

Savoring Sweet: Carbohydrates in Infant, Toddler, and Child Nutrition

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Nutrition supports the remarkable rate of growth of infants and toddlers: weight gain, linear growth, and continued development and refinement of organs and physiological systems.¹ Human milk is sweet and fragrant to stimulate avid sucking. Human milk is a complex bioactive fluid with a broad array of components, including indigestible human milk oligosaccharides that support the developing immune system, and factors that promote digestion, regulate hormonal signaling, stimulate tissue development, and modulate inflammation to ensure a stable transition from *in utero* to *ex utero* life.^{2,3} Gastrointestinal motility, which is rudimentary at birth, coordinates over time, paralleling changes in the gut nervous system. Similarly, gastric, intestinal and pancreatic digestive functions develop gradually in response to daily exposure to swallowed material, including nutrients, allergens, microbes, and chemicals. An entire secondary digestive system is established through bacterial colonization, which begins a dialogue with the host's metabolism.^{4,5}

From birth, the infant/toddler engages in intense sensory-motor exploration that results in extremely rapid brain expansion.⁶ By 12 months the infant brain will double and by 36 months triple in volume, due to synaptogenesis and myelination of axons. During this period, the brain accounts for 50-60% of the infant's basal metabolic rate.¹

Initial food choices have consequences beyond growth. Human milk provides complete nutrition until around 6 months of age when the infant's needs for energy, iron, and zinc require complementary foods (CFs). The sensory and motor experiences associated with first foods, the type, variety and timing, including the many colors, flavors, smells, and textures contribute to life-long food preferences. CFs are a critical contributor to cognitive, social, and emotional maturation. Attention, affect, learning capacity, memory, and motivation all are affected by diet quality.⁷ Although individual nutrients are important (eg, iron, omega-3 fatty acids, choline), it is the synergy between nutrients that matters. A deficiency in one nutrient affects how other nutrients function. This makes dietary diversity and balance a crucial target, in alignment with the 2015 Dietary Guidelines for Americans (DGA).^{8,9} If the 20th century was the era of the individual nutrient, the 21st century will be the era of the dietary pattern.

A dietary pattern is the totality of foods and beverages an individual consumes regularly over time. The DGA states that "these dietary components act synergistically in relation to health."⁸ The health benefits of nutrition, as well as the mitigation of chronic disease risk, arises from the quality of foods consumed. Every individual has a personal dietary pattern, based on their exposures, food preferences, family eating style, and cultural norms. Improvements occur from substitution of more nutrient-rich items for ones of lesser nutritional value. Changes that occur incrementally are sustained longer.

Between 6 and 24 months of age, the infant/toddler will evolve a stable set of food preferences and eating habits.⁹ Formerly, individual solid foods were introduced in a sequence meant to prevent allergic reactions. Recent research showed that, contrary to conventional teaching, withholding allergenic proteins increased, not decreased, the risk of allergic symptoms. Instead, the aim of CFs should be to repeatedly offer the infant/ toddler every flavor, taste, and texture of nutrient-rich foods in each of the five food groups (ie, fruits, vegetables, whole grains, dairy, quality proteins). First foods differ world-wide. But offering small tastes of a wide variety of foods will be more advantageous for the infant than large servings of a few foods.

Although nutrient consumption among 6-12 months old in the US is generally good, there remain problems with parental/caregiver food selection.⁹ Breast milk and/or infant formula provide a strong nutritional framework. At 6 months, a modest 20% additional energy is needed; by 12 months an additional 50%. The infant's need for iron and zinc is tantamount. Formerly, introduction of beef and iron-fortified cereals covered both well. Discouragement of red meat throughout the 20th century led to a dramatic fall in beef consumption. National Health and Nutrition Examination Survey (NHANES) data show that only 11.3% of infants are offered beef on any given day. Nearly as many infants are given deli meats and hot dogs, low in iron but high in sodium. Use of infant cereals has fallen with time too, creating the need for other sources of iron and zinc among CFs.^{10,11} Choices made by US caregivers could be strengthened for each of the 5 food groups. Inappropriate early introduction of cow's milk before 12 months is still found in 14-20% of infants. Powerful protein sources such as fish, eggs, and yogurt are not commonly utilized, yet snack type foods and desserts and soft drinks are often fed in over half the infants in the US. One-half of fruit servings are consumed as 100% juice. If juice is withheld until 12 months, as recommended, then caregivers must compensate with more whole fruit. Unfortunately, green vegetables are only offered to 6% and 7% of infants and toddlers, respectively, a percentage that changes little as the child ages.^{10,11}

Assuring a strong initial dietary pattern represents a new goal for parents/caregivers.⁹ The social and emotional exchange between infant and caregiver during meals is a factor in food enjoyment. Birth-to-24-month dietary guidance will need to emphasize parent/caregiver feeding style to ensure that the quality of CFs matches the extraordinary needs of early childhood. Parents/caregivers who encourage "play" with new foods can capitalize on the natural sensory and motor exploratory skills of the infant/toddler to increase new food acceptance.

