Air-Aspirated Cleaning to Separate Sound from Preharvest-Sprouted Wheat[1]

A. D. BETTGE[2] and Y. POMERANZ[3]

ABSTRACT

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An air-aspirated wheat cleaner fractionated two sets of preharvest-sprouted wheats (falling numbers 62-376) through the combined influences of aerodynamic drag, kernel volume, and kernel weight. One set was fractionated at a water column (WC) air pressure of 3.81 cm (1.5 in.); the other set was fractionated under WC air pressures of 2.54, 3.81, and 5.08 cm (1, 1.5, and 2 in., respectively). Each treatment resulted in a lifted fraction and a fraction passing through the air-aspirated cleaner. The fractions, plus the original grain, were analyzed for physicochemical, α-amylase, and end-use parameters. The first set of samples showed significant physical and physicochemical differences between lifted and throughs fractions. The improvements were most meaningful for wheats of moderate preharvest sprouting (falling numbers between 200 and 300). Throughs fractions produced better sponge cakes, in volume and texture, than the other fractions. The second set of samples exhibited a similar pattern: significant improvement in wheat of moderate preharvest sprouting but no meaningful improvements in either highly or lightly sprouted samples. Significant improvement was observed in fractions passing through the aspirator relative to the original and to the lifted fractions in samples of moderate preharvest sprouting. This improvement was most evident in the fraction passing through the aspirator at 5.08-cm WC air pressure. Aspiration at this air pressure causes about 50% of the sample to be removed.

Every five to seven years, the Pacific Northwest (PNW) wheat-growing region of the United States receives rain during harvest that results in preharvest sprouting of the mature wheat crop. Preharvest sprouting reduces the quality of the wheat both in grading and in functional properties. Reduction in grade lowers the price received by farmers and causes economic and marketing problems for the grain trade. An economic method to separate preharvest-sprouted grain from sound grain would be economically beneficial.

Various methods have been used to separate grain into fractions. The grain spectrometer of Katz et al (1954) separated insect-infested grain by launching grain into the air with rapidly moving conveyor belts. The grain landed in bins arrayed along the flight path. More dense, sound kernels flew farther than infested kernels. Recently, air-cleaning devices have been used to improve the quality of sound wheat by removing the least dense fraction (Bettge et al 1989, Tkachuk et al 1990). Tkachuk et al (1991) employed specific gravity tables to separate sprouted fractions from sound fractions of hard red spring wheats. The method employs the interaction of friction and lifting power of air pressure to segregate the wheat. Air-aspirated cleaning does not use friction as a factor to segregate the sample; only air pressure is used.

The behavior of particles in a moving fluid, air in this case, is defined as

$$\frac{dV}{dt} = g\,(\frac{\gamma_p - \gamma}{\gamma_p}) - C\,(\frac{V^2 \gamma A}{2gM})$$

where C is the aerodynamic drag coefficient (constant), V is relative velocity, g is gravity, γ is fluid (or air) specific weight, A is projected particle area, t is time, γ_p is particle specific weight, and M is particle mass.

The equation (Henderson and Perry 1976) indicates that air velocity, being a second-order variable, has the greatest influence on the motion of particles moving within the air. An increase in pressure across openings of fixed area results in increased air velocity. Air pressure is more easily measured than velocity, and air pressure is proportional in its relationship to velocity. Therefore, air pressure was used in this study as the term of measurement instead of velocity. The effect of air velocity on particles is squared for each change in the magnitude of air pressure (velocity). However, density of the particle (weight divided by volume) and surface texture (roughness) also play roles. Surface texture was not examined in this study. However, visual examination of wheat kernels indicates a roughening of surface texture as field sprouting progresses, culminating in the appearance of a primary root and acrospire. As germination proceeds, increased surface roughness causes greater interaction with the airstream and, therefore, generation of more lifting power. Density, in this descriptive equation, is broken into its two components, projected area, a two-dimensional reflection of volume, and mass. Although the two taken together represent density (mass/volume), area exposed to action by moving air and the particle mass are more descriptive taken individually rather than as a combined density term. Specific gravity of the air is fixed, so changes in the specific gravity of the particle become important. Irreversible kernel swelling during wetting and drying and carbohydrate respiration as the embryo germinates (supplied with sugars by amylolytic action) affect both volume and weight. Swelling and loss of mass imply that forces applied to the kernels because of volume and mass are amplified.

The air-aspirated cleaner uses these effects to segregate the grain in ways that can be taken advantage of to obtain grain of improved physicochemical and functional properties. This study explores the potential of air-aspirated cleaning to separate preharvest-sprouted fractions from sound fractions in soft white wheat (SWW).

