Preferences for Natural and Artificial Sweeteners in Heat-Stressed Chicks of Different Ages[1]

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Abstract

Chicks are capable of discriminating various taste stimuli and their aversions for cyclamate and preferences for glucose are similar to those reported for various rodents. The age differences found here deserve further investigation as does the effect of heat-stress during incubation on preference behavior.

Introduction

Preferences for various sugars are found throughout the animal kindgom, particularly among mammals. Until recently, reports of sugar preference in chickens had been sporadic and contradictory (4, 5). However, Wagner and Gunther (9) have shown that new-born chicks have definite preferences for glucose and sucrose over water and gradually develop an aversion for lactose. Higher incubation temperatures (heat-stress) failed to result in marked sugar preference differences although heat-stress has been shown to produce marked differences in other behaviors such as discrimination learning, reversal learning, frequency of pecking, and color preferences (1, 2, 3).

Research on sweeteners other than sugars (sweet as judged by humans and accepted as rewards by rodents) as well as the well-publicized ban on cyclamates has spurred the study of preferences for various substances such as saccharin and cyclamate. Wagner (6, 7) and Wagner and Gunther (9) have found several rodent species which prefer saccharin and avoid cyclamate. Whether this cyclamate aversion is because of its taste (or off-taste) or to the suspected toxicity of cyclamates has not been resolved.

The purpose of the present study was to examine preferences for saccharin, cyclamate, glucose, and water in normal and heat-stressed chicks at various ages. The chemicals were purchased from a chemical supply house and are of reagent grade.

Methods

All control and experimental chicks were hatched from buff White Rock eggs in commercial Montgomery Ward incubators, modified for electronic control of temperature within ±0.5°C. Humidity was kept con-

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stant. Both temperature and humidity were continuously monitored and recorded during incubation by electronic recorders. The eggs were turned 3 times each 24-hour period. The sugar, saccharin, and cyclamate solutions were made with tap water and the strength of the solution determined on a weight/volume basis. The concentration of the sugar was standardized at 8% and 16%, sodium cyclamate at 0.91%, the calcium cyclamate at 1.81%, and sodium saccharin at 0.23%. These concentrations have been noted in the literature and are well above threshold for all animals that have been tested. The reasons for the choices of values have been discussed elsewhere (9).

Control chicks were hatched from eggs incubated at the optimal temperature of 37.5°C for 21 days. Experimental chicks were placed in a nonoptimally high temperature incubator at a temperature of 41°C for the first 72 hours of incubation, after which they were placed in the normal temperature incubator until hatching. After hatching, the chicks were banded and placed in heated starting battery brooders, eight or nine chicks per group. The solutions were presented in a watering trough with three removable waterproof sections containing water and the various concentrations of sweeteners (see reference 10 for additional details of presenting solutions and measuring solution intake). Table 1 shows the experimental paradigm.

Measurement of daily intake was made in Class A graduated cylinders to the nearest milliliter, and the volume recorded was the total intake for each group of chicks. The solutions were discarded after measurements, and fresh solutions were introduced from the refrigerated stock.

Commercial starting mash was available to the chicks at all times. The chicks were completely isolated from other animals and humans, except for those periods necessary to rotate the sections and to measure and change the solutions. Humidity and temperature were kept constant in the battery room since this facility had no windows (zone air-conditioning). Light-dark conditions were made to match those of the normal day-night at this time of the year. The experiments were conducted during July and August.

Results

Since chicks were housed in groups (for practicality as well as the necessity of rearing infant chicks in a warm environment), measurement of individual intake and preference was precluded. Because of this, the analyses of variance were more limited in scope since the interaction variances had to be used as error terms instead of within and between subject variability, and all interpretations would, therefore, tend to be conservative estimates of actual differences.

The data for the analyses are per cent intake, and for graphical presentation are mean per cent intake with the standard error of the mean as a vertical line to indicate variability. Per cent intake was used since this method of computation equates for greater bodyweight in

TABLE 1. *Experimental Paradigm.*

Age	Solution Choices					
	Water 8% glucose 0.91% Na Cyc	Water 16% glucose 0.91% Na Cyc	Water 8% glucose 1.81% Ca Cyc	Water 16% glucose 1.81% Ca Cyc	Water 8% glucose 0.23% Na Saccharin	Water 16% glucose 0.23% Na Saccharin
4 Days old	Exp. 3 Group I (n=8)	Exp. 3 Group II (n=8)		Exp. 3 Group III (n=8)		
17 Days old			Exp. 4 Group II (n=8)		Exp. 4 Group III (n=8)	Exp. 4 Group I (n=8)
30 Days old	Exp. 1 Group I (n=9)	Exp. 1 Group II (n=9)	Exp. 1 Group III (n=9)			
30 Days old	Exp. 2 Group I (n=9)	Exp. 2 Group II (n=9)	Exp. 2 Group III (n=9)			

