Water-Insoluble Pentosans of Wheat: Composition and Some Physical Properties

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ABSTRACT

Water-insoluble pentosans (WIP) were isolated from flours of seven Canadian wheat varieties belonging to several classes, and their chemical composition and physical properties were determined. Xylose and arabinose, determined by high-performance liquid chromatography, were the most abundant monosaccharides; small amounts of glucose were also present. The degree of branching (arabinose/xylose ratio) ranged between 0.96 and 0.58, whereas the ferulic acid content of various WIP preparations was 1.10–0.86 μg/mg of pentosans. Comparison of the ferulic acid content between flours and the respective WIP indicated that this phenolic constituent is not uniformly distributed in wheat endosperm. Solubility of WIP in NaOH solutions increased with increasing alkali concentration; approximately 80% of WIP were solubilized in 1.0*M* NaOH. Oxidative gelation studies of WIP (H_2O_2/peroxidase) using small deformation oscillatory rheological testing revealed that WIP are amenable to further cross-linking via free feruloyl residues in the polymeric matrix. The farinograph water absorption of WIP-supplemented doughs depended strongly on the chemical and baking characteristics of the base flour.

INTRODUCTION

The wheat grain contains a number of chemical constituents, the main ones being starch and proteins. Wheat flours also contain certain minor constituents that clearly contribute to their functional properties. Among them, the pentosans, a nonstarch polysaccharide fraction of wheat flour, may significantly affect the rheological properties of dough and thereby the quality of bread (Jelaca and Hlynka 1971, Holas and Tipples 1978, Hoseney 1984, McCleary 1986, Meuser and Suckow 1986). Both water-soluble pentosans (WSP) and water-insoluble pentosans (WIP) contribute to the water absorption of wheat flour (Jelaca and Hlynka 1971, Neukom 1976, Hoseney 1984, Amado and Neukom 1985, Meuser and Suckow 1986). The water-binding capacity of wheat flours is of great interest when selecting wheat varieties for breadmaking (Ablett et al 1986, Bushuk 1966).

Much is known about the chemistry, the physical properties (Ciacco and D'Appolonia 1982, Hoseney 1984, Saini and Henry 1989), and the role in breadmaking (Jelaca and Hlynka 1971, Holas and Tipples 1978, Hoseney 1984, McCleary 1986, Meuser and Suckow 1986) of WSP. Less attention has been devoted, however, to the WIP (Cole 1967, Kim and D'Appolonia 1976, DuPont and Selvendran 1987). In fact, some contradictory results have been reported with respect to the role of WIP in the breadmaking process (Hoseney 1984, Meuser and Suckow 1986). The reasons for the inconsistencies may lie in the fractionation procedures used to obtain the pentosan fraction as well as in the inherent differences in structure and properties of these materials isolated from different wheat varieties. Another difficulty associated with the characterization of WIP is that some methods of solubilization (required for characterization) may cause decomposition and thereby a change in properties. Also, the question as to the extent of contribution of WIP to the intervarietal differences in water absorption still remains open. Accordingly, the aim of this study was to investigate the chemical and physical properties of WIP isolated from flours milled from wheat varieties of diverse technological characteristics.

MATERIALS AND METHODS

Preparation and Analysis of Flours and Pentosans

WIP were prepared from six varieties each belonging to a different class of Canadian wheat and from one unregistered variety (Marshall), a U.S. hard red spring wheat. Wheat was milled on a Buhler laboratory mill with tempering moisture appropriate for each wheat class. The yield of straight grade flour ranged from 67.5 to 75.2%. In the case of durum wheat (Hercules), the WIP were prepared from flour provided by the Grain Research Laboratory (Winnipeg, MB). Ash content of the flours was determined by the AACC approved method (1983). Loaf volume was determined according to Kilborn and Tipples (1981). The protein (N × 5.7) content of the flours was determined according to the AACC method (1983) and that of the WIP according to the method of Lowry et al (1951). Total and water-insoluble pentosan contents of flours were determined by the phloroglucinol method of Douglas (1981). The WSP contents were determined according to the method of Holas and Tipples (1978).

