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The sensory and motor experiences associated with feeding, the type, variety, and timing of foods, their flavors, smells, and textures, as well as the social and emotional context of feeding, all contribute substantially to cognitive, social, and emotional maturation

Ann Nutr Metab 2017;70(suppl 3):38–46

Savoring Sweet: Sugars in Infant and Toddler Feeding

by Robert D. Murray

Key insights

A child's first taste experiences are primarily sweet, starting before birth and continuing throughout breastfeeding. Sweetness is not just of nutritive significance, but also invokes powerful social and emotional connotations for the infant. During the introduction of complementary feeding, infants gain exposure to a wide variety of novel foods and flavors. Not only do infants learn eating skills, but this phase also sets the stage for the child's later dietary habits. Parenting skills play a critical role in shaping the toddler's emerging dietary pattern, laying the groundwork for future eating habits and nutrition.

Current knowledge

The American Academy of Pediatrics Committee on Nutrition recommends that infants be introduced to solid foods as a complement to breastfeeding at around 6 months of age, although the exact timing depends upon the infant and the family circumstances. The primal response to sweetness is initially an advantage, when the sweetness of breastmilk encourages consumption and soothes the neonate. Later, however, the inappropriate introduction of sweetened non-milk solids and beverages increases the newborn's risk of later obesity and may discourage the acceptance of foods with bitter or sour tastes. Studies have shown that up to 60% of infants are introduced to foods and beverages containing added sugars, a major threat to diet quality.

Practical implications

The infant's natural preference for sweet taste can be harnessed to reinforce the introduction and acceptance of healthy items such as whole fruits and vegetables. The strategy of pairing sweet foods with those which are sour or bitter can help in gaining infant acceptance. Between 6 and 12 months of age, parents should introduce as many flavors, colors, textures, and tastes from the main food groups, coupled with breast milk or formula. Repeated exposure is important to achieve acceptance of a new food item: some infants may need to be exposed 10–15 times to an item before they accept it. Pairing bitter or sour foods with a familiar and well-liked food or flavor, such as sweet, salty, or fat (termed "flavor-flavor learning") may enhance acceptance.

Stage	Key goals	Strategy
6–12 months	Introduction of healthy complementary foods	– Introducing items with no added sugars – Pairing new foods with breast milk or formula – Encouraging exploration and repeated exposure to new food items
12–24 months	Acceptance of a variety of healthy foods in the diet	– Pairing new foods with familiar ones ("flavor-flavor learning") – Judicious use of salt, added fats, and sugars – Using persistence and repeated exposure to gain acceptance

Strategies for encouraging the acceptance of novel food items among infants and toddlers.

Recommended reading

Miles G, Siega-Riz AM: Trends in food and beverage consumption among infants and toddlers: 2005–2012. Pediatrics 2017; 139:e20163290.

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Sweetness: Developmental and Functional Effects

Annals of Nutrition & Metabolism

Ann Nutr Metab 2017;70(suppl 3):38–46
DOI: 10.1159/000479246

Published online: September 14, 2017

Savoring Sweet: Sugars in Infant and Toddler Feeding

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Key Messages

- **Sweetness from natural and added sugars is integral to the infant and toddler feeding experience.**
- **The timing, amount, and nutritional quality of complementary foods and beverages introduced from 6 to 24 months fuels not only the child's rapid physical growth but also the extensive expansion of the brain.**
- **Parenting skills are a critical factor in shaping the toddler's first dietary pattern, which lays a foundation for food preferences, eating habits, and future nutrition.**

Keywords

Complementary foods · Added sugars · Sweet · Infant · Toddler · Parenting · Dietary pattern

