Cereal Pentosans: Their Estimation and Significance. III. Pentosans in Abraded Grains and Milling By-Products[1]

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ABSTRACT

Water-soluble, enzyme-extractable, and total pentosans were estimated by the orcinol method in whole wheat, barley, oats, sorghum, and brown rice, in laboratory abraded grains, in pearlings from abraded grains, and in commercial samples of brewers' dried grain, wheat bran, oat hulls and bran, rice hulls and bran, corn bran and soybean hulls. The enzyme-extractable pentosans were estimated after treatment with a multi-component system of *Trichoderma viride*. Total pentosans were estimated after hydrolysis with 2*N* HCl at 100° C, neutralization, and fermentation with fresh, compressed bakers' yeast. Pearled grains generally contained less water-soluble, enzyme-extractable, and especially total pentosans than the whole grains; this was reflected in the high concentrations of pentosans in the pearlings. Among the commercial milling by-products, water-soluble pentosans were highest in soybean hulls (1.55%) and wheat bran (1.02%). Enzyme-extracted pentosans were highest in brewer's dried grains (3.94%), soybean hulls (3.81%), and oat bran (3.16%). Total pentosans were highest in corn bran (34.72%) and wheat bran (22.53%). Oat bran (4.07%) and rice bran (5.63-7.15%) were low in total pentosans. The ranges were 0.1-1.6% for water-soluble, 0.2-3.9% for enzyme-extractable, and 4.1-34.7 for total pentosans. Distinct linear regression lines were established for the plots between ash and total pentosan for individual grains from the abrasion series. Positive correlation coefficients between protein and enzyme-extractable pentosans were significant at the 0.01 level for the samples from the abrasion series, commercial by-products, and combined samples.

Determination of pentosans can be used in rapid routine estimation of dietary fiber. Bell (1985) found a correlation of 0.998 between the pentose values determined by the orcinol method and dietary fiber.

We previously described (Hashimoto et al 1986) a method for the estimation of water-soluble, enzyme-extractable, and total pentosans in wheat and milled wheat products. We now describe use of this method to estimate pentosans in high-fiber whole and abraded cereal grains and in commercial milling by-products.

MATERIALS AND METHODS

Commercial hard red winter wheat, covered six-rowed barley, oats, grain sorghum, and brown rice were abraded for 15–45 sec in a Strong-Scott barley pearler to produce about 15% (13.1–19.5%, average 16.3%) pearlings. Protein and ash contents of the whole and pearled grains and pearlings are shown in Table I. The protein and ash of commercial milling by-products are given in Table II. As the rice bran samples (regular and parboiled, each from two food manufacturers) were high in oil, they were defatted by exhaustive extraction with petroleum-ether in a Soxhlet apparatus. Their oil, ash, and protein contents are given in Table III. In addition, whole wheat and seven milling streams (three flours, coarse bran, fine bran, shorts, and red dog) from laboratory-milled hard red winter wheat (cultivar Centurk) were used. They were described in Hashimoto et al (1986).

Moisture, ash, and protein were determined by AACC methods 44-15A, 08-01, and 76-11, respectively (AACC 1984). Water-soluble, enzyme-extractable, and total pentosans were estimated as described in Hashimoto et al (1986). The whole grains, pearled grains, and commercial by-products of milling were ground on a Wiley laboratory mill to pass a 20-mesh sieve. Analytical determinations were made on duplicate samples; the results were averaged and evaluated statistically.

[1]Mention of firm names or trade products does not constitute endorsement by the USDA over others not mentioned.

