EFFECT OF VARIOUS SUGARS ON DEVELOPMENT AND WING PRODUCTION IN THE APHID *Myzus persicae*

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ABSTRACT

Neonate larvae of the green peach aphid, *Myzus persicae* Sulzer, feeding on artificial diets require at least 2% sucrose for phagostimulation, which is irreplacable by other sugars. Individual supplementation of a 2% sucrose diet with either glucose or fructose to 15% is inferior to a whole sucrose diet, or to 2% sucrose supplemented with equal portions of glucose and fructose. Larviposition and subsequent survival is poor on a trehalose-supplemented diet. On galactose or raffinose (galactosyl-sucrose) diets, larviposition was enhanced and subsequent survival was normal. Galactose-supplemented diets significantly depress wing production. This effect may be related to the varying level of galactosyl oligosaccharides during the various physiological stages of the host-plant.

INTRODUCTION

The importance of carbohydrates in aphid nutrition has been reviewed by Auclair (1969). Phloem sap of plants contains carbohydrates in concentrations of 10-30% with sucrose being dominant (Zimmerman, 1960, 1961; see review by Ziegler, 1968). Preference studies with *Aphis pisum* have demonstrated that sucrose is preferred over all other sugars offered (Auclair, 1965). We have found this to be the case for *Myzus persicae* as well. Dadd and Mittler (1965) evaluated sucrose as a metabolic constituent in aphid nutrition, and Mittler (1967) its value as a feeding stimulant. In general, sucrose appears to be crucial for feeding and growth of aphids on synthetic diets.

Various sugars other than sucrose appear in the phloem sap of numerous plants, particularly of the raffinose family. Some effects have been assayed on development of *A. pisum*, (Auclair, 1965), *Aphis gossypii* (Auclair, 1967) and *M. persicae* (Mittler *et al.,* 1970). The present investigation was carried out in order to determine whether sucrose or other sugars appearing in phloem sap affect in any manner wing production in *M. persicae.*

MATERIALS AND METHODS

Stock colonies of *M. persicae* Sulzer, the green peach aphid, were cultured on Chinese cabbage in glass cages, in an air-conditioned glasshouse at $20 \pm 2^{\circ}C$. Adult apterae were transferred to sachets with the synthetic diet of Dadd *et al.* (1967), where they larviposited. Only larvae from the second to the fifth day of fecundity were used for the experiments reported in this paper. Aphids reared on synthetic diets were maintained in a cabinet with controlled temperature of $20 \pm 1^{\circ}C$ and 12 hr photoperiod.

A stock solution of diet was prepared containing all the ingredients of the Dadd *et al.* (1967) diet, except that it contained only 2% sucrose. This concentration was found to be minimal for phagostimulation. All other sugars were added in amounts to augment the sugar concentration to the 15% level, as present in the Dadd *et al.* (1967) diet. Raffinose was added to saturation concentration. Diets were brought to pH 7.0, and the final volume was obtained by diluting with twice distilled water.

Results were recorded as percentages of alatae of the total aphid population in an experimental cage. Alatae were determined after the fourth moult or on the 6th day of larval life. The results were analysed statistically by the Wilcoxon-Mann-Whitney ranking test method (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

The influence of increasing concentrations of sucrose in larval diet on wing formation was first determined. Larvae which had been deposited overnight on the standard diet were transferred to the test diet for 72 hr and then returned to a fresh standard diet. This procedure allowed us to test even low concentrations of sucrose which do not permit complete development (Table 3, and Mittler *et al.*, 1970).

After 72 hr on a 1% sucrose diet, growth was so profoundly retarded that subsequent transfer to the standard diet was unable to alleviate it (Table 1). Increasing this initial concentration to 2% sucrose sufficed for subsequent normal development, although this treatment did adversely affect the ultimate degree of alatae in the population. We tend to attribute this apterizing effect to the reduced uptake of diet at 2% sucrose concentration. This would limit availability to all essential dietary constituents.

