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Sweetness of Diet and Food Consumption by Infants (41629)

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Abstract. Normal female infants were studied from 8 to 112 days of age to determine the effect on food consumption of feeding formulas that differed widely in sweetness. One formula contained sucrose and the other a bland-tasting cornstarch hydrolysate. In a balanced, cross-over design, it was found that food consumption was significantly greater during intervals in which the sweeter formula was fed.

Based on the volumes of aqueous solutions consumed under standardized conditions during a single feeding, infants appear to prefer sweeter over less sweet carbohydrates. At the same molar concentration, sucrose appears to be preferred over lactose (1) and fructose over glucose (1, 2). In addition, tongue pressure recorded during suckling has been reported to be greater when infants are fed sucrose-containing than when they are fed glucose-containing solutions (3). When the same sugar is fed, more concentrated solutions appear to be preferred to dilute solutions (1–3). The preference for sweetness can also be demonstrated when different carbohydrates are fed as components of milk-based formulas. When two formulas of identical composition except for the carbohydrate were offered, greater volumes of the sweeter (4.7 g sucrose and 2.3 g lactose/67 kcal) than of the less sweet (7.0 g lactose/67 kcal) formula were consumed (4).

Long-term studies of the effect of sweetness on food consumption have not been reported in infants. We have previously studied the effect of caloric density on food consumption by feeding formulas that were as identical as possible except for energy concentration (5, 6). Volume of formula consumed was inversely proportional to energy concentration. With energy concentrations as different as 54 and 100 kcal/dl (6), energy intakes were remarkably similar. Further, altering the ratio of energy supplied from carbohydrate and fat did not affect energy intake (7). The level of salt in the diet did not influence food intake of 4-month-old or 7-month-old infants (8). There is, therefore, considerable evidence that the amount of food energy consumed by normal infants during periods of weeks or months is closely regulated. There is no evidence so far that taste is capable of modifying energy intake in the long term.

Nevertheless, because the single feeding studies of infants have consistently demonstrated an apparent preference of the infant for sweeter solutions or formulas, we have carried out a longer term study of normal infants fed two formulas that differed widely in sweetness. In one formula the carbohydrate was sucrose, which ranks among the sweetest of carbohydrates used in commercially available infant formulas; in the other, the carbohydrate was a cornstarch hydrolysate of bland taste. From 8 to 112 days of age the two formulas were fed alternatingly for periods of 20 or 28 days. Thus, each infant received each formula during two separate periods.

Materials and Methods. Normal fullterm female Caucasian infants with birth weights greater than 2500 g were enrolled in the study during the first 9 days after birth. Female infants were chosen for study because females had been reported (4) to be more influenced than males by formula sweetness. The majority of the subjects were daughters of students or faculty of the University of Iowa. Between August 16, 1980 and January 26, 1981, all female infants available for enrollment in a study of this type were assigned alternately to feeding group A or feeding group B. The study was reviewed and approved by the University of Iowa Human Subjects Review Committee. At the time an infant was enrolled in the study, the mother was inter-

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viewed by one of us (BBE), the program was outlined in detail, written consent was obtained, and written instructions were provided.

From the time of birth until enrollment in the study, the infants were fed commercially available milk-based formulas. Thereafter, each infant was fed *ad libitum* experimental formula I 8008 or I 8009. Each formula was prepared from soy protein isolate (Edipro A, Ralston Purina Co., St. Louis, Mo.), vegetable oils (58% corn oil and 42% coconut oil), carbohydrate, vitamins, and minerals. The carbohydrate of formula I 8008 was sucrose and the carbohydrate of I 8009 was Polycose (Ross Laboratories, Columbus, Ohio), a D.E. 20 cornstarch hydrolysate. The energy density of each formula, determined by bomb calorimetry, was 68 kcal/dl. Protein, fat, and carbohydrate contributed 12, 48, and 40% of energy, respectively. The experimental formulas were supplied in ready-to-feed disposable glass bottles containing 240 ml. The entire supply (6000 bottles) of each formula was prepared by the manufacturer as a single batch. Subjects in group A received formula I 8008 from 8 through 27 days and from 56 through 83 days of age and formula I 8009 from 28 through 55 and 85 through 111 days of age. Subjects of group B received the formulas in the opposite sequence, beginning with formula I 8009 from 8 through 27 days of age. A supply of formula sufficient for 7 days was weighed and delivered to the family. When a new supply was delivered 7 days later, the bottles from the previous supply, including any unconsumed amounts of formula, were collected and again weighed. Bottles for each 24-hr period were weighed separately. Throughout the period of study from 8 through 111 days of age the formulas and a fluoride supplement (Karidium Liquid, Lorvic Corporation, St. Louis, Mo.) served as the sole sources of nutrients. Measurements of length, weight, and skinfold thicknesses were carried out in the manner previously described (9) and at the same ages as in previous studies (7). Data analysis was carried out by analysis of variance to compare performance during periods in which the sucrose-containing formula (I 8008) was fed with that during periods in which the Polycose-containing formula (I 8009) was fed. To correct for the effect of age, analysis was also performed with age as covariate (analysis of covariance).