Abstract

During the first years of life, the sweetness of sugars has a capacity to hinder or to help in laying a strong nutritional foundation for food preferences that often extend over a lifetime. Aside from supplying 4 g/kcal of energy, sugars are non-nutritive. However, sugars have a powerful attribute, sweetness, which strongly influences human food preference. A child's first relationship with sweet taste begins even before birth and continues to evolve throughout complementary feeding. The sweetness of breastmilk encourages consumption and soothes the neonate. Conversely, inappropriate introduction of non-milk solids and beverages that are sweet at 0–4 months of age raises the newborn's risk for later obesity and may discourage the acceptance of other bitter or sour foods. Although cereals, fruits, 100% fruit juices, and some grains have naturally occurring sugars that impart sweet flavor notes, there is no clear role for added sugars between 6 and 12 months of age. Yet, 60% of infants are introduced to foods and beverages containing added sugars, threatening diet quality. Pairing foods with naturally occurring sugars, such as fruits, with foods that tend to be resisted initially, such as vegetables, can mask bitterness and promote acceptance. Utilizing the infants' extraordinary capacity for sensory-motor exploration is another strategy to expose them repeatedly to challenging tastes and flavors. The transitional year, as breast milk and infant formula are withdrawn, is a time when nutritional needs are high and diet quality often precarious. Rapid growth, along with brain and cognitive development, demand high-quality nutrition. Snacks are necessary both for energy and valuable nutrients. However, the selection of snack foods often exposes toddlers to items that offer concentrated energy with low nutrient value. Recent trends suggest a rapid fall in added sugars among infants and toddlers. Parenting practices that use small amounts of sugars to promote nutrient-rich foods from all 5 food groups can enhance rather than hinder their child's emerging dietary pattern.

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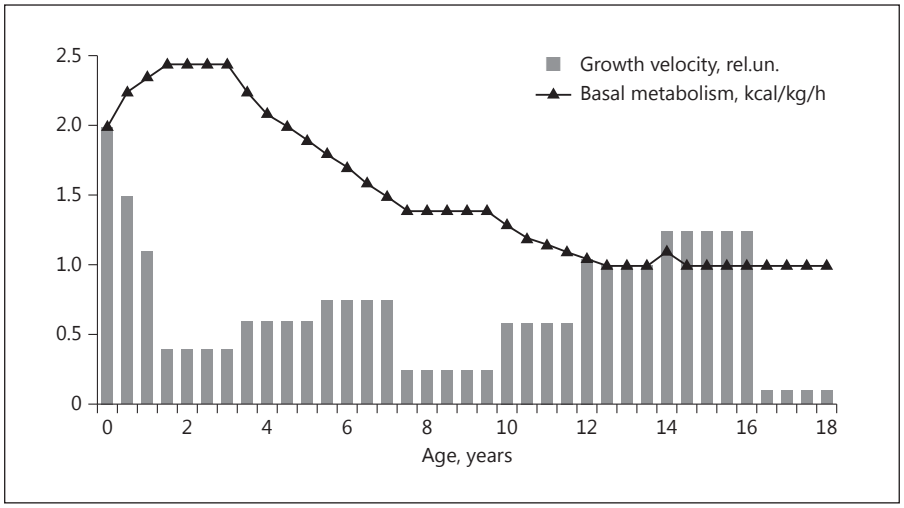

Fig. 1. Basal metabolic rate (BMR) of infants and toddlers relative to later life. Brain expansion, development, and daily function account for more than half of the BMR during the infant/toddler period. Adapted from Son'kin and Tambovtseva [2].

A Singular Need for Diet Quality

The first 1,000 days of life represent a true singularity. Growth and organ development established during fetal life continue after birth. Linear growth increases by 7 inches (18 cm) in the first year, another 4–5 inches in the second year, and doubles birth length by 5 years. Weight doubles in just 4 months and triples by a year, then quintuples by 5 years [1, 2]. However, nutrients in the first months not only support increased bone, muscle, and tissue mass but also are substantially utilized for the continuing development of several highly metabolic organs, such as the gastrointestinal (GI) tract, the immune system, the central nervous system, the cardio-respiratory system, and the kidneys. As a result, a human's maximal basal metabolic rate (BMR) occurs during the first few years.