Determination of Neutral Sugars

For neutral sugar analysis, the pentosan preparations (10–20 mg) were hydrolyzed with 0.1*M* sulfuric acid in a boiling water bath for 2 hr. The solution was cooled, neutralized with barium carbonate, and centrifuged. The monosaccharide composition of the clear supernatants was determined by high-performance liquid chromatography (HPLC) according to Wentz et al (1982). A Waters Associates liquid chromatograph equipped with an M 6000A solvent delivery system, a U6K injector, and a refractive index detector was used. The system was interfaced to a VISTA data station (Varian 401) for data acquisition and peak area integration. All samples (20-μl injection volume) were run isocratically at a flow rate of 0.6 ml/min, using filtered and degassed distilled water as eluent, through an Aminex HPX 87P (300 × 7.8 mm) column (Bio-Rad, Richmond, CA) at 60° C in conjunction with a guard column.

Determination of Ferulic Acid

The ferulic acid content of flours and WIP preparations was determined by the HPLC method of Pussayanawin and Wetzel (1987). A Waters liquid chromatograph equipped with a UV detector model 440 and an Ultremex 5 C18 column (250 × 4.6 mm) was used. The mobile phase was a mixture of 10% methanol and sodium citrate buffer (0.01*M*, pH 5.40). The flow rate was 1.0 ml/min. The samples and standards were protected from light (Smith and Hartley 1983) and stored in the refrigerator before being injected into the chromatograph. Ferulic acid used as standard was obtained from Aldrich Chemical Co. Inc. (Milwaukee, WI).

Preparation of WIP

The procedure for isolation of WIP was similar to that described by Jelaca and Hlynka (1971), Cole (1967), and Kim and D'Appolonia (1976), with some modifications. Approximately

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TABLE I
Chemical, Milling, and Dough Characteristics of Flours Used for Preparation of Water-Insoluble Pentosans

Wheat Class Variety[a]	Flour Yield (%)	Protein[b] (%)	Ash (%)	Pentosan Content[c] Total (%)	Pentosan Content[c] Water-Insoluble (% total)	Ferulic Acid[c] (μg/mg)	Starch Damage (%)	Farinograph Absorption (%)	Dough Development Time (min)	Loaf Volume (cm^3)
Katepwa (CWRS)	72.0	12.1	0.42	2.06 ± 0.04	66.7 ± 1.0	0.050 ± 0.003	24	63.7	7.5	745
Glenlea (CU)	70.1	12.1	0.48	1.67 ± 0.07	67.0 ± 0.9	0.047 ± 0.004	31	62.3	2.5	740
HY 320 (CPS)	67.5	10.0	0.39	1.96 ± 0.05	67.7 ± 1.0	0.053 ± 0.006	10	56.5	5.0	610
Norstar (CWRW)	75.2	11.3	0.33	1.37 ± 0.07	60.6 ± 0.5	0.057 ± 0.005	19	56.7	7.5	740
Fielder (CWSWS)	69.1	10.0	0.39	1.86 ± 0.05	67.7 ± 1.2	0.054 ± 0.004	6	54.3	2.0	400
Marshall (HRS)	75.1	12.7	0.41	1.76 ± 0.07	64.5 ± 1.2	0.040 ± 0.001	19	60.3	4.5	825
Hercules (CWAD)	71.2	12.7	0.68	1.95 ± 0.06	82.8 ± 1.0	0.072 ± 0.004	NA[d]	NA	NA	NA

[a] CWRS = Canada western red spring, CU = Canada utility, CPS = Canada prairie spring, CWRW = Canada western red winter, CWSWS = Canada western soft white spring, HRS = hard red spring, CWAD = Canada western amber durum.
[b] N × 5.7; on 14% moisture basis.
[c] Calculated on a dry basis.
[d] Not analyzed.

