Air-Classification and Baking Characteristics of High-Protein Atlas 66 X Comanche Lines of Hard Red Winter Wheat[1]

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ABSTRACT

Atlas 66, a soft wheat, has been used since 1953 as a genetic source of higher protein in wheat. Eleven high-protein Atlas 66 X Comanche lines with a range of endosperm hardness, and parent varieties, were evaluated for their air-classification and baking properties. The coarse fraction from Atlas 66 was 3.7% higher in protein content than the parent flour. Its "pastry fraction" was higher in protein content than that normally separated from a low-protein soft wheat flour. High-protein lines with soft endosperm exhibited fractionation properties similar to those of Atlas 66. Therefore, a completely new scheme for product use would be necessary in the air classification of high-protein soft wheats derived from Atlas 66.

Air-classified fractions were blended to 12% flour protein for the baking evaluation. Dough-mixing properties ranged between the parental types. Five selections were equal to Comanche in loaf volume and bread rating.

Protein level in wheat (*Triticum aestivum* L.) is the first limiting factor for bread production. There are also nutritional ramifications associated with the percentage of the protein and its amino acid composition.

As wheat yields have increased through breeding and improved cultural practices, grain protein contents have generally decreased. Wheat yields in the USA have increased from 14.3 bu. per acre, in the 5-year period beginning with 1901, to 25.5 bu. per acre in the 1961–1965 period.

The protein content of wheat can be increased with timely nitrogen fertilizer applications. Usually the first response to nitrogen fertilizer applied in the fall of the year is increased yield. Higher protein contents are possible with correct timing and level of application, but for the producer in the Great Plains region there has not been economic encouragement to fertilize at the high levels required to produce adequate protein levels in wheat.

Urea foliar spraying at flowering time (1) offers potential for increased protein when the general moisture conditions would ensure high yield but associated low protein content (Table I). However, uncertainties in weather and in optimum conditions for absorption of the urea can make prediction of a final protein content questionable.

The Great Plains region has unpredictable weather conditions which may vary widely from year to year. The same nitrogen fertilizer program will not guarantee

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TABLE I. EFFECT OF FOLIAR SPRAYING OF PAWNEE WHEAT WITH UREA SOLUTIONS, MANHATTAN, KANSAS, 1950[a]

Time of Spraying	Wheat Yields with Indicated lb. N/A			Protein Content of Wheat with Indicated lb. N/A		
	10	30	50	10	30	50
days	bu./a.	bu./a.	bu./a.	%	%	%
21 Before flowering	35	40	36	11.8	12.5	12.8
Flowering	35	34	30	11.6	13.3	15.2
2 After flowering	30	38	34	11.7	13.5	15.2
7 After flowering	31	30	27	11.7	12.7	13.5
14 After flowering	34	24	30	11.1	12.5	13.2
Control (no urea)		29 bu./a.			10.8%	

[a]Reference 1 reprinted with permission of the publisher and the authors.

reproducible results in different years. In wet years, fertilizer can cause rank growth and lodging which may result in shriveled, high-protein grain. In dry years when spring growth is rapid and flowering is early, conditions may be favorable for high grain protein content. In years when conditions are such that wheat protein content would be high, there may be little response to nitrogen application.

One promising approach to the development of higher protein content in wheat is to incorporate genes which could add higher protein potential to bread wheat varieties. The source of genetic material for higher protein potential in wheat became available with the identification of a high-protein SRW wheat, Atlas 66 (2). This variety was introduced into the Nebraska breeding program in 1953 as a new source of leaf-rust resistance and high protein for the HRW wheats (3).

The objective of the research was to evaluate the air-classification and baking properties of high-protein lines developed in the co-operative Nebraska-ARS wheat-breeding program.

MATERIALS AND METHODS

Samples of Comanche (Cmn) and eleven high-protein lines were comparable blends of wheat grown in 1961 at Lincoln and North Platte, Nebraska. Atlas 66 (Atl 66) was produced in North Carolina in 1963.

Flour milling was performed with a Buhler laboratory experimental mill, Model MLU-202. Tempering varied from 13.5 to 15.0% for soft and hard types, respectively.

Air classification of flours was done on a Walther laboratory classifier, Model 150, according to the separation scheme outlined in Fig. 1. A setting of 30 on the secondary air valve separated flour particles at approximately 40 μ. The coarse and fine fractions were designated as 30C and 30F, respectively. The 30F fraction was pin-milled at 14,000 r.p.m., with an Alpine Kolloplex laboratory pin mill, Model 160Z, before being reclassified at a secondary air setting of 8. This gave a cut point at approximately 13 μ. These fractions were designated 8C and 8F.

