THE ACID-EXTRACTED PENTOSAN CONTENT OF WHEAT AS A MEASURE OF MILLING QUALITY OF PACIFIC NORTHWEST WHEATS[1]

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ABSTRACT

The determination of the acid-extracted pentosan content of wheat was examined critically to see if it would serve as a routine index for milling quality. It was found that the reproducibility of the analysis for the pentosan content was related to sample weight, grinding tube clearance, grinding speed and time, and extraction time and temperature.

Photometric measurements involving the orcinol procedure for the determination of pentosan using different instruments, aliquots or dilutions, and other laboratory techniques were in good agreement. The procedure for this determination is fully described and demonstrated to be satisfactory for routine analysis.

The correlation coefficient between the pentosan value and milling score was -0.74 and -0.84 for selected winter and spring wheats respectively. The correlation coefficients between pentosan and flour yield, bran weight, and bran cleanup were significant at the 1% level.

A chemical determination which is correlated with a desirable agronomic characteristic such as milling quality would be of benefit to the wheat breeder, provided the procedure is relatively quick, simple, and accurate. Such an analysis which correlates the milling

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properties of wheat with acid-extracted pentosans has been described by Elder, Lubisich, and Mecham (1). These workers found, in a series of 39 samples of 10 varieties, that the acid-extracted pentosans were correlated significantly with milling scores and straight flour yields. The milling score of the varieties reported ranged from 76.4 (Rex) to 94.2 (Elgin). Thus it would appear that this method could be applied in a routine manner for evaluating the milling properties of wheat when only a small sample is available.

The object of this research was to determine the range and degree of usefulness of the acid-extracted pentosan analyses of wheat kernels as a basis for selecting Pacific Northwest soft wheats of superior milling quality. In this paper are described the chemical procedure, its limitations and usefulness in estimating the milling quality of both spring wheats and winter wheat varieties and selections.

Materials and Methods

Samples of widely diverse varieties and selections of both winter and spring wheats were grown in small plots at the Pendleton Experiment Station, Pendleton, Oregon, during 1956 and 1957.

The wheats were grown on land that had previously been summer-fallowed, which is the principal cropping practice of the area. The plots were uniformly fertilized with a nitrogenous fertilizer, a standard agronomic practice.

Representative samples of each variety were sent to the Western Regional Wheat Quality Laboratory, Pullman, Washington, for milling tests and evaluation.

The acid-extracted pentosan content of duplicate samples was determined in this laboratory. The method was based upon the procedure described by Elder *et al.* (1) as modified by Mecham and Hale[2]. It had been indicated that the endosperm should be disintegrated with a minimum of grinding of bran before acid extraction (1). This was accomplished by using a motor-driven (1,000 r.p.m.) Tissue Grinder of 10-ml. capacity. Grinding tubes were made from precision-bore Pyrex tubing, the ends of which were molded to fit the pestle.

For the pentosan determination, three or four kernels of wheat (125–150 mg.) were weighed into each of the grinding tubes and steeped overnight at room temperature in 1 ml. of water and 1 drop of toluene. The sample was then ground with the tissue grinder for exactly 1.5 minutes, during which time there was a slight up-and-down movement of the grinding tube, about once per second, to apply

[2]Mecham, D. K., and Hale, W. H. Personal communication.

a slight pressure to the kernels. If properly ground, the endosperm was homogenized to a milky suspension and pieces of bran were visible between the pestle and the sides of the grinding tube. Both the grinding tube and contents were then placed in a 500-ml. Erlenmeyer flask and the pestle was thoroughly rinsed with 200 ml. of 2.0*N* HCl. The flask was stoppered and shaken gently for exactly 3 hours at room temperature (25°C.). A portion of the digest was immediately filtered, using vacuum and fritted glass filter funnels which had been layered with Celite Analytical Filter Aid. The first portion of the filtrate was discarded and from 5 to 15 ml. were then collected. (The volume depends upon the time available between samples.) The pentosan content of 1 to 2 ml. of the filtrate was then determined by an adapted orcinol procedure described in detail by Elder *et al.* (1).