200 g of flour was slurried in 1,000 ml of distilled cold water, stirred for 1.5 min using a mixer, and centrifuged at 5,000 × *g* for 30 min. The upper layer of the sediment was removed with a spatula, mixed with cold water, and centrifuged (5,000 × *g*). This procedure was repeated five to seven times to completely remove the water-soluble components. Subsequently, the sediment was wet-sieved through a 37-μm stainless steel sieve. The residue on the sieve was washed with water, centrifuged (5,000 × *g*), and then subjected to amyloglucosidase digestion to hydrolyze the starch. Each time, before the addition of the enzyme (0.2 mg of amyloglucosidase per 100 mg of starch; Boehringer GmbH, Mannheim, Germany), the suspension was heated in a boiling water bath for 10 min to gelatinize the starch. The digestion was performed at 37°C for 48 hr, at pH 5.0. The suspension was then dialyzed against distilled water at 4°C for 48 hr. Both processes (digestion and dialysis) were repeated seven times to remove the contaminating starch. The resulting WIP were freeze-dried and finely ground.

Solubilization of WIP by Alkali

The preparations of WIP were solubilized by sodium hydroxide solutions ranging in concentration from 0.05 to 1.0*M* at 4°C for 3 hr, under constant stirring. Some solubilization experiments were performed in the presence of 10 mmol of $NaBH_4$ (DuPont and Selvendran 1987) to test the possibility of alkaline degradation of these nonstarch polysaccharides. The solutions obtained were centrifuged (10,000 × *g* for 20 min at 4°C), and the supernatants were analyzed for carbohydrates, using the phenol-sulfuric acid method (Dubois et al 1956), and subjected to gel filtration chromatography.

Gel Filtration Chromatography

Gel filtration chromatography of WIP (solubilized in 0.4*M* NaOH) was performed on a Sepharose CL 4B column (2.6 × 80 cm) at 22°C. The column was equilibrated and subsequently eluted with 0.4*M* NaOH (room temperature) at a flow rate of 20 ml/hr. Fractions of 5 ml were collected. The eluates were assayed for total carbohydrates using the phenol-sulfuric acid method. The void (V_o) and total (V_t) volumes were determined by chromatography of Blue Dextran 2000 and xylose, respectively. Other molecular weight markers included a series of linear dextrans (Pharmacia Ltd, Montreal, PQ): dextran T-40 (M_r 41,000), dextran T-150 (M_r 143,000), and dextran T-500 (M_r 466,000).

Rheological Testing

The viscoelastic behavior of aqueous WIP suspensions was examined on a Bohlin VOR rheometer system (Bohlin Reologi, Edison, NJ). A parallel plate system (30 mm in diameter) with a gap of 1 mm and a torque element of 19.5 g·cm was used. All measurements were performed at 20°C ± 0.1, a frequency of 1.0 Hz, and 4.4% strain. The measurements were made on 1.5% (w/w) WIP suspensions in distilled water prepared by dispersing the WIP in boiling water (3 min) and then cooling to room temperature before testing.

Additionally, WIP isolated from Glenlea and Norstar flours were deesterified before gelation to examine the effect of the phenolic acids content (mainly ferulic) on the oxidative gelation of pentosans. After solubilization of WIP in 0.4*M* sodium hydroxide and neutralization with acetic acid to pH 5.5–5.6, the samples were dialyzed and freeze-dried. Rheological measurements were done both on control samples (WIP only) and on suspensions to which horseradish peroxidase (0.22 purpurogallin units) in 0.1*M* potassium phosphate buffer, pH 6.0, and 1.2 ppm of hydrogen peroxide were added. The time-dependence of the rheological properties of WIP dispersions was measured, beginning immediately after adding the oxidizing agents. The reported data are means of two, and in some cases three, replicates; values for the storge modulus (G') and phase angle (δ) were obtained using the software analysis programs of the Bohlin rheometer.

TABLE II
Chemical Composition of Water-Insoluble Pentosans (WIP) (db) Isolated from Different Wheat Flours

Source of WIP	Protein (%)	Ara:Xyl:Glu	Ferulic Acid (μg/mg)
Katepwa	10.7 ± 0.4	0.647:1:0.414	1.08 ± 0.06
Glenlea	12.3 ± 0.5	0.691:1:0.202	NA[a]
HY 320	10.4 ± 0.4	0.664:1:0.099	1.10 ± 0.04
Norstar	8.0 ± 0.6	0.579:1:0.102	0.81 ± 0.06
Fielder	8.0 ± 0.3	0.591:1:0.220	0.61 ± 0.06
Marshall	13.1 ± 0.4	0.710:1:0.331	0.43 ± 0.03
Hercules	12.4 ± 0.4	0.963:1:1.025	0.86 ± 0.04

[a] Not analyzed.