Nutrient and energy needs are high between 12 and 24 months, and taste preferences and eating habits are being established. Fluid milk assumes a similar, but narrower role in the diet of toddlers once breast milk and infant formula are withdrawn. Our Western dietary pattern—high in saturated fats, sugars, starches, sodium and kilocalories, but low in nutrients—takes root during this period. Fifty percent of toddlers consume sweetened drinks and 90% consume added sugars daily, while nearly half consume potatoes and one-third consume sweetened cereals.^{11,12} Toddlers eat every 3-4 hours due to energy needs. Generally, toddlers consume 3 meals and 3 smaller eating sessions daily. Unfortunately, the term "snack" is applied to what should be considered mini-meals. Toddler snacks account for 288 kcal/day and many nutrients, such as fiber, Vitamins C, D, E, and B12, along with calcium, iron, zinc, and potassium.^{12,13} But the snacks also contain many foods high in energy but low in nutrients. Over 90% of US toddlers consume daily sweet-salty snack foods, and over 80% consume desserts. These foods lower diet quality scores among children and teens 2-5 years old (59.9), 6-11 years old (53.7), and 12-17 years old (52.3) (Healthy Eating Index, HEI, a global assessment of dietary pattern using 12 component categories and scoring a maximum of 100 points).¹⁴ Nearly ubiquitous among school age children, snack type foods account for 40% of daily calories.¹³

Approximately 8-10% of calories consumed by infants/toddlers are added sugars.^{12,15} There is no guidance for an acceptable amount in early life. Infants do not derive any benefit from added sugars. Toddlers may benefit from small amounts of added sugars used to promote new or high-quality food items.⁷ Added sugar consumption in the US has fallen more than 20% since 2000 to levels below those of the late 1970s. Despite that, obesity continues to rise.⁷ The DGA, the American Heart Association, and the World Health Organization have all promoted added sugar intake at less than 10% of total calories. This level was not based on data showing harm above the 10% level. Rather, the value was modeled: if a person consumes the recommended servings per day from each of the 5 food groups, then less than 10% of calories are available for added sugars.⁸ Currently, no nation in the world has a per capita added sugar intake below the 10% level. Systematic reviews and meta-analyses fail to show a correlation between added sugar consumption and obesity or between sugar intake and nutrient insufficiency until sugar intake exceeds 20-25% of total calories.^{16,17}

Five foods/beverages account for 75% added sugar intake in children: soft drinks, fruit-flavored drinks, grain desserts, other desserts, and candy (Fig. 1).^{8,18} Nutrient-rich foods that contain added sugars, such as yogurt, flavored milks, sweetened cereals, and 100% fruit juice, contribute little to total added sugar intake. But they do contribute substantially to diet quality.¹⁹ Nutrition advice in the 21st century should seek to improve diet quality. It's not the sugar as much as the nutrient contribution of the food containing sugar that matters.

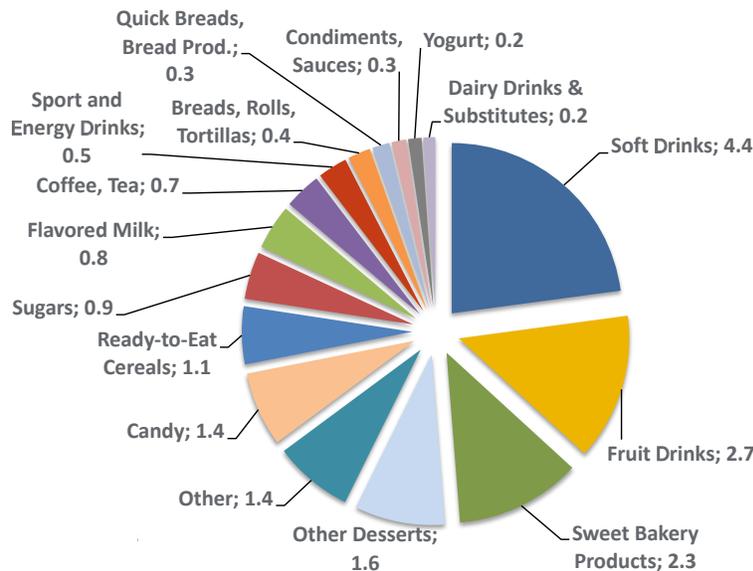


Fig 1. Added sugars in children's diets.
National Health and Nutrition Examination Survey (NHANES) 2007-2010,
2-18 years of age.