In each cell there are two groups: Control group; Experimental (heat-stressed) group; each group was tested for eight days, 24 hrs/day, combinations in the empty cells were not made.

older chicks and, hence, greater fluid intake by presenting relative intake instead of absolute intake.

Replication: Experiment 1 vs. Experiment 2 (30-day-old chicks)

There were no significant differences in preference upon replication (Fig. 1).

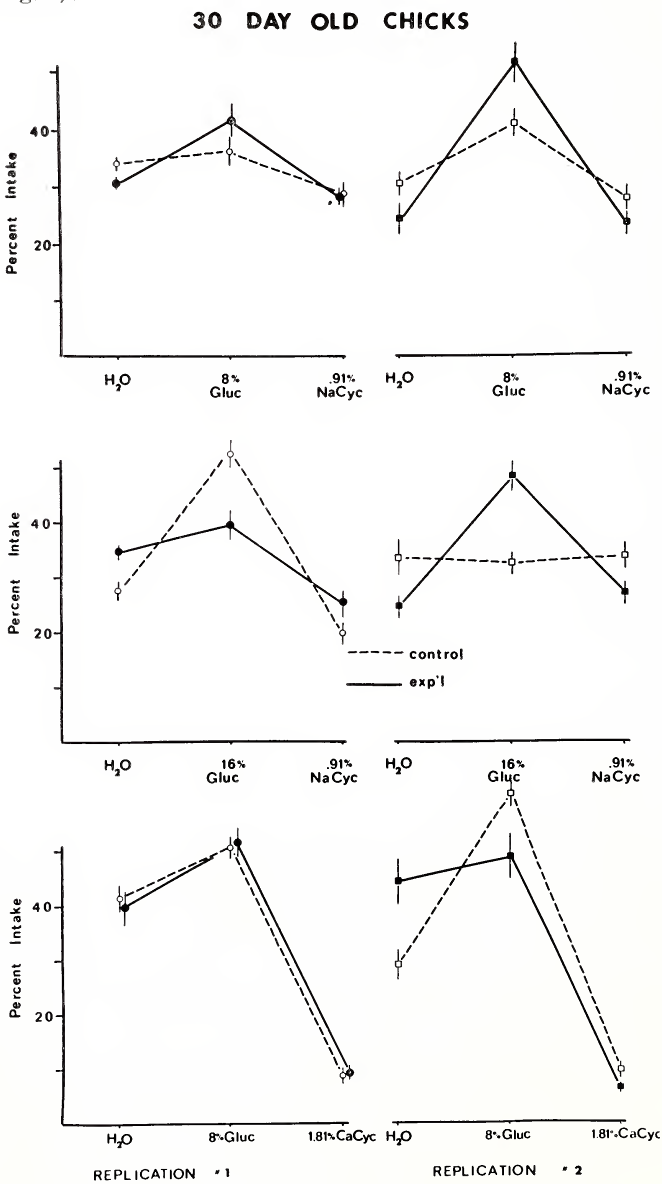


FIGURE 1. *Experiment 1 (replication 1) vs. Experiment 2 (replication 2); Group I for each replication at top of figure, Group II next, and Group III at bottom of figure.*

Experiments 1 and 2, Group I (water; 8% glucose; 0.91% sodium cyclamate) vs. Group II (water; 16% glucose; 0.91% sodium cyclamate) showed no overall difference between the two conditions of having differing glucose concentrations available. Glucose was significantly preferred to both water and cyclamate ($F = 42.089$; $df = 2/2$; $p < .025$) regardless of its relative concentration (see Table 1 for distinctions relating to Experiments 1 through 4 and Groups I through III).

In Experiments 1 and 2, Group I (water; 8% glucose; 0.91% sodium cyclamate) vs. Group III (water; 8% glucose; 1.81% calcium cyclamate) there were no overall intake differences in preferences which could be traced to the two different salts or concentrations of cyclamate. Eight per cent glucose was preferred to water or cyclamate regardless of cyclamate salt or concentration ($F = 21.50$; $df = 2/2$; $p < .05$).