Determination of Water Absorption

Water absorption of flours supplemented with WIP and of Katepwa flours having different degrees of starch damage was determined using a microfarinograph, according to AACC procedure (1983). Flours with different levels of damaged starch were prepared by multiple passes through a set of Allis Chalmers break rolls. The degree of starch damage was determined by the AACC procedure (1983).

RESULTS AND DISCUSSION

Composition of Flours

The chemical composition as well as the physical, milling, and dough properties of wheat flours used for the isolation of WIP are given in Table I. The wheat flours used for these studies varied widely in chemical, milling, and baking characteristics. The protein content of the flours ranged from 12.7% (Marshall) to 10.0% (Fielder and HY 320). The total pentosan content (Table I) varied from 1.37% (Norstar) to 2.06% (Katepwa). The relatively

large contribution of the WIP fraction to the total pentosan content of Hercules, compared to that of the other wheat flours, was also accompanied by a high ash content, which could imply a higher contamination of bran material for this flour. However, the fact that the extraction rate of Hercules wheat (71.2%) was within the range of flour yields obtained for the rest of the samples suggests that the high WIP and ash contents of Hercules flour may reflect the true properties and composition of the endosperm of this wheat.

Chemical Composition of WIP

Table II summarizes the composition of WIP from the seven wheat varieties. The only sugars detected were xylose, arabinose, and glucose. Galactose and mannose, reported by Mares and Stone (1973a) and Meuser and Suckow (1986) as an integral part of WIP, were not detected in our preparations by the HPLC method used. The higher ratios of arabinose to xylose, indicative of the degree of branching of these biopolymers (Delcour et al 1989), was observed for WIP isolated from the durum variety Hercules (0.963) and the semidwarf hard red spring wheat variety, Marshall (0.710). The lower ratios of arabinose to xylose were 0.579 and 0.591 for WIP isolated from the Canada western hard red winter Norstar and the Canada western soft white spring wheat Fielder, respectively. These values are in good agreement with earlier observations (Jelaca and Hlynka 1971, Kim and D'Appolonia 1976, Saini and Henry 1989) except for WIP from the durum wheat (Hercules). For the latter, Jelaca and Hlynka (1971) reported only a slightly higher degree of branching in comparison to WIP of Canada western hard red spring wheat flours. The high value for Hercules WIP obtained in this work suggests a highly branched structure and warrants further investigation.

In spite of the same treatment being used for all the samples during their isolation, different contents of glucose in WIP preparations were found (Table II). The presence of distinct amounts of glucose in WIP wheat preparations was reported earlier by Kim and D'Appolonia (1976). The highest content of glucose, about 50% of the sum of arabinose and xylose, was observed for Hercules WIP. The Norstar and HY 320 preparations had the lowest glucose content. It is possible that some of the glucose in Hercules WIP may originate from β-glucan (Mares and Stone 1973a, Neukom 1976, Shibuya and Iwasaki 1978, Bacic and Stone 1980, Henry 1987) and/or α-D-glucan polymers that are entrapped within the insoluble polysaccharide matrix (Neukom 1976, Smith and Hartley 1983). As a result, its complete removal by washing (β-glucan) or α-amylase treatment (to degrade starch) may be difficult.

The presence of different amounts of nitrogenous compounds in wheat pentosan preparations is well documented (Cole 1967, Mares and Stone 1973a, Neukom 1976). The protein contents obtained in the present studies ranged between 8.0 and 13.1% (Table II). The highest value was for WIP isolated from Hercules and Marshall flours, whereas the lowest was for Norstar and Fielder. Protein contents of WIP reported in the literature vary and seem to depend on the method of isolation (Cole 1967, Jelaca and Hlynka 1971) and particularly on whether proteolytic enzymes are used to hydrolyze contaminating proteins (Mares and Stone 1973b, Neukom 1976, McCleary 1986). A high protein content of 13.4% was reported for pentosans isolated from durum wheat by Jelaca and Hlynka (1971). It has been suggested that the protein component of WIP is an integral part of cell walls and is not covalently bound to the WIP polysaccharides (Mares and Stone 1973b). However, the presence of cross-links between feruloyl residues and amino acids (eg, tyrosine and cysteine) has been suggested (Gallus and Jennings 1971, Neukom 1976, Hoseney 1984, Jackson and Hoseney 1986, Guillon and Thibault 1988). Further work is obviously needed to reveal the nature of association between proteins and pentosan polysaccharides in wheat endosperm cell walls.

