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Feeding Responses of the Sweetclover Weevil to Various Sugars and Related Compounds

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ABSTRACT

The sweetclover root disk bioassay was used to test the activity of 21 sugars and related compounds as feeding stimulants for the sweetclover weevil *Sitona cylindricollis* Fåhraeus. Of the compounds tested, sucrose was the most effective feeding stimulant. Compounds with moderate stimulant activity were fructose, glucose, galactose, mannose, myo-inositol, and maltose. Slightly active feeding stimulants included ribose, xylose, sorbose, and sedoheptulose. Arabinose, arabitol, mannitol, xylitol, cellobiose, raffinose, soluble starch, ascorbic acid, glucuronic acid, and glucosamine failed to exhibit feeding stimulant activity in these tests. Four compounds (arabinose, ascorbic acid, glucuronic acid, and mannitol) were tested for feeding deterrent activity, and all displayed such activity. Although the structural requirements for feeding stimulant or deterrent activity were not established, it was clear that small differences in chemical structure could cause large differences in feeding response.

The sugars sucrose, fructose, and glucose recently have been identified as the active components of Stimulant A, a water-soluble fraction of *Melilotus officinalis* (L.) Lam. leaves which stimulates feeding by the sweetclover weevil, *Sitona cylindricollis* Fåhraeus, (Akeson et al. 1969). The sweetclover weevil is not unique in responding to these sugars; the reviews of Beck (1965) and Thorsteinson (1960) cited several earlier cases in which sugars served as feeding stimulants for phytophagous insects. The observation that 3 different sugars stimulated sweetclover weevil feeding suggested the possibility that still other sugars and related compounds might influence the feeding of this insect. The experiments described in this report were undertaken to investigate this possibility.

Materials and Methods.—Compounds were tested for their effects on feeding by the root disk bioassay described previously (Akeson et al. 1967). The compounds were grouped for testing as shown in Table 1. Pentoses were included in one comparison, hexoses in another, etc. Comparisons were made at 2 concentration levels, 0.25% and 1.25% (wt/v, in water). For each compound, a single treatment consisted of 5 root disks impregnated with a mixture of 0.10 ml of solution mixed with 0.05 ml of water. Thus, average quantities of compound applied per disk were 50 and 250 μg for the 0.25% and 1.25% concentrations, respectively. All treatments within a comparison and at a given concentration were assayed together in the same chamber with a population of 3 weevils/disk, and with a feeding time of 6 hr. Each comparison was replicated 5 times. Disks treated with water and with sucrose at the indicated concentrations were included as controls in each comparison.

Reagent grade chemicals were used in all comparisons. Duncan's mutiple range test (Steel and Torrie 1960) was used in analyzing the results.

Results and Discussion.—The results (Table 1) indicate that, as a weevil-feeding stimulant, sucrose was clearly superior to all other compounds tested.

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Table 1.—Feeding stimulant assay of various sugars and related compounds. Each mean represents a total of 25 root disks.

Comparison	Compound tested	Mean disk area consumed (%)[a] 50 µg of compound/disk	250 µg of compound/disk
I	Control (water)	1.5 a	1.5 a
	D-Arabinose	0.3 a	0.0 a
	D-Ribose	2.5 a	9.7 b
	D-Xylose	5.1 a	9.8 b
	Sucrose	21.1 b	28.7 c
II	Control (water)	1.5 a	2.3 a
	D-Sorbose	7.8 b	6.5 a,b
	D-Mannose	11.9 b	11.6 b
	D-Galactose	7.7 b	13.0 b
	D-Glucose	13.0 b	17.1 b,c
	D-Fructose	12.9 b	24.4 c
	Sucrose	26.7 c	33.7 d
III	Control (water)	1.2 a,b	1.9 a
	D-Arabitol	0.3 a	1.0 a
	D-Mannitol	0.5 a	2.8 a
	D-Xylitol	6.7 b,c	7.4 a
	Myo-inositol	9.9 c	16.2 b
	Sucrose	29.9 d	39.4 c
IV	Control (water)	1.4 a	4.5 a
	Cellobiose	1.1 a	2.1 a
	Raffinose	1.7 a	3.5 a
	Soluble starch	4.8 a	5.5 a
	Maltose	14.7 b	16.8 b
	Sucrose	33.1 c	37.4 c
V	Control (water)	2.3 a	1.5 a
	L-Ascorbic acid	1.1 a	0.1 a
	D-Glucuronic acid	3.1 a	0.2 a
	D-Glucosamine	6.8 a	4.2 a,b
	D-Sedoheptulose	4.1 a	8.6 b
	Sucrose	26.2 b	34.1 c

[a] Within each comparison and treatment level, means followed by different letters differ from each other at the 0.05 level of significance according to Duncan's multiple range test.

Pentoses were not highly effective as feeding stimulants, although some feeding occurred on disks treated with the higher concentration of ribose and xylose (Comparison I). Hexoses generally displayed moderate stimulant activity at both concentrations (Comparison II). Of the alcohols tested, only the cyclitol, myo-inositol, was significantly active as a feeding stimulant (Comparison III); and of the oligosaccharides tested, only maltose was active (Comparison IV). Of the miscellaneous compounds included in Comparison V, only sedoheptulose at the higher concentration was significantly active.

Inclusion of the sucrose and water controls in each feeding comparison permitted some evaluation of relative responses between comparisons. For example, the feeding results indicate that mannitol was not an effective stimulant, whereas mannose was moderately effective. Similarly glucose was an active stimulant, but glucuronic acid and glucosamine were not. These observations suggest that the feeding-stimulant activity characteristic of hexoses was lost if these sugars were converted to the corresponding alcohols, uronic acids, or amines. However, conclusions based on relative responses observed in separate comparisons must be regarded as tentative. Results within comparisons provide other examples in which apparently small structural differences, such as that between maltose and cellobiose, were associated with pronounced differences in stimulant activity.

Table 2.—Feeding deterrent assay of various compounds. Each mean represents a total of 25 root disks. Disks were treated with an average of 125 µg of sucrose plus a like amount of the other compound indicated.

Mixture tested	Mean disk area consumed (%)[a]
Arabinose + sucrose	0.8 a
Ascorbic acid + sucrose	1.9 a
Glucuronic acid + sucrose	3.5 a
Mannitol + sucrose	7.0 a
Sucrose (control)	25.9 b

[a] Means followed by different letters differ from each other at the 0.05 level of significance according to Duncan's multiple range test.

Several of the compounds displayed no feeding stimulant activity. Four of these compounds (arabinose, mannitol, glucuronic acid, and ascorbic acid) were tested for deterrent activity by the procedures previously described (Akeson et al. 1968). In this deterrent assay, a 0.625-mg portion of each compound to be tested was mixed with an equal quantity of sucrose in 0.15 ml of water, and each mixture was applied to 5 root disks which were subsequently offered to adult weevils in a feeding chamber. Control disks were treated with sucrose alone. The test was replicated 5 times. All 4 of the compounds behaved as feeding deterrents in this assay (Table 2). Therefore, it is apparent that suitable alteration of a single functional group can convert a feeding stimulant, such as glucose or mannose, to a feeding deterrent.

These experiments were not sufficiently extensive to permit any general conclusions regarding structural requirements for weevil feeding stimulant or deterrent activity. However, the results do indicate clearly that sugars and related compounds differ widely in their effects on weevil feeding, and in several instances small structural differences are associated with large changes in feeding response.

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