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POLYSACCHARIDES OF SAPONIN-BEARING PLANTS. X. AN INVESTIGATION OF THE CARBOHYDRATES OF *Acanthophyllum pungens*

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Polysaccharides have been isolated from the epigeal and hypogeal organs of Acanthophyllum pungens *and their qualitative presence and quantitative compositions have been determined. A neutral polysaccharide from the epigeal organs is of the galactan type, while a neutral polysaccharide from the roots is a glucogalactan.*

Continuing an investigation of saponin-bearing plants, we have studied the polysaccharides (PSs) of the epigeal and hypogeal organs of rock-garden spine pink *Acanthophyllum pungens* Boiss. (fam. Caryophyllaceae), which is widely distributed in Central Asia.

To eliminate pigmentary and low-molecular-mass substances, the air-dry raw material was first extracted with chloroform and then with methanol. From the residual raw material we obtained successively: by extraction with water, the water-soluble polysaccharides (WSPSs); then, by heating with a mixture of 0.5% solutions of oxalic acid and ammonium oxalate, the pectin substances (PcSs); and, finally, by extraction with a 10% solution of caustic soda, the hemicelluloses (HCs).

The polysaccharides isolated were hydrolyzed with 2 N H_2SO_4 at 100°C, and, after neutralization with $BaCO_3$, the monosaccharides in the hydrolysate were determined by PC and GLC. The amounts, monosaccharide compositions, and ratios of the monosaccharides in the polysaccharides are given in Table 1. All the polysaccharides contained uronic acids in addition to neutral sugars.

As can be seen from Table 1, PcSs predominated quantitatively in the epigeal organs of the plant, and WSPSs in the roots. In the PcSs of the epigeal organs the predominating monosaccharides were galactose, glucose, and rhamnose, while in the PcSs of the roots arabinose predominated. In the WSPSs of the roots the main monosaccharides were galactose and glucose, while in the WSPSs of the epigeal organs galactose predominated. The analysis showed that the WSPSs contained galacturonic acid, and to obtain a neutral polysaccharide (NPS) the WSPSs from the epigeal organs were passed through a column of DEAE-cellulose (carbonate form). This gave a 40% yield of a NPS consisting solely of galactose, which enabled it to be assigned to the galactan type of polysaccharides [1]. By elution with a solution of caustic soda (0.1 N) we isolated a fraction of an acidic polysaccharide (APS) composed of galacturonic acid, together with galactose, mannose, xylose, arabinose, and rhamnose.

By separating the WSPSs of the roots we obtained 50% of a NPS, consisting mainly of glucose and galactose, and an APS consisting of residues of galacturonic acid, glucose, xylose, arabinose, and rhamnose. The NPS of the roots was a polysaccharide of the glucogalactan type [2].

The hemicelluloses isolated formed a cream-colored powder sparingly soluble in water but soluble in alkaline solutions. The level of HCs in the roots was greater than that in the epigeal organs. The predominating monosaccharides in both organs were galactose, glucose, mannose, and xylose.

Thus the polysaccharides of the epigeal and hypogeal organs of *A. pungens* have been investigated, and the water-soluble polysaccharides, the pectin substances,and the hemicelluloses have been characterized. A neutral polysaccharide of the epigeal organs of the plant is a polysaccharide of the galactan type and the roots contain one of the glucogalactan type.

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TABLE 1. Characteristics of the Polysaccharides from Various Organs of *A. pungens*

Plant organ, type of PS	Yield of PS, % of air-dry wt.	Monosaccharide composition					
		Gal	Glc	Man	Xyl	Ara	Rha
Epigeal organs							
WSPSs	4.3	49.0	–	2.1	1.0	2.0	1.8
PcSs	5.8	6.0	6.4	1.9	1.0	2.3	4.6
HCs	2.4	16.7	14.7	5.6	5.0	1.9	1.0
Roots							
WSPSs	10.0	32.4	12.3	–	Tr.	1.0	2.4
PcSs	3.6	1.2	1.9	1.1	–	5.6	1.0
HCs	4.3	3.3	6.7	2.7	3.9	2.1	1.0

EXPERIMENTAL

PC and GLC were conducted under the conditions given in [3]. Acetates of aldononitriles and polyols were obtained as in [4].

Inactivation of the Plant. Samples weighing 200.0 g of the ground air-dry raw material (epigeal and hypogeal organs of the plant separately) were first inactivated three times with chloroform in a ratio of 1:10 in the boiling water bath for 2 h, and, after filtration, the plant residue was dried in the air and it was then inactivated twice with methanol in a ratio of 1:10 at the boil for 2 h and, after filtration, the plant material was dried and the chloroform and methanol extracts were evaporated. The WSPSs, PcSs and HCs were extracted from the residual raw material successively.

Isolation of the WSPSs. The raw material after inactivation was extracted with water in a ratio of 1:6 at room temperature for 2 h. Extraction was repeated twice more, the extracts were combined, protein was eliminated by Sevag's method [5], the aqueous solution was evaporated in vacuum in a rotary evaporator at 40°C to a volume of 0.5 liter, and the polysaccharides were precipitated with alcohol in a ratio of 1:3. The precipitate was separated off by centrifugation, washed with alcohol, and dried in vacuum over P_2O_5. The yield from the epigeal organs was 8.6 g, and that from the roots 20.0 g.

Isolation of the PcSs. The residual raw material after the isolation of the WSPSs was extracted twice with a mixture of equal volumes of 0.5% solutions of oxalic acid and ammonium oxalate (1:8) at 80°C for 2 h. The combined extracts were evaporated and precipitated with alcohol (1:3), the precipitate was separated off, washed with alcohol and with acetone, and dried over P_2O_5 in vacuum. The yield of PcSs from the epigeal organs was 11.6 g and that from the roots 7.2 g.

Isolation of the HCs. The residual raw material was treated once with a 10% solution of caustic soda (1:10) at room temperature for 2 h. The alkaline extract was neutralized with acetic acid, evaporated to 1/3 volume, and precipitated with methanol (1:2), and the precipitate was separated off and dried. The yield of HCs from the epigeal organs amounted to 1.8 g, and that from the roots to 8.6 g.

Separation of the WSPSs on DEAE-Cellulose. DEAE-cellulose (polymer beads; 200 g) was treated successively with 0.5 N NaOH (1 liter), water, 1 M $(NH_4)_2CO_3$ (1 liter), and water again to neutrality. The DEAE-cellulose was charged into a column (4.5 × 70 cm) and was washed with water, and then a solution of the WSPSs from the epigeal organs (8 g/100 ml) was passed through and elution was performed with 1 liter of water. The efflux of polysaccharides was monitored by the phenol/sulfuric method [6]. The eluate was evaporated and precipitated with alcohol (1:3), and the residue was separated off and dried over P_2O_5 in vacuum. The yield of NPSs was 3.2 g. Then the column was eluted with 1 M $(NH_4)_2CO_3$ (1 liter) and with 1 liter of a 0.1 N solution of NaOH, the eluates were combined and precipitated with methanol (1:3) and the precipitate was separated off and dried. The yield of APSs was 2.4 g. In a similar manner, the WSPSs of the roots (10.0 g) gave 5.0 g of NPSs and 3.5 g of APSs.

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