Whereas ferulic acid determination by gas chromatographic techniques requires a derivatization step (Krygier et al 1982, Ford and Hartley 1989) and is rather complex, HPLC methodologies have been recently developed to measure ferulic acid in milling fractions for a rapid assessment of the endosperm purity (Pussayanawin and Wetzel 1987). In the present study, mild acid hydrolysis was employed to liberate ferulic acid from WIP, according to Pussayanawin and Wetzel (1987). The content of ferulic acid for flours (Table I) varied between 0.04 and 0.057 μg/mg. These values are in good agreement with the findings of Jackson and Hoseney (1986), Pussayanawin and Wetzel (1987), and Sosulski et al (1982). A high content of ferulic acid was found for Hercules (0.072 μg/mg). Apparently, phenolic acids (eg, ferulic acid) in this variety are esterified to a greater extent in the cell wall polysaccharides, thereby providing the means for cross-linking between cell wall polysaccharides and lignin (DuPont and Selvendran 1987). The most recent results of Ford and Hartley (1989) on light-induced cyclodimerization of *trans*-ferulic and *trans-p*-coumaric acids "in vitro" and the detection of such cyclodimers containing ferulic acid in plant cell walls agree with this view. This type of intermolecular association between cell wall polysaccharides might also contribute to wheat grain hardness. With respect to WIP (Table II), higher amounts of ferulic acid were found for HY 320 (1.10 μg/mg), Katepwa (1.08 μg/mg), and Hercules (0.86 μg/mg). The fact that the ranking of WIP preparations in terms of ferulic acid contents (Table II) did not coincide with that of the flours (Table I) suggests that this constituent is not uniformly distributed in the endosperm of various wheat varieties.

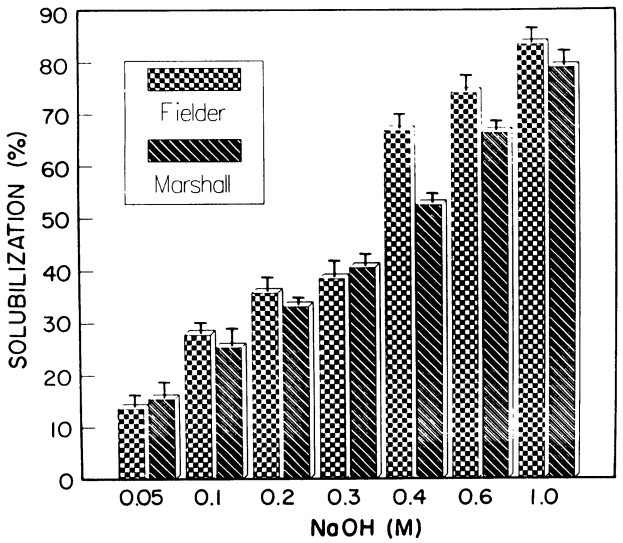

Fig. 1. Effect of sodium hydroxide concentration on solubility of WIP preparations from two wheat cultivars.

Solubility of the WIP

Figure 1 shows the relationship between concentration of sodium hydroxide and solubility of WIP preparations isolated from two wheat varieties. As expected, the solubility of WIP increased with increasing concentration of sodium hydroxide. In the case of 0.05*M* NaOH, the degree of solubilization was only about 14–15%. These values increased with NaOH concentration up to about 80% for 1*M* NaOH. Similar solubilization patterns were observed for WIP isolated from all wheat varieties tested. In contrast to WIP preparations of the present study, DuPont and Selvendran (1987) reported that only about 35% of cell wall material isolated from wheat bran can be solubilized by 4.0*M* NaOH. It would appear that for lignified cell walls, phenolics and lignin form alkali-stable ester linkages with the polysaccharides; ie, complete solubilization of the polymeric carbohydrates requires delignification of the cell wall material before alkali extraction. The results of our experiments, therefore, suggest that WIP from wheat endosperm are polymerized to a lower degree than WIP from wheat bran. Smith and Hartley (1983) have reported that although water-soluble wheat flour pentosans contain 0.4 μmol of feruloyl groups per gram of polymer, pentosans