Results. Eight infants were assigned to group A and eight to group B. The birth weight of one infant in group A was subsequently found to be less than 2500 g and this infant was therefore considered ineligible for the study. Another infant in group A moved from the city after the visit at 56 days of age. Data analysis is restricted to performance of the six infants in group A and eight infants in group B who completed the planned period of observation. One subject in group A developed a gastrointestinal illness and consumed only small amounts of formula for several days at about 56 days of age (the time of change from formula I 8009 to I 8008). Data concerning this infant were therefore omitted from analysis for the last week before and the first week after the change in feeding. Mean birth weight was 3624 g for the six infants in group A and 3459 g for the eight infants in group B.

Table I and Fig. 1 demonstrate that energy intake per unit of body weight was greater when infants were fed the sucrose-containing formula (I 8008) than when they were fed the Polycose-containing formula (I 8009). Analysis of variance and covariance (with age as the covariate) demonstrated that the difference was significant ($P < 0.01$). As may be seen from Fig. 1, the feeding-related difference in energy intake persisted through the 28-day periods of observation. During the last 7 days of each feeding period the feeding-related difference in energy intake was statistically significant (analysis of covariance, $P = 0.015$).

The difference in mean gain in weight was not statistically significant (analysis of covariance, $P = 0.06$). Corresponding values for gains in weight per unit of energy intake were 5.70 and 5.41 g/100 kcal ($P = 0.25$), and for change in skinfold thickness 0.068 and 0.044 mm/day ($P = 0.07$). In most age intervals (Table I), gains in length were actually greater by infants fed the Polycose-containing formula than by those fed the sucrose-containing formula, but the difference was not statistically significant ($P = 0.06$).

Discussion. In view of suggestions from our previous studies that energy requirements are a powerful determinant of energy intake, we had not anticipated that energy intakes over

periods as long as 28 days would be appreciably influenced by sweetness of the formula. In our previous study of food consumption by male infants fed two isocaloric formulas prepared from the same ingredients—nonfat milk solids, lactose, and vegetable oils—but differing in percentage of energy provided by carbohydrate and fat (7), carbohydrate provided 5.3 g/dl in one formula and 10.0 g/dl in the other. Such concentration differences of several sugars were demonstrated by Desor *et al.* (1) to influence food consumption by newborn infants in single-feeding tests. In our study (7), energy intakes between 8 and 112 days of age were remarkably similar for the two groups of infants. The difference between our results and those reported by Desor *et al.* (1) might be attributed to difference in the age of the infants, to an adaptation to prolonged feeding (weeks of feeding rather than single feedings), to differences between perceived sweetness of carbohydrates in aqueous solutions and milk mixtures, or to a number of unrecognized factors. Results of the present study suggest that differences in type of carbohydrate in an infant formula may influence food consumption over intervals of at least 28 days. The possibility that differences in sweetness may lead to differences in weight gain and/or body composition require careful assessment.

TABLE I. ENERGY INTAKE AND GROWTH

Infant age (days)	I 8008 Mean	I 8008 SD	I 8009 Mean	I 8009 SD
Energy intake (kcal/kg/d)				
8–27	117	13	111	20
28–55	118	19	108	18
56–83	106	17	101	14
84–111	106	7	96	9
Change in weight (g/day)				
8–27	35.7	9.3	27.4	4.1
28–55	29.6	5.1	31.0	8.6
56–83	29.9	5.2	25.6	6.7
84–111	27.8	3.6	27.8	7.5
Change in weight (g/100 kcal)				
8–27	7.67	1.76	6.68	1.03
28–55	5.74	0.98	5.84	1.39
56–83	5.16	1.05	4.82	1.05
84–111	4.39	0.49	4.40	1.00
Change in skinfold thickness (mm/day)				
8–27	0.137	0.042	0.093	0.059
28–55	0.060	0.042	0.022	0.038
56–83	0.053	0.055	0.022	0.043
84–111	0.032	0.054	0.037	0.053
Change in length (mm/day)				
8–27	1.3	0.3	1.4	0.3
28–55	1.2	0.2	1.4	0.1
56–83	1.0	0.3	1.0	0.1
84–111	0.8	0.1	0.9	0.2

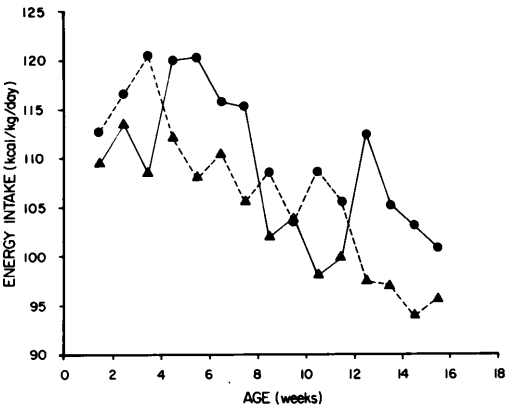

FIG. 1. Energy intake in relation to age. Each solid circle indicates mean intake of energy during a 7-day period in which the sucrose-containing formula (I 8008) was fed and each triangle indicates mean intake during a 7-day period in which the Polycose-containing formula (I 8009) was fed. Intakes by infants in Group A are connected by an interrupted line; intakes by infants in Group B are connected by a solid line.

Although we have tentatively attributed the greater energy intakes during periods in which the sucrose-containing formula was fed to the greater sweetness of sucrose than of Polycose, other explanations should also be considered. We cannot exclude a primarily metabolic effect of sucrose as a cause of the increased energy consumption. Among the documented effects of sucrose consumption are alteration in insulin secretion (10) and stimulation of sympathetic nervous system activity (11). The mechanism by which carbohydrates influence food consumption and the circumstances under which the influence can be demonstrated remain to be defined.

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