A Note on Varietal and Environmental Variations in Falling Number Values of Flour[1]

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The falling number test developed by Hagberg (1,2) and Perten (3) is being used increasingly in the United States to evaluate the alpha-amylase activity in flour and wheat samples. Variations in experimental conditions which can affect falling number values have been documented (4,5).

The falling number (FN) test is particularly useful for detection of sprout damage in wheat samples and in controlling the alpha-amylase activity in bakery flours. However, to fully evaluate FN data, it would be of interest to know what variations in FN values might be found in sound wheat samples. To this end, we have determined the FN values of flour from sound hard red spring wheats representing six varieties grown at six North Dakota locations in the 1964, 1965, and 1966 crop years.

METHODS

Wheats were ground to flour in a Buhler experimental flour mill. Falling number test equipment and procedure were essentially as described by Perten (3). Each sample was tested in duplicate and the results were averaged. Duplicate determinations always agreed within $\pm$ 3%. For each year, samples were tested within 3 months after harvest. Sample size was 5.0 g. (dry basis). This was less material than is generally recommended for this test. Sound wheats, however, tend to have very high (400–600 sec.) FN values when 7.0 g. (14 or 15% m.b.) samples are used. For convenience in this work, the smaller sample size was chosen. Greenaway and Neustadt (5) have shown that FN values are essentially linearly related to sample size. Preliminary data indicated that the values obtained in this work would all be relatively the same, though higher, if the standard sample size had been used.

Certain flours were fractionated into gluten, starch, sludge, and water-solubles by the procedure of Gilles, Kaelble, and Youngs (6). The water-solubles, starch, and sludge were used in an attempt to determine which fractions were contributing to the variations in FN values of the original flours.

RESULTS

Falling number data for flours from the various wheat varieties are shown in Table I. A summary of the statistical analysis of variance on these data is shown in Table II.

Of the six varieties tested in this study, Justin and Pembina generally

[1]Published with the approval of the Director of the Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, as Journal Series No. 129.

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TABLE I

FALLING NUMBER VALUES[a] OF HARD RED SPRING WHEAT FLOURS

VARIETY	CROP YEAR	STATION WHERE GROWN[b]						YEARLY AVERAGE	THREE-YEAR AVERAGE
		Fargo	Williston	Minot	Mandan	Langdon	Edgeley		
Thatcher	1964	315	300	314	339	314	318	317	
	1965	293	327	307	319	368	292	318	
	1966	353	339	306	344	297	292	322	319
Selkirk	1964	341	304	322	334	319	310	322	
	1965	300	310	309	311	384	298	319	
	1966	341	336	306	379	282	331	329	323
Pembina	1964	309	286	287	309	279	289	293	
	1965	292	297	295	297	297	296	296	
	1966	343	326	292	334	269	323	314	301
Justin	1964	271	295	277	298	287	281	285	
	1965	270	295	291	271	272	270	278	
	1966	323	329	270	308	269	300	300	288
Crim	1964	331	340	356	355	309	334	338	
	1965	318	319	327	317	327	324	322	
	1966	355	343	219	368	266	342	316	325
Chris	1964	304	310	321	323	319	303	313	
	1965	323	319	319	294	315	313	314	
	1966	345	290	304	338	332	324	322	316
Station average	1964	312	306	313	326	304	306	311	
	1965	299	311	308	302	327	299	308	
	1966	343	327	283	345	286	319	317	312
	Three year	318	315	301	324	306	308	312	

[a]Falling number values from 5.0-g. (dry basis) samples.

[b]Grown at Main (Fargo) and Branch Experiment Stations, Agricultural Experiment Station, North Dakota State University, Fargo.

TABLE II

ANALYSIS OF VARIANCE OF FALLING NUMBER VALUES

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	VARIANCE	F VALUE
Varieties	5	19,332.60	3,866.52	12.41**
Location of growth	5	6,603.49	1,320.70	4.24**
Year	2	1,625.91	812.95	2.61
Variety × location (interaction)	25	8,058.68	322.35	1.03
Variety × year (interaction)	10	3,734.43	373.44	1.20
Location × year (interaction)	10	21,419.87	2,141.99	6.87**
Location × year × variety (interaction)	50	15,579.80	311.60	
Total	107	76,354.77		

had lower FN values than the other four. Crim and Selkirk generally had higher FN values, with the Thatcher and Chris somewhat intermediate. The rather consistent differences among these varieties indicated a definite varietal factor which affected FN values.

Location of growth also significantly affected FN values. This is reflected in the station averages, but is more easily seen by comparing the values for a single variety at the various stations.

The effect of crop year was not statistically significant. This undoubtedly is due to the use of only sound wheats in this study. It should not be interpreted to mean that year-to-year variations in FN values do not occur because of variations in harvest conditions.

The only significant interaction was between location of growth and year of growth. This indicates that the effect of environment may vary from year to year, even though crop year itself was not a significant source of variation.

Biochemical Factors Contributing to FN Variations

It is generally considered that the FN value reflects the alpha-amylase activity in a flour sample. For relatively wide variations in FN values, this is undoubtedly true. Perten (3) showed that FN differences also could result from differences in the susceptibility of various starches to enzyme attack. Since only sound wheats were used in this study, an attempt was made to determine whether the major source of variation in these samples was alpha-amylase activity or starch susceptibility.

Several flours which varied in FN values were fractionated into four major fractions: gluten, starch, sludge, and water-solubles. Starch and sludge were combined after drying. To test the susceptibility of the starch-sludge to alpha-amylase attack, 5.0 g. of the various starch-sludge mixtures was placed in FN tubes. Water (24 ml.) and 1 ml. of alpha-amylase solution[3] (0.2 mg./ml.) were added to the sample in the tube and the test completed in the usual way. The water-solubles were assumed to contain the alpha-amylase from the flour. To test the relative activity of these fractions, a standard quantity (0.5 g.) of the various water-soluble fractions was added to 5.0 g. of standard wheat starch[4] and also to 5.0-g. portions of starch-sludge from the corresponding original flour. The FN test was then completed on these samples in the normal manner.

TABLE III

FALLING NUMBER VALUES OF RECOMBINED FLOUR FRACTIONS

SAMPLE	ORIGINAL FLOUR	STARCH + SLUDGE + WATER-SOLUBLES	STARCH + SLUDGE + ALPHA-AMYLASE	STANDARD STARCH + WATER-SOLUBLES
Selkirk (Mandan 64)	334	280	248	392
Justin (Minot 65)	291	226	210	337
Selkirk (Langdon 66)	282	245	240	378
Justin (Mandan 65)	271	233	205	365

As is usual with reconstitution experiments, not all results were clear-cut. Typical data are shown in Table III. In general, for the samples fractionated in this work, it appeared that differences in both starch susceptibility and enzyme activity were contributing to the differences in FN values observed in the original flours.

[3] Alpha-amylase, special for analytical purposes. Wallerstein Laboratories, New York.
[4] Laboratory-isolated HRS wheat starch.

Acknowledgments

The authors gratefully acknowledge the technical assistance of Mrs. Linda Hermanson. Co-operation of the personnel of the North Dakota Agricultural Experiment Station in providing the wheat samples is also acknowledged.

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[Received June 19, 1967. Accepted February 12, 1968]