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RESULTS AND DISCUSSION

Water-soluble, enzyme-extractable, and total pentosans of whole grains, pearled grains, and pearlings are given in Table IV. The pearled grains, generally, contained less water-soluble and enzyme-extractable pentosans than the whole grains. The largest changes were in total pentosans; the pearlings contained at least twice as much total pentosans as the whole grains, with the exception of oats, in which the pearling process (apparently) removed only a portion of the hulls plus bran. Plots of ash versus total pentosan contents of the whole grains, pearled grains, and

TABLE I
Kernel Weight, Protein, and Ash of Whole Grains Pearled Grains, and Pearlings

Original Kernel Wt (mg) and Abrasion Product	Protein[a] (%)	Ash[a] (%)
Wheat (23.3)	11.8	1.49
Pearled	11.0	1.16
Pearlings	15.2	3.15
Barley (39.1)	11.8	2.43
Pearled	11.6	1.69
Pearlings	14.3	7.10
Oats (19.6)	14.4	1.82
Pearled	13.9	1.56
Pearlings	17.5	3.03
Rice (19.5)	7.0	5.34
Pearled	7.7	3.03
Pearlings	5.4	12.58
Sorghum (26.4)	9.1	1.38
Pearled	8.8	0.91
Pearlings	10.8	3.39

[a]On a 14% moisture basis.

TABLE II
Protein and Ash of Commercial Milling By-Products

Product	Protein[a] (%)	Ash[a] (%)
Wheat bran	13.5	5.55
Brewers' dried grain (barley)	27.7	3.86
Rice hulls I	2.2	21.82
Rice hulls II	2.5	17.17
Parboiled rice hulls	1.9	21.67
Oat hulls	7.6	3.73
Oat bran	19.5	2.96
Corn bran	5.0	0.39
Soybean hulls	9.4	3.82

[a]On a 14% moisture basis.

pearlings are given in Figure 1. In each linear plot, the lowest values represent abraded grains, the intermediate values whole grains, and the highest values pearlings. The various linear slopes reflect differences in ratios of ash to total pentosan for the five grains; these ratios were 1.74 for rice, 0.574 for oats, 0.660 for sorghum, 0.342 for barley, and 0.222 for wheat. A similar order was obtained for the ratios of ash to enzyme-extractable pentosan (17.23 for rice, 1.24 for oats, 3.37 for sorghum, 1.32 for barley, and 0.81 for wheat).

TABLE III
Protein, Ash, and Oil of Commercial Rice Bran

Product	Protein[a] (%)	Ash[a] (%)	Oil[a] (%)
Rice bran I	15.1	10.05	21.2
Rice bran II	12.7	11.89	18.0
Parboiled rice bran I	16.3	10.00	25.5
Parboiled rice bran II	13.3	10.16	19.1

[a]On a 14% moisture basis.

TABLE IV
Water-Soluble, Enzyme-Extractable, and Total Pentosan of Whole Grain, Pearled Grains, and Pearlings

Grain and Abrasion Product	Pentosan (%)[a] Water-Soluble	Enzyme-Extractable	Total
Wheat	0.68	1.84	6.71
Pearled	0.67	1.96	5.91
Pearlings	1.02	2.15	13.30
Barley	0.41	1.84	7.10
Pearled	0.31	1.97	5.18
Pearlings	0.63	2.61	16.44
Oats	0.20	1.47	3.17
Pearled	0.18	1.43	3.49
Pearlings	0.34	2.53	3.37
Rice	0.07	0.31	3.07
Pearled	0.05	0.33	1.82
Pearlings	0.11	0.31	6.82
Sorghum	0.09	0.41	2.09
Pearled	0.09	0.32	0.97
Pearlings	0.41	0.90	6.28

[a]On a 14% moisture basis.

