Alimentary Absorption of Reducing Sugars by Embryos and Young Chicks.* (26596)

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The aim of this research was two-fold. It sought to determine the relative absorption rates from the chick alimentary tract of a variety of sugars, including 6 pentoses, 5 hexoses, a heptose and a disaccharide. On the basis of this information several sugars differing in both molecular size and absorption characteristics were selected for an exploratory study of intestinal absorptive capacity of embryos and newly-hatched chicks. In mammals, studies of intestinal absorptive function during the transition from pre- to postnatal life are encumbered by the inaccessibility of the fetus. This difficulty was obviated by choosing the chick as the experimental animal.

Materials and methods. The embryos and chicks used throughout this investigation were of a cross of White Leghorn males to Flightless females and were unsexed. Alimentary absorption rates of 13 reducing sugars in aqueous solution (18% w/v) were determined by the Cori method(1) essentially as outlined for the chick by Golden and Long (2).

The following procedure was devised for experiments involving embryos. Eggs incubated for 17 days were opened at the blunt end. Membranes above the embryo were peeled back and the blood vessels carefully parted to allow raising of the embryo's head. After delivery of the sugar solution *via* a catheter into the crop, the head was stabilized outside the egg by means of a collar of aluminum foil (which also served to minimize evaporation of the egg's contents). The embryo was then returned to the incubator for the absorption interval. Thereafter the embryo was lifted from the egg and extra-embryonic vessels were severed. The body cavity was immediately opened, the heart removed, and adhering blood washed away. Sugar was recovered from the alimentary tract first by perfusion and then by washing after slitting it open *in situ*.

The volumes of sugar introduced into the crops of the 14-, 3- and 0-day-old chicks and embryos were 2.0, 0.6 and 0.15 ml, respectively. Chicks were not permitted access to food for 24 hours prior to experiments. The quantity of sugar absorbed was determined by computing the difference between the amount fed and that recovered from the entire alimentary tract after a 30 min absorption period. Absorption rates were expressed as an absorption coefficient, *viz.*, mg of sugar absorbed/100 g body weight/30 min. Body weights were exclusive of yolk-sac weights. Mean absorption rates of sugars were based on no less than 2 separate experiments on different lots of chicks. Quantitative determinations of reducing sugars were carried out according to the method outlined by Somogyi(3).

Results. Relative absorption rates of sugars fed to the experimental birds are graphically represented in Fig. 1. To the right of each bar is tabulated the number of chicks, mean dose of sugar administered and standard deviation of the mean absorption rate for that group. Sugars within a single bracket were not absorbed at significantly different rates as determined by the Multiple Range Test of Duncan(4).

Results obtained with 14-day-old chicks indicated that D-galactose, D-glucose, D-xylose and D-fructose were absorbed at significantly faster rates than the 9 remaining sugars tested, with the sole exception that D-fructose and D-altrose were not significantly different. Three-day-old chicks also absorbed

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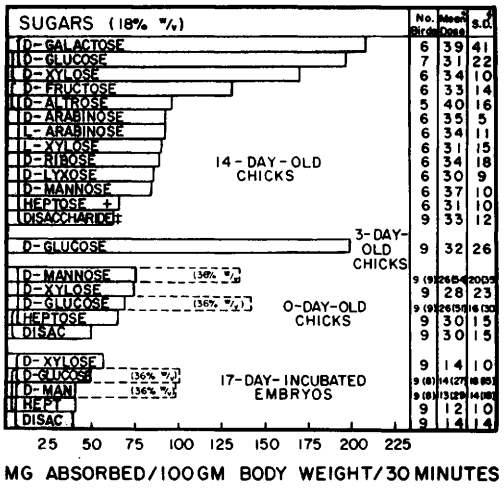

* mg/10 g body wt.
† D-glycero-D-galacto-heptose.
‡ Cellobiose.
§ Stand. dev. of mean absorption rate.

FIG. 1. Mean alimentary absorption rates of sugars fed to chicks. Differences between sugars within a single bracket were not significant at $P = 0.05$.

glucose rapidly at a rate similar to that of the older birds. Henceforth D-galactose, D-glucose, D-xylose, and D-fructose will be designated as rapidly absorbed and all the other sugars as slowly absorbed.

