FOCUS

Exposure to different flavors early in life

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Complementary Foods and Flavor Experiences: Setting the Foundation

by Julie A. Mennella and Jillian C. Trabulsi

Key insights

This article focuses on weaning in terms of infant nutrient needs and the effects of early exposure on later food acceptance.

Current knowledge

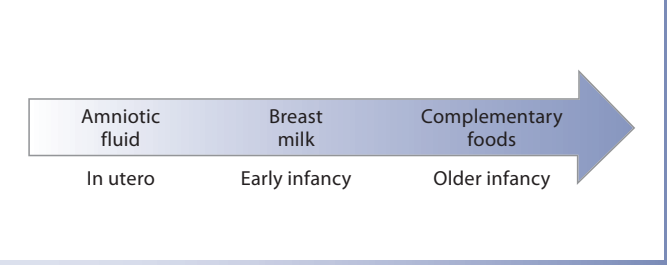
The transition from an exclusive liquid diet in early infancy to a diet that includes solid foods in late infancy is an important milestone. Many flavors that mothers either ingest or inhale are transmitted to their milk and/or amniotic fluid. Evidence from experimental research suggests that early experiences influence later eating patterns, due to inherent plasticity in the development of the chemical senses, which interact with early-life experiences to ensure that a child is not restricted to a narrow range of foodstuffs.

Practical implications

Because infants consume more of foods that have a familiar flavor, mothers should eat a variety of foods during pregnancy and lactation and be encouraged to breastfeed. Complementary foods offered to the infant should be nutrient rich and varied. Mothers should be encouraged to provide repeated taste opportunities for their infants to learn to like the taste of a new food. They should focus on their infants' willingness to eat the food and not just the facial expressions made during feeding. They should also be made aware that, with repeated dietary exposure, it may take longer to observe changes in facial expressions than intake.

Recommended reading

Forestell CA, Mennella JA: Early determinants of fruit and vegetable acceptance. Pediatrics 2007;120:1247–1254.



Continuum of opportunities for early exposure to flavor of vegetables/fruits during infancy. Exposure to different flavors begins early in life. Infants learn about flavors prior to their first taste of solid food via amniotic fluid/breast milk. Maternal/family diet plays a critical role in the timing and types of flavors and types of complementary foods proffered to the child.

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Complementary Foods and Flavor Experiences: Setting the Foundation

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Key Messages

- **Infants can discriminate the flavors of different fruits and vegetables, and both tasting specific foods and experiencing a variety of flavors promote the willingness to eat varied foods. Mothers should introduce their infants repeatedly to a variety of nutrient-rich fruits and vegetables, both within and between meals, and provide novel flavors along with a familiar food to help accustom infants to novel foods.**
- **Many flavors that mothers either ingest or inhale are transmitted to their milk and/or amniotic fluid. Since infants consume more of foods that have a familiar flavor, mothers should eat a variety of foods during pregnancy and lactation and be encouraged to breastfeed.**
- **Mothers may be unaware of infants' increased acceptance during repeated exposures to some bitter vegetables (e.g. green beans) and may give up too soon. Mothers should not focus on the infants' facial expressions but rather on their willingness to eat the food and continue to provide repeated taste opportunities.**

Key Words

Breastfeeding · Complementary feeding · First-food acceptance · Flavor variety · Health outcomes · Infant nutrition · Taste

Abstract

Increased fruit and vegetable consumption early in life may lead to life-long intake of fruits and vegetables, which in turn may be beneficial for weight control and other health outcomes in later life. Although health officials worldwide recommend delaying solid foods until 6 months of age, younger infants often receive solid food, which may affect later obesity rates. The timing of introduction to solid foods is important both nutritionally and developmentally and may affect acceptance of foods both in infancy and later in life. Infants can clearly discriminate the flavors of different fruits and vegetables. Repeated flavor experiences promote the willingness to eat a variety of foods: infants will consume more of foods that have a familiar flavor and are more accepting of novel flavors if they have experience with flavor variety. Many flavors that the mother either ingests or inhales are transmitted to her milk and/or amniotic fluid. Moth-

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ers can help the transition from a diet exclusively of milk or formula to a mixed diet by providing the infant familiar flavors in both milk or formula and solid foods. Exposure to a variety of flavors during and between meals appears to facilitate acceptance of novel foods. Providing novelty in the context of a familiar food might prove to be an optimal combination to progressively accustom infants to a diversity of novel foods. When repeatedly exposing infants to flavors of some vegetables that have bitter tastes, mothers should focus not on infants' facial expressions but on their willingness to eat the food and should continue to provide repeated opportunities to taste the food. Introducing children repeatedly to individual as well as a variety of fruits and vegetables, both within and between meals, might help them be more accepting of fruits and vegetables, which is difficult to enhance beyond toddlerhood.

Introduction

During the first year of life, infants make the dramatic transition from an exclusively liquid diet to a mixed diet consisting of milk and a variety of complementary foods. The transition is necessary to address changing nutrient requirements of the growing infant and to prepare for the eventual cessation of breastfeeding or formula feeding in early childhood. The nutrient needs of the weaning infant must be met by a combination of the liquid diet and complementary foods, so it is important to provide nutrient-rich complementary foods. During this transition, the infant is likely to encounter a wide range of flavors and textures; the infant must have the oral-motor functioning skills and, in some cases, the manual skills needed to ingest such foods. Thus, it is not surprising that concerns about the introduction to complementary foods represent one of the primary matters discussed by mothers with their pediatrician [1]. This poses a challenge for health care providers because little evidence-based research addresses optimal complementary foods, or whether there is an optimal way to introduce these foods into the diet [2]. This paper focuses on complementary foods by first reviewing infant nutrient needs and then describing how mothers can help build the important foundation that early-life diet sets for later-life diet and health outcome.

Developmental and Nutritional Perspectives of Complementary Foods

Human milk is recognized by health authorities globally as the preferred source of nutrition for infants [3–6]. In adequately nourished mothers, human milk contains the essential macronutrients, vitamins, and minerals required for healthy infant growth and development during early infancy [4, 7]. The concentration of vitamin D in human milk is notably low [8, 9], and vitamin D supplementation for all breastfed and partially breastfed infants is recommended by some health authorities [10]. Additionally, adequate exposure to sunlight or supplementation with vitamin D for the lactating mother [11, 12] has been shown to increase circulating concentrations of 25-hydroxy-vitamin D in both the mother and infant. Human milk also contains numerous biologic components thought to confer nutritional and immunologic benefits throughout infancy, such as immunoglobulins, lysozymes, lactoferrin, α-lactalbumin, and oligosaccharides [13–15].