More than just a food source, breast milk is a complex bioactive fluid with a broad array of components that aid immunity, promote digestion, regulate hormonal signaling, stimulate organ development, modulate inflammation, and ensure a stable transition to postnatal life [3, 4]. Breast milk stimulates rapid postnatal organ maturation, particularly of the GI tract and brain. Motility, which is rudimentary at birth, coordinates over months, paralleling changes in the gut nervous system. Similarly, gastric, intestinal, and pancreatic digestive functions develop gradually in response to daily exposure to nutrients [5]. In essence, the GI tract refines its absorptive, nervous, and immune functions through a process of sampling, analyzing, responding to, and signaling the body about the contents of swallowed material, including nutrients, allergens, microbes, and a variety of chemicals. An entire secondary digestive system is established through bacterial colonization, a process that leads to a stable, protective symbiosis by the age of 2 years [6, 7]. Colonization patterns differ between breastfed and formula-fed babies, vaginal and C-section babies, term and preterm babies. The choice of feeding affects the microflora, which in turn affects GI function, stimulates the gut immune system, and helps to set the body's metabolism during this critical window of time [3].

Over half of the infant's BMR is accounted for by brain development alone [2] (Fig. 1). At delivery, information from all 5 senses begins to trigger synaptogenesis, forming connections at a rate estimated to approach 700 per second [8]. Starting with a simple "birthday kit" of rudimentary reflexes, the infant will engage in intense daily sensory-motor exploration, resulting in increasingly complex skills that correlate with brain expansion. By 12 months, the infant brain will have doubled and by 36 months tripled in volume to nearly 85% of its ultimate adult size, based almost exclusively on synapse formation and myelination of axons [8]. The singular expansion of neuronal connections and brain volume in the first years presents a vital need for many different nutrients (Table 1).

During this critical period, feeding has consequences far beyond corporal growth. The sensory and motor experiences associated with feeding, the type, variety, and timing of foods, their flavors, smells, and textures, as well as the social and emotional context of feeding, all contribute substantially to cognitive, social, and emotional maturation [9]. All higher cognitive performance is based on this platform of sensory and motor development [8]. Just

Table 1. Nutrient roles in brain growth, development, and function

Vitamin B_1 (thiamine)	rapidly depleted; glucose utilization; modulation of cognition; language development; neurotransmitter synthesis and mood
Vitamins B_1, B_6, B_{12}, and choline, tryptophan, tyrosine, histidine, threonine, copper	synthesis of neurotransmitters
Vitamin B_{12}	cognition, language, myelination
Vitamin C	antioxidant protection; cognition; hippocampal development and spatial memory; myelin production
Vitamin D	prevention of neuronal damage; dopamine development
Vitamin E	antioxidant protection; cell membrane integrity; omega-3 fatty acid (DHA) protection;
Flavonoids/phytonutrients	protect neuronal integrity and enhance function; anti-inflammatory; promote memory, learning, cognition; neurogenesis
Iron	oxygen delivery; synthesis and integrity of myelin; neurotransmitter synthesis; information processing; hippocampal structure and memory
Magnesium	energy; ion regulation; neural plasticity; neuroprotection
Zinc	axonal and synaptic transmission; enzymatic control of cell proliferation and neurogenesis; taste perception; neuromotor function
Iodine	(via thyroid) cellular energy metabolism
Omega-3 PUFA	cognition, visual development
Lutein	macular protection; concentrates in infant hippocampus and visual, auditory, and frontal cortex; optical density correlates with processing speed, language, memory

as linear growth, weight gain, and tissue enlargement depend on complete, quality nutrition, so too does the development and function of the brain. A child's attention span, affect, learning capacity, memory, and motivation all are affected by diet quality [9–11].