MATERIALS AND METHODS

This study consists of two sections: an exploration of the methods to separate sound and preharvest-sprouted wheat by air-aspirated cleaning and a more detailed study of a selected method. The materials and methods used in both sections were the same, except where noted.

Preliminary Study

Ten commercial SWW samples were from the 1989 PNW harvest. Wheats were selected to cover a range of preharvest sprouting from sound to highly sprouted on the basis of falling number values.

The wheat was processed through a Kice KD6T laboratory air-aspirated dockage tester (Kice Metal Products Co., Wichita, KS) operating with a 3.81-cm water column (WC). The fraction lifted out was passed back through the air cleaner at 1.78-cm WC air pressure to remove chaff, dust, and broken kernels, which were discarded. Air pressure was measured across the cleaning "ladder" with a Bourdon tube gauge.

The preliminary study set was composed of three fractions per sample: 1) original sample (original), 2) fraction passing through the KD6T (throughs), and 3) fraction lifted out (liftings).

For analytical assays, samples were ground on a Udy cyclone

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[2] USDA, Agricultural Research Service, Western Wheat Quality Laboratory, Pullman, WA 99164.

[3] Department of Food Science and Human Nutrition, Washington State University, Pullman 99164.

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mill (Udy Corp., Fort Collins, CO) equipped with a 0.5-mm screen (round openings). α-Amylase determinations were made by three methods: falling number (method 56-81B, AACC 1983), Cibacron blue dye (method 22-06, AACC 1983), and Rapid Visco Analyser (RVA) (Newport Scientific, Narrabeen, NSW, Australia) (Ross et al 1987). The RVA method was modified as follows: 4 g of wheat meal (14% moisture basis) and 25 ml of water were incubated in the instrument at 45°C for 2 min and heated to 93°C at the instrument's maximum heating rate until peak viscosity was achieved. Preincubation of the wheat meal at 45°C allowed the full impact of α-amylase activity on starch to be expressed. The peak viscosity (cP/10) was recorded.

Test weight (TWT) (method 55-10, AACC 1983) and wheat moisture (method 44-16, modified by heating for 40 min at 130°C; AACC 1983) analyses were determined on all samples.

Samples exhibiting low to moderate preharvest sprouting, as determined by the falling number, were selected for further study. Samples exhibiting no preharvest sprouting and samples exhibiting extreme preharvest sprouting were not subjected to further analysis because fractions produced by air cleaning differed little in falling number, colorimetric, and RVA determinations.

The three fractions of the moderately preharvest-sprouted samples were milled on a modified Quadrumat Jr. laboratory mill (C. W. Brabender Instruments, South Hackensack, NJ) (Jeffers and Rubenthaler 1977). Flour protein (percent N × 5.7), mixograph, flour ash, and flour moisture (methods 46-12, 54-40A, 08-01, and 44-16, respectively; AACC 1983) determinations were made. Japanese sponge cake evaluations were performed (Nagao et al 1976, Ohtsubo et al 1978) as a means of determining alterations in functional performance due to the presence of α-amylase. Falling number and RVA determinations were performed. The RVA procedure was modified, using 3.5 g (14% mb) flour instead of 4 g as with wheat meal. This modification normalized the amount of starch present in the analysis and maintained the instrumental output on scale. Amylograph (AACC method 22-10) evaluations (100 g of flour in 450 ml of water) were made on the flours.

The PC-SAS general linear models procedure (SAS 1987) was used for analysis of variance. Least significant difference was used to determine significant differences among experimental means. The degree of confidence used throughout the studies was $\alpha = 0.05$. All determinations were replicated, and results were averaged.

Detailed Study

Nine 1-bu samples of SWW, selected to represent preharvest sprouting from sound to highly preharvest sprouted, were obtained from the 1989 crop from areas in the PNW affected by preharvest sprouting.

The samples were fractionated by a Kice 6F6 semicommercial air-aspirated seed cleaner (Kice Metal Products Co.). Three WC air pressures, 2.54, 3.81, and 5.08 cm, were chosen as a reasonable range for wheat fractionation. The 2.54-cm WC air pressure was enough to begin lifting wheat kernels, the 5.08-cm WC removed almost 50% of the initial sample, and the 3.81-cm WC was selected as an intermediate value. After removing chaff, dust, and broken kernels at 1.78-cm WC air pressure, the wheat was divided into four equal aliquots. One aliquot represented the original control sample. The three remaining aliquots were passed through the air cleaner at the three air pressures. Seven fractions were generated for each sample: 1) original, 2) 2.54-cm WC throughs, 3) 2.54-cm WC liftings, 4) 3.81-cm WC throughs, 5) 3.81-cm WC liftings, 6) 5.08-cm WC throughs, and 7) 5.08-cm WC liftings.