As the infant ages, transition to a solid food diet is important for both developmental and nutritional reasons. The introduction of solid foods is important developmentally because it may affect acceptance of foods both in infancy and later in life. Compared to infants introduced to solid foods between 6 and 9 months of age, infants introduced to solid foods at 10 months of age or later consumed fewer solid foods of all kinds and were less likely to be eating foods on the family table at 15 months of age [16]. A follow-up study of these same infants found that at 7 years of age, those introduced to lumpy solids after 9 months of age ate less of many food groups, including all 10 categories of fruit and vegetables, and were reported as having significantly more feeding problems, compared to those who were introduced to lumpy foods between 6 and 9 months of age [17]. However, we caution that these studies are associational and thus cannot reveal cause and effect.

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The transition to solid foods in the diet is important nutritionally because the requirements for iron, zinc, and several other nutrients are greater in older infants (6–12 months old) than in early infancy (0–6 months of age) [18]. Thus, the nutrients provided by complementary/solid foods in the diet are of great nutritional importance to the older infant.

Increasing evidence indicates that there are critical or sensitive periods in life during which nutrition and growth may have a programming or long-lasting effect on later-life health outcomes, such as obesity [19]. One such period is infancy. Infants with high weight gain velocity ('rapid' weight gain) or greater increases in weight for length have been shown to have a higher body mass index and higher percent body fat at 6 months of age compared to their 'normal'-growing counterparts [20–22]. Further, numerous studies have shown that rapid weight gain in infancy is an independent risk factor for overweight and obesity in both childhood and adulthood [23–28]. Further research is needed to determine if the impact of increasing fruit and vegetable consumption in older infancy affects weight gain in infants at high risk for rapid gain.

Guidance on Complementary Feeding

Health authorities worldwide have similar recommendations regarding the age at which complementary foods should be introduced. The American Academy of Pediatrics Policy Statement on 'Breastfeeding and the Use of Human Milk' states that 'complementary foods rich in iron should be introduced around 6 months of age' and that 'unique needs of individual infants may warrant introduction as early as 4 months of age whereas other infants may not be ready to accept other foods until approximately 8 months of age' [29], while the American Academy of Pediatrics Committee on Nutrition states that 'complementary foods may be introduced between 4 and 6 months of age on the basis of developmental readiness and nutritional needs' [3, 30]. According to the European Society for Pediatric Gastroenterology and Nutrition, 'exclusive or full breast-feeding for around 6 months is a desirable goal', and 'complementary food should not be introduced to the diet of any infant before 17 weeks and all infants should start complementary feeding by 26 weeks of age' [31]. According to the World Health Organization, 'infants should be exclusively breastfed for the first 6 months of life […] thereafter, infants should receive nutritionally adequate and safe complementary food' [6].

The timing of complementary food introduction has been proposed to affect later-life health outcomes such as obesity, with the hypothesis being that early an introduction may increase obesity risk [32–36]. However, a recent systematic review of the literature found mixed results and concluded that there is no clear association between timing of the introduction of solid food and risk of overweight and obesity in infancy and childhood [37]. Furthermore, both duration of breastfeeding and feeding type (human milk vs. infant formula) are risk factors for obesity [38–41], yet not all studies adjusted for these confounders. One recent study that did stratify subjects by feeding type found the introduction of solid foods before the age of 4 months to be associated with a 6-fold increase in the odds of obesity at age 3 years in formula-fed infants only [42]. Thus, there is some associational evidence that food experiences of infants, including timing of the introduction of complementary foods, can interact to affect later-life health.

Guidance on the type of complementary foods that should be included in the diet of older infants has been put forth by health authorities worldwide.

Guidance on the type of complementary foods that should be included in the diet of older infants has been put forth by health authorities worldwide; table 1 summarizes the principles related to assuring adequate nutrient intake from complementary foods. It should be noted that guidance on the quantity of complementary food that should be included in the diet of older infants is less common.

Complementary Food Introduction

Current Feeding Practice

Despite the recommendations of health authorities worldwide, data on current feeding practices suggest that the introduction of solid foods before 6 months of age is common in many countries [43–45]. The 2002 and 2008 Feeding Infants and Toddlers Studies [43, 46], designed to update knowledge on the feeding patterns of American children, revealed that despite the recommendations to delay the introduction of solid foods, 10.9% of infants between 0 and 3.9 months of age had received solid foods, predominately in the form of infant cereal; by 4–6 months of age, half of the infants had received infant cereal [43, 47]. The proportion of 6.0- to 8.9- and 9.0- to 11.9-month-old infants who consumed any fruit or juice on a given day was 64.5 and 80.6%, respectively, and in these same age groups, the proportion of infants who consumed any vegetable was 62.8 and 72.3% [43]. But perhaps more

Table 1. Recommendations by worldwide authorities for types of foods to include in the complementary diet

Authority	Principles
American Academy of Pediatrics [30]	• Introduce 'single-ingredient' foods, one new food at a time. • Choose foods that provide key nutrients and help meet energy needs (iron-fortified infant cereals and pureed meats are recommended as first foods because of their high protein, iron, and zinc content). • Introduce a variety of foods by the end of the first year. • Do not give cow's milk (or other milks not specifically formulated for infants) during the first year of life. • Ensure adequate calcium intake from complementary foods. • Do not give fruit juice until 6 months of age; thereafter, limit fruit juice to 4–6 oz/day of 100% juice.
European Society for Pediatric Gastroenterology and Nutrition [31]	• Complementary foods should be added one at a time to allow detection of reaction to individual components. • During the complementary feeding period, >90% of iron requirements of a breastfed infant must be met by complementary foods; foods should be a good source of bioavailable iron. • Cow's milk should not be provided as the main milk before 12 months of age. • It is prudent to avoid both early (<4 months) and late (≥7 months) introduction of gluten and to introduce gluten gradually. • Infants receiving a vegetarian diet should receive a sufficient amount (~500 ml) of milk (breast milk or formula) and dairy products. • A vegan diet should not be given to infants and young children. • Fat content of the complementary diet should not be below 25% of energy intake; include good sources of long-chain polyunsaturated fatty acids (e.g. oily fish) in the complementary diet. Offer complementary foods without added sugars and salt.
World Health Organization [104]	• Infants should be fed a variety of foods to ensure that nutrient needs are met. • Meat, poultry, fish, or eggs should be eaten daily, or as often as possible. • Vegetarian diets cannot meet nutrient needs at this age unless nutrient supplements or fortified products are used. • Vitamin A-rich fruits and vegetables should be eaten daily. • A diet with adequate fat content should be provided. • Avoid giving drinks with low nutrient intake (e.g. tea, coffee, soda); the amount of juice offered should be limited to avoid displacing more nutrient-rich foods.