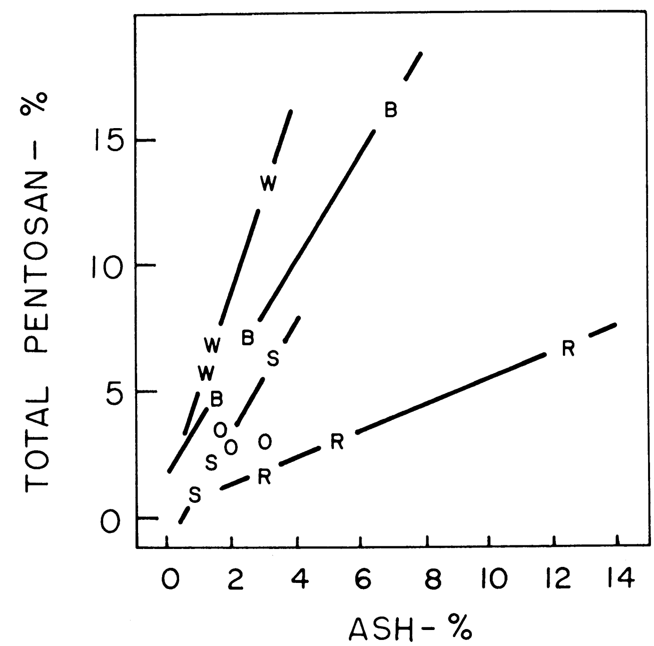

Fig. 1. Plot of linear regression lines between ash and total pentosan for wheat (**W**) $y = 3.80x + 1.30$, $r = 0.998$; barley (**B**) $y = 2.06x + 1.89$, $r = 1.00$; oats (**O**) $y = -0.005x + 3.35$, $r = 0.02$; sorghum (**S**) $y = 2.12x - 0.91$, $r = 0.998$; and rice (**R**) $y = 0.52x + 0.26$, $r = 1.00$. The highest values in each plot for each grain represent pearlings, the intermediate values whole grain, and the lowest values abraded grain.

Water-soluble, enzyme-extractable, and total pentosan contents of the milling by-products are summarized in Table V. Soybean hulls (1.55%) and wheat bran (1.02%) were highest and rice hulls were lowest (0.13-0.14%) in water-soluble pentosans. The enzyme-extracted pentosans were highest in brewers' dried grain (3.94%), soybean hulls (3.81%), and oat bran (3.16%) and lowest in rice hulls (0.20-0.29%). The richest sources of total pentosans were corn bran (34.72%) and wheat bran (22.53%); oat bran contained least total pentosans (4.07%). Rice bran I and parboiled rice bran I were from one food manufacturer and rice bran II and parboiled rice bran II from a second food manufacturer (Tables III and VI). Water-soluble pentosans were higher in regular than in parboiled rice bran, and in bran from manufacturer I than from manufacturer II. As the rice bran was rich in oil (Table III), enzyme-extractable pentosans were estimated before and after defatting. Defatting did not have a consistent effect on the amount of enzyme-extractable pentosan (Table VI) when the results were calculated on an as-is, nondefatted basis. Again, the rice bran samples from manufacturer II were lower in enzyme-extractable pentosans than those from manufacturer I. There were no

TABLE V
Water-Soluble, Enzyme-Extractable, and Total Pentosan of Commercial Milling By-Products

Products	Pentosan (%)[a] Water-Soluble	Enzyme-Extractable	Total
Wheat bran	1.02	1.70	22.53
Brewer's dried grain	0.52	3.94	13.55
Rice hulls I	0.13	0.20	9.72
Rice hulls II	0.14	0.22	10.74
Parboiled rice hulls	0.13	0.29	10.71
Oat hulls	0.47	1.49	10.22
Oat bran	0.38	3.16	4.07
Corn bran	0.33	0.97	34.72
Soybean hulls	1.55	3.81	15.23

[a]On a 14% moisture basis.

TABLE VI
Water-Soluble, Enzyme-Extractable, and Total Pentosan of Commercial Rice Bran

Product	Pentosan (%)[a] Water-Soluble	Enzyme-Extractable As is	Enzyme-Extractable After Defatting	Total
Rice bran I	0.90	1.49	1.80 (1.42)[b]	5.63
Rice bran II	0.41	0.83	0.91 (0.74)[b]	5.94
Parboiled rice bran I	0.44	1.36	1.97 (1.46)[b]	7.15
Parboiled rice bran II	0.27	1.13	1.53 (1.24)[b]	4.87

[a]On a 14% moisture basis; unless stated otherwise.
[b]Calculated on an as-is, nondefatted, basis.

TABLE VII
Correlation Coefficients for Several Parameters in the Samples from the Abrasion Series and Commercial By-Products

Parameter	Protein	Ash	Water-Soluble Pentosan	Enzyme-Extractable Pentosan	Total Pentosan
← Abrasion Series → (upper right)					
Protein		−0.374	0.550*[a]	0.859**	0.368
Ash	−0.597		−0.109	−0.187	0.380
Water-soluble Pentosan	0.294	−0.529		0.735**	0.777**
Enzyme-extractable pentosan	0.838**	−0.695*	0.658		0.610*
Total	−0.129	−0.409	0.215	−0.105	
← Commercial By-Products → (lower left)					

[a]* and ** indicate significance at the 0.05 and 0.01 levels, respectively.