Procedures used for evaluating the wheat fractions were the same as those listed for the trial study. Wheat and flour protein analyses in this portion of the study were made using a Leco FP-428 nitrogen determination instrument (Leco Inc., St. Joseph, MI) with nitrogen determined thermo-gravimetrically. Protein was calculated as percent N × 5.7. Grain density was computed from grain volume measurements with a Quantichrome multipycnometer (Quantichrome Inc., Syosset, NY), which operates with compressed air.

Wheat and flour hardness values were obtained using a Technicon IA450 instrument (Bran + Luebbe Analyzing Technologies, Inc., Elmsford, NY) employing a two-wavelength calibration for hardness (method 39-70A, AACC 1983). Wheat and flour hardness calibrations were standardized through the use of the official USDA-ARS Federal Grain Inspection Service sample set.

Some mill fractions were not included in statistical analysis of milling results (Quadrumat Jr. laboratory mill). Sample size limitations for some fractions reduced sieve loading and resulted in erratic flour yields. The inconsistent results were excluded.

Flour amylograph determinations used the method of Tipples (1980): 65 g of flour in 450 ml of water. Chinese steam breads were produced with a modification of the method of Rubenthaler et al (1990): 100 g of flour was used, and bake absorption was calculated as optimum mixograph absorption minus 4%. Texture was expressed as grams of force needed to penetrate 1 cm into a 2.54-cm-thick slice of steam bread with a 1-cm^2 probe using a Fudoh rheometer (model J, Fudoh Co., Tokyo, Japan). Volume was measured in cubic centimeters by rapeseed displacement.

RESULTS AND DISCUSSION

Preliminary Study

The preliminary study used 10 wheat samples, of which four were fully analyzed, including milling and baking tests. Wheat α-amylase determinations indicated that only samples of light to moderate preharvest sprouting were meaningfully improved by air-aspirated fractionation.

Improvements in performance factors were not always statistically significant because of low sample numbers, but they still may be economically desirable in that the quality parameters exceed a grading cutoff point (i.e., TWT greater than 60 lb/bu). Improvement was more marked in the case of wheat that was slightly to moderately preharvest sprouted (falling number in the

TABLE I

Test Weight, α-Amylase, and Flour Yield Parameters for Lightly and Moderately Sprouted Wheat Samples[a]

Parameter	Original	Liftings	Throughs	LSD[b]
Lightly sprouted ($n = 2$)				
Test weight, lb/bu	59.9 a	57.5 b	60.7 a	1.28
α-Amylase, DU/g	0.173 ab	0.204 b	0.130 a	0.0516
Falling number, sec	324 ab	305 b	344 a	29.1
RVA,[c] cP/10	206 ab	175 b	224 a	44.9
Flour yield, %	67.6 a	66.8 a	67.3 a	3.57
Moderately sprouted ($n = 2$)				
Test weight, lb/bu	60.6 a	58.6 b	61.4 a	1.18
α-Amylase, DU/g	0.247 a	0.272 a	0.213 a	0.1181
Falling number, sec	284 ab	265 b	313 a	26.5
RVA, cP/10	202 a	186 a	215 a	29.1
Flour yield, %	67.0 a	65.2 a	67.5 a	2.37

[a] Parameters with the same letter in a line are not significantly different at $\alpha = 0.05$.

[b] Least significant difference.

[c] Rapid Visco Analyser.

200–300 range) than in the case of heavily preharvest sprouted wheat (falling number below 200) or wheat that exhibited generally accepted sound grain characteristics (falling number much above 300).

Shifts in TWT, α-amylase, falling number, and RVA were observed between liftings and throughs of lightly sprouted wheat and also in TWT and falling number in moderately sprouted wheat. The fraction passing through the aspirator was improved relative to the lifted fraction (Table I). However, the throughs fraction was not significantly improved relative to the original sample. In heavily preharvest-sprouted samples, the fractions did not differ significantly. Amylase levels, as assessed by the colorimetric α-amylase assay, RVA, and falling number were not significantly improved in either highly preharvest-sprouted or nonsprouted samples (data not reported here). The differences were minimal and of little potential economic value. In the lightly preharvest-sprouted wheats, improvements were seen in all three parameters (Table I). The throughs had a significantly reduced amylase activity relative to the liftings. In moderately preharvest-sprouted samples, a similar pattern was observed. No consistent or significant differences were observed in the nonsprouted or in the highly preharvest-sprouted samples (data not reported here). No significant improvement in flour yield was observed (Table I).