alarmingly, the data on fruit and vegetable intake indicate that approximately 1 in 3 infants 6–8.9 months old and 1 in 5 infants 9–11.9 months old did not consume any fruit on a given day, and the same trend was observed for vegetable intake. Instead, they were more likely to be eating fatty foods and sweet-tasting snacks and beverages and less likely to be eating bitter-tasting vegetables. None of the top 5 vegetables consumed by toddlers was a dark green vegetable [48, 49]. The most commonly consumed vegetable was French fries. The proportion of infants eating a dessert, sweets, or sweetened beverage tripled from 6–9 months to 9–11 months, such that 43% of 9- to 12-month-old infants were consuming such foods on a given day [43].

Such dietary habits demonstrate that, at least in the United States, the actual intake of the macronutrients (carbohydrate, protein, and fat), antioxidants (vitamins C and E), B vitamins (B_1, B_2, B_3, B_6, B_{12}, and folate), and bone-related nutrients (calcium, phosphorus, magnesium, and vitamin D) was greater than the 'adequate intake' level for these nutrients, indicating that the prevalence of nutrient inadequacy was likely low [47]. Since 2 out of 3 babies are being fed infant formulas at 6–9 months, we hypothesize that the consumption of this fortified product may be masking the low dietary intakes of such nutrients in solid foods. While mean and median intake of iron and zinc exceeded the 'estimated average requirement' for these nutrients in 6- to 11-month-old infants, there was a subset of infants who did not meet the requirements for these nutrients; 12% of infants had inadequate iron intake and 6% had inadequate zinc intake [47]. This underscores the importance of selecting and incorporating complementary foods rich in these nutrients.

Evidence-Based Strategies to Enhance Infant Acceptance

It is one thing to recommend how parents should feed their infants; it is another thing to provide effective tools

for them to facilitate healthy eating early in life. Until the past decade, evidenced-based research regarding the optimal complementary foods and methods to introduce these foods was lacking in the scientific literature. Consequently, many feeding practices are based on idiosyncratic parental behavior, family traditions, or medical lore [50]. One example of medical lore is that infants should not have any prior experience with fruits before they are introduced to green vegetables, since their inherent sweet preferences will interfere with acceptance of foods that taste bitter. Although no data support the contention that experience with fruits hinders vegetable acceptance [51], evidence from experimental research suggests that other early experiences promote healthy eating patterns. We focus first on the primary determinant of acceptance of fruits and vegetables during childhood – its flavor [52].

While there are innate responses to the basic tastes (e.g. children have innate preferences for high levels of sweet [53] and salt [54]) and some individuals may be more sensitive to bitter tastes due to genotype [55], there is an inherent plasticity in the development of these chemical senses that interact with early-life experiences to ensure that a child is not restricted to a narrow range of foodstuffs because of innate preferences for and aversions to certain tastes [see ref. 56, 57 for review]. That early nutrition has far-reaching effects on behavior is supported by emerging research that revealed the existence of periods during postnatal development in which the developing brain has heightened sensitivity to environmental influences [58] – heightened epochs of brain plasticity when the early environment is able to shape neural circuits and thus determine both structural and functional aspects of the brain, and thus behaviors. Such functional plasticity, one of the main characteristics of the human brain, highlights the ability to change behavior based on experience. Below, we summarize the basic research that reveals that sensory experiences before and at the initial stages of feeding complementary foods affect the child's food likes and dislikes.

While there are innate responses to the basic tastes, there is an inherent plasticity in the development of the chemical senses that interact with early-life experiences.

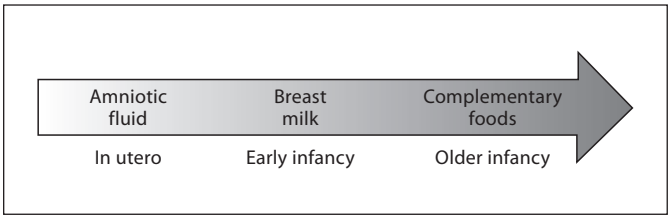

Fig. 1. Continuum of opportunities for early exposure to flavor of vegetables/fruits during infancy. Exposure to different flavors begins early in life. Infants learn about flavor prior to their first taste of solid food via amniotic fluid/breast milk. Maternal/family diet plays a critical role in the timing and types of flavors and types of complementary foods offered to the infant.

Flavor of First Foods

Infants learn about flavors before their first taste of solid foods (fig. 1). Through experimental research, we have found that a wide variety of flavors that the mother either ingests (e.g. fruits, vegetables, and spices) or inhales (e.g. tobacco and perfumes) are transmitted to her milk and/or amniotic fluid [57, 59–64]. In general, the intensity of the flavor in mother's milk increased significantly within hours after consumption and decreased thereafter. For all cases, the flavor change in the milk was transient and paralleled the changing concentration of the food volatiles in the milk [for a review, see ref. 57]. That amniotic fluid and breast milk share flavor profiles with foods eaten by the mother suggests that breast milk may be a 'bridge' between experiences with flavors in utero and those in solid foods. These variations in flavor from mother to mother and from feeding to feeding suggest that breastfeeding, unlike formula feeding, provides the infant with the potential for a rich source of sensory variety. The types and intensity of flavors experienced may be unique for each infant and characteristic of their family's culture. These are the foods their mothers eat and will likely be the foods that their mothers will feed them as they grow [65, 66].