Experiment 3 (4-day-old chicks)

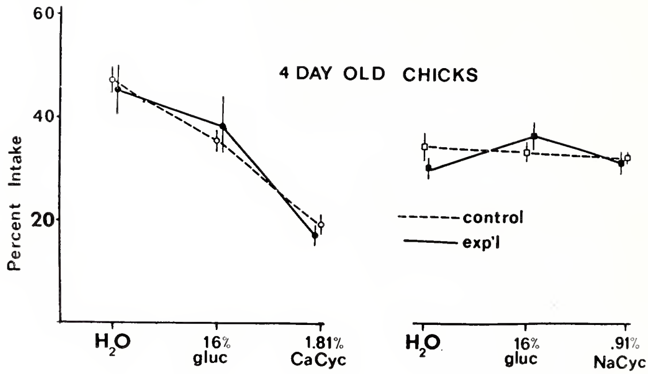
Four-day-old chicks did not discriminate between water, 16% glucose and 0.91% sodium cyclamate (Group II), nor were their preferences different from those chicks which received water, 8% glucose and 0.91% sodium cyclamate. However, when the choices were different cyclamate salts and concentrations (Group II: water, 16% glucose; 0.91% sodium cyclamate *vs.* Group III: water; 16% glucose; 1.81% calcium cyclamate) overall analysis indicated that cyclamate was not preferred ($F = 1{,}350.959$; $df = 2/2$; $p < .001$), heat-stressed chicks preferred glucose to cyclamate $F = 66.81$; $df = 2/2$; $p < .025$), and chicks having 1.81% calcium cyclamate as a choice preferred glucose and avoided cyclamate to a greater extent than chicks having 0.91% sodium cyclamate as an alternative ($F = 1{,}218.143$; $df = 2/2$; $p < .001$) (Fig. 2.)

Experiment 4 (17-day-old chicks)

Seventeen-day-old chicks preferred glucose (either 16% or 8%) to water or saccharin (Groups I and III) ($F = 24.44$; $df = 2/2$; $p < .05$). If the choices involved cyclamate or saccharin (Groups II and III respectively) chicks preferred glucose to either water or the artificial sweetener ($F = 78.37$; $df = 2/2$; $p. < .025$) and further, Group III chicks drank relatively more saccharin (and less 8% glucose) and Group II chicks drank relatively less cyclamate (glucose II vs. glucose III, $t = 4.373$; $df = 14$; $p < .001$; saccharin III vs. cyclamate II, $t = 4.19$; $df = 14$; $p < .001$) (Fig. 2).

Age Differences

Thirty-day-old chicks preferred glucose to either water or sodium cyclamate while four-day-old chicks were indiscriminate (water; 16% glucose; 0.91% sodium cyclamate; $F = 36.513$; $df = 2/2$; $p < .05$). Any differences between 30-day-old and 4-day-old chicks when presented with choices of water, 8% glucose, and 0.91% sodium cyclamate were not due to experimental manipulation, but were the results of excessive variability.



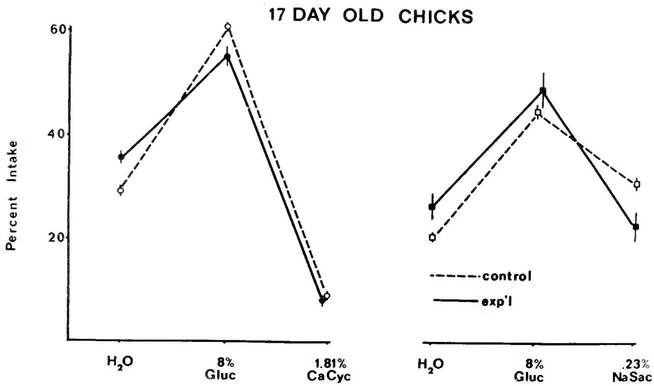


FIGURE 2. *Experiments 3 (top) and 4 (bottom); only Group III, left and Group II, right (Exp. 3) and Group III, right and Group II left (Exp. 4) compared in each experiment.*

Seventeen and 30-day-old chicks were both given choices of water, 8% glucose, and 1.81% calcium cyclamate. For all chicks glucose intake was greatest and cyclamate least ($F = 2{,}403.959$; $df = 2/2$; $p<.001$). Heat-stressed chicks drank relatively more water, less glucose and equal small amounts of cyclamate—still preferring glucose, however, ($F = 35.325$; $df = 2/2$; $p<.05$), and finally, the younger chicks (17 days old) showed a more pronounced glucose preference ($F = 26.435$; $df = 2/2$; $p<.05$) (Fig. 3).