Analytical procedures were from AACC Methods (4). Flour ash, maltose, and nitrogen were determined by methods 08-03, 22-15, and 46-11, respectively.

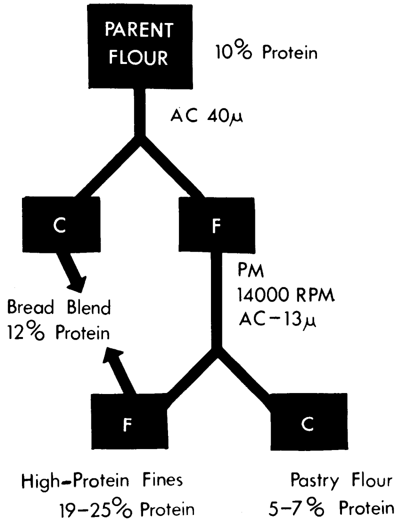

Fig. 1. Air-classification procedure for a HRW wheat flour.

The AACC straight dough test procedure, 10-10 (4), was used in conjunction with optimum mixing and bromate levels.

RESULTS AND DISCUSSION

Agronomic Characteristics

Grain yields and protein contents of promising advanced-generation high-protein lines and commercial varieties are presented in Table II. The Atlas 66 derivatives are both productive and high in protein content of their grain. All were high-yielding and had from 2.5 to 4.0% more actual protein in their grain than the parental varieties Comanche and Wichita. Two selections were higher-yielding than Lancer, a popular new commercial variety in Nebraska. Comprehensive agronomic information on the high-protein lines is available in another publication (3).

TABLE II. GRAIN YIELD AND PROTEIN CONTENT OF HIGH-PROTEIN AND STANDARD VARIETIES AT TWO LOCATIONS IN NEBRASKA, 1965

Variety	C.I. or Sel. No.	Mean Grain Yield bu./a	Mean Grain Protein[a] %
Atlas 66 X Cmn	631068	40.2	18.5
Atlas 66 X Cmn	631423	45.3	17.5
Atlas 66 X Cmn	631417	37.6	17.5
Atlas 66 X Wi	631168	42.9	17.1
Atlas 66 X Cmn	631250	40.1	17.0
Lancer	13547	40.9	14.8
Comanche	11673	29.6	14.4
Wichita	11952	28.2	14.0

[a]14% moisture basis.

Environmental effects remain an important factor in the level of protein in the wheat grain. Unpublished data indicate that in years when wheat protein content of conventional varieties is low the high-protein lines also show reduced levels, but their superiority over the conventional varieties is maintained.

Differential Translocation of Nitrogen into Grain as a Basis of Grain Protein Differences

The high-protein characteristic does not appear to be related to high uptake of soil nitrogen by a variety. Warrior, a low-protein HRW wheat variety, was found to have high foliar nitrogen content in all stages of growth (5). In contrast, high-protein varieties had no more, and sometimes less, nitrogen in their foliage than lower-protein varieties. Analyses of the grain at weekly intervals during its development revealed that the high-protein lines were higher in grain protein than other varieties throughout the entire grain maturation period. The protein content of the grain of all varieties studied increased during grain development except in the first week.

Air Classification

Atlas 66, the high-protein parent, is a soft, poor-milling wheat. Bran clean-up and sifting properties are poor, and flour ash content is high in comparison to that of the low-protein parent, Comanche. During the early crossing work the only consideration for selection was grain protein content. When identified high-protein lines were increased for a quality study they exhibited wide variations in milling properties. The complete expected range between the extreme milling types of the parents was recovered. It is fortunate that satisfactory hard milling types were found among the high-protein-derived lines.

One approach to the study of the endosperm breakdown properties of the high-protein selections was to observe their relative processing characteristics in air-classification studies. A comparison of the responses to air classification for the Atlas 66 and Comanche parents appears in Table III. Wheat protein contents were 17.2 and 11.3%, respectively, and flour proteins 16.1 and 10.3%, respectively. "Cutting" the flours from Atlas 66 and its high-protein derivatives at approximately 40 μ (mass median diameter), produced a coarse fraction with a protein content greater than that of the parent flour. This effect has been observed to a lesser extent with other conventional varieties (6). It has been explained by the presence

TABLE III. COMPARISON OF AIR-CLASSIFICATION PROPERTIES FOR ATLAS 66 AND COMANCHE[a]

Sample	% Protein		Amount of Parent Flour	
	Atlas 66 %	Cmn %	Atlas 66 %	Cmn %
Wheat	17.2	11.3	...	...
Flour	16.1	10.3	...	...
30C	19.8	10.2	56.0	74.2
30F	11.6	9.7	44.0	25.8
8C	8.4	7.7	36.8	23.4
8F	24.0	24.1	7.2	2.4

[a]Air-classified fractions, particle size in mass median diameter: 30C, above 40 μ; 30F, below 40 μ; 8C, 13 to 40 μ; 8F, below 13 μ.