To experimentally test the hypothesis that pre- and postnatal flavor experiences affect liking of flavors at weaning, we conducted the first randomized clinical study in which pregnant women who planned to breastfeed their infants were randomly assigned to one of three groups that differed in whether and when they drank carrot juice [67]. Mothers in one group drank carrot juice for several days each week during the last trimester of pregnancy, those in a second group drank carrot juice for a similar period during the first 3 months of lactation, and

those in the control group drank water and avoided carrots and carrot juice during both pregnancy and lactation. When mothers' decision to wean their infants to cereal was established, we tested the infants' acceptance of a plain cereal on one day and carrot-flavored cereal on another. Infants who had experienced the flavor of carrots in either amniotic fluid or mother's milk responded more favorably (e.g. ate more, made less negative faces) to carrot-flavored cereal than did non-exposed control infants. Similarly, breastfed infants were more accepting of fruits and vegetables than were formula-fed infants [68, 69], but only if their mothers regularly ate these foods themselves.

In addition to being more accepting of cereal if it contained a flavor (e.g. carrot, fruits) previously experienced in amniotic fluid or mother's milk [67], infants consumed significantly more cereal if it was prepared with mother's milk [70] than if it was prepared with water, and they displayed a series of behaviors signaling their preference for it. Adding mother's milk to the cereal may have made the cereal more palatable because it contained particular tastes and flavors that infants find attractive, either because of their inherent pleasantness or because of previous experiences with these flavors. Although never experimentally tested, we hypothesize that formula-fed infants may be more accepting of cereals if prepared with their familiar brand of formula. The convergence of research findings suggests that the transition from a diet based exclusively on milk or formula to a mixed diet may be facilitated by providing the infant with bridges of familiarity such that the infant experiences similar flavors in the two feeding situations.

That amniotic fluid and breast milk share flavor profiles with foods eaten by the mother suggests that breast milk may be a 'bridge' between experiences with flavors in utero and those in solid foods.

We have suggested that these findings reveal a fundamental feature of mammalian dietary learning [57, 67]. By definition, mammalian mothers can produce milk to nourish their young. Invariably, the time must come for the young animal to accept solid foods. Thus, developmental processes must ensure that young mammals learn what to eat. One such developmental process is that young mammals learn about the dietary choices of the mother through transmitted flavor cues. Provenza and Launchbauch [71] puts this early learning from the mother in an ecologic perspective. Learned food preferences are transmitted from mammalian mothers to their offspring, resulting in greater biodiversity that benefits both plants and animals. Through such early experiences, young animals learn how to forage, acquire preferences for particular foods, and physically adapt to using particular types of foods.

This pattern makes evolutionary sense because the foods that a mother eats when she is pregnant and nursing are precisely the ones that her infant should prefer. All else being equal, these are the flavors associated with nutritious foods or, at the very least, with foods the mother has access to, and hence the foods to which the infant will have the earliest exposure. The varied sensory experiences with food flavors in mother's milk in those children whose mothers eat a varied diet may explain why children who were breastfed tend to be less picky [72] and more willing to try new foods during childhood [65, 72–74].

Repeated Exposure to a Complementary Food Facilitates Acceptance

While breastfed infants have an advantage in initial acceptance of food if they have been exposed to the flavor in mother's milk [68], once they are weaned to complementary foods, both breast- and formula-fed infants respond to repeated exposure to a food. As found in older children [75], infants ate significantly more of a particular pureed fruit [68, 76] or vegetable [51, 68, 69, 76] after repeated exposure (around 8–9 days) to that particular food (table 2). Merely looking at the food does not appear to be sufficient since children have to taste the food to learn to like it [68, 77].

Mothers may be unaware of changes in acceptance as infants are repeatedly exposed to flavors of some vegetables and so they may give up too soon when introducing foods that have bitter tastes [68]. In one study, both breast- and formula-fed infants repeatedly exposed to green beans ate more green beans than did infants not previously exposed. Mothers were apparently unaware of these changes in acceptance, perhaps because they focused on the infant's facial expressions rather than on how much the infant ate. Instead, mothers should be encouraged to focus on their infant's willingness to eat the food and to continue to provide repeated opportunities to taste the food as well as other foods within that category.

Table 2. Summary of research findings on factors that affect acceptance of pureed fruits and vegetables

Type of exposure[1]	Exposed food	Test food	Findings	References
8 days of repeated exposure	Pears	Pears, green beans	Increased acceptance of pears; no effect on acceptance of novel vegetable (green beans)	Mennella et al., 2008 [76]
8 days of repeated exposure	Peaches	Peaches	Increased acceptance of peaches	Forestell and Mennella, 2007 [68]
9 days of repeated exposure	Carrots	Carrots	Increased acceptance of carrots	Gerrish and Mennella, 2001
8 days of repeated exposure	Green beans	Green beans	Increased acceptance of green beans	Sullivan and Birch, 1994; Mennella et al., 2008; Forestell and Mennella, 2007 [68]
8 days of between-meal variety	Peaches, prunes, apples	Pears, green beans	Increased acceptance of novel fruit (pears); no effect of acceptance of novel vegetable (green beans)	Mennella et al., 2008 [76]
9 days of between-meal variety	Peas, potatoes, squash	Carrots	Increased acceptance of novel vegetable (carrots)	Gerrish and Mennella, 2001 [51]
8 days of between-meal variety	Squash, spinach, carrots	Carrots, spinach, green beans	Increased acceptance of carrots and spinach; increased acceptance of novel vegetable (green beans)	Mennella et al., 2008 [76]
8 days of between- and within-meal variety	Squash/peas, carrot/peas, squash/spinach	Carrots, spinach, green beans	Increased acceptance of carrots and spinach; increased acceptance of novel vegetable (green beans)	Mennella et al., 2008 [76]

[1] Baby was fed either exposed food at the same time of day for 8–9 consecutive days (repeated exposure); one exposed food each day but type of food alternated daily (BM variety); pair of exposed foods each day and the pair alternated daily (BM-WM variety). After the exposure period, infants' acceptance of a target food was assessed during infant-led feeding paradigms.

Experience with Variety Sets the Pattern for a Diversified Diet

Dietary experience includes not only actually tasting the vegetable but also experience with a variety of flavors. Exposure to a variety of flavors between meals, not just repeated exposure to a single flavor or food, appears to facilitate acceptance of novel foods. Infants who were repeatedly exposed to a different starchy vegetable each day ate as many carrots after the exposure as did infants who were repeatedly exposed to carrots [51]. Similarly, repeated experience with a variety of fruits enhanced acceptance of a novel fruit, although it had no effect on infants' acceptance of green vegetables [68, 76]. Because rejection of bitter taste is innate, infants may need actual experience with bitter taste, or more exposures, to enhance acceptance of green vegetables [76]. That varied experiences with food flavors increase food acceptance may help explain why children who were breastfed are less picky during childhood [72].