of endosperm cell walls and bran cell walls contain 5.6 and 34.0 μmol/g of walls, respectively. Since formation of covalent cross-links between adjacent arabinoxylan chains involves ferulic acid residues, the content of phenolics in cell wall preparations would be inversely related to the degree of solubilization of these materials by alkali (Neukom 1976, DuPont and Selvendran 1987).

Fractionation of the WIP by Gel Chromatography

The WIP solubilized in 0.4*M* NaOH was subjected to gel filtration chromatography on Sepharose CL 4B using 0.4*M* sodium hydroxide as eluent, to obtain information about the molecular weight distribution of its carbohydrate constituents (Figs. 2 and 3). The elution profiles were characterized by one slightly asymmetric peak in the vicinity of the void volume. Identical elution profiles were obtained when WIP were solubilized by alkali in the presence of $NaBH_4$ (data not shown), thus indicating that under the conditions employed for solubilization and chromatography no alkaline degradation takes place. In comparison with the WIP isolated from the same flours (eg, Katepwa, Fig. 2), the WIP preparations appeared more homogeneous in molecular size since they did not contain the arabinogalactan (low molecular species of the WSP). Our results indicate that wheat WIP are highly polymerized materials of high molecular weight; the peak elution volumes were smaller than those of dextran T-150 and T-500. Preliminary experiments have shown that solubilization of WIP in increasing concentrations (up to 0.4*M*) of sodium hydroxide (4°C) did not cause degradation of the polymers as assessed by gel filtration (data not shown). The elution profiles obtained in this work for WIP also indicated more homogeneous molecular weight distributions for these materials compared to the findings of Mares and Stone (1973b). The reason for that might be the different method employed for isolation of WIP by these authors; variations in composition and properties for WIP due to different methods of purification were also reported by Meuser and Suckow (1986).

Gelation Studies

Measurements of the rheological properties of aqueous suspensions of WIP by small-amplitude oscillatory testing were performed to examine the gelation potential of these materials upon oxidation. The results of storage modulus (G') and phase angle (δ) for dispersions of WIP in water before and after addition of hydrogen peroxide/peroxidase (plateau values of G') are shown in Fig. 4 and Table III. In general, all WIP preparations showed a rapid increase in their G' modulus values during the first 15 min and remained relatively constant thereafter (Fig. 4). Values of G' and δ did not change upon storage of the suspension for periods longer than 30 min. Differences in G' and phase angle values were found among the WIP examined. In all cases, except for the deesterified samples (ferulic acid contents of the deesterified WIP from Glenlea and Norstar were 0.03 and 0.05 μg/mg, respectively), pentosan dispersions to which H_2O_2/peroxidase were added exhibited higher G' values than those of the control. These results suggest that phenolic acids are responsible for the gelation of WIP preparations, ie, via oxidative coupling involving free feruloyl groups.

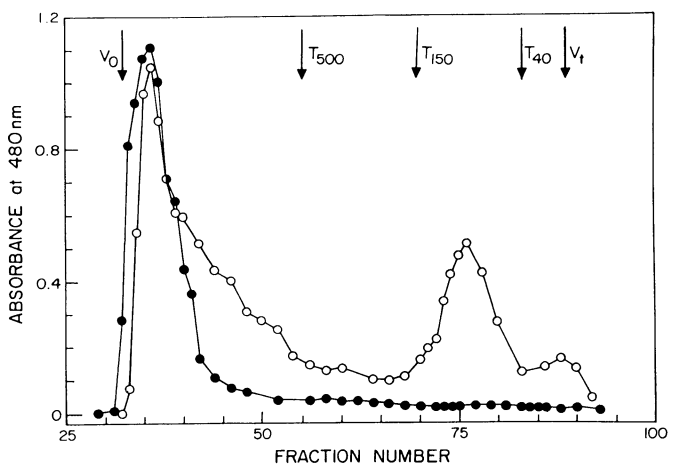

Fig. 2. Chromatographic profiles of water-soluble pentosans (○) and water-insoluble pentosans (●) obtained from Katepwa wheat flour. Chromatographic conditions: Sepharose CL 4B (2.6/80 cm), 0.4*M* NaOH as eluant, flow rate 20 ml/hr, 22°C; arrows indicate peak elution volumes of dextran standards (T-500, T-150, and T-40) used as molecular weight markers.

