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ABSTRACT: The use of disaccharides to discourage bird depredation to agricultural crops has elicited some interest during the last few years. Data developed in these trials indicate that several avian species are intolerant to sucrose because of the lack of sucrase enzymes in their digestive systems. Based on this research it is hypothesized that progressively increasing rates and volumes of solutions would elicit consistent adverse stress reactions. Furthermore, that if birds were intolerant to sucrose, because of their co-evolutionary development with plants, then they should lack the ability to digest lactose. The data developed in these trials does not support either hypothesis. A maximum of 60% of the birds tested showed stress symptoms to 0.75 M sucrose (6.26 mg/Kg body wt.) and 1.00 M lactose solutions (9.15 mg/Kg body wt.) when the birds were subjected to 2 cc treatments. Less than 40% were stressed by the lower concentrations. No adverse reactions were noted with 1 cc concentrations of either solutions or rates. Treating fruit with sucrose did not appear to affect the results until 1.00 M (3.83 mg/Kg) sucrose solutions were applied. No adverse results were obtained with lactose treated fruit.

KEY WORDS: vertebrate pest control, birds, starlings, intolerance, disaccharide, sucrose, lactose

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INTRODUCTION

The use of disaccharides to discourage bird depredation to agricultural crops has elicited some interest during the last few years (Martinez del Rio et al. 1988). Data suggest that the lack of specific digesting enzymes preclude the digestion of distinct disaccharides in avian species when their substrates are rare or absent from the diet. It has been suggested that the lack of sucrase enzymes precludes the use of sucrose as a useful energy source (Martinez del Rio and Stevens 1989).

From this, as well as other work, the concept of developing high sucrose fruit varieties, through genetic engineering, could be pursued if the threshold concentration of sucrose intolerance of targeted bird species could be established (Brugger and Nelms 1991; Brugger 1992; Brugger et al. 1993). The suggestion unfortunately ignores the data of Martinez del Rio and his colleagues (1988) as well as Stiles (1976), who demonstrated that sucrose intolerance is not uniform among avian species. Moreover, the development of high sucrose content fruit within the near future, with current genetic engineering strategies, does not appear to be forthcoming. An interim alternative, until the latter becomes possible, may be the development of a treatment strategy that incorporates disaccharides as an exterior coating to reduce depredation.

Data to develop such strategies, however, are lacking. Martinez del Rio and his colleagues (1988) found that European starlings (*Sturnus vulgaris*) and Red-winged blackbirds (*Agelaius phoeniceus*) immediately rejected 0.70 M solutions of sucrose, but total amounts of sucrose required to achieve these results were not determined. Brugger and Nelms (1991) found that plant cell agar containing 15% sucrose was sufficient to reduce consumption by American robins (*Turdus migratorius*) over a 60 min. time span but again did not record total amounts required to achieve these results. To address this deficiency a series of trials were conducted to determine the amount of sucrose required to cause physical discomfort in starlings. It was hypothesized that the amount of sucrose needed to elicit discomfort could be determined by forced-feeding a test population, with whom prior symptoms had been shown, progressively increasing rates and volumes of solutions until 90% of the birds showed symptoms of stress.

With past research concentrating on sucrose and sucrase enzymes the potential aversion to lactose has been ignored. Lactose (4-O-ß-D-Galactopyranosyl-D- glucose; 4-[ß-D-galactosido]-D-glucose) is a milk sugar to which many species of mammals, including some humans, are intolerant (Olson 1988). There is some reason to believe that this intolerance may extend to birds. Intolerance appears to be correlated with lactase enzymes deficiencies, and with mammals is often associated with the succession of breast feeding. If the absence of sucrose enzymes is a result of the co-evolutionary development between birds and plants, as suggested by Martinez del Rio and Stevens and accepted by others, then it can be hypothesized that lactase enzymes do not exist in any avian species. If lactase enzymes are absent, then avian species will exhibit signs of progressive discomfort to increasing concentration and rates of lactose.

To test these hypotheses a series of trials were conducted in which birds were subjected, through forced- or free-feeding to known quantities of either sucrose or lactose.