Results and Discussion

Some difficulties were encountered in adapting this procedure to an extended program. Four varieties of wheat — Rex, Golden, Brevor, and Elgin — of known pentosan content served as standards in determining the reproducibility of the analyses.

Grinding Tube Clearance. Initially the reproducibility of the analyses of the samples from the four varieties averaged ± 0.30% D-xylose. When the clearance between the Teflon pestle and the grinding tube was increased from about 0.004 to 0.012–0.014 in., the reproducibility improved to an average value of ± 0.09%. Therefore, it appeared that the clearance between the Teflon pestle and the grinding tube was critical and should be standardized carefully.

Extraction Temperature. It was noted that the temperature of the laboratory usually rose considerably during the 3-hour extraction period. This was due to uncontrollable internal-heat-producing features as well as external climatic conditions. Consequently, for each sample the temperature was recorded initially and at hourly intervals during the 3-hour extraction period. The average of the four temperature readings was considered to be the average laboratory temperature. The pentosan content of each of the four standard varieties was then plotted against the average laboratory temperature. The difference in the pentosan content was found to be as much as 0.80% D-xylose at a given temperature. This difference was relatively constant at the various temperatures. Consequently, it was possible to derive a temperature standardization factor for 75°F. which was used thereafter for all samples. A standard wheat sample was included in each series of 12 determinations. Over a 4-year period considerable data relating to the laboratory temperature have been

TABLE I

STANDARDIZATION OF THE ACID-EXTRACTED PENTOSAN CONTENT OF REX WHEAT KERNELS TO 75°F.

TEMPERATURE	NUMBER OF DETERMINATIONS	AVERAGE PERCENT[a] PENTOSAN	STANDARD DEVIATION	CONVERSION TO 75°F.[b]
°F.		%		%
70	4	2.68	0.142	+0.25
71	10	2.76	0.096	+0.19
72	20	2.80	0.175	+0.13
73	38	2.80	0.147	+0.09
74	41	2.87	0.149	+0.05
75	49	2.87	0.138	0.00
76	33	2.93	0.117	−0.06
77	28	3.08	0.125	−0.12
78	22	3.09	0.171	−0.18
79	12	3.12	0.157	−0.23
80	10	3.22	0.256	−0.31
81	14	3.27	0.114	−0.38
82	6	3.37	0.220	−0.46
83	7	3.47	0.138	−0.51
84	6	3.43	0.131	−0.55
85	6	3.50	0.141	−0.56
86	5	3.56	0.147	−0.58

[a] Percent D-xylose equivalent.
[b] Applied to all varieties.

obtained and they are summarized in Table I.

It may be noted that from 70° to 83°F. the amount of acid-extracted pentosan increases almost proportionally with temperature. At higher temperatures it appears that this relationship is more constant. However, it is to be remembered that the temperature of the laboratory does not necessarily increase proportionally over a 3-hour period, and this would have a corresponding effect on the pentosan extraction. In order to minimize this effect, the 3-hour extraction was predetermined to occur during the period of the least laboratory temperature fluctuation. This was one of the major difficulties in making this procedure a routine method, for it was necessary to wait until the laboratory had assumed a fairly high temperature before the 3-hour extraction period could be started. An air-conditioned laboratory would eliminate this problem.

Sample Weight and Preparation. In general, increasing the sample weight improved the reproducibility of the results. However, it was not feasible to grind more than three to four kernels per grinding tube, and consequently more grinding tubes were needed per sample. The time factor involved in the quantitative procedures in combining grinding tubes as well as the reduction in the number of daily samples precluded any increase in the sample weight.

Steeping the sample overnight at room temperature did not change the pentosan content, since similar samples steeped at room temperature, in the refrigerator, or placed in a boiling water bath for 20 minutes before steeping at room temperature overnight, gave similar results.

When the speed of the pestle was increased from 1,000 to 1,500 r.p.m. or when the grinding time was extended beyond 1.5 minutes, there was a decrease in the reproducibility among samples.

It was also found that a 2-hour extraction period resulted in low irregular values. The extraction time of 3 hours proved to be satisfactory, although the results were very similar to a 2.5-hour period.