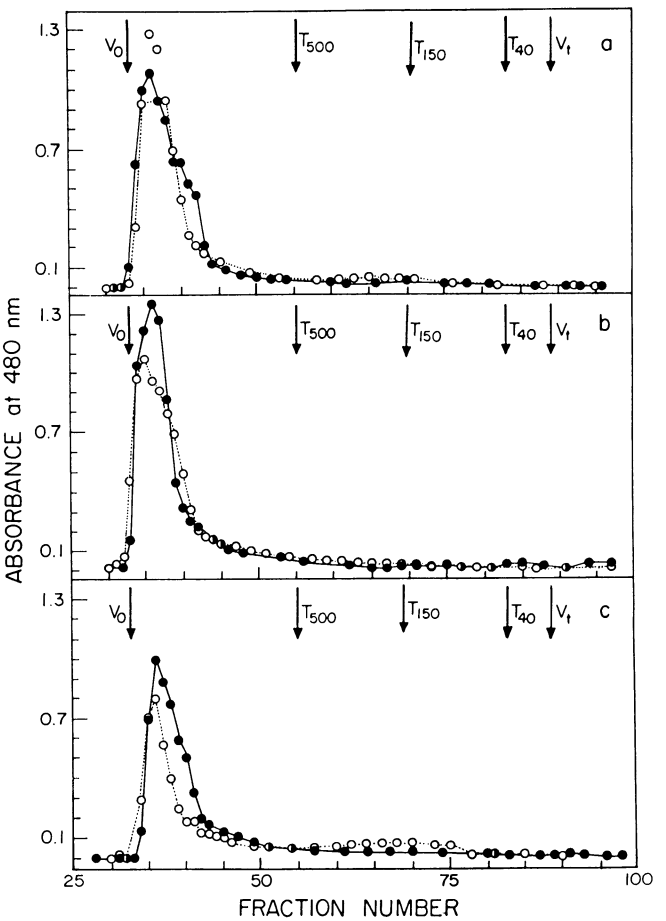

Fig. 3. Sepharose CL 4B elution profiles of water-insoluble pentosans obtained from different wheat varieties: **a**, HY 320 (○) and Fielder (●); **b**, Glenlea (○) and Norstar (●); **c**, Hercules (○) and Marshall (●). Chromatographic conditions were as in Fig. 2.

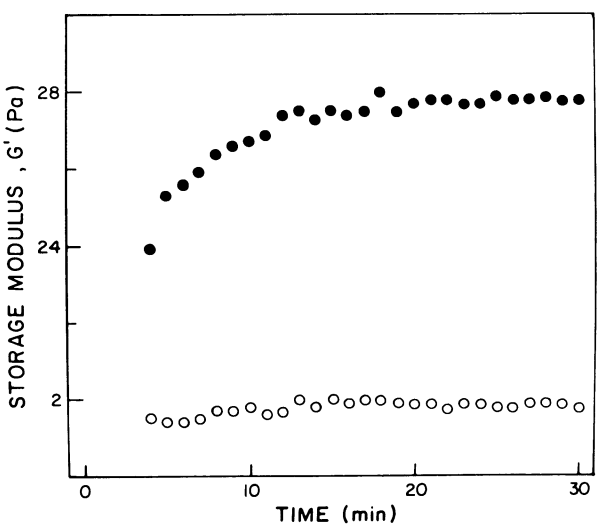

Fig. 4. Storage modulus (G') vs time for 1.5% (w/w) WIP (Katepwa) suspensions in water with (●) or without (○) addition of peroxidase (0.22 purpurogallin units) in 0.1*M* potassium phosphate buffer (pH 6.0) and 1.2 ppm of H_2O_2. Data were obtained at 1.0 Hz and 4.4% strain.

