

## POLYSACCHARIDES OF *Plantago ovata* SEEDS

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Plants of the *Plantago* genus (plantain) belong to the Plantaginaceae family. These plants are used in Chinese medicine as hemostatics and astringents and for chronic bronchitis and pleuritis [1]. Data on the polysaccharides (PSa) from *P. major* [2] and *P. psyllium* [3] seeds have been reported. We studied carbohydrates from *P. ovata* seeds collected in 2004 in Khoten district of Karakash region of China.

Carbohydrates were isolated by treating *P. ovata* seeds with alcohol (82%) to remove low-molecular-weight and colored compounds. The alcohol extract was evaporated. Descending PC using BuOH:Pyr:H<sub>2</sub>O (6:4:3) on Filtrak FN 12 and 15 paper identified rhamnose, glucose, galactose, and an oligosaccharide with  $R_f$  0.33 according to development by anilinium biphthalate (1) and urea (2).

After inactivation with alcohol, the raw material was extracted three times with cold water (1:10, 1:5 twice) to produce a viscous extract that was precipitated with alcohol in a 1:4 ratio. The resulting precipitate was separated, washed with alcohol and acetone, and dried in vacuo over P<sub>2</sub>O<sub>5</sub>. The yield of water-soluble polysaccharides (WSPS-1) was 5.4%.

Next the remaining raw material was extracted with hot water (1:8, 1:5, 1:3) at 90°C. The extracts did not give a reaction with iodine. Therefore, WSPS-2 did not contain starchy polysaccharides. The yield of WSPS-2 was 8.8%.

WSPS-1 and -2 were white powders with a cream tint. They dissolved in water to form thick viscous solutions. The IR spectra of the WSPS exhibited absorption bands at 808 cm<sup>-1</sup> (pyranose ring), 892 (β-glycoside bond), and 1258 and 1720 (esters). Titration established that WSPS-1 contained 4.3% *O*-acetyls; WSPS-2, 4.5% [4]. Therefore, WSPS isolated from *P. ovata* were naturally acetylated polysaccharides.

WSPS samples were hydrolyzed by H<sub>2</sub>SO<sub>4</sub> (2 N) at 100°C for 8 h. The monosaccharides were determined qualitatively by PC using the aforementioned system and developers 1 and 2. The content of neutral monosaccharides was determined quantitatively using GC-MS of the aldonitrile acetates [5] in a PE-TurboMass Aidosystem XL, PE 5 MS spectrometer, quartz column (30 × 0.25 mm), 200°C, flow rate 35 mL/min, and N<sub>2</sub> carrier gas. Table shows data indicating that the monosaccharide composition of WSPS-1 is rhamnoxyloaraban; of WSPS-2, glucoxyloaraban.

After isolating WSPS-1 and -2, the seed pulp was extracted twice with oxalic acid and ammonium oxalate solutions (0.5% each, 1:1) at 70°C for 2 h at a 1:3 ratio. The extracts were combined, dialyzed, evaporated, and precipitated with alcohol (1:3) to afford pectinic substances (PS) in 4.5% yield.

The PS were a white powder with a cream tint. They dissolved in water to form a viscous solution. Titration determined the content of free carboxylic groups (Af) as 18%; of esterified carboxylic groups (Ae), 49.05%, degree of esterification (λ), 72.7% [6]. Therefore, PS of *P. ovata* seeds were highly esterified PS. Hydrolysis of PS (H<sub>2</sub>SO<sub>4</sub>, 2 N, 100°C, 48 h) and analysis of the monosaccharides were carried out as above. PC detected galacturonic acid and neutral monosaccharides, the ratio of which was analyzed by GC-MS. Table 1 shows that the dominant components were xylose and arabinose.

Hemicelluloses (HC) were extracted by base solution (5%). The extract was dialyzed, evaporated, and precipitated with ether (1:3) to afford HC in 8% yield. The dominant monosaccharides in the HC hydrolysate (H<sub>2</sub>SO<sub>4</sub>, 2 N, 100°C, 72 h) were galactose, arabinose, and xylose.

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TABLE 1. Monosaccharide Content and Composition of Carbohydrates from *P. ovata* Seeds

| PSa type | Yield, % | Monosaccharide composition, % |     |      |     |      |     |
|----------|----------|-------------------------------|-----|------|-----|------|-----|
|          |          | Rha                           | Xyl | Ara  | Man | Glc  | Gal |
| WSPS-1   | 5.4      | 4.5                           | 5.5 | 27.3 | -   | -    | 1.0 |
| WSPS-2   | 8.8      | 1.0                           | 3.2 | 7.8  | Tr. | 2.4  | Tr. |
| PS       | 4.5      | 2.6                           | 6.6 | 13.6 | -   | 1.0  | 1.0 |
| HC       | 8.0      | -                             | 1.0 | 3.3  | 1.8 | 1.03 | 4.0 |

Thus, carbohydrates of *P. ovata* seeds are WSPS, PS, and HC in which arabinose is the principal component.

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