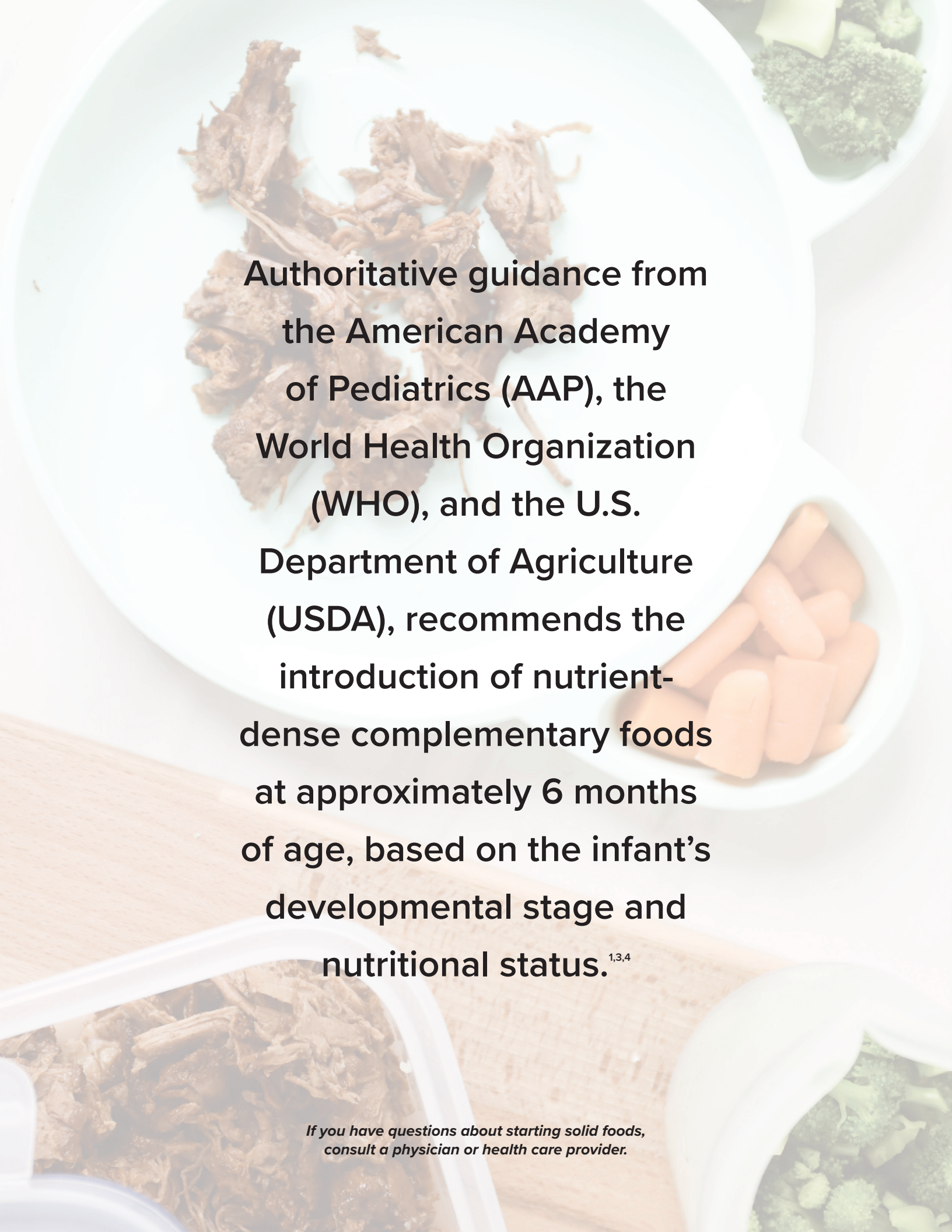
BEEF RESEARCH

# BEEF IN THE EARLY YEARS

A RESEARCH BRIEF DETAILING BEEF AS A COMPLEMENTARY FIRST FOOD

Authoritative guidance from the American Academy of Pediatrics (AAP), the World Health Organization (WHO), and the U.S. Department of Agriculture (USDA), recommends the introduction of nutrient-dense complementary foods at approximately 6 months of age, based on the infant's developmental stage and nutritional status.[1,3,4]

*If you have questions about starting solid foods, consult a physician or health care provider.*

## Why Complementary Feeding is Important

