A COMPARISON OF THE SENSORY RESPONSES OF POLISTES AND LUCILIA TO SUGARS

Cyril E. Abbott, *Harding College, Searcy*

Any one who has compared subjectively the relative sweetness of various sugars is aware of the enormous differences in their stimulating value. Sucrose, for example, is "sweeter" than glucose, i.e., produces a stronger sensation. The difference is not the result of molecular concentration, since raffinose, which is a trisaccharide, does not produce so strong a sensation, quantity for quantity, as sucrose, which is a disacharride. Moreover, dulcin, saccharin, and various other substances having no structural relationship to sugars produce intense sensations of sweetness.

The results of the experiments which follow indicate that what is true of human gustation holds for other organisms also, but that the degree of sensory perception of a given sugar varies with the species.

The organisms tested were the common paper-making wasp, **Polistes fuscatus** Fab., and the "green-bottle" fly, **Lucilia sericata** Meig. Although the methods employed in testing the two species were somewhat different and more or less involved, it is believed that the results are strictly comparable.

Six sugars and one "sugar alcohol" were used: sucrose, fructose, glucose, galactose, xylose, raffinose, and mannitol. Of these, fructose, glucose, and galactose are monosaccharide hexoses; sucrose a disaccharide; raffinose a trisaccharide, and xylose a pentose. Mannitol is a hexahydric alcohol resembling the monosaccharides.

In a cage containing thirty wasps, starved for twenty-four hours, but plentifully supplied with water, were placed two Syracuse watch glasses, each containing 1 gm. of the sugar to be compared. The wasps were then observed for two hour intervals for twenty-four hours, and an average taken of the number of insects frequenting each dish. Every possible combination (21) was tried. The insects invariably favored one of the sugars, although there was considerable variation in the degree of difference in different cases. By averaging the numbers visiting a given sugar in all combinations where it was used, it was possible to determine the attractiveness of said sugar as compared with that of the others. To present the complete data would require too much space and perhaps tire the reader's patience, but the method used is indicated in Table I, which gives the result obtained for glucose.

Table I. Averaging the Responses of Polistes to Glucose

Paired Sugars	(to glucose) No. Responding	%Response	Average No.	Average %
glucose-sucrose	9	29.7		
" -fructose	15	49.5		
" -mannitol	19	62.7		
" -xylose	29	95.7		
" -galactose	30	100.0		
" -raffinose	30	100.0		
			22	72.7

By comparing averages similarly determined for other sugars, it was evident that Polistes exhibits the following order of preference: sucrose, fructose, glucose, mannitol, xylose, galactose, and raffinose.

To determine the order of preference of Lucilia was more difficult. For various reasons the method employed with Polistes is impractical when applied to Lucilia. After some consideration, the percentage of flies extending the proboscides when the tarsi were dipped in sugar solutions was adopted as an index of sensitivity. Unfortunately, and in spite of efforts to control rigidly the nutritive condition of the flies, there was considerable variation in the proboscis response, and the difficulty was increased because the slightest change in the dilution of the sugar might affect it. The results of preliminary experiments also indicated that Lucilia is extremely sensitive to some sugars and almost insensible to others. The method of comparison finally adopted was to determine the lowest molar dilution of each sugar which would result in proboscis extension of 70% of the flies. This entailed a great deal of laborious experimentation but gave satisfactory results.

No effort was made to test the sexes separately, although an effort was made to keep the numbers about equal. In the final tests forty flies were individually observed, each insect being attached to a wire "handle" by means of adhesive tape binding the wings. All flies were starved for five hours previous to a single series of tests, but received a plentiful supply of water. Flies in excess of the number required were tested with water before sugar was used, and the flies extending the proboscides in response to water alone were excluded. The results of these tests are given in Table II.

Table II. Critical Molar Concentrations for Lucilia

Sugar	No. Responding	% Responding	Molar Concentration
sucrose	29	72.2	M/60
fructose	28	70.0	M/32
glucose	28	70.0	M/30
raffinose	28	70.0	M/7
galactose	27	67.5	M/6
xylose	27	67.5	M/2
mannitol	26	65.0	1 M

The results indicate that the order of preference for Lucilia is: sucrose, fructose, glucose, raffinose, galactose, xylose, and mannitol. Evidently Lucilia is very sensitive to sucrose even in very low concentrations; it is almost insensitive to mannitol, for even at full molar concentration that sugar elicits a response from only 65% of the flies. The difference in sensitivity of the flies to some pairs of sugars is very slight, as may be seen by comparing results obtained with fructose and glucose.

Table III. Comparative Responses of Polistes and Lucilia

Polistes	Lucilia
sucrose	sucrose
fructose	fructose
d-glucose	d-glucose
d-mannitol	raffinose
d-xylose	d-galactose
d-galactose	d-xylose
raffinose	d-mannitol

By consulting Table III, one finds that while the order of preference is the same in both Polistes and Lucilia for the first three sugars, in the case of the remaining compounds the order of preference for one species is just the reverse of what it is for the other. This fact at once indicates that neither the structural relationships of the sugars nor their occurrence in nature accounts wholly for their gustatory effects. Neither is there a close adaptive relationship between the gustatory effect of a given sugar and its utilization as a food, for preliminary experiments indicate that mannitol, which is not readily distinguished as food by Lucilia, will support the life of flies for a period of at least 20 days. It is rather to be expected that flies and wasps would exhibit strong preferences for sucrose, fructose, and glucose, since all three of these sugars are widely distributed and constitute important carbohydrate foods for many species of organisms.

But it is evident that the gustatory responses of the species studied are only adaptive in a very limited sense. It seems likely that the differences discovered are physiological and inherent. Tarsal gustatory sense is feeble or absent in Polistes, while Lucilia has gustatory receptors on both the tarsi and oral lobes; yet mere difference in location is certainly insufficient to account for differences in sensory behavior of the two species.

The chief factor determining this difference may be in the operation of the receptors - that is to say, their action must be specific, and in a sense, subjective.

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