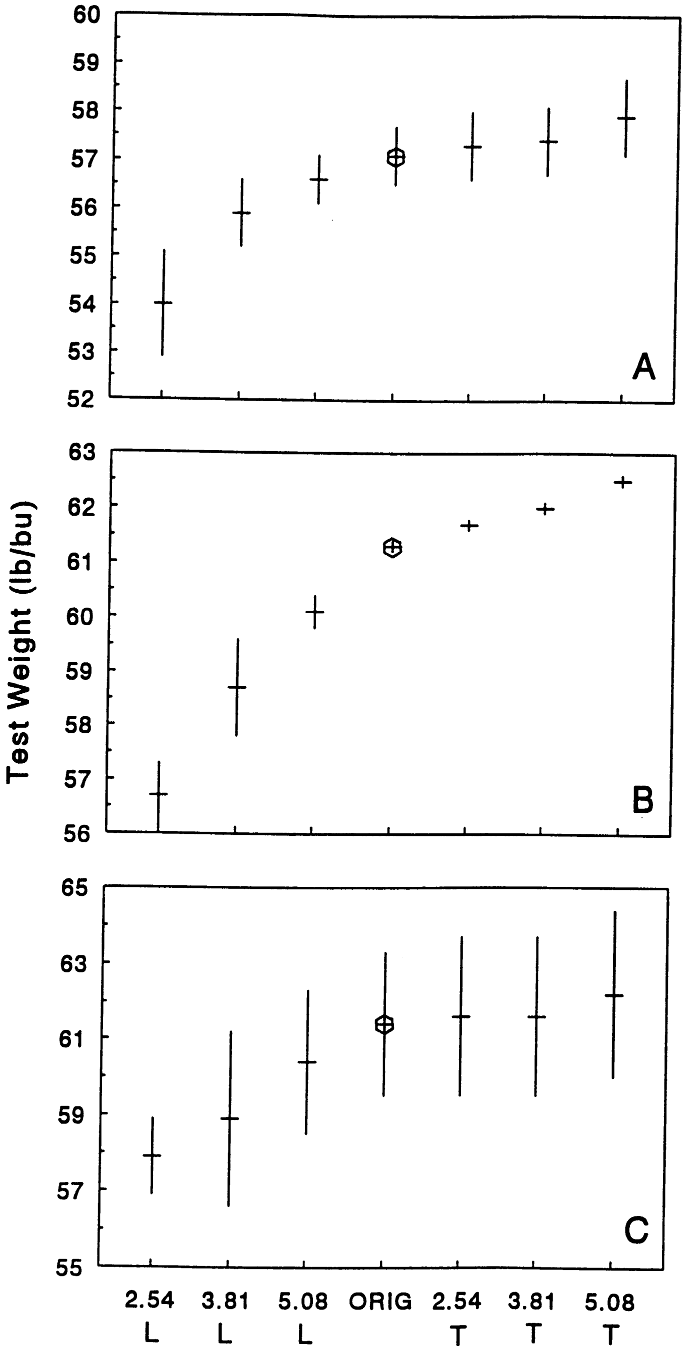

Fig. 1. Test weight (mean, with one standard deviation) for detailed study samples in highly, moderately, and lightly sprouted wheats (**A–C**, respectively) using 2.54-, 3.81-, and 5.08-cm water columns. Original sample mean indicated by hexagon. L = liftings, T = throughs.

Results of sponge-cake baking indicate that in one sample of moderate preharvest sprouting (other data not shown), the lifted fraction produced a better sponge cake than the other two fractions. This fraction had an α-amylase concentration of 0.224 dextrinizing units (DU) per gram, falling number of 268, and RVA value of 208—all indicators of moderate sprouting activity. Sponge-cake volume in this lifted fraction was 1,340 cm^3 (1,318 cm^3 in the throughs, 1,320 cm^3 in the original; standard deviations 7.1, 10.6, and 7.1, respectively). Finney et al (1981) found that low to moderate α-amylase levels increased sponge-cake volumes above those from controls. At greater amylase concentrations, sponge-cake volumes were sharply reduced. Both proteolytic and starch hydrolyzing enzymes are produced, albeit not at constant and equal rates, during wheat sprouting (Hanford 1967, Hwang and Bushuk 1973). The authors indicated that proteases and amylases influence flour functionality in a complex manner, with limited enzymatic action sometimes improving end-use functionality.

The preliminary study demonstrated that the functional quality of wheat samples with slight to moderate preharvest sprouting was improved with air-aspirated fractionation, most markedly in physicochemical attributes. Thus further exploration of air-aspirated fractionation of preharvest-sprouted wheat was warranted.

Detailed Study

As in the preliminary study, no meaningful or statistically significant improvements resulted from air-aspirated cleaning in lightly or highly sprouted wheats. The lightly sprouted wheat (falling number greater than 300 in the original sample) showed insignificant improvements in quality similar to those seen previously in TWT, falling number, and flour yield (Figs. 1–3). The best separation was achieved for the moderately sprouted wheats. In general, within each category, the overall trend was for better separation when higher WC air pressure values were used.