Based on the above findings, 2 rapidly absorbed and 3 slowly absorbed sugars of differing molecular size were selected for the experiments with embryos and 0-day-old chicks. These results (Fig. 1) showed that 1) since D-glucose and D-xylose were absorbed at the same slow rates as the other sugars of similar size, at these early ages the sugars could not be segregated into rapidly and slowly absorbed groups; 2) there was a tendency for the largest sugars (the heptose and disaccharide) to be the most slowly absorbed, suggesting an inverse relationship between absorption rate and molecular size; 3) when concentration (hence the dose) of D-glucose and D-mannose was doubled, absorption rate was proportionately elevated, so that even at these higher dose levels there was no apparent difference between the "rapidly" absorbed and "slowly" absorbed sugars; and 4) adjustment of the glucose absorption coefficients of the embryos and 0-day-old chicks to a dose of 31 mg/10 g body weight, for comparison with the 14-day-old chicks fed this sugar, gave the values 107 and 82, respectively. Clearly these adjusted absorption coefficients are closer to those of sugars slowly absorbed by the older birds than to that recorded for glucose.

Discussion. The results of a survey comparing alimentary absorption rates of 13 sugars in 14-day-old chicks showed that the rates for these sugars decreased (without regard for statistical significance) in this order: D-galactose, D-glucose, D-xylose, D-fructose, D-altrose, D- and L-arabinose, L-xylose, D-ribose, D-lyxose, D-mannose, heptose, and disaccharide. Of the 4 most rapidly absorbed, the rate for D-galactose did not differ significantly from that for D-glucose, but it was significantly greater than that either for D-xylose or D-fructose. D-glucose differed significantly only from D-fructose. Of the 9 most slowly absorbed, the rate for only D-altrose was not significantly less than for that of D-fructose, the slowest of those rapidly absorbed. The observed differences in absorption rates for compounds of similar size suggest that the rapidly absorbed sugars—D-galactose, D-glucose, D-xylose and D-fructose—are selectively absorbed by this species. The absorptive capacity of the chick, with regard to sugars, therefore resembles closely that of the pigeon(5) and the mammal(6).

Studies with the 0-day-old chicks and embryos indicated that selective absorption does not occur at these ages, at least not to an extent measurable by the technique employed. The uniformly slow absorption velocities of all sugars tested, including D-glucose and D-xylose, suggest a passive mode of absorption. If, indeed, the laws of simple diffusion prevail at these ages, then the negligible differences between the absorption rates of the sugars are only an expected consequence of the equally small differences in their molecular size. Even so, there was a tendency for the largest molecules to be the most slowly absorbed.

In contrast, chicks only 3 days of age absorbed glucose as rapidly as the 14-day-old chicks, or at a rate more than twice that

calculated for 0-day-old chicks fed a comparable dose of the sugar.

These data suggest that the special mechanisms invoked to explain the selective absorption of sugars such as D-glucose are probably not fully functional until some time between 1 and 3 days after hatching.

Summary. A comparison of the alimentary absorption rates of 13 sugars in 14-day-old chicks indicated that D-galactose, D-glucose, D-xylose and D-fructose are selectively absorbed by this species. Furthermore, the ability to selectively absorb sugars seems to be fully developed in chicks just 3 days of age. In contrast to these older birds, embryos and 0-day-old chicks absorbed D-glucose and D-xylose at rates suggestive of a passive mode of absorption. These data have been interpreted as meaning that the selective absorptive capacity of the chick gut is not maximally developed until 1 to 3 days after hatching.

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Development of Intestinal Selective Absorption of Glucose in Newly-Hatched Chicks.*† (26597)

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In an exploratory study of alimentary absorptive function in young chicks, the absorption velocity of glucose was found to increase by several fold between 0 and 3 days of age (1). The aim of the experiments described below was to characterize more fully this apparent change in absorptive capacity which occurs just after hatching. Accordingly, the absorption rates of glucose and sorbose, each alone and each in the presence of phlorhizin, were compared in chicks between 0 and 10 days of age. Sorbose, a passively absorbed sugar(2), was selected to obtain an estimate of the amount of hexose which leaves the intestine by simple diffusion. Any glucose absorbed in excess of this amount would presumably reflect the activity of selective absorption mechanisms. Phlorhizin was chosen because of its relatively specific ability to inhibit glucose absorption(3). It was of interest to see if its potency, in this respect, might vary with the changing functional capacity of the absorbing cells.

Materials and methods. Chicks, used without regard to sex, were obtained from a local hatchery and were of a Mount Hope-Babcock strain cross. Alimentary absorption rates were determined by the Cori method(4) essentially as adapted for the chick by Golden and Long(5). In these experiments the sugar absorbed was estimated by the difference between the quantity of sugar initially introduced into the crop and that recovered from the entire alimentary tract after a 30 minute absorption interval. In the recovery procedure a clamp was placed at the uppermost part of the duodenum so that the sugar retained above and below this point could be measured separately.

Sugars were administered as 10% solutions in distilled water. When phlorhizin was used, it was added to the sugar solution in final

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