16.42%, respectively. Variety sample sizes of 100, 125,

TABLE I
Analysis of Variance of Sample Size and Blending Time on the Overall Average Barley Protein of Varieties "R" and "L" after Blending[a]

Source of Variation	Mean Square R	Mean Square L
Sample size	0.056	0.023
Blending time	0.047	0.033
Error	0.061	0.031

[a]After blending, overall average barley protein of R and L was 14.74 and 16.49%, respectively.

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[2]Assistant Professor, Department of Cereal Chemistry and Technology.
[3]O. J. Banasik, North Dakota State University, personal communication, 1976.

TABLE II
Average (A) and Blend (B) Malt Quality Data

Variety	Quality Parameter[a]																							
	Col		Plmp		Thn		PScr		MRcy		TPro		SPro		SPro		TPro		Ext		F-C		DP		AA	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Dickson	52.9	54.8	47.8	49.0	17.7	14.6	530	534	90.5	90.7	14.9	14.5	4.38	4.05	29.5	27.9	73.7	73.2	4.6	3.8	155	144	43.5	59.2
Klages	52.0	52.6	55.9	58.8	9.8	7.2	546	552	90.8	90.5	15.8	15.3	4.82	4.62	30.7	30.2	75.5	75.1	4.9	4.7	136	128	53.6	67.6
Beacon	52.3	52.3	72.4	75.4	3.9	2.6	569	573	90.1	90.0	16.1	15.9	4.65	4.62	28.9	29.8	74.3	74.6	2.1	2.0	176	180	44.0	60.5
Shabet	52.1	51.4	48.1	57.8	14.5	7.0	534	551	91.0	91.0	15.5	15.0	4.04	4.06	26.1	27.1	73.4	74.5	8.0	9.0	104	101	39.1	51.0
Vanguard	52.1	52.6	50.1	60.4	13.1	6.8	537	554	90.4	90.5	15.0	14.8	4.15	3.87	27.7	26.1	73.8	73.7	7.0	6.8	123	122	48.0	62.5
Georgie	49.5	50.6	69.5	76.6	8.0	3.2	561	573	91.5	89.3	15.5	15.2	3.45	3.31	22.2	21.8	72.5	73.2	7.7	5.3	68	71	32.3	43.7
Multum	48.2	50.0	82.3	87.0	3.8	1.2	578	586	91.1	89.8	15.2	14.9	3.97	3.37	26.1	22.6	73.5	74.2	6.5	5.7	107	109	40.3	56.0
Bonanza	51.2	52.2	69.5	71.0	4.7	3.0	565	568	89.6	89.0	15.6	15.2	4.89	4.79	30.9	31.5	75.4	75.9	1.8	2.2	161	163	53.8	68.0
ND-231	52.3	52.5	64.2	68.0	7.0	4.2	557	564	89.6	90.0	16.2	15.8	5.14	5.17	31.7	32.7	74.3	74.5	2.0	1.8	179	184	52.1	65.7
Manker	50.3	50.7	73.8	75.2	6.3	5.2	567	570	90.0	89.6	15.8	15.9	5.45	5.94	34.5	37.3	74.4	74.7	2.6	3.9	161	169	40.2	51.3
Karl	49.8	48.3	49.5	55.4	13.9	9.2	536	546	90.3	90.0	12.3	11.7	4.35	4.24	35.3	36.2	77.5	77.3	3.7	2.2	123	125	49.3	63.2

[a]Abbreviations used for the quality parameters are: barley color (Col), plump kernels (Plmp), thin kernels (Thn), plump score (PScr), malt recovery (MRcy), total protein (TPro), soluble protein (SPro), ratio of soluble to total protein (SPro/TPro), fine grind extract (Ext), fine-coarse grind extract difference (F-C), diastatic power (DP), and α-amylase (AA).

150, and 175 g were blended for 1.0, 1.5, 2.0, and 3.0 min. Analysis of variance (ANOVA) of sample size and blending time on the protein of each variety after blending is shown in Table I. There was no significant effect of sample size or blending time on the average blended barley protein of either sample. Least significant difference analysis produced the same results. There was no significant difference between the observed and expected average barley protein of the 16 blended samples of varieties R and L according to t-statistics. Based on these data, sample sizes of 100 g and mixing times of 1 min were used to investigate the effect of variety blending on malt quality.

Since the 77 samples, malted individually or as their variety blends, were diverse in genetic origin and overall quality, a lack of statistically significant differences between each parameter of blend and average malt quality would unequivocally show variety blending to be the best method for streamlining the testing program. Overall malt quality ranged from unsatisfactory to satisfactory, reflecting the presence of malting varieties approved for growth in North Dakota, malting varieties not approved for growth in North Dakota, and feed varieties.

The average and blend malt quality data of the 11 varieties used in this study are listed in Table II. The ANOVA and correlation of the average and blend malt quality parameters are shown in Table III. It is readily evident that α-amylase is the only quality parameter showing a significant difference between average and blend. Differences in the soluble starch substrate preparation and/or instrument response were precluded on the basis of the diastatic power data. Since the increasing orders of the average and blend α-amylase values (Table II) were identical, the major source of the significant difference was attributed to differences in preparation of the α-amylase standards. The time lag between malting the individual and blend samples may have exerted a minor influence through undetectable differences in growth rate and/or overall growth. The highly significant correlation between the average and blend α-amylase data indicates that there was no loss in accuracy in measurement of this activity. Therefore, α-amylase quality differences are the same with either data set, and the significant difference is not meaningful from a quality evaluation standpoint.