Sweetness Supports the Newborn

Due to the combined nutritive and bioactive properties of breast milk, the American Academy of Pediatrics (AAP) strongly encourages its introduction for every baby, including premature infants, from the first feeding and throughout the first year [1]. It has long been known that breast milk's hedonic properties encourage avid sucking and higher volume intake by the newborn [12–14]. Newborns have an innate preference for sweet flavor. Human milk contains 7 g/100 mL of lactose, which equates to the sweetness intensity equivalent to a 2.12% sucrose solution, much higher than cow or goat milk [15]. Human milk also contains the odorants furaneol and maltol, both of which have a sweet caramelized smell [16]. In humans, evidence of a preference for sweetness has even been reported before birth. When the non-nutritive sweetener saccharin was injected into the amniotic fluid of the mother, the fetus swallowed more rapidly [16]. Likewise, newborns (term and preterm) given sucrose increased the frequency and strength of sucking, relative to water or an unflavored pacifier. Irrespective of calories, sweetness evokes a positive hedonic response across the lifespan. Infants and children consistently prefer more concentrated sucrose than adults do. This affective response may result from energy needs related to their rapid growth and high BMR. Infant preferences can be assessed by 2 complementary research methods: observation and coding of facial responses and consumption of solutions that vary in taste and concentration [17, 18].

Learned associations between feeding and nurturing start to reinforce the infant's hardwired preference for

sweetness from the first day of life. The nursing newborn quickly associates the satiating sweetness of milk with the nurturing closeness of maternal contact, linking sensations of warmth, touch, taste, and smell. The newborn brain shows widespread cortical activation during the act of breastfeeding, including hypothalamic, limbic, and brain stem areas [19, 20]. Brain responses during feeding reflect the pleasurable tastes and smells, the satiation of hunger, as well as the calming, and even analgesic, effects of consuming milk.

Breast milk also provides infants with their first experiences with the complex flavors of food by passing sensory elements from the maternal diet directly to the baby. Studies suggest that these ever-changing flavor notes prime the newborn for later acceptance of novel foods and beverages when they are introduced [21]. Taste, touch, and smell during feeding are integrated by the newborn's brain to form perceptions that we characterize as flavor [22]. In this way, feeding serves as an integral part of the daily sensory-motor exploration that typifies infants' first year of life and contributes directly to their brain development. Infant formulas have been designed to mirror the macro- and micronutrients of breast milk and more recently have incorporated its first bioactive ingredient, human milk oligosaccharides. Lactose in infant formula offers the bottle-fed infant the same sweetness as breast milk, but formula cannot deliver the complex, ever-changing flavors, smells, and mouth feel experienced by the breast fed infant.

Feeding serves as an integral part of the daily sensory-motor exploration that typifies infants' first year of life and contributes directly to their brain development

Inappropriate Early Introduction of Complementary Foods

Parental and caregiver feeding trends for infants and toddlers are tracked through the National Health and Examination Survey (NHANES), a nationally representative, cross-sectional survey on the nutrition and health status of the US population conducted by the National Center for Health Statistics, in which participants complete in-home interviews, physical examinations, dietary interviews, and post-examination components [23]. Additional data are available through the Nestlé Feeding Infants and Toddler Study (FITS), a recurring cross-sectional survey of feeding among a representative sample of US children from birth to 4 years, overseen by researchers within the Gerber Medical Division [24, 25].

The AAP recommends exclusive breastfeeding for the first 6 months as ideal. No other solids or liquids except breastmilk or commercial infant formula should be offered until the infant is at least 4–6 months of age, with the exception of fluoride and iron supplementation for specific populations [1]. A recent review of NHANES data was conducted examining infant feeding over 2 different time periods (2005–2008 and 2009–2012) [26]. Breast and infant formula feeding rates remained stable, with formula being more commonly consumed. Early introduction of non-milk items declined significantly from 50.4 to 39.6% of infants during this span, largely due to falling consumption of infant cereals and fruit juices in the first 5 months of life. The most commonly offered items were sweet tasting: infant cereals (25.9%), fruits (13.6%), and 100% fruit juice. Of note, consumption of the latter fell sharply from almost 13 to 6.5% of infants between the two survey periods. Offerings of snacks, desserts, and sweetened beverages did not change over time, with inappropriate exposure still seen in 5% of infants [26]. The reasons for caregivers offering non-milk foods in the first 6 months are varied, but one important factor may be confusion over conflicting messages about whether foods should initially be offered after 4 months, "around 6 months," or after 6 months of age [1, 27, 28].