Values are teaspoons per day equivalents.

IMPORTANT NOTICE: Breastfeeding is best for babies and is recommended for as long as possible during infancy.

References:

1. Son'kin V, Tambovtseva R. Energy metabolism in children and adolescents. In: Clark K, ed. Bioenergetics. InTech Press; 2012:121-142. <http://www.intechopen.com/books/bioenergetics/energy-metabolism-in-children-and-adolescents>. Accessed July 10, 2018.
2. Bode L. Human milk oligosaccharides: every baby needs a sugar mama. *Glycobiology*. 2012;22(9):1147-1162.
3. Castanys-Munoz E, Martin MJ, Vazquez E. Building a beneficial microbiome from birth. *Adv Nutr*. 2016;7(2):323-330.
4. Canfora EE, Jocken JW, Blaak, EE. Short-chain fatty acids in control of body weight and insulin sensitivity. *Nat Rev Endocrinol*. 2015;11(10):577-591.
5. Tan J, McKenzie C, Potamitis M, Thorburn AN, Mackay CR, Macia L. The role of short-chain fatty acids in health and disease. *Adv Immunol*. 2014;121:91-119.

6. Holland D, Chang L, Ernst TM, et al. Structural growth trajectories and rates of change in the first 3 months of infant brain development. *JAMA Neurol.* 2014;71(10):1266-1274.
7. Murray RD. Savoring sweet: sugars in infant and toddler feeding. *Ann Nutr Metab.* 2017;70(Suppl 3):38-46.
8. U.S. Dept of Health and Human Services, U.S. Dept of Agriculture. 2015-2020 *Dietary Guidelines for Americans*. 8th Edition. December 2015. <http://health.gov/dietaryguidelines/2015/guidelines/>. Accessed July 10, 2018.
9. Pérez-Escamilla R, Segura-Pérez S, Lott M, et al. Feeding guidelines for infants and young toddlers: a responsive parenting approach. 2017:1095. <https://healthyeatingresearch.org/research/feeding-guidelines-for-infants-and-young-toddlers-a-responsive-parenting-approach/>. Accessed July 10, 2018.
10. Miles G, Siega-Riz AM. Trends in food and beverage consumption among infants and toddlers: 2005-2012. *Pediatrics.* 2017;139(6):e20163290.
11. Grimes CA, Szymlek-Gay EA, Campbell KJ, Nicklas TA. Food sources of total energy and nutrients among U.S. infants and toddlers: National Health and Nutrition Examination Survey 2005-2012. *Nutrients.* 2015;7(8):6797-6836.
12. Moshfegh AJ, Rhodes DG, Goldman, JD, Clemens JC. Characterizing the dietary landscape of children, 12 to 35 months old. *Nutr Today.* 2017;52 (suppl 2):s52-s59.
13. Hess J, Slavin J. Snacking for a cause: nutritional insufficiencies and excesses of U.S. children, a critical review of food consumption patterns and macronutrient and micronutrient intake of U.S. children. *Nutrients.* 2014;6(11):4750-4759.
14. National Center for Health Statistics. National Health and Nutrition Examination Survey. U.S. Department of Agriculture, Center for Nutrition Policy and Promotion, U.S. Department of Health and Human Services. *Healthy Eating Index-2010*. <https://www.childstats.gov/americaschildren/health6.asp>. https://www.cnpp.usda.gov/sites/default/files/healthy_eating_index/CNPPFactSheetNo2.pdf. Accessed July 10, 2018.
15. Welsh JA, Figueroa J. Intake of added sugars during the early toddler period. *Nutr Today.* 2017;52(suppl 2):S60-S68.
16. Rippe JM, Angelopoulos TJ. Relationship between added sugars consumption and chronic disease risk factors: current understanding. *Nutrients.* 2016;8(11):pii:E697.
17. Khan TA, Sievenpiper JL. Controversies about sugars: results from systematic reviews and meta-analyses on obesity, cardiometabolic disease and diabetes. *Eur J Nutr.* 2016; 55 (suppl 2):s25-s43.
18. Bailey RL, Fulgoni VL, Cowan AE, Gaine PC. Sources of added sugars in young children, adolescents, and adults with low and high intakes of added sugars. *Nutrients.* 2018;10(1):pii:E102.
19. Murray R, Bhatia J, American Academy of Pediatrics' Council on School Health, Committee on Nutrition. *Pediatrics.* 2015;135(3):575-583.