Malt recovery was the only quality parameter not significantly correlated, due to the obviously lower recoveries of the blended Georgie and Multum samples. The increased malting loss of the blended samples could be due to changes occurring in these two varieties during the 3-month additional storage time before the blends were prepared and malted. There was no difference between average and blend malt recovery of the remaining nine varieties ($r = 0.855^{**}$). In any case, this nonsignificant correlation is not a problem in this investigation because malt recovery is not a rated variable in evaluation of overall malt quality (5).

TABLE III
Analysis of Variance and Correlation of Average and Blend Malt Quality Parameters by Variety

Source of Variation	F_{calc}[a]	r
Barley color	0.50	0.812**
Plump kernels	0.86	0.966**
Thin kernels	3.62	0.910**
Plump score	1.50	0.952**
Malt recovery	2.48	0.243
Total protein	0.50	0.989**
Soluble protein	0.15	0.962**
Soluble protein / Total protein	<0.00[b]	0.956**
Fine grind extract	0.19	0.929**
Fine-coarse grind extract difference	0.10	0.898**
Diastatic power	<0.00[b]	0.987**
α-Amylase	19.72	0.977**

[a]$F_{0.05} = 4.35$; $F_{0.01} = 8.10$.
[b]Prob > $F_{calc} = 0.98$.

TABLE IV
Analysis of Variance of Blend and Individual Station Malt Quality Data by Variety

Source of Variation	F_{calc}[a] of Station[b]						
	CD	CI	Di	Fa	La	Mi	Wi
Barley color	NS	8.92	NS	NS	NS	12.38	34.80
Plump kernels	NS	NS	NS	NS	NS	4.48	48.47
Thin kernels	NS	NS	NS	NS	NS	NS	17.96
Plump score	NS	NS	NS	NS	NS	NS	35.57
Malt recovery	NS	NS	NS	NS	11.83	NS	NS
Total protein	NS	NS	NS	8.27	5.39	NS	NS
Soluble protein	NS	NS	NS	6.99	NS	NS	NS
Soluble protein / Total protein	NS	NS	NS	NS	NS	NS	NS
Fine grind extract	NS	NS	NS	NS	NS	NS	17.16
Fine-coarse grind extract difference	NS	NS	NS	NS	NS	NS	NS
Diastatic power	NS	NS	NS	NS	NS	NS	NS
α-Amylase	18.89	20.60	18.94	24.66	25.88	18.96	4.37

[a] $F_{0.05} = 4.35$, $F_{0.01} = 8.10$; NS = not significant.
[b] The abbreviation used for each experiment station is Carrington dry land (CD), Carrington irrigated (CI), Dickinson (Di), Fargo (Fa), Langdon (La), Minot (Mi), and Williston (Wi).

Barley color is another routinely determined parameter not used in rating overall malt quality (5). The Gardner L value is converted to a color score (7) in the testing program and used to eliminate advanced selections of equal quality except for consistently low kernel brightness. The average and blend values gave essentially the same color score for each variety except Dickson, Multum, and Karl. Per cent plump and thin kernels is indirectly rated in overall quality by use of the plumpness score (3,5). Examination of Table II shows that the plumpness score did not vary to as large an extent as the individual percentages, especially the per cent thin kernels. This reinforces the use of this single-figure weighted summation to evaluate overall kernel plumpness.

The ANOVA of the blend and individual station malt quality data is shown in Table IV. These data expand the station-dependent differences in quality examined in a previous study (3). The data from the Dickinson and Williston stations are excluded from this discussion, as selections to be analyzed for malt quality are not grown at these sites. Note the highly significant difference between the α-amylase activity of the blend and each station. This is consistent with the data of Tables II and III. Barley color of samples from the irrigated Carrington and Minot stations was significantly lower than that of the blend, reflecting high moisture conditions during harvest (2). The increased staining of samples at these two locations is not reflected in the average color. Since malt recovery of selections from Langdon averaged 0.8 percentage points higher than that of the blend, the significant difference observed was expected. The increased level of total protein of the Fargo (+1.9%) and Langdon (+1.1%) stations was significant and reflected the hot, windy conditions during kernel maturation (2). In addition, the level of soluble protein paralleled that of total protein with selections from Fargo. However, the ratio of soluble to total protein of each station, including Fargo and Langdon, was not significantly different from that of the blend. The significantly higher per cent plump kernels of the Minot station was not observed in the plumpness score, again showing the increased reliability of this single-figure index of overall plumpness.

The important aspect of the specific significant differences observed between the blend and individual station data is that they were not transferred to the average data. Thus, variety average and blend quality data equally mirror the contributions of each station of growth and are equal for all practical purposes. The general rating (3,5) of each variety blend was identical to that of each corresponding variety average. In addition, although the specific differences between blend and individual station data would change from crop year to crop year, these influences would not alter the relationship between variety blend and average data.

Variety blending precludes examination of variety-station interactions. Thus, variety blending is limited to those cases in which station effects are not desired or are well known in advance. Variety blending has been adopted in our malt quality testing program because the general effect of each station on the various quality parameters is predictable (3). In addition, the selections in the variety plot trial of each experiment branch station will be malted individually to allow tabulation of station effects on malt quality.

SUMMARY

Sample size (≥100 g) and blending time (≥1.0 min) did not influence the quality profile of variety blends, as assessed by barley total protein. The quality profiles of 11 variety blends were not significantly different from those of the corresponding variety averages. The significant difference between variety blend and average α-amylase activity was not meaningful, as the order of blend and average absolute values was identical. There were specific station effects that reflected the environmental conditions of growth. However, these effects were treated equally whether variety blends or variety averages were employed. There was no loss in varietal quality differentation when data from single varieties blended before malting and analyzing were substituted for the corresponding average data.

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