The Introduction to Complementary Feeding: 6–12 Months

Complementary feeding (CF), the provision of first non-milk foods and beverages, is necessary not merely to boost energy and nutrients at a critical period of growth, but equally to ensure acceptance of a wide variety of novel foods and flavors [17, 29, 30]. With time, CF also should introduce increasingly complex food textures, developing the infant's nascent chewing and swallowing skills [31]. Encouraging food acceptance entails not only food selection, but also positive parenting behaviors that promote their consumption [17, 30]. This phase of feeding sets the stage for the toddler's first appreciable dietary pattern, the components of which generally remain relatively stable after 24 months of age.

The AAP Committee on Nutrition recommends that infants be introduced to solid foods as a complement to milk-based feeding "around 6 months of age" [1]. This is not based solely on chronologic age. The infant's devel-

opmental and physical readiness, feeding behavior, and need for additional age-appropriate nutrients are important considerations [1, 32]. Against a backdrop of rapid growth in height, weight, and brain volume, as reflected by an extremely high BMR, consistent provision of nutrient-rich foods is a fundamental goal. Importantly, during this time, breast milk and/or infant formula continue to provide the primary nutritional foundation, supporting the infant as CF foods are expanded gradually. Health Canada guidelines [33] note that from 6 to 8 months CF should ensure about one-fifth of total daily energy, while from 9 to 11 months, one-half.

Breast milk, infant formula, and baby foods combined to contribute 73.5% of total energy intake among infants aged 6–12 months and they remained important sources of macro- and micronutrients over the first year, but to a diminishing extent as other foods were added to the infant diet [34]. Additional sources of total energy, contributing at least 2% to the diets of 6- to 12-month-old infants, were cow milk, fruits, and mixed grain-based dishes. Inappropriate introduction of cow milk prior to 12 months was noted in 14%, but this has been declining with time [26, 34, 35]. Fruits, baby beverages, and 100% juice combined to contribute roughly 3–4% to total carbohydrates, with sweet grain desserts contributing another 1.8% [34]. 100% fruit juice contributed only 1.5% of daily energy, but comprised over one-half of all the fruit servings consumed. Concerns about the frequency of low-nutrient foods offered to infants, as well as the overrepresentation of a few individual food items, such as sugars, starches, and juices, has led to close scrutiny of CF [30, 36–38]. The contribution of 100% juice to total energy is small among 6- to 12-month-olds and generally is consumed within the guidelines of the AAP, providing a valuable source of nutrients [39]. However, in a recent revision of the 2005 AAP policy statement on 100% juice consumption, the Committee on Nutrition urged that 100% juice be excluded from the 6- to 12-month CF recommendations [40]. The committee was concerned about reinforcing intensely sweet preferences early in the exploratory phase of eating. The Committee on Nutrition also theorized that minimizing sweet liquids might lessen future consumption of sweet beverages, lowering the risk for obesity. A recent meta-analysis by Auerbach et al. [41] found almost no support for a connection between 100% juice and obesity, however.

The infant's preference for sweet is easily reinforced during the 6- to 12-month stage of complementary food exploration, often to the detriment of diet quality [17, 42]. Consumption of sugar-sweetened beverages (other than breast milk, infant formula, or 100% fruit juice) was noted in 25% of 6- to 12-month-olds and in 50% of 12- to 24-month-olds [26, 35]. Acceptable toddler daily limits for added sugars have not been set, but for children over the age of 2 years and for adults, both the DGA and the WHO have recommended a limit for added sugars of <10% of total energy [43, 44]. Promoting food acceptance in the 6- to 12-month period entails a conscious effort to introduce the baby to as many different flavors, colors, textures, and taste combinations as possible from each of the 5 food groups: fruits, vegetables, (whole) grains, dairy, and protein sources. If caregivers regularly offer a rotating variety of food experiences throughout the day of nutrient-rich foods in appropriate serving sizes, coupled with 32 ounces per day of breast milk or iron-containing infant formula, there will be little room for added sugars [26, 45].