Because flavor variety is associated with greater variety in the nutritive content of foods, a preference for varied flavors should ultimately increase the range of nutrients consumed and the likelihood that a well-balanced diet is achieved.

Because flavor variety is associated with greater variety in the nutritive content of foods [78], a preference for varied flavors should ultimately increase the range of nutrients consumed and the likelihood that a well-balanced diet is achieved. In other words, the variety effect may reflect an important adaptive mechanism in the regulation of food intake among omnivores [78–81].

That the effects of experience with variety may be more pronounced during early development is suggested by laboratory and field studies [80]. Immature and mature laboratory rats drank either one or three different types of flavored water with their food for 12 days. Initial acceptance of a novel liquid was greater in those immature animals that experienced the variety of flavored waters. Comparable findings were not observed in mature animals [80]. In field studies, Scott and Provenza [82] demonstrated that when the nutritional content of the diet was held constant, lambs preferred to forage in locations that offered a variety of flavors. Exposing young calves and sheep to a variety of foods and different locations minimized transition problems to new environments. In other words, early experiences with diversity prepared young animals for diversity or unfamiliarity later in life, which in turn enabled them to best select a diet that suits their needs. It is not that older animals cannot learn to accept new foods, it is just easier and quicker to teach a younger animal [71].

Animal model studies have revealed that weanling rats repeatedly offered a variety of foods within meals ate more than those exposed to variety between meals [83]. Therefore, we conducted an experimental study to determine whether experience with a variety of vegetables within a meal as well as between meals would lead to greater acceptance of vegetables [76]. We found that both variety groups ate more of all three of the target foods (green beans, carrots, and spinach) after the exposure period than did the group that was repeatedly exposed only to a single food with no variety [76]. It is unclear what infants 'learned' from the between- and within-meal varied diet. Studies on rats and humans have indicated that the variety effect was more robust when the foods had pronounced sensory differences [78, 83]. Because the pairs of foods fed to the infants within each meal always included a green and an orange vegetable, infants experienced contrasts across many sensory domains: color, texture, and flavor. Moreover, these infants also experienced different pairs of foods and ate varying amounts of these from one day to the next, providing them with sensory diversity. Exposure to such multiple sensory contrasts might have accelerated the 'transfer of diversity' effect by providing more varied flavor experiences and more opportunities to develop conditioned flavor preferences based on the post-ingestive reinforcing effects of these nutritious foods [84]. Such feeding strategies, providing novelty in the context of a familiar food, might prove to be an optimal combination to progressively accustom infants to a diversity of novel foods. Moreover, the sensory diversity within a meal might help to prevent sensory-specific satiety, i.e. the decline in perceived pleasantness compared to that of other foods, which is greater in meals with less varied flavors [78].

Taken together, this body of research suggests not only that infants can clearly discriminate flavors but also that repeated opportunities to taste a particular food and a variety of foods may promote willingness to eat fruits and vegetables, the consumption of which is generally low in the pediatric population and the acceptance of which is difficult to enhance beyond toddlerhood [85].

Conclusions

The well-documented pediatric obesity epidemic [86, 87] and dramatic increases in its associated clinical diseases are major public health challenges facing countries globally [88–91]. The long-lasting impact of early nutrition on health (obesity [32, 92], metabolic syndrome [93], and mortality from cardiovascular disease [94]) leads some to argue that the focus should be on early life for both preventative intervention and further scientific inquiry [19, 93, 95]. One dietary strategy to prevent or treat obesity in children and adults combines an increased consumption of foods that are rich in nutrients and fiber, yet low in excess energy from added sugars and fats (e.g. fruits and vegetables) with a decreased consumption of energy-dense and less nutritionally desirable foods (e.g. French fries and desserts). The type of complementary foods introduced in infancy not only affect current nutritional status but possibly also food preferences in later life [17, 65]. Although many of these studies are correlational in nature [96] and do not reveal cause and effect [97], it is entirely possible that an increased fruit and vegetable consumption early in life may lead to a life-long intake of fruits and vegetables, which in turn may be beneficial for weight control in later life [98].

The types of complementary foods introduced in infancy not only affect current nutritional status but possibly also food preferences in later life.

The experimental research on flavor learning during infancy described here suggests not only that infants can clearly discriminate the flavors of different fruits and

vegetables, but also that repeated experience with a particular fruit or vegetable and a variety of these foods promotes the willingness to eat these complementary foods and, it is hoped, preferences for the tastes of these foods in the long term. The consumption of fruits and vegetables is generally low in the pediatric population [99]. Developing strategies to promote the liking of the taste of healthful foods is extremely important since the best predictor of fruit and vegetable intake is whether children like how they taste [100]. Because mothers may be unaware of incremental changes in acceptance, mothers should focus on the infant's willingness to eat the food rather than their facial expressions, and continue to provide repeated opportunities to taste the food, as well as other foods within that food category. Because there is no evidence that supports the need to restrict or avoid any foods for weaned infants who are not at risk for allergies or atopy [2, 31, 101, 102], introducing children repeatedly to individual as well as a variety of fruits and vegetables, both within and between meals, will help them be more accepting of fruits and vegetables, which is difficult to enhance beyond toddlerhood [103].