MATERIALS AND METHODS

Subjects

Approximately 200 European starlings were live-captured and maintained in a 6 m x 2 m x 12 m wire enclosed outdoor aviary at the Washington State University E.H. Stephen Research, Teaching and Extension Center in Pullman, Washington. Twice each day the birds were fed a prepared diet of banana mash (45% by weight), commercial pelletized bird meal (20% by weight), meal worms in corn meal (5% by weight) mixed with water (30% by weight). Cooked, French-fried potatoes were served at two-day intervals as supplementary food. Fresh water was available ad lib. All sick and injured birds captured in the field were removed from the population during the two week acclimatization period. No mortality occurred in the population during the trials.

Test Materials and Methods

Pre-trial procedures, to develop treatment and observation strategies, were conducted with 25 birds randomly selected from the core population. All subjects were released into an adjacent aviary after the procedures were established to preclude inclusion as candidates in subsequent tests.

During each phase of the trial, five birds were captured from the core population, weighed, and placed in 60 cm x 90 cm x 120 cm wooden framed wire cages with papered drop pans below each cage and water 6 hr. prior to each treatment. In each trial four of the five birds were randomly selected and subjected to either sucrose or lactose gavage treatments or a no choice source of food. The fifth bird was designated as a control and its behavior monitored, for comparison, with the treated birds. Behavioral changes indicating stress were defined as ruffled feathers, increased water ingestion and defecation, lethargy and disorientation. Time of stress onset and termination (full recovery), in minutes after treatment, were recorded. Number of droppings were counted on each paper removed from the drop pans before and after each trial. Each treatment was replicated five times. Prior to the trials five birds were randomly drawn from the population to determine the total amount of liquid they could be force-fed without injury and the optimal amount of currants they would consume after five hours of deprivation.

Immediately before each trial 0.25 M, 0.50 M, 0.75 M, and 1.0 M sucrose (mol. wt. 342.30) and lactose (mol. wt. 209.24) solutions were prepared. Each subject was gavaged with either 1 cc or 2 cc sucrose or lactose solution or given access to 25 whole currents (ave. wt. 2.84 g) soaked in 1 cc of the prepared solutions for 5 min. Each trial was replicated five times and all birds were observed at ten minute intervals for 2.5 hr. post-treatment.

RESULTS

Pre-treatment

A little more than 2 cc was determined to be the optimal amount of liquid that could be injected, by gavage, into the average starling in the pre-treatment test sample.

A little more than 25 currants (2.84 g) were found to be sufficient to placate the subjects for 1 hr. after a 5 hr. food deprivation period. A 30 min. observation period, with 10 min. reassessments during the following 2.5 hr. was determined to be an adequate observation strategy.

Sucrose by Gavage

A stepwise aversion to sucrose was not noted with increased dosage (Table 1). No consistent behavioral changes were observed between the controls and the birds within each dose rates. No adverse reactions were noted with 1 cc gavage treatments (data not included). Less than 50% of the subjects showed any form of stress at the 0.25 M, 0.50 M and 1.00 M rates with the 2 cc treatments. At least a 75 M solution was required to effect a response in 60% of the test group. The onset of symptoms ranged from 3.5 to 15.0 min. and lasted from 4.0 to 16.0 min. The 1.0 M sucrose solution produced the quickest stress reaction (3 min.) and the longest duration (16 min.). Water ingestion and defecation rates were not significantly different among subjects and treatments. Treatment rates of 6 to 9 mg/kg were necessary to induce stress in 50% of the test population. No significant differences were noted between number of bird droppings pre- and post-treatment.

Sucrose-treated Fruit

A stepwise progression in sucrose aversion with sucrose treated fruit was also absent. Only 20% of the test subjects showed any aversive signs to the 0.25 M treated currents. None of the subjects showed any aversion signs to the 0.50 M and 0.75 M treated material. All of the subjects in the 1.00 M treated current trials, however, appeared to be affected. Stress symptoms began approximately 16 min. after the birds fed on the treated samples. Signs of physical stress lasted about 11 min. The average amount of sucrose consumed was 3.83 mg/kg. Water was consumed an average of 1.4 times during the 30 min. observation period. No significant differences were noted between number of bird droppings pre- and post-treatment.