Highly sprouted wheats (falling number less than 200 in the original sample) showed improvement in TWT in the fractions passing through the aspirator at the 5.08-cm WC relative to those being lifted and to the original sample (Fig. 1). However, TWT, even for the 5.08-cm WC throughs fraction, still placed the wheat in the U.S. no. 3 grade (FGIS 1984). The improvement, although statistically significant, is economically of little consequence. Falling number determinations demonstrated no significant differences (Fig. 2). No significant or consistent differences were observed in flour yield (Fig. 3) or in steam bread volume or texture.

The weighted average amount of wheat removed at each air pressure is listed in Table II. On the average, 4.6% was removed at 2.54-cm WC air pressure, 16.0% at 3.81-cm WC, and 44.8% at 5.08-cm WC. For moderately preharvest-sprouted wheat, improvements in TWT, falling number, and flour yield were most evident at 5.08-cm WC (Table III and Figs. 1–3); however, almost half of the sample was removed at this airflow. Minor improvements were seen at 3.81-cm WC. The poorest quality wheat was already lifted out at 2.54-m WC. With increasing airflow, poor-quality kernels were removed as well as kernels of slightly better quality. Air aspiration was more efficient in increasing TWT, falling number, and flour yield in throughs of moderately preharvest-sprouted wheat than of lightly or highly sprouted wheats.

Wheats with moderate preharvest sprouting (falling number between 200 and 300 in the original sample) were improved (α-amylase reduced and RVA value increased) by aspiration (Table III). Test weight was significantly increased in the through fractions relative to the original fraction and to the liftings (Fig. 1). The 5.08-cm WC liftings graded U.S. no. 1, 3.81-cm WC liftings graded U.S. no. 2, and the 2.54-cm WC liftings graded U.S. no. 3 (FGIS 1984). All throughs graded U.S. no. 1 in TWT (i.e., above 60 lb/bu), but so did the original wheat. It appears that the grade of moderately sprouted wheat can be improved by air aspiration.

Analysis of variance indicated significant differences in the amounts of wheat lifted out between lightly and moderately sprouted samples at 2.54-cm WC (Table II). No significant differences were observed among the other fractions at either the 3.81- or 5.08-cm WC air pressures. Evidently ranges of wheat kernel volume, weight, and surface texture characteristics, regardless of degree of germination, produced interactions that resulted in similar separation. The air pressure (manifested as air velocity) appears to be the primary determinant in fractionation.

Air aspiration resulted in a shift between liftings and throughs in thousand-kernel weight and kernel volume in samples of moderate sprouting (Table IV). The 5.08-cm WC throughs were greater in weight and volume than the other fractions. There was reduced significant separation for highly sprouted and lightly sprouted samples. Kernel density (grams per cubic centimeter) did not differ among fractions or sprouting categories. These results indicate that factors other than kernel density interact with the moving air to separate kernels in the grain lots. Density does not describe