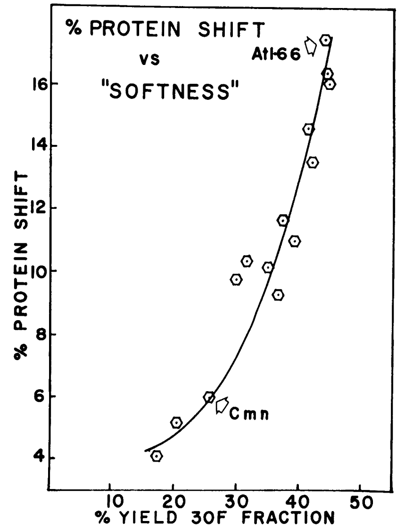

Fig. 2. Percent protein shift vs. percent yield of 30F fraction.

of subaleurone endosperm cells of high protein content (7). On the basis of protein content, the fraction below 40 μ could be used directly for bread production (if other quality factors were present). The pastry fraction, 8C (13 to 40 μ), from Atlas 66 is slightly higher in protein content than the same fraction from the HRW wheat parent Comanche. It could be used in certain baking applications, however. It is perhaps not surprising that the high-protein fine flour fractions (8F) from Atlas 66 and Comanche differ only in amount and not in their total protein content of 24%.

Percent Protein Shift

The percentage of protein shift described by Gracza (8) provides an index to the softness of a wheat variety. Protein shift in the two parental varieties and eleven progeny lines was determined. The percent protein shift was 17.5 and 6.0% for Atlas 66 and Comanche, respectively; that for the progeny ranged from 4.1 to 16.3% with an average of 10.2%. This was in close agreement with the actual average of 10.9% for all progeny samples tested. The progeny samples originally had been selected only on the basis of superior protein contents and agronomic properties. However, the samples are a good representation of all possible air-classification types which one would expect from the parental material.

Another way to ascertain "softness" in a wheat endosperm is to plot the percent protein shift vs. the percent yield of the fractions either above or below 40 μ (9). Figure 2 shows the plot of percent yield of the sample below 40 μ (30F). An almost continuous distribution of hardness types supports the statements above. For the rather small number of progeny selected it was fortuitous that such a broad range of milling types was represented. Of particular interest are the two samples which have harder indices than the hard parent, Comanche. This substantiates unpublished milling data in which normal HRW wheats were identified. It is obvious, therefore, that selecting for satisfactory milling types presents no problem.

Dough-Mixing Properties

Flour fractions available from air-classification studies were composited to near 12.0% protein (14% m.b.) so that protein differences would not complicate the baking and dough-mixing evaluation. It was hoped that this would give the most meaningful comparison between low-protein parents and high-protein progeny lines. An inherent problem from an imbalance of other flour constituents was a possibility. Table IV compares protein, ash, and maltose from the straight-grade and bread-blend flours. Other factors could, of course, be important.

Mixograms for the diverse parental varieties and eleven progenies are shown in Fig. 3. Family 308 exhibited the closest similarity to the Comanche mixing characteristic. Families 305, 306, and 324 are a decided improvement over the short-mixing, high-protein parent Atlas 66. Additional back-crosses of promising high-protein progenies to good mixing-type varieties have been made. This should lead to the identification of high-protein material which will have entirely satisfactory hard-wheat mixing characteristics. It appears that recovery of satisfactory mixing characteristics will not be a major obstacle in the development of high-protein bread wheats.

This agreed with earlier studies (3) made with F_2-derived families which showed that the mixing characteristics of the better-quality, low-protein parent Comanche had been essentially recovered. The data were obtained on samples of differing protein contents.

Baking Properties

Earlier testing for baking (3) had shown promise for new high-protein progeny lines, but the evaluation was questionable because of differences in protein level. Flour samples adjusted to 12% protein content by compositing air-classified fractions also were evaluated for baking. A compilation of the data from the baking studies is presented in Table V.