Lactose by Gavage

Subjects in the lactose gavage test series did not exhibit stress symptoms consistent with treatment rates (Table 1). Again, no adverse reactions were noted with 1 cc treatments (data not included). Stress symptoms were evident in over 50% of the test group at the 1.00 M solution rate. The onset of stress began to appear approximately 6 to 13 min. post-treatment and lasted about 7 to 15 min. Water was rarely consumed during the 30 min. observation period post-treatment. Defecation frequencies did not increase. No significant differences were noted between number of bird droppings pre- and post-treatment.

Lactose-treated Fruit

No signs of stress were observed in the birds of the lactose-treated food series (Table 1). Again, no significant differences were noted between number of bird droppings pre-and post-treatment.

DISCUSSION AND SUMMARY

The data from these trials do not support the hypotheses that birds are intolerant to sucrose and lactose. No consistent step-wise progression of stress symptoms were noted the forced-feeding or free-feeding trials.

A maximum of 60% of the birds tested showed stress symptoms to 0.75 M sucrose (6.26 mg/Kg body wt) and 1.00 M lactose solutions (9.15 mg/Kg body wt) when the birds were subjected to 2 cc treatments (Table 1). Less than 40% were stressed by the lower concentrations. No adverse reactions were noted with 1 cc concentrations of either solutions or rates.

Table 1. Stress symptoms in European Starlings subjected to .25, .50, .75, and 1.0 M solutions of lactose and sucrose.

	Solution Rate (M)	Stress (% of sample)	Onset of Symptoms (min.)*	Total time of Stress (min.)	Wt./ Bird (g)	Treatment mg/kg.	Water intake (average)	Fruit consumed (No. of currents
	0.25	40.00	13.50	7.50	77.20	2.22	0.20	
Lactose	0.50	20.00	6.00	11.00	74.00	4.63	0.00	
Gavage	0.75	40.00	8.00	15.50	81.80	6.28	0.00	
	1.00	60.00	11.67	9.67	74.80	9.15	0.00	
	Mean	40.00	9.79	10.92	76.95	5.57	0.05	
	Stdev	16.33	3.41	3.38	3.51	2.91	0.10	
	0.25	20.00	15.00	10.00	79.00	2.17	0.60	
Sucrose	0.50	0.00	0.00	0.00	82.60	4.14	0.00	
Gavage	0.75	60.00	12.33	4.33	82.00	6.26	0.20	
	1.00	40.00	3.50	16.00	77.00	8.94	0.20	
	Mean	30.00	7.71	7.58	80.15	5.38	0.25	
	Stdev	25.82	7.11	6.95	2.62	2.91	0.25	
	0.25	0.00	0.00	0.00	76.25	0.67	1.00	19.50
Lactose	0.50	0.00	0.00	0.00	85.50	1.24	1.00	24.25
Fruit	0.75	0.00	0.00	0.00	76.00	2.64	1.50	18.75
	1.00	0.00	0.00	0.00	82.75	3.27	2.25	17.00
	Mean	0.00	0.00	0.00	80.13	1.96	1.44	
	Stdev	0.00	0.00	0.00	4.75	1.20	0.59	3.10
	0.25	20.00	15.00	11.00	75.00	0.87	1.00	16.40
Sucrose	0.50	0.00	0.00	0.00	77.80	1.67	1.20	19.20
Fruit	0.75	0.00	0.00	0.00	81.60	2.61	0.60	23.80
	1.00	100.00	16.40	11.00	73.20	3.83	1.40	23.60
	Mean	30.00	7.85	5.50	76.90	2.25	1.05	
	Stdev	47.61	9.08	6.35	3.66	1.28	0.34	3.59

*Time from treatment to first signs of physical stress.

Treating fruit with sucrose did not appear to affect the results until 1.00 M (3.83 mg/Kg) sucrose solutions were applied. As with the gavage treatments, no step-wise progression of stress symptoms were noted between control and increasing sucrose concentrations. No intolerance was noted in the lactose fruit treatments.

This leaves several unanswered questions. First, if this avian species lacks specific disaccharide digestive enzymes, as suggested by prior research, why did more of the test population not show signs of stress after forced-feeding or free-feeding on either of these disaccharides? Moreover, why were no consistent progressions in symptoms observed as dose rates were increased?

The results of these trials suggest that more research, using protracted feeding regimes with larger population sizes, are needed before any of the hypotheses presented can be accepted or rejected.

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