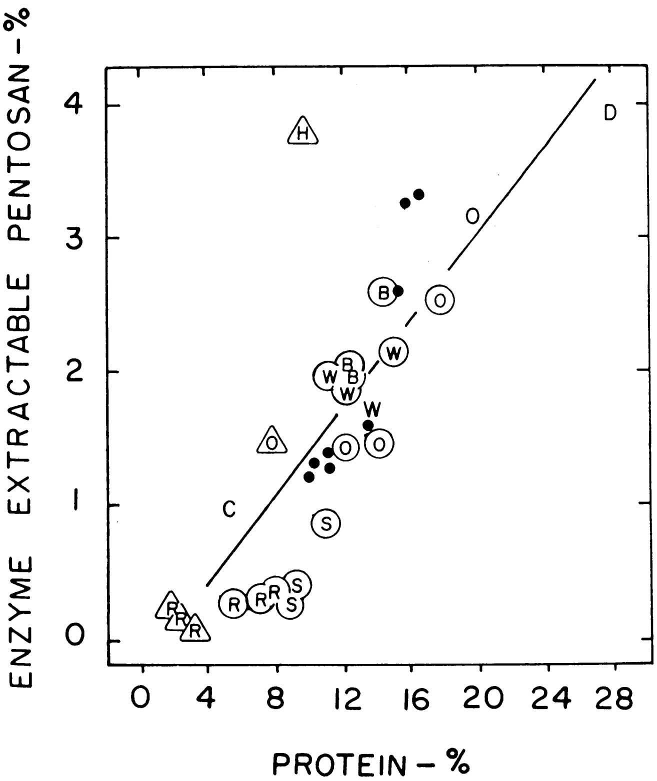

Fig. 2. Plot of correlation between protein content and enzyme-extractable pentosans in whole grains, abraded grains and pearlings of wheat Ⓦ, barley Ⓑ, oats Ⓞ, rice Ⓡ, and sorghum Ⓢ; milling streams of hard red winter wheat (•) Centurk; and commercial milling by-products: wheat bran (**W**), brewers' dried grain (**D**), oat bran (**O**), corn bran (**C**), oat hulls △O, rice hulls △R, and soybean hulls △H.

consistent differences in the amounts of total pentosans, indicating that the differences in the water-soluble and enzyme-extractable pentosans resulted from differences in processing conditions rather than from differences in rices used by the two manufacturers. The amounts of pentosan, especially total, in the rice bran samples were low and only slightly higher than in oat bran.

The correlation coefficients between pairs of the following variables are summarized in Table VII: protein, ash, water-soluble pentosan, enzyme-extractable pentosan, and total pentosan for the samples from the abrasion series and for the commercial by-products. In addition to some significant correlations between pairs of various forms of pentosans in the abrasion series (i.e., enzyme-extractable vs. water-soluble and total), the interesting significant correlations were between protein and enzyme-extractable pentosans in both series of samples. When correlation coefficients for all samples (described in Tables I, II, and III) were calculated the following ones were found to be significant (* at the 0.05 level and ** at the 0.01 level): protein versus enzyme-extractable pentosan, $r = 0.745$**; water-soluble pentosan versus enzyme-extractable pentosan, $r = 0.671$**; protein versus ash, $r = -0.442$*; ash versus enzyme-extractable pentosan, $r = -0.442$*; water-soluble pentosan versus total pentosan, $r = 0.410$*.

The significant and consistent correlation between protein and enzyme-extractable pentosan is reflected in Figure 2, in which data for three groups of samples are given: the abrasion series, the milling streams of the hard red winter wheat Centurk, and the commercial milling by-products (except for rice bran). The highly significant correlation coefficient was 0.800 for the combined, highly-diverse samples. This correlation decreased to 0.751 when the four rice bran samples were included.

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