Research suggests that repeated exposure is central to infant acceptance of novel CF. Young children learn to prefer familiar foods [17, 30]. Neophobia – the resistance to trying new tastes or textures – is a reflection of infant temperament and of the intensity of the infant's perception of a bitter sensation. Other factors include the feeding environment, parental expectations, distractions, lack of feeding routines, and family eating habits [29]. The number of exposures needed to induce acceptance of novel flavors and textures may exceed 10 or even 15 times [17, 30, 42]. It is incumbent on caregivers to persist in offering new foods repeatedly and in novel ways, especially those that were rejected initially. Bitter or sour foods may be more readily tried if offered first when hunger is highest.

The strategy of pairing sweet flavored foods with foods on the bitter end of the spectrum also can be helpful [17, 25]. The duality between preference for sweet and aversion to bitter and sour is a crucial factor for successful CF from 6 to 12 months. As innately preferred tastes, saltiness and sweetness can be used to mask or minimize less pleasant, largely bitter tastes in novel foods. When paired together, using a strategy termed "associative" or "flavor-flavor" learning, tastes and flavors with high likability can be utilized to encourage acceptance of foods commonly rejected [16, 17]. However, fruits with naturally occurring sugars can be used to the same advantage during this period as foods with added sugars, leading many experts to question whether added sugars have any role in CF during the 6- to 12-month period [33, 45].

The young child uses seeing, touching, smelling, tasting, and eventually swallowing of novel foods as the path to gradual acceptance [17, 29]. The standard practice of

exposing the infant to new flavors, smells, tastes, and textures through spoon-feeding by an adult may not be the only or the best strategy. A baby-led approach to feeding has been advocated in which advances in CF are determined and directed by the baby, relying on the child's curiosity [46–49]. This type of self-feeding mirrors the strategy used by Clara Davis in her landmark studies on toddler self-feeding in the 1920s [50]. Although the research is still in an early stage, baby-led weaning may have much to offer as a strategy to encourage acceptance of novel foods through exploration and repeated exposure.

Transitional Year CF: 12–24 Months

The transition period is arguably the most important year in human nutrition for a variety of reasons: (1) high energy and nutrient needs to support rapid linear and organic growth, coupled with continued organic development, (2) extensive expansion and wiring of brain due to sensory and motor exploration, including that during feeding, (3) formative first experiences with a variety of foods, (4) establishment of food and flavor preferences, as well as eating habits, and (5) development of social, emotional, and cognitive skills. All require sound nutrition.

Added sugars and sweet flavors can have a positive impact if limited in quantity and associated with nutrient-rich foods

In the transition year, sweetness and sugars show both positive and negative effects on the toddler diet. Breast milk and/or formula are usually replaced by cow milk in the second year [38]. Less reliance on milks requires a greater emphasis on consuming CF. Baby foods are replaced by finger foods, table foods, and eventually family foods. Snacks assume an influential role in the diet. The toddler's acceptance of new CF becomes a crucial factor in diet quality. Because this transition can be challenging for many toddlers, some researchers have suggested extending breastfeeding, formula feeding, or the use of "growing-up milks" well into the second year [51, 52], although the majority of toddlers have energy and nutrient intakes that appear to match recommendations [35, 53–55].

The dietary pattern of the toddler and its future effect on development, health, and academic outcomes is a burgeoning area of research [11, 38, 56–58]. The DGA 2015 [43] described the concept of a dietary pattern by stating that, "over the course of any given day, week, or year, individuals consume foods and beverages in combination – an eating pattern. An eating pattern is more than the sum of its parts; it represents the totality of what individuals habitually eat and drink, and these dietary components act synergistically in relation to health." Within the toddler dietary pattern, added sugars and sweet flavors can have a positive impact if limited in quantity and associated with nutrient-rich foods. Yet, current surveys raise several concerns about the timing, amount, and overall contribution of sugars to the toddler dietary pattern [26, 34, 35, 37, 38].