Flour absorptions in the Atlas 66 X Comanche lines were lower than in the quality parent Comanche. The reason for this is not apparent from flour data given in Table IV. Five selections were rated equal to Comanche in loaf volume and

TABLE IV. COMPARISON OF PROTEIN, ASH, AND MALTOSE FROM STRAIGHT-GRADE AND BREAD-BLEND FLOURS

Variety	Flour Protein		Flour Ash		Maltose	
	Straight Grade %	Bread Blend %	Straight Grade %	Bread Blend %	Straight Grade	Bread Blend
Atlas 66	16.05	12.10	0.575	0.474	74	88
Comanche (302)	10.30	12.15	0.420	0.465	133	167
Atl X Cmn (305)	13.45	12.30	0.455	0.521	145	110
(306)	13.60	12.40	0.420	0.404	74	68
(307)	13.05	12.20	0.417	0.401	118	117
(308)	13.80	12.05	0.445	0.416	81	82
(309)	14.00	11.90	0.455	0.428	94	99
(312)	12.15	12.20	0.435	0.429	130	130
(317)	13.90	11.80	0.605	0.470	82	78
(320)	13.35	12.10	0.505	0.476	80	80
(324)	11.30	11.85	0.435	0.440	111	92
(326)	13.70	11.95	0.445	0.416	112	109
(329)	12.20	11.85	0.390	0.439	62	57

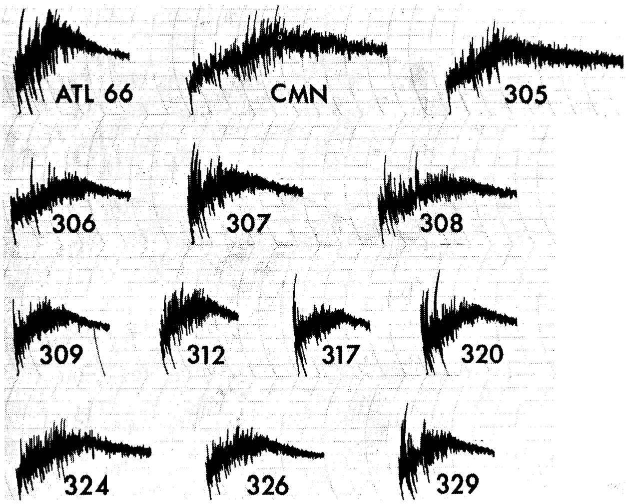

Fig. 3. Mixograms of parental varieties and high-protein progeny.

general bread rating, which included the grain and crumb characteristics. There is a tendency for certain selections to produce a softer bread crumb. This would be rated differently by a cross-section of the baking industry, depending on personal preferences or requirements. Many of these samples produce more extensible doughs than typical hard winter commercial varieties now being grown. It would, therefore, be possible to select over a wide range of physical dough properties.

TABLE V. BAKING DATA ON FLOUR ADJUSTED TO 12% PROTEIN CONTENT FROM SUITABLE AIR-CLASSIFIED FRACTIONS

		Bread-Baking Data					
Variety	Flour Protein %	Absorption %	Mixing Time[a] min.	Mixing Tolerance[b]	$KBrO_3$ Requirement mg.	Loaf Volume cc.	General Bread Rating
Atlas	12.10	60	2	2	2	855	Poor
Comanche	12.15	67	4 2/3	5	0.75	890	Good
Atl X Cmn (305)	12.30	62	3 2/3	4	1	915	Good
(306)	12.40	60	3 2/3	3	1.75	965	Good
(307)	12.20	60	3	3	0.75	875	Poor
(308)	12.05	60	4	3	1	940	Good
(309)	11.90	60	2 2/3	2	1.75	835	Poor
(312)	12.20	60	2 1/3	2	1	800	Poor
(317)	11.80	60	2 1/3	2	2	810	Poor
(320)	12.10	60	2 2/3	2	1.5	890	Fair
(324)	11.70	60	3 2/3	3	1.5	910	Good
(326)	11.95	60	3	2–	1.5	935	Good
(329)	11.85	60	2 1/3	2	1	820	Poor

[a]Mixograph.

[b]1, Very unsatisfactory; 2, unsatisfactory; 3, satisfactory; 4, satisfactory plus; 5, outstanding.

Flours baked at higher protein levels did not give the loaf-volume differentials usually seen with typical conventional varieties.

In general, the future for the baking potential appears promising for lines selected from these F_2 increases. The present material is not agronomically satisfactory for commercial release. More advanced breeding material from additional back-crossing to quality wheats is now under study. Perhaps new high-protein commercial varieties will be forthcoming from this material.

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