*Chemistry of Natural Compounds, Vol. 30, No. 5, 1994*

# POLYSACCHARIDES FROM THE WASTES OF VEGETABLE AND MELON-TYPE CROPS

**R. K. Rakhmanberdyeva, D. A. Rakhimov, and A. Nigmatullaev**

UDC 547.917

*The water-soluble polysaccharides and pectin substances from the wastes of vegetable and melon-type crops have been studied and their monosaccharide compositions have been determined. High- and low-methoxyl pectins have been isolated, and the physicochemical characteristics are given.*

The ever-increasing interest in polysaccharides requires an expansion of the raw material basis by the incorporation of new types of nonfood agricultural plant wastes. Among such types of wastes it is possible to use successfully a nontraditional raw material: the epigeal part of vegetable and melon-type crops after harvesting.

We have determined the amounts of water-polysaccharides (WSPS) and pectin substances (PcSs) in the representatives of eleven genera from six plant families. The monosaccharide compositions of the WSPSs and PcSs were studied by complete acid hydrolysis. Analysis was performed with the aid of PC and GLC [1-3]. The qualitative and quantitative monosaccharide compositions are given in Table 1.

The samples of WSPs consisted of free-flowing amorphous powders with different water solubilities. The WSPs isolated contained no starch, as was shown by the negative reaction with iodine.

The yields of WSPSs for plants of the Solanaceae family were between 3.4 and 9.1%. It was possible to observe a considerable amount of WSPSs in the epigeal parts of the carrot (fam. Apiaceae) and radish (fam. Brassicaceae), where they amounted to 6.8 and 10.9%, respectively.

The samples of WSPSs differed from one another both with respect to the nature of the monocarbohydrate inclusions and with respect to their ratio. In the hydrolysates of samples VI, X, and XII, the predominating components were rhamnose and glucose. WSPS-IV was found to contain a considerable amount of rhamnose, glucose, and galactose. Larger amounts of rhamnose and arabinose were found in sample VII, and of arabinose and galactose in XV.

The samples of PCSs consisted of amorphous powders with colors ranging from cream to dark brown. The yields of PCSs for the plants studied were between 2.4 and 7.8%. The PCSs of samples III, VII, XI, and XII were characterized by high levels of O—$CH_3$ groups. The PCSs isolated differed by their solubility in water. PCSs IV, VII, and VIII formed solutions with relative viscosities of 12.7, 38.4, and 7.2 (*c* 0.5; $H_2O$), respectively. Their molecular masses, determined viscosimetrically [4], were 70,000, 110,000 and 60,000. The other pectin substances had molecular masses of 35,000-60,000, respectively, and, consequently, lower values of the relative viscosity — 3.55-5.7 (*c* 0.5; $H_2O$).

The degrees of esterification of the PCSs were determined by a titrimetric method [5]. On the basis of the results obtained, the PCSs of the samples I, II, XIII, and XIV were assigned to the low-esterified and the others to the high-methoxyl pectins.

Thus, the characterization of the polysaccharides from 12 plant species has revealed raw material sources for obtaining WSPs and PCSs. For an initial all-sided pharmacological investigation with the aim of determining the possibility of their use as raw materials for drugs it is possible to recommend the polysaccharides from *Solanum tuberosum* L. and *Raphanus sativus* var. *radicula* Pers.

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Institute of the Chemistry of Plant Substances, Academy of Sciences of the Republic of Uzbekistan, Tashkent, fax (3712) 89 14 75. Translated from Khimiya Prirodnykh Soedinenii, No. 5, pp. 597-600, September-October, 1994. Original article submitted February 7, 1994.