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References

1 Skinner JD, Carruth BR, Houch K, Moran J, Coletta F, Cotter R, Ott D, McLeod M: Transitions in infant feeding during the first year of life. J Am Coll Nutr 1997;16:209–213.
2 Butte N, Cobb K, Dwyer J, Graney L, Heird W, Rickard K: The Start Healthy Feeding Guidelines for Infants and Toddlers. J Am Diet Assoc 2004;104:442–454.
3 Committee on Nutrition, American Academy of Pediatrics: Formula feeding of term infants; in Kleinman RE (ed): Pediatric Nutrition Handbook, ed 6. Elk Grove Village, American Academy of Pediatrics, 2009, pp 61–78.
4 Committee on Nutrition, American Academy of Pediatrics: Breastfeeding; in Kleinman RE (ed): Pediatric Nutrition Handbook, ed 6. Elk Grove Village, American Academy of Pediatrics, 2009, pp 29–59.
5 ESPGHAN Committee on Nutrition, Agostoni C, Braegger C, Decsi T, et al: Breastfeeding: a commentary by the ESPGHAN Committee on Nutrition. J Pediatr Gastroenterol Nutr 2009;49:112–125.
6 World Health Organization: Global Strategy for Infant and Young Children Feeding. Geneva, World Health Organization, 2003. http://www.paho.org/english/ad/fch/ca/GSIYCF_infantfeeding_eng.pdf (accessed September 19, 2011).
7 Butte NF, Treuth MS, Mehta NR, Wong WW, Hopkinson JM, Smith EO: Energy requirements of women of reproductive age. Am J Clin Nutr 2003;77:630–638.
8 Ballester I, Cortes E, Moya M, Campello MJ: Improved method for quantifying vitamin D in proprietary infants' formulas and in breast milk. Clin Chem 1987;33:796–799.
9 Reeve LE, Chesney RW, DeLuca HF: Vitamin D of human milk: identification of biologically active forms. Am J Clin Nutr 1982;36:122–1226.
10 Wagner CL, Greer FR: Prevention of rickets and vitamin D deficiency in infants, children, and adolescents. Pediatrics 2008;122:1142–1152.
11 Haggerty LL: Maternal supplementation for prevention and treatment of vitamin D deficiency in exclusively breastfed infants. Breastfeed Med 2011;6:137–144.
12 Taylor SN, Wagner CL, Hollis BW: Vitamin D supplementation during lactation to support infant and mother. J Am Coll Nutr 2008;27:690–701.
13 Picciano MF: Nutrient composition of human milk. Pediatr Clin North Am 2001;48:53–67.
14 Kunz C, Rudloff S: Potential anti-inflammatory and anti-infectious effects of human milk oligosaccharides. Adv Exp Med Biol 2008;606:455–465.
15 Lonnerdal B: Human milk proteins: key components for the biological activity of human milk. Adv Exp Med Biol 2004;554:11–25.
16 Northstone K, Emmett P, Nethersole F: The effect of age of introduction to lumpy solids on foods eaten and reported feeding difficulties at 6 and 15 months. J Hum Nutr Diet 2001;14:43–54.
17 Coulthard H, Harris G, Emmett P: Delayed introduction of lumpy foods to children during the complementary feeding period affects child's food acceptance and feeding at 7 years of age. Matern Child Nutr 2009;5:75–85.
18 Institute of Medicine, National Academy of Science Food and Nutrition Board: Dietary Reference Intakes: Applications in Dietary Assessment. Washington, National Academies Press, 2000.
19 Gluckman PD, Hanson MA: Developmental and epigenetic pathways to obesity: an evolutionary-developmental perspective. Int J Obes (Lond) 2008;32(suppl 7):S62–S71.
20 Karaolis-Danckert N, Buyken AE, Bolzenius K, Perim de Faria C, Lentze MJ, Kroke A: Rapid growth among term children whose birth weight was appropriate for gestational age has a longer lasting effect on body fat percentage than on body mass index. Am J Clin Nutr 2006;84:1449–1455.
21 Taveras EM, Rifas-Shiman SL, Belfort MB, Kleinman KP, Oken E, Gillman MW: Weight status in the first 6 months of life and obesity at 3 years of age. Pediatrics 2009;123:1177–1183.
22 Ong KK, Emmett P, Northstone K, Golding J, Rogers I, Ness AR, Wells JC, Dunger DB: Infancy weight gain predicts childhood body fat and age at menarche in girls. J Clin Endocrinol Metab 2009;94:1527–1532.
23 Eid EE: Follow-up study of physical growth of children who had excessive weight gain in first six months of life. Br Med J 1970;2:74–76.