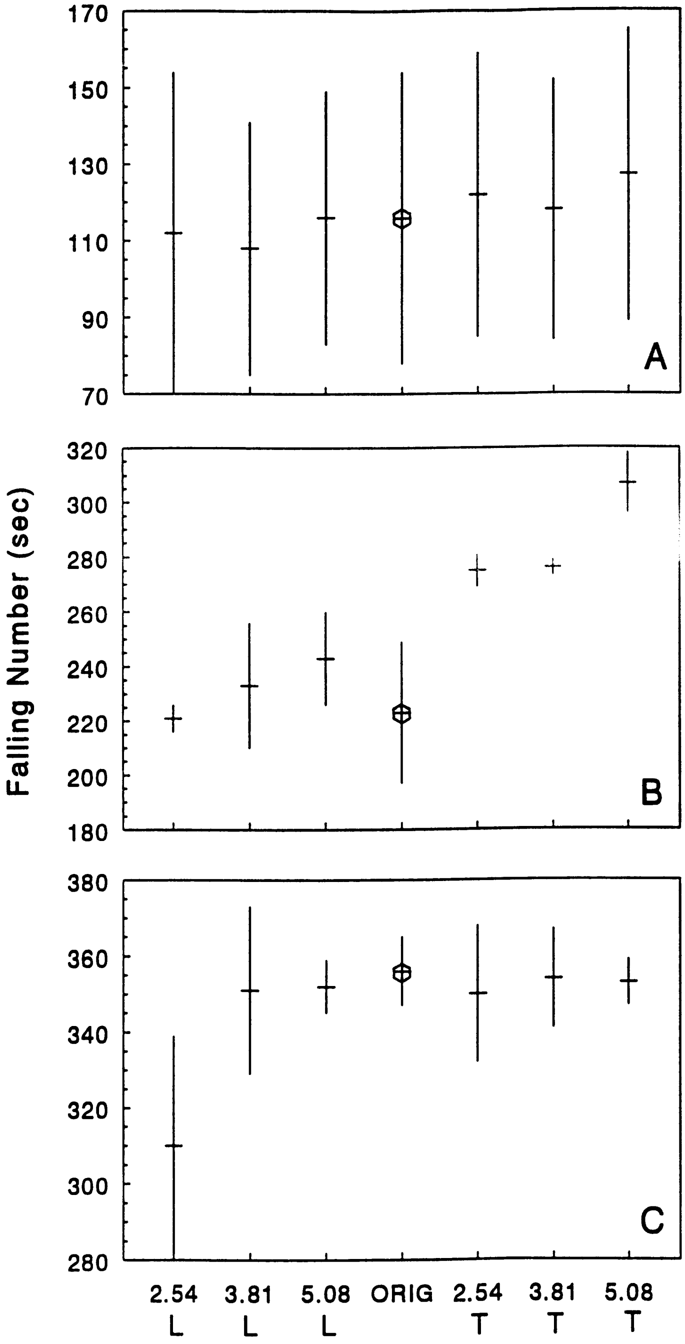

Fig. 2. Wheat falling number (mean, with one standard deviation) for detailed study samples on highly, moderately, and lightly sprouted wheats (**A–C**, respectively) using 2.54-, 3.81-, and 5.08-cm water columns. Original sample mean indicated by hexagon. L = liftings, T = throughs.

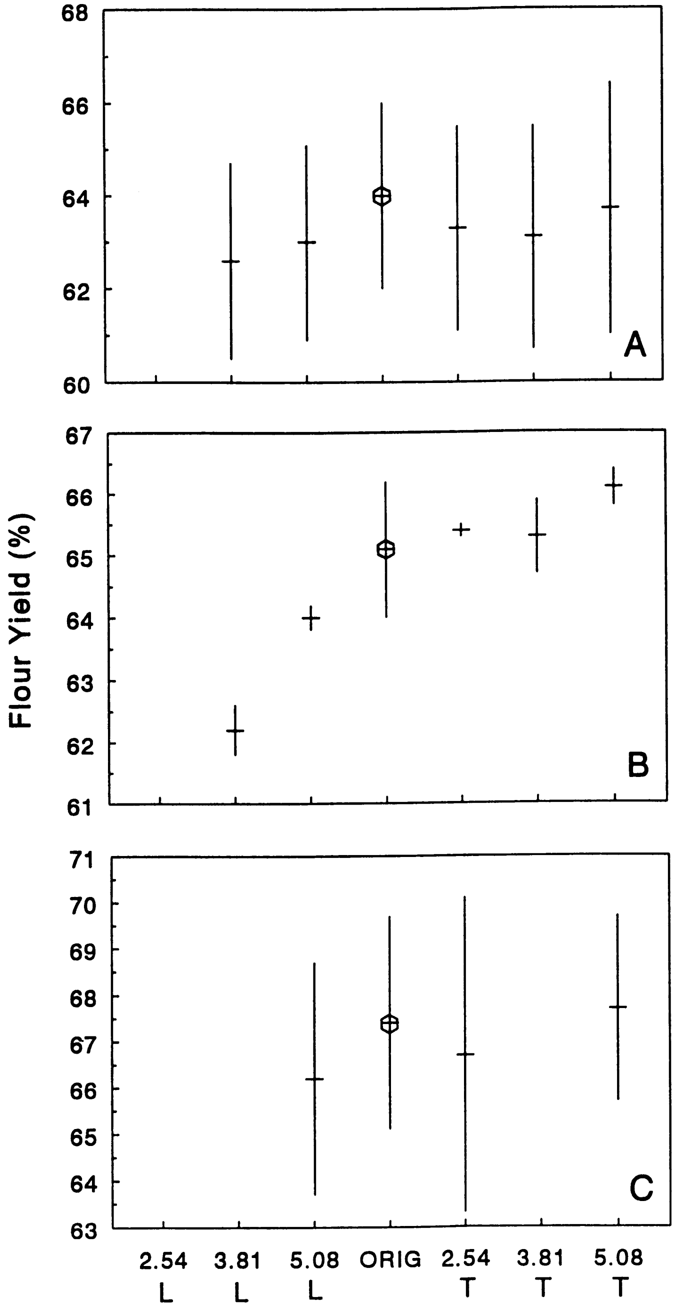

Fig. 3. Percent flour yield (mean, with one standard deviation) for detailed study samples on highly, moderately, and lightly sprouted wheats (**A–C**, respectively) using 2.54-, 3.81-, and 5.08-cm water columns. Original sample mean indicated by hexagon. L = liftings, T = throughs.