Moshfegh and colleagues [35, 54] described current dietary intakes among toddlers between 1 and 2 years of age based on the "What We Eat in America" component of the 2011–2012 NHANES. Energy averaged 1,335 kcal/day over this period, with daily energy increasing from 1,201 to 1,441 kcal between 12 and 24 months, respectively. Carbohydrates comprised 55% of daily energy, with total sugars making up one-half of those calories. Natural sugars comprised 40% of total energy, mostly from dairy sources, while added sugars contributed an average of 10%. Moshfegh et al. [35] noted that 40% of the toddlers were consuming more than the 10% average.

Miles and Siega-Riz [26] examined trends in toddler feeding between 2005 and 2012 using the NHANES data. The more recent survey showed a further fall in vegetable intake in the transition year, along with no discernable improvement in whole fruit. On the other hand, the survey found a marked decline in infant cookies and biscuits at 6–12 months that carried over into the 12- to 24-month period, with cookies and sweets falling steeply. However, the authors cited wide differences among non-Hispanic white, non-Hispanic blacks, and Mexican-Americans in terms of food and beverage trends during the CF period. The decline in sugar consumption among infants and toddlers mirrors that of the US population generally, with a steadily falling consumption since 2000, despite a continued rise in obesity rates (Fig. 2) [26, 59, 60].

Combining NHANES 2009–2010 data with the Food Patterns Equivalent Database, Welsh and Figueroa [36] looked specifically at total and added sugars in the diets of toddlers aged 1–2 years. In their analysis, nearly all toddlers (99%) were found to consume some added sugars daily, accounting for 8.4% of their total daily energy. Between 6 and 24 months, added sugar intake rose linearly. Previous research indicates that added sugars will continue to climb in the preschool- and school-age years, accounting for nearly 17% of daily energy in adolescence

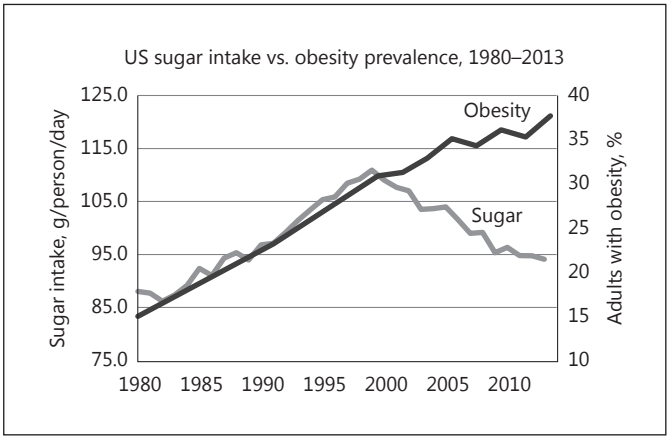

Fig. 2. Since 2000, as obesity rates have continued to rise, consumption of sugars has fallen sharply among the US population, including infants and toddlers, with sweetened drinks and candies leading the fall. Reprinted with permission from Guyenet [60].

[59]. High-energy, low-quality foods were commonly offered to toddlers between 6 and 24 months. For instance, 1 in 3 toddlers consumed candy, 2 in 5 consumed dessert items, such as cakes, cookies, and pastries, while 1 in 10 consumed frozen dairy desserts [35]. Nutrient-rich items, such as yogurt, sweetened fruits, and sweetened cereals also contributed added sugars, but added substantially to the nutrient pool as well [36]. Grimes et al. [34] pointed out several sources of added sugars or naturally sweet-tasting foods and beverages that provide a wide array of nutrients to the toddler dietary pattern, including milks, yogurts, cereals, grain-based products, 100% fruit juices, baby foods, fruits, and starchy vegetables.

Beverages accounted for 25% of a toddler's daily energy. Milk, the most common beverage, contributed the most nutrients and the most energy among the category [26, 35, 36]. Milk, mainly whole milk, was consumed by 80% of toddlers at least once daily, averaging 1¾ cups per day, close to recommendations. Milk was followed by water and 100% fruit juice [35, 36]. Other beverages with added sugars included sweetened fruit drinks (24%), soft drinks (6–14%), and flavored milks (7–9%). Sweetened juices and drinks were the leading source of added sugars. Of the 26 g/day average intake of added sugars, 10.5 g were attributed to beverages [36]. However, a recent NHANES analysis from 2013–2014, showed a sharp falloff in the consumption of 100% fruit juice (–16%), fruit drinks (–9%), and soft drinks (–13%) over the prior decade [35]. Added sugars from beverages contributed only 2.7% to the total daily energy of 12- to 24-month-old children. Still, studies show that after the transition year, sweetened beverage consumption rises steadily throughout childhood and adolescence [36].