Photometric Measurements. Various aliquots or dilutions had no undesirable effects in color development. The xylose content of the filtrate following the 3-hour extraction period and after color development was found to be stable overnight when read in the Coleman Model 14 Universal Spectrophotometer. Modifications using Hi-Flo Supercel instead of Celite and altering the color reagent so that it could be added with a 10-ml. syringe did not improve the method markedly.

Satisfactory and reproducible standard curves of D-xylose were maintained. The concentration of the standard solutions was alternated with each set of determinations to prevent any systematic error. Recovery of added D-xylose to the wheat kernels before grinding resulted in 98% recovery.

Filtrates after extraction from Rex and Elgin samples, as well as standard D-xylose solutions, were also compared using a Cary Recording Quartz Spectrophotometer Model 11. The agreement between this and the Coleman Spectrophotometer was excellent.

Applications. The procedure as described in the preceding paragraphs was used to determine the acid-extracted pentosan content of 17 winter wheat varieties and 16 spring wheat varieties on which the milling score (2) had been determined (Table II).

The milling scores ranged from a high of 94.03 for the excellent milling variety Omar to a low of 73.25 for the notoriously poor milling variety Rex. The pentosan values ranged from 3.29 for the variety Rio to 2.10 for Elmar. Correlation coefficients between the acid-extractable pentosan values and milling scores were –0.74 and –0.84 for the winter and spring wheats, respectively. Combining the two groups gave a correlation of –0.74.

Correlation coefficients were also computed between the pentosan values and the milling quality values as represented by the flour

TABLE II

MILLING SCORES AND ACID-EXTRACTED PENTOSAN VALUES FOR DIVERSE SPRING AND WINTER WHEAT VARIETIES GROWN AT PENDLETON, OREGON, IN 1956 AND 1957

VARIETY	MILLING SCORE	PENTOSAN VALUE	VARIETY	MILLING SCORE	PENTOSAN VALUE
		%			%
WINTER WHEATS			SPRING WHEATS		
Brevor	74.47	2.92	Baart	77.86	2.78
Burt	86.07	3.03	Baart 46	75.54	2.82
Cheyenne	87.82	2.57	Federation	81.88	2.85
Columbia	83.01	2.60	Henry	88.74	2.38
Comanche	83.21	2.67	H.R.P.-Clarendon	91.10	2.25
Elgin	89.93	2.16	Idaed	86.97	2.51
Elmar	87.59	2.10	Lemhi	82.67	2.45
Golden	80.15	2.75	Lemhi 53	82.49	2.40
Omar	94.03	2.18	Marfed	79.70	2.80
Orf-Hyb-50-3	86.59	2.84	Marfed-Merit 28	82.81	2.77
Orf-Wasatch	78.87	3.00	Onas	77.53	2.81
Requa	78.08	2.90	Onas 52	77.39	2.86
Rex	73.25	3.12	Orfed	85.47	2.58
Rio	80.22	3.29	Ramona 44	78.44	3.00
Triplet	84.73	2.63	Selkirk	88.20	2.45
Wasatch	81.73	2.86	Thatcher	81.79	2.59
Yogo	87.88	2.63			
r=−0.7444**			r=−0.8363**		

Combined r=−0.7459**

TABLE III

CORRELATION COEFFICIENTS BETWEEN MILLING QUALITY VALUES AND THE ACID-EXTRACTED PENTOSAN CONTENT OF WINTER AND SPRING WHEATS GROWN AT PENDLETON, OREGON, IN 1956 AND 1957

RELATIONSHIP	SPRING WHEATS	WINTER WHEATS
Flour yield vs. pentosan	−0.350**	−0.373**
Bran weight vs. pentosan	+0.313**	+0.276**
Bran cleanup vs. pentosan	....	+0.252**

yield, bran weight, and bran cleanup rating. These correlations are given in Table III.

While all of the correlation coefficients were significant, they were of rather low magnitude. The fact that these relationships were determined on widely diverse types, both hard- and soft-textured varieties, might account for this rather poor relationship.

The usefulness of this method to the plant breeder in the selection of high-milling-quality spring and winter wheats is being further investigated.

Literature Cited

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