TABLE II
Mean Percentage of Sample Removed During Aspiration of Wheat[a]

	Water Column, cm		
Degree of Sprouting	2.54	3.81	5.08
Light ($n = 2$)	5.4 (0.63)	14.3 (5.09)	40.8 (4.38)
Moderate ($n = 2$)	3.5 (0.35)	11.7 (3.00)	48.0 (10.25)
High ($n = 5$)	4.7 (0.70)	18.4 (6.28)	45.1 (1.66)

[a] Means, with standard deviation in parentheses.

interaction with air during aspiration as well as kernel weight and kernel volume. Large and heavy wheat kernels pass through the air aspirator, and small and light kernels are lifted out. Since the ratio of surface area to volume affects the amount of force applied per kernel, the small kernels are acted upon more forcefully than the large kernels because of lighter weight and larger surface area. Since the large kernels are also heavier, they tend to drop through the instrument. Density alone does not seem to be the primary determinant of which kernels are lifted out and which pass through; the two components of density, mass and volume, do.

Wheat and flour protein were significantly higher in the lifted fractions than in the throughs and original fractions in all three sprouting categories (data shown for moderately sprouted wheat in Table III). The differences in protein between liftings and original and between liftings and throughs were largest at 2.54-cm WC, intermediate at 3.81-cm WC, and smallest at 5.08-cm WC. A generally similar pattern occurs in flour protein. Metabolism of starch during sprouting decreases the amount of carbohydrates and thereby increases the relative concentration of nitrogen. In nonsprouted wheat, the smaller and lighter kernels (the liftings) had greater percentages of protein because of decreased kernel size and, consequently, lower starchy endosperm content. As postulated in previous research (Bettge et al 1989), these kernels have structural protein in place, but they were not completely filled with starchy endosperm at the time of grain ripening. The decreased endosperm filling has the effect of increasing wheat protein concentration. An opposite pattern is observed in α-amylase parameters, i.e., the throughs were lower than the original or liftings. The liftings were higher in ash than the throughs or original wheat at 2.54-cm WC; no differences were observed at increased air pressures (data not shown).

For samples of moderate preharvest sprouting, determinations of α-amylase activity by Cibacron blue and RVA all showed sig-

TABLE III
Protein and Amylase Parameters for Two Moderately Sprouted Wheats Separated by Air Aspiration[a]

		Water Column, cm						
		2.54		3.81		5.08		
Parameter	**Original**	**L[b]**	**T[c]**	**L**	**T**	**L**	**T**	**LSD[d]**
Wheat protein[e]	10.8 c	11.7 a	10.8 c	11.5 a	10.7 cd	11.2 b	10.6 d	0.20
Flour protein[e]	9.1 d	10.2 a	9.1 d	9.7 b	9.1 d	9.5 c	8.9 d	0.22
Wheat RVA,[f] cP/10	140 bc	117 d	157 b	131 cd	160 b	144 bc	195 a	20.6
Flour RVA, cP/10	179 b	133 c	197 a	168 b	200 a	179 b	205 a	16.0
α-Amylase, DU/g	0.402 c	0.810 a	0.296 cd	0.553 b	0.295 cd	0.389 c	0.204 d	0.1477
Amylograph	250 ab	118 b	334 a	209 ab	306 a	243 ab	344 a	139.1

[a] Parameters with the same letter in a line are not significantly different at $\alpha = 0.05$.
[b] Liftings.
[c] Throughs
[d] Least significant difference.
[e] 14% moisture basis.
[f] Rapid Visco Analyser.

TABLE IV
Kernel Weight and Volume from Lightly, Moderately, and Highly Sprouted Wheats Separated by Air Aspiration[a,b]

		Water Column, cm					
		2.54	3.81		5.08		
Wheat Kernel Parameters	**Original**	**T[c]**	**L[d]**	**T**	**L**	**T**	**LSD[e]**
Lightly sprouted ($n = 2$)							
Thousand-kernel weight, g	36.1 a	. . .	28.8 b	37.6 a	30.8 b	38.8 a	2.16
Thousand-kernel volume, cm^3	25.9 ab	. . .	30.2 c	26.6 ab	23.6 bc	27.2 a	2.16
Moderately sprouted ($n = 2$)							
Thousand-kernel weight, g	31.5 b	33.2 b	24.8 d	33.4 b	27.6 c	38.1 a	2.51
Thousand-kernel volume, cm^3	22.5 c	23.6 bc	17.7 e	24.3 b	19.7 d	27.0 a	1.66
Highly sprouted ($n = 5$)							
Thousand-kernel weight, g	33.3 c	34.4 bc	28.9 e	35.0 b	31.2 d	36.2 a	2.01
Thousand-kernel volume, cm^3	25.2 c	25.9 bc	21.7 e	26.4 ab	23.7 d	27.3 a	2.01

[a] Parameters with the same letter in a line are not significantly different at $\alpha = 0.05$.
[b] 2.54-cm WC liftings were not analyzed.
[c] Throughs.
[d] Liftings.
[e] Least significant difference.