24 Melbin T, Vuille J: Weight gain in infancy and physical development between 7 and 10 1/2 years of age. Br J Prev Soc Med 1976;30: 233–238.
25 Parsons TJ, Power C, Manor O: Fetal and early life growth and body mass index from birth to early adulthood in 1958 British cohort: longitudinal study. BMJ 2001;323: 1331–1335.
26 Stettler N, Kumanyika SK, Katz SH, Zemel BS, Stallings VA: Rapid weight gain during infancy and obesity in young adulthood in a cohort of African Americans. Am J Clin Nutr 2003;77:1374–1378.
27 Stettler N, Zemel BS, Kumanyika S, Stallings VA: Infant weight gain and childhood overweight status in a multicenter, cohort study. Pediatrics 2002;109:194–199.
28 Dennison BA, Edmunds LS, Stratton HH, Pruzek RM: Rapid infant weight gain predicts childhood overweight. Obesity (Silver Spring) 2006;14:491–499.
29 Gartner LM, Morton J, Lawrence RA, Naylor AJ, O'Hare D, Schanler RJ, Eidelman AI: Breastfeeding and the use of human milk. Pediatrics 2005;115:496–506.
30 Committee on Nutrition, American Academy of Pediatrics: Complementary feeding; in Kleinman RE (ed): Pediatric Nutrition Handbook, ed 6. Elk Grove Village, American Academy of Pediatrics, 2009.
31 Agostoni C, Decsi T, Fewtrell M, Goulet O, Kolacek S, Koletzko B, Michaelsen KF, Moreno L, Puntis J, Rigo J, et al: Complementary feeding: a commentary by the ESPGHAN Committee on Nutrition. J Pediatr Gastroenterol Nutr 2008;46:99–110.
32 Baird J, Fisher D, Lucas P, Kleijnen J, Roberts H, Law C: Being big or growing fast: systematic review of size and growth in infancy and later obesity. BMJ 2005;331:929.
33 Baker JL, Michaelsen KF, Rasmussen KM, Sorensen TI: Maternal prepregnant body mass index, duration of breastfeeding, and timing of complementary food introduction are associated with infant weight gain. Am J Clin Nutr 2004;80:1579–1588.
34 Kramer MS, Barr RG, Leduc DG, Boisjoly C, McVey-White L, Pless IB: Determinants of weight and adiposity in the first year of life. J Pediatr 1985;106:10–14.
35 Sloan S, Gildea A, Stewart M, Sneddon H, Iwaniec D: Early weaning is related to weight and rate of weight gain in infancy. Child Care Health Dev 2008;34:59–64.
36 Wilson AC, Forsyth JS, Greene SA, Irvine L, Hau C, Howie PW: Relation of infant diet to childhood health: seven year follow up of cohort of children in Dundee infant feeding study. BMJ 1998;316:21–25.
37 Moorcroft KE, Marshall JL, McCormick FM: Association between timing of introducing solid foods and obesity in infancy and childhood: a systematic review. Matern Child Nutr 2011;7:3–26.
38 Kramer MS, Guo T, Platt RW, Vanilovich I, Sevkovskaya Z, Dzikovich I, Michaelsen KF, Dewey K: Feeding effects on growth during infancy. J Pediatr 2004;145:600–605.
39 Owen CG, Martin RM, Whincup PH, Smith GD, Cook DG: Effect of infant feeding on the risk of obesity across the life course: a quantitative review of published evidence. Pediatrics 2005;115:1367–1377.
40 Arenz S, Rückerl R, Koletzko B, von Kries R: Breast-feeding and childhood obesity – a systematic review. Int J Obes Relat Metab Disord 2004;28:1247–1256.
41 Dewey KG, Heinig MJ, Nommsen LA, Peerson JM, Lonnerdal B: Breast-fed infants are leaner than formula-fed infants at 1 y of age: the DARLING study. Am J Clin Nutr 1993; 57:140–145.
42 Huh SY, Rifas-Shiman SL, Taveras EM, Oken E, Gillman MW: Timing of solid food introduction and risk of obesity in preschool-aged children. Pediatrics 2011;127: e544–e551.
43 Siega-Riz AM, Deming DM, Reidy KC, Fox MK, Condon E, Briefel RR: Food consumption patterns of infants and toddlers: where are we now? J Am Diet Assoc 2010;110:S38–S51.
44 Giovannini M, Riva E, Banderali G, Scaglioni S, Veehof SH, Sala M, Radaelli G, Agostoni C: Feeding practices of infants through the first year of life in Italy. Acta Paediatr 2004;93:492–497.
45 Scott JA, Binns CW, Graham KI, Oddy WH: Predictors of the early introduction of solid foods in infants: results of a cohort study. BMC Pediatr 2009;9:60.
46 Ziegler P, Briefel R, Clusen N, Devaney B: Feeding Infants and Toddlers Study (FITS): development of the FITS survey in comparison to other dietary survey methods. J Am Diet Assoc 2006;106:S12–S27.
47 Butte NF, Fox MK, Briefel RR, Siega-Riz AM, Dwyer JT, Deming DM, Reidy KC: Nutrient intakes of US infants, toddlers, and preschoolers meet or exceed dietary reference intakes. J Am Diet Assoc 2010;110:S27–S37.
48 Mennella JA, Turnbull B, Ziegler PJ, Martinez H: Infant feeding practices and early flavor experiences in Mexican infants: an intracultural study. J Am Diet Assoc 2005;105: 908–915.
49 Fox MK, Pac S, Devaney B, Jankowski L: Feeding infants and toddlers study: what foods are infants and toddlers eating? J Am Diet Assoc 2004;104:S22–S30.
50 Gidding SS, Dennison BA, Birch LL, Daniels SR, Gillman MW, Lichtenstein AH, Rattay KT, Steinberger J, Stettler N, Van Horn L: Dietary recommendations for children and adolescents: a guide for practitioners: consensus statement from the American Heart Association. Circulation 2005;112:2061–2075.
51 Gerrish CJ, Mennella JA: Flavor variety enhances food acceptance in formula-fed infants. Am J Clin Nutr 2001;73:1080–1085.
52 Birch LL, Sullivan SA: Measuring children's food preferences. J Sch Health 1991;61:212–214.
53 Mennella JA, Lukasewycz LD, Griffith JW, Beauchamp GK: Evaluation of the Monell forced-choice, paired-comparison tracking procedure for determining sweet taste preferences across the lifespan. Chem Senses 2011;36:345–355.
54 Beauchamp GK, Moran M: Acceptance of sweet and salty tastes in 2-year-old children. Appetite 1984;5:291–305.
55 Mennella JA, Pepino MY, Duke FF, Reed DR: Age modifies the genotype-phenotype relationship for the bitter receptor TAS2R38. BMC Genet 2010;11:60.
56 Mennella JA, Beauchamp GK: The role of early life experiences in flavor perception and delight; in Dube L, Bechara A, Dagher A, Drewnowski A, LeBel J, James P, Richard D, Yada RY (eds): Obesity Prevention: The Role of Society and Brain on Individual Behavior. London, Elsevier, 2010, pp 203–218.
57 Mennella JA: The chemical senses and the development of flavor preferences in humans; in Hale TW, Hartmann PE (eds): Textbook on Human Lactation. Amarillo, Hale Publishing, 2007, pp 403–414.
58 Roth T, Sweatt JD: Epigenetic mechanisms and environmental shaping of the brain during sensitive periods of development. J Child Psychol Psychiatr 2011;52:398–408.
59 Mennella JA, Johnson A, Beauchamp GK: Garlic ingestion by pregnant women alters the odor of amniotic fluid. Chem Senses 1995;20:207–209.
60 Mennella JA, Beauchamp GK: Smoking and the flavor of breast milk. N Engl J Med 1998; 339:1559–1560.
61 Mennella JA, Beauchamp GK: Maternal diet alters the sensory qualities of human milk and the nursling's behavior. Pediatrics 1991; 88:737–744.
62 Mennella JA, Beauchamp GK: The transfer of alcohol to human milk. Effects on flavor and the infant's behavior. N Engl J Med 1991; 325:981–985.
63 Mennella JA, Beauchamp GK: The human infants' responses to vanilla flavors in human milk and formula. Infant Behav Dev 1996;19:13–19.
64 Mennella JA, Beauchamp GK: Experience with a flavor in mother's milk modifies the infant's acceptance of flavored cereal. Dev Psychobiol 1999;35:197–203.
65 Skinner JD, Carruth BR, Wendy B, Ziegler PJ: Children's food preferences: a longitudinal analysis. J Am Diet Assoc 2002;102: 1638–1646.
66 Park SY, Paik HY, Skinner JD, Ok SW, Spindler AA: Mothers' acculturation and eating behaviors of Korean American families in California. J Nutr Educ Behav 2003;35:142–147.