TABLE III
Values for the Storage Modules (G') and Phase Angle (δ) of Aqueous Water-Insoluble Pentosan Dispersions from Different Wheat Varieties, Before (Control) and After Addition of H_2O_2/Peroxidase (Plateau Values)

Water-Insoluble Pentosans	Control		Oxidized[a]	
	G' (Pa)	δ (degrees)	G' (Pa)	δ (degrees)
Katepwa	1.98	13.38	2.71 ± 0.06	8.92 ± 0.01
Glenlea	0.31	23.40	1.49 ± 0.03	11.98 ± 0.20
Deesterified	0.29	63.99	0.26 ± 0.14	66.09 ± 0.75
Norstar	0.96	20.99	6.95 ± 0.07	7.41 ± 0.35
Deesterified	0.86	57.65	0.74 ± 0.12	60.50 ± 1.40
Fielder	3.11	15.39	11.32 ± 0.76	6.32 ± 0.20
Marshall	3.97	12.73	7.35 ± 0.40	8.36 ± 0.25
Hercules	0.16	29.73	0.43 ± 0.35	15.68 ± 0.30

[a] Values 30 min after addition of H_2O_2/peroxidase.

TABLE IV
Effects of Added Water-Insoluble Pentosans (WIP) on Farinographic Water Absorption of Wheat Flours

Wheat Flour	WIP Added (%)	Water Absorption (%)
Katepwa	0	62.3 ± 0.2[a]
	1.0	67.0 ± 0.5
	2.0	71.9 ± 0.3
	3.0	76.2 ± 0.5
	5.0	83.9 ± 0.4
	$r = 0.998$	
HY 320	0	55.8 ± 0.4
	1.0	61.2 ± 0.0
	2.0	65.4 ± 0.3
Marshall	0	59.7 ± 0.5
	1.0	63.2 ± 0.3
	2.0	68.2 ± 0.3

[a] $n = 3$.

Effect of WIP on Water Absorption of Wheat Flour

Water absorption is an important characteristic of wheat flour in the context of its overall breadmaking quality (Bushuk 1966, Holas and Tipples 1978). Jelaca and Hlynka (1971) observed an increase in the water absorption of wheat flour upon addition of 1% WIP. To provide information on potential functional implications of WIP in breadmaking, we examined the effect of adding various amounts of WIP on the water absorption of flours and compared it with that resulting from increased starch damage. The results shown in Table IV support and extend the findings of Jelaca and Hlynka (1971). As can be noted, addition of WIP to Katepwa flour markedly increased the water absorption values of the doughs. The relationships between the amount of WIP added and water absorption of the supplemented doughs, within the range of 1–5% WIP for Katepwa and 1–3% for Marshall and HY 320 wheat flours, were essentially linear. Calculations showed that the same preparation of WIP absorbed 5.6 ± 0.3 g of H_2O per gram of WIP when WIP were added to HY 320 wheat flour and 5.2 ± 0.2, 4.5 ± 0.4, and 3.2 ± 0.2 g of H_2O per gram of WIP when added to Katepwa, Marshall, and Fielder wheats, respectively. These results indicate that the apparent water binding capacity of WIP also depends on the chemical and baking quality of flour.

To compare the effect of adding WIP with that of starch damage on the magnitude of water absorption increase, Katepwa wheat flours having three starch damage levels (28, 36, and 42%) were also tested. The corresponding water absorption values for these three samples were 70, 71, and 74%. These findings in conjunction with the above data on WIP suggest that supplementation of flour with WIP is more effective in increasing the water binding properties of wheat flours than is increasing starch damage.

In conclusion, WIP isolated from flours of seven wheat varieties differed in their chemical composition (monosaccharide profiles, ferulic acid and protein contents). The high molecular weight polysaccharides of WIP, mainly arabinoxylans, were readily solubilized in dilute NaOH solutions and, in small amounts, greatly enhanced the water binding capacity of WIP-supplemented doughs. Oxidative cross-linking reactions (H_2O_2/peroxidase) of the polymeric constituents of WIP involved free feruloyl residues and resulted in rigidity increases of aqueous WIP suspensions.

ACKNOWLEDGMENTS

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