Sucrose cannot be totally replaced by other sugars (Mittler *et al.*, 1970). Therefore, when assaying other sugars, the minimal concentration of 2% sucrose, necessary as a phagostimulant, was always added to the diets. The effect of such diets on larviposition of adults, and on development and alate production in their progeny, is presented in Table 2.

Table 1. The effect of increasing concentration of sucrose on
survival and wing formation in *M. persicae*.

Percent sucrose in diet	No. of replicates	% survival*	% alatae**
1.0	9	0.0	0.0
2.0	9	83.0	19.5
3.0	9	67.0	35.0
4.0	9	62.0	42.0
5.0	9	62.0	34.0
6.0	9	88.0	41.0

* No significant difference between 2-6% sucrose on the percentage of aphids reaching the adult stage.

** Significant difference between aphids reared on 2% sucrose and all other diets containing higher concentration of sucrose ($P < 0.05$).

Table 2. Effect of different sugars in the diet on adult larviposition and on subsequent larval survival and wing formation of *M. persicae*

Sugars	No. of aphids	larviposition (per aphid)	Progeny % survival	% alatae
2% sucrose	100	1.6	—	—
13% sucrose	125	17.2	54	56
2% sucrose + 13% glucose	100	3.5	—	—
2% sucrose + 13% fructose	100	14.7	46	23
2% sucrose + approx. 12% raffinose (saturated solution)	100	28.1	41	46
2% sucrose + 13% galactose	100	22.3	40	10.5
2% sucrose + 13% trehalose	100	9.1	10	—

Sucrose alone, or supplemented with 13% glucose, drastically reduced larviposition. This effect is less pronounced when 2% sucrose was supplemented with 13% trehalose or fructose, and larviposition was augmented in the presence of raffinose or galactose.

Sugars which enabled the aphids to larviposit adequate numbers of larvae were tested for their further effect on survival and wing production in the progeny (Table 2). Survival was apparently unaffected by the sugar replacement, except on the trehalose diet. On the other hand, wing formation decreased somewhat on the fructose, and markedly on the galactose diet. Additional experiments, in which the effect of galactose in depressing alate production was re-examined, indicate the significance of this response (Table 3).

Table 3. Effect of galactose on wing formation in *M. persicae*

Sugar	No. of neonate larvae	% survival	% alatae
15% sucrose	800	56.8	37.0
2% sucrose + 13% galactose	800	40.2	6.3

Difference between diets is significant ($P < 0.05$).

Finally, some experiments were performed in order to determine whether the poor individual dietary value of glucose and fructose (Table 2) is due to the necessity for both these sugars together. To this end, 2% sucrose was supplemented with equal proportions of these two sugars, as would appear after hydrolysis of sucrose. Table 4 shows that this mixture appears to have the same dietary value as does a 15% sucrose diet.

Table 4. Comparison of a mixture of glucose and fructose and of sucrose
in their effect on survival and wing formation in *M. persicae*.

Sugar	No. of neonate larvae	% survival	% alatae*
2% sucrose	135	2.0	—
15% sucrose	224	69.0	27.6
2% sucrose + 6.5% fructose + 6.5% glucose	225	71.0	36.5

* No significant difference between complete diet and the mixture on survival and wing formation. ($P > 0.1$).

It is premature at this stage to venture speculations as to the manner in which dietary galactose suppresses wing formation in developing *M. persicae.* This cannot result merely from inadequate nutrition, for survival and development appear in all other respects to be normal. Assuming that wing determination is under hormonal control, galactose could be affecting functions at any of the many steps between hormone production and action. Corpus allatum activity is reportedly correlated with the degree of alate production in aphids (White, 1965; 1968; 1971), but whether this necessarily implicates juvenile hormone in the control of this phenomenon is uncertain. Alternatively, the apterizing response to dietary galactose may result from direct stimulus of oral receptors as proposed by Dadd (1968).

Galactose could appear during digestion of phloem sap by enzymic hydrolysis of raffinose or higher galactosyl oligosaccharides. Its ecological significance in suppressing wing production in *M. persicae* might be by reflecting the physiological status of the plants on which these aphids feed.

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