67 Mennella JA, Jagnow CP, Beauchamp GK: Prenatal and postnatal flavor learning by human infants. Pediatrics 2001;107:E88.
68 Forestell CA, Mennella JA: Early determinants of fruit and vegetable acceptance. Pediatrics 2007;120:1247–1254.
69 Sullivan SA, Birch LL: Infant dietary experience and acceptance of solid foods. Pediatrics 1994;93:271–277.
70 Mennella JA, Beauchamp GK: Mothers' milk enhances the acceptance of cereal during weaning. Pediatr Res 1997;41:188–192.
71 Provenza FD, Launchbauch KL: Foraging on the edge of chaos; in Mosley JC (ed): Grazing Behavior of Livestock and Wildlife. Idaho Forest, Wildlife and Range Experiment Station Bulletin 70. Moscow, University of Idaho, 1999, pp 1–12.
72 Galloway AT, Lee Y, Birch LL: Predictors and consequences of food neophobia and pickiness in young girls. J Am Diet Assoc 2003; 103:692–698.
73 Skinner JD, Carruth BR, Bounds W, Ziegler P, Reidy K: Do food-related experiences in the first 2 years of life predict dietary variety in school-aged children? J Nutr Educ Behav 2002;34:310–315.
74 Cooke LJ, Wardle J, Gibson EL, Sapochnik M, Sheiham A, Lawson M: Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. Public Health Nutr 2004;7:295–302.
75 Birch LL, Marlin DW: I don't like it; I never tried it: effects of exposure on two-year-old children's food preferences. Appetite 1982;3: 353–360.
76 Mennella JA, Nicklaus S, Jagolino AL, Yourshaw LM: Variety is the spice of life: strategies for promoting fruit and vegetable acceptance during infancy. Physiol Behav 2008;94: 29–38.
77 Birch LL, McPhee L, Shoba BC, Pirok E, Steinberg L: What kind of exposure reduces children's food neophobia? Looking vs. tasting. Appetite 1987;9:171–178.
78 Rolls BJ, Rowe EA, Rolls ET, Kingston B, Megson A, Gunary R: Variety in a meal enhances food intake in man. Physiol Behav 1981;26:215–221.
79 Treit D, Spetch ML, Deutsch JA: Variety in the flavor of food enhances eating in the rat: a controlled demonstration. Physiol Behav 1983;30:207–211.
80 Capretta PJ, Petersik JT, Steward DJ: Acceptance of novel flavours is increased after early experience of diverse taste. Nature 1975; 254:689–691.
81 Scott LL, Provenza FD: Variation in food selection among lambs: effects of basal diet and foods offered in a meal. J Anim Sci 1999;77: 2391–2397.
82 Scott LL, Provenza FD: Variety of foods and flavors affects selection of foraging location by sheep. Appl Anim Behav Sci 1998;61:113–122.
83 Rolls BJ, Van Duijvenvoorde PM, Rowe EA: Variety in the diet enhances intake in a meal and contributes to the development of obesity in the rat. Physiol Behav 1983;31:21–27.
84 Myers KP, Sclafani A: Development of learned flavor preferences. Dev Psychobiol 2006;48:380–388.
85 Wardle J, Herrera ML, Cooke L, Gibson EL: Modifying children's food preferences: the effects of exposure and reward on acceptance of an unfamiliar vegetable. Eur J Clin Nutr 2003;57:341–348.
86 de Onis M, Blossner M, Borghi E: Global prevalence and trends of overweight and obesity among preschool children. Am J Clin Nutr 2010;92:1257–1264.
87 Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM: Prevalence of high body mass index in US children and adolescents, 2007–2008. JAMA 2010;303:242–249.
88 Dietz WH: Health consequences of obesity in youth: childhood predictors of adult disease. Pediatrics 1998;101:518–525.
89 Tai A, Volkmer R, Burton A: Association between asthma symptoms and obesity in preschool (4–5 year old) children. J Asthma 2009;46:362–365.
90 Wiegand S, Keller KM, Robl M, L'Allemand D, Reinehr T, Widhalm K, Holl RW: Obese boys at increased risk for nonalcoholic liver disease: evaluation of 16,390 overweight or obese children and adolescents. Int J Obes (Lond) 2010;34:1468–1474.
91 Lobstein T, Jackson-Leach R: Estimated burden of paediatric obesity and co-morbidities in Europe. Part 2. Numbers of children with indicators of obesity-related disease. Int J Pediatr Obes 2006;1:33–41.
92 Chomtho S, Wells JC, Davies PS, Lucas A, Fewtrell MS: Early growth and body composition in infancy. Adv Exp Med Biol 2009; 646:165–168.
93 Ekelund U, Ong KK, Linne Y, Neovius M, Brage S, Dunger DB, Wareham NJ, Rossner S: Association of weight gain in infancy and early childhood with metabolic risk in young adults. J Clin Endocrinol Metab 2007;92:98–103.
94 Barker DJ: The developmental origins of chronic adult disease. Acta Paediatr Suppl 2004;93:26–33.
95 Lucas A: The developmental origins of adult health and well-being. Adv Exp Med Biol 2005;569:13–15.
96 Nicklaus S, Boggio V, Chabanet C, Issanchou S: A prospective study of food variety seeking in childhood, adolescence and early adult life. Appetite 2005;44:289–297.
97 Lucas A: Programming by early nutrition: an experimental approach. J Nutr 1998;128: 401S–406S.
98 Rolls BJ, Drewnowski A, Ledikwe JH: Changing the energy density of the diet as a strategy for weight management. J Am Diet Assoc 2005;105:S98–S103.
99 Mennella JA, Ziegler P, Briefel R, Novak T: Feeding Infants and Toddlers Study: the types of foods fed to Hispanic infants and toddlers. J Am Diet Assoc 2006;106:S96–S106.
100 Resnicow K, Smith M, Baranowski T, Baranowski J, Vaughan R, Davis M: 2-year tracking of children's fruit and vegetable intake. J Am Diet Assoc 1998;98:785–789.
101 Prescott SL, Smith P, Tang M, Palmer DJ, Sinn J, Huntley SJ, Cormack B, Heine RG, Gibson RA, Makrides M: The importance of early complementary feeding in the development of oral tolerance: concerns and controversies. Pediatr Allergy Immunol 2008;19:375–380.
102 Greer FR: Issues in establishing vitamin D recommendations for infants and children. Am J Clin Nutr 2004;80:1759S–1762S.
103 Wardle J, Cooke LJ, Gibson EL, Sapochnik M, Sheiham A, Lawson M: Increasing children's acceptance of vegetables; a randomized trial of parent-led exposure. Appetite 2003;40:155–162.
104 Dewey K: Guiding principles for complementary feeding of the breastfed child. Washington, Pan American Health Organization, World Health Organization, 2003. http://www.paho.org/English/AD/FCH/NU/Guiding_Principles_CF.htm (accessed September 19, 2011).