Discussion

Wagner and Gunther (10) previously have shown that chicks can discriminate various taste stimuli, preferring some over water, while avoiding others. The present studies clearly reinforce this.

Chicks consistently avoid cyclamates, the sole exception being 4-day-old chicks which were indiscriminate to a 16% glucose or 0.91%

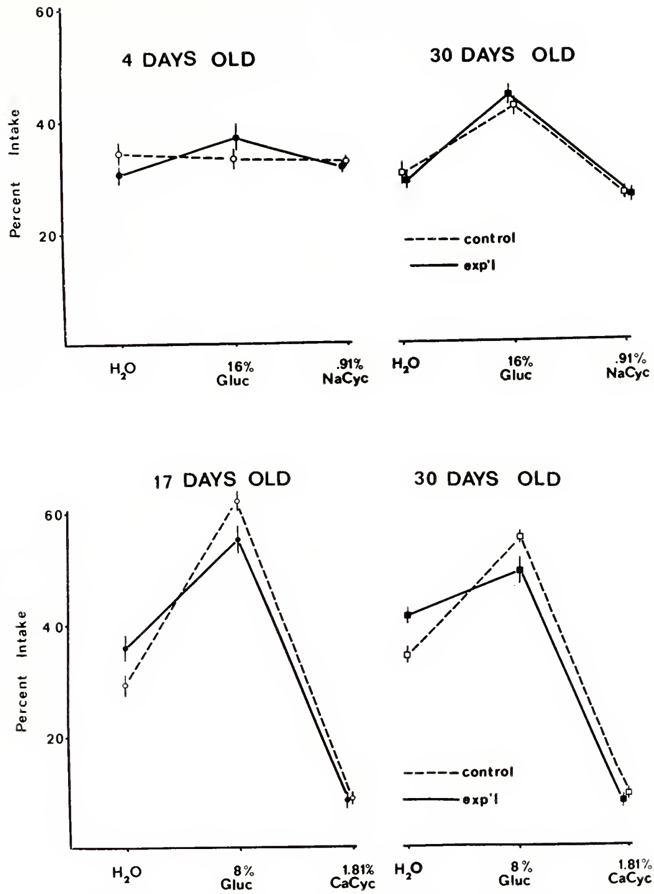


FIGURE 3. *Age differences in intake of water and sweetners.*

sodium cyclamate. Are chicks avoiding cyclamates because of the suspected toxicity of cyclamate, or because of some taste-quality inhert in cyclamate solutions? Dr. Jacqueline Verrett (unpublished research progress reports, U.S. Food and Drug Adm.) found that cyclamate injected into incubating eggs produced embryonic deformities, but it is difficult to generalize from such studies to food preferences or aversions (6). Chicks reject toxic lactose, but the aversion develops gradually (10). In the present study, the nonintake of cyclamate was immediate, suggesting that taste rather than toxicity accounts for the aversion. This same phenomenon has been observed in rodents (7, 8, 9).

A comparison of rodent and chick preferences and aversions for sweeteners does not imply that these two species inhabit similar sensory worlds in general. However, the universality of the chemical sense and its function in food selection might lead one to expect some similarities in taste preferences for simple sweeteners. Since, in nature, sweets are a source of calories basic to the energy requirements of all living creatures, especially warm-blooded animals, it is quite logical to make comparative analyses of sweet preferences and aversions across diverse species with some expectation of finding similarities.

While chicks never preferred the saccharin to glucose, comparative data from rats and mice would suggest that this should not be expected since rats and mice prefer 8% glucose to 0.23% sodium saccharin (8, 9).

Perhaps a better test of relative palatability of the two artificial sweeteners is the observation that saccharin was drunk to a much greater extent than 1.81% cyclamate under similar conditions by 17-day-old chicks.

The effects of heat-stress during incubation are overshadowed by preference differences because of age and type of choice available. In fact, heat related differences might be considered equivocal since heat-stressed 4-day-old chicks drank relatively less water and more glucose than their normal counterparts, whereas heat-stressed 17-day-old and 30-day-old chicks drank relatively more water and less glucose than their normal counterparts. Previously cited research also found stress differences to be less pronounced than preference differences because of type of sugar choice available.

Acknowledgment

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