Almost 100% of US children and adolescents snack at least once daily [61]. Snacks are necessary for young children in order to augment daily energy and provide crucial micronutrients [62]. Yet, many caregivers described snacks as an emotional indulgence, independent of the child's primary diet [63]. The most recent NHANES data show that daily snacking frequency among toddlers has increased from 69 to 98% prevalence over the past 3 decades. There has been a corresponding rise in the contribution of snacks to total daily energy, from 16% in 1977 to 31% in 2014, accounting for more daily calories than are consumed at breakfast, lunch, or dinner meals [35]. FITS 2008 data on a low-income population showed that nearly half were given 3–4 snacks per day [59]. On the other hand, the nutrient profile derived from toddler snacking is generally good [34, 35, 59]. NHANES data showed that snacking not only contributed 20% of protein, 35% of carbohydrate, 42% of total fat, and 32% of saturated fat, but also 25% of daily fiber, 35% of calcium, over 20% of iron, 31% of potassium, and approximately 35% of vitamins C, D, and E [35].

The white potato accounted for one-third of all vegetables among infants and one-half among toddlers [26]. Although yellow vegetables were consumed by nearly 50% during the 6- to 12-month period, mostly from baby food, fewer than 20% consumed them in the second year. Green vegetables were consumed by only 7.5% of toddlers, despite decades of public health admonitions. Pairing bitter or sour foods with a familiar and well-liked food or flavor, such as sweet, salty, or fat, (so-called "flavor-flavor learning") has been suggested to enhance acceptance [17]. Some but not all studies have shown that small amounts of sugar or salt help overcome a young child's resistance. A recent AAP policy statement suggested that small amounts of fats, sodium, and added sugars should be utilized specifically to promote increased consumption of nutrient-rich foods in all 5 food groups [64].

An ideal upper limit for the contribution of total and added sugars to total daily energy has not been established for toddlers. For children above the age of 2 years, as well as adolescents and adults, the DGA 2015 and the WHO both have recommended that added sugars be limited to less than 10 percent [43, 44]. This limit was not established using toxicity data, but rather was based on modeling of food patterns with varying intakes of added sugars. To meet food group and nutrient needs within appropriate calorie limits, added sugars needed to contrib-

ute less than 10% of energy. Similar modeling of CF within the toddler dietary pattern has not been done. Still, the same rationale applies. Thoughtful use of added sugars tied with high-nutrient foods and beverages may aid consumption of nutrient-laden foods among toddlers in this crucial phase of life.

Sweetness is a central component of the feeding experiences of the fetus, infant, and toddler. Both natural and added sugars comprise a substantial part of daily carbohydrate intake. Research suggests that early food preferences track over the lifespan. This has raised concerns that early eating habits may fuel obesity. However, obesity is a complex, multifactorial disorder and not solely the result of diet. Although many caregivers use added sugars at inappropriate times, in excessive portions, and too commonly, it is not the whole story. Added sugars also encourage the consumption of nutrient-rich foods, which are vital to the growth and development of the young child. They make eating and drinking pleasurable. Paired with other flavor components, natural and added sugars may be a valuable tool to help the young child assimilate less readily accepted foods, enhance diet quality, and lay a strong foundation for life-long nutrition.

Disclosure Statement

Dr. Murray is on the speaker's bureau for Abbott Nutrition and the American Dairy Association. He also serves as a consultant for Dannon Co., the National Dairy Association, The American Egg Council, the National Cattleman's Beef Association, Sabra Dipping Co., and the Hass Avocado Board. The writing of this article was supported by Nestlé Nutrition Institute.

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