TABLE V
Volume and Texture of Steamed Bread Made from Two Moderately Sprouted Wheats Separated by Air Aspiration[a,b]

		Water Column, cm					
		2.54	3.81		5.08		
Steamed Bread Parameters	**Original**	**T[c]**	**L[d]**	**T**	**L**	**T**	**LSD[e]**
Volume, cm^3	634 b	636 b	675 a	629 b	629 b	616 b	24.0
Texture	30.0 a	28.9 ab	23.3 b	30.6 a	25.7 ab	30.8 a	6.31

[a] Parameters with the same letter in a line are not significantly different at $\alpha = 0.05$.
[b] 2.54-cm liftings were not analyzed.
[c] Throughs.
[d] Liftings.
[e] Least significant difference.

nificant improvement in the fractions passing through the aspirator. Whereas the Cibacron blue method measures only α-amylase activity, the RVA and amylograph methods measure combined enzyme activity and starch modification. The 5.08-cm WC throughs showed the greatest improvement. The falling number for this fraction increased, on the average, 84 sec, from 223 in the original sample to 307 (Fig. 2). Colorimetrically determined amylase levels were significantly reduced in the 5.08-cm WC throughs from 0.402 DU/g in the original sample to 0.204 DU/g (Table III). The 2.54- and 3.81-cm WC throughs showed significant improvements relative to the liftings but not relative to the original fraction. The RVA wheat parameters of the 5.08-cm WC throughs fraction were improved relative to all other fractions. The 2.54- and 3.81-cm WC throughs were improved relative to the liftings but not to the original fraction. Air-aspirated fractions of lightly and highly preharvest-sprouted wheats demonstrated no differences in amylase levels (data not shown). No differences were observed in wheat or flour hardness characteristics in any fraction of any sprouting category.

No differences were observed in steam-bread volume or texture in lightly or highly preharvest-sprouted wheats (data not shown). Steam-bread volume and texture in samples of moderate preharvest sprouting responded to air-aspirated cleaning (Table V) in a similar manner to the volume response of sponge cake in the preliminary study. The 3.81-cm WC liftings produced steam bread of greater volume and more tender texture than steam bread for the other fractions. Morad and Rubenthaler (1983) demonstrated increased loaf volume in SWW of moderate preharvest sprouting (0.256 DU/g) relative to both sound (0.023 DU/g) and highly sprouted (1.245 DU/g) wheat. Small amounts of preharvest sprouting are beneficial in some fermented end-use products. Bhatt et al (1981) indicated that proteases hydrolyze glutenins during the early stages of sprouting. If gluten is lacking in extensibility, reduced loaf volume and firmer texture results. Protease modification may permit more optimal functionality. There may be a selective effect for liftings of moderately preharvest-sprouted wheat at the 3.81-cm WC pressure for improved functionality as defined by steam-bread quality parameters. Test weight as a grading factor indicated reduced quality in the 3.81-cm WC liftings fractions, but the steam-bread functionality of the flour was enhanced (Fig. 1 and Table V). No significant differences were observed among fractions from lightly or highly preharvest-sprouted wheats.

CONCLUSIONS

The results of this research indicate that improvement in physical quality factors is possible through air-aspirated fractionation of preharvest-sprouted wheat. Test weight was improved in moderately but not in lightly or highly preharvest-sprouted wheats. The amount of α-amylase present was reduced in a fraction passing through the aspirator relative to a lifted fraction and to the original wheat. Viscometric analyses (falling number, RVA, and amylograph) indicated that α-amylase-induced starch damage was lowered in throughs. The most meaningful improvement was in moderately preharvest-sprouted wheat (falling number 200–300). However, increased air pressures (5.08-cm WC) must be used, and almost half of the sample was removed to achieve the improvement.

Entirely sound grain may not be the optimum material for the highest-quality sponge cake and steamed bread. Low-amylase wheat performed better than sound or highly preharvest-sprouted grain. Specifically, the fraction lifted out at 3.81-cm WC air pressure outperformed all other fractions in both sponge cake and steamed bread production.

Specific gravity tables, in the study by Tkachuk (1991), recover about 6% more wheat than air-aspirated fractionation described here (62 vs. 56%). However, the wheat from the specific gravity table method was to be blended with feed-grade wheat to convert maximum feed-grade wheat to Canada no. 3 grade wheat. The air-aspirated method studied here was to generate fractions sufficiently improved in grade and functional properties for use without blending. Additionally, many country elevators and grain mills operate air-aspirated cleaners. Our results indicate that air-aspirated cleaning devices can enhance economic value and end-use performance.

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