0009-3130/94/3005-0547$12.50 

TABLE 1. Amounts and Monosaccharide Compositions of the WSPSs and PCSs

| Species and organ of the plant | Carbohydrate | Yield, % | O–$CH_3$, % | Monosaccharide composition | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Rha | Ara | Xyl | Man | Glc | Gal |
| Fam. Chenopodiaceae | | | | | | | | | |
| 1. Beta vulgaris L. — Common beet (epigeal part) | WSPSs | 3.2 | | 8.5 | 3.2 | 1.0 | Tr. | 1.8 | 3.1 |
| | PCSs | 1.5 | 3.3 | 1.0 | 5.5 | 2.0 | – | – | 1.5 |
| 2. B. vulgaris L. var. saccharifera Alef. — sugar beet (epigeal part) | WSPSs | 4.0 | | 9.0 | 9.4 | 1.0 | 1.3 | 13.5 | 3.4 |
| | PCSs | 1.0 | 2.4 | – | 6.2 | 3.3 | – | – | 1.0 |
| Fam. Cucurbitaceae | | | | | | | | | |
| 3. Citrullus vulgaris scharad. — water melon (rind) | WSPSs | 5.7 | | Tr. | 2.4 | 1.0 | 1.0 | 2.0 | 2.9 |
| | PCSs | 4.3 | 6.2 | 8.7 | 5.5 | 1.1 | – | 1.0 | 16.5 |
| 4. Cucumis sativus L. — cucumber (fruit) | WSPSs | 8.9 | | 14.0 | 4.0 | 1.0 | 1.0 | 6.8 | 11.4 |
| | PCSs | 7.3 | | 34.4 | 8.3 | – | 1.0 | Tr. | 9.2 |
| 5. C. sativus L. — cucumber (epigeal part) | WSPSs | 3.4 | | 2.0 | 1.0 | Tr. | Tr. | 3.9 | – |
| | PCSs | 2.4 | 1.3 | 1.8 | 3.2 | Tr. | Tr. | 1.0 | 1.8 |
| 11. Solanum melongena L. — eggplant (rind) | WSPSs | 3.4 | | 4.4 | 3.6 | 1.3 | 1.0 | 23.0 | – |
| | PCSs | 5.3 | 5.0 | 24.5 | 4.3 | 1.4 | 1.0 | 4.3 | 6.1 |
| 12. S. tuberosum L. — potato (epigeal part) | WSPSs | 10.8 | | 13.7 | 3.6 | 1.0 | – | 17.0 | 7.6 |
| | PCSs | 3.2 | 5.5 | 2.4 | 1.0 | – | – | 3.0 | 3.0 |
| Fam. Apiaceae | | | | | | | | | |
| 13. Coriandrum sativum L. — coriander (epigeal part) | PCSs | 3.0 | 3.6 | 20.8 | 15.6 | – | – | Tr. | 14.3 |
| 14. Daucus carota var. sativus Hoffm. — carrot (epigeal part) | WSPSs | 6.8 | | 1.5 | 3.4 | 5.0 | – | 1.0 | – |
| | PCSs | 7.8 | 3.2 | 1.3 | 3.2 | 4.8 | – | – | 1.0 |
| Fam. Brassicaceae | | | | | | | | | |
| 15. Raphanus sativus var. radicula Pers. — radish (epigeal part) | WSPSs | 10.9 | | 3.5 | 9.0 | 1.0 | 1.0 | 6.7 | 19.0 |
| | PCSs | 6.6 | 3.7 | 10.0 | 7.0 | – | – | – | 1.0 |

TABLE 1. (Continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 16. Cucurbita pepo L. — pumpkin (rind) | WSPSs | 1.6 | | 10.6 | 1.0 | 3.4 | – | 19.8 | – |
| | PCSs | 5.8 | 3.3 | 2.5 | – | 1.0 | – | 60.9 | – |
| | | | | Fam. Fabaceae | | | | | |
| 17. Phaseolus vulgaris L. — kidney bean (pods) | WSPSs | 2.9 | | 10.2 | 13.2 | 1.0 | Tr. | 5.4 | – |
| | PCSs | 6.0 | 6.2 | 2.7 | 1.0 | – | – | 6.8 | – |
| | | | | Fam. Solanaceae | | | | | |
| 18. Capsicum annuum L. — pepper (receptacle) | PCSs | 5.3 | 2.3 | 6.4 | – | Tr. | – | 2.3 | 1.0 |
| 19. C. annuum L. — pepper (receptacle) | WSPSs | 7.0 | | 5.2 | 4.3 | – | 1.0 | 4.7 | 5.5 |
| | PCSs | 4.3 | 3.6 | 3.6 | – | 1.0 | – | Tr. | Tr. |
| 20. Lycopersicon esculentum Mill. — tomato (epigeal part) | WSPSs | 9.1 | | 20.0 | 1.0 | 6.8 | – | 40.0 | – |
| | PCSs | 1.4 | 2.9 | 2.0 | 1.0 | – | Tr. | 3.0 | – |

TABLE 2. Titrimetric Indices of the Pectins

| Pectin | $K_f$ | $K_e$ | $\lambda$ |
|---|---|---|---|
| I | 47.0 | 31.9 | 40.4 |
| II | 21.4 | 13.4 | 38.5 |
| V | 35.1 | 51.3 | 59.3 |
| VI | 27.6 | 48.9 | 63.9 |
| VII | 22.1 | 27.1 | 55.0 |
| VIII | 3.8 | 4.3 | 56.0 |
| IX | 12.1 | 38.8 | 76.2 |
| X | 25.0 | 28.0 | 52.8 |
| XII | 7.6 | 16.1 | 67.5 |
| XIII | 31.4 | 21.6 | 40.7 |
| XIV | 40.3 | 25.3 | 38.6 |
| XV | 10.0 | 7.0 | 41.2 |

## EXPERIMENTAL

Monosaccharides were chromatographed on FN 3,1,12 paper in the butan-1-ol—pyridine—water (6:4:3) system with acid aniline phalate as revealing agent. TLC of the samples was conducted on a Chrom-5 instrument with a flame-ionization detector, using a steel column (0.3 × 200 cm) filled with 5% of XE-60 on Chromaton N-AW 0.200-0.250 mm with the carrier gas helium (60 nm/min), 210°C.

The WSPS samples were hydrolyzed with 2 N $H_2SO_4$ at 100°C for 8 h and the PCSs for 48 h.

The viscosities of the PCSs were measured on an Ostwald viscometer (volume 10 ml) at 30°C (*c* 0.5; $H_2O$) [4].

The uronide constituent was determined by the titrimetric method [5].

**Isolation of the WSPSs and PCSs.** The WSPSs and PCSs were isolated from 50 g of air-dry raw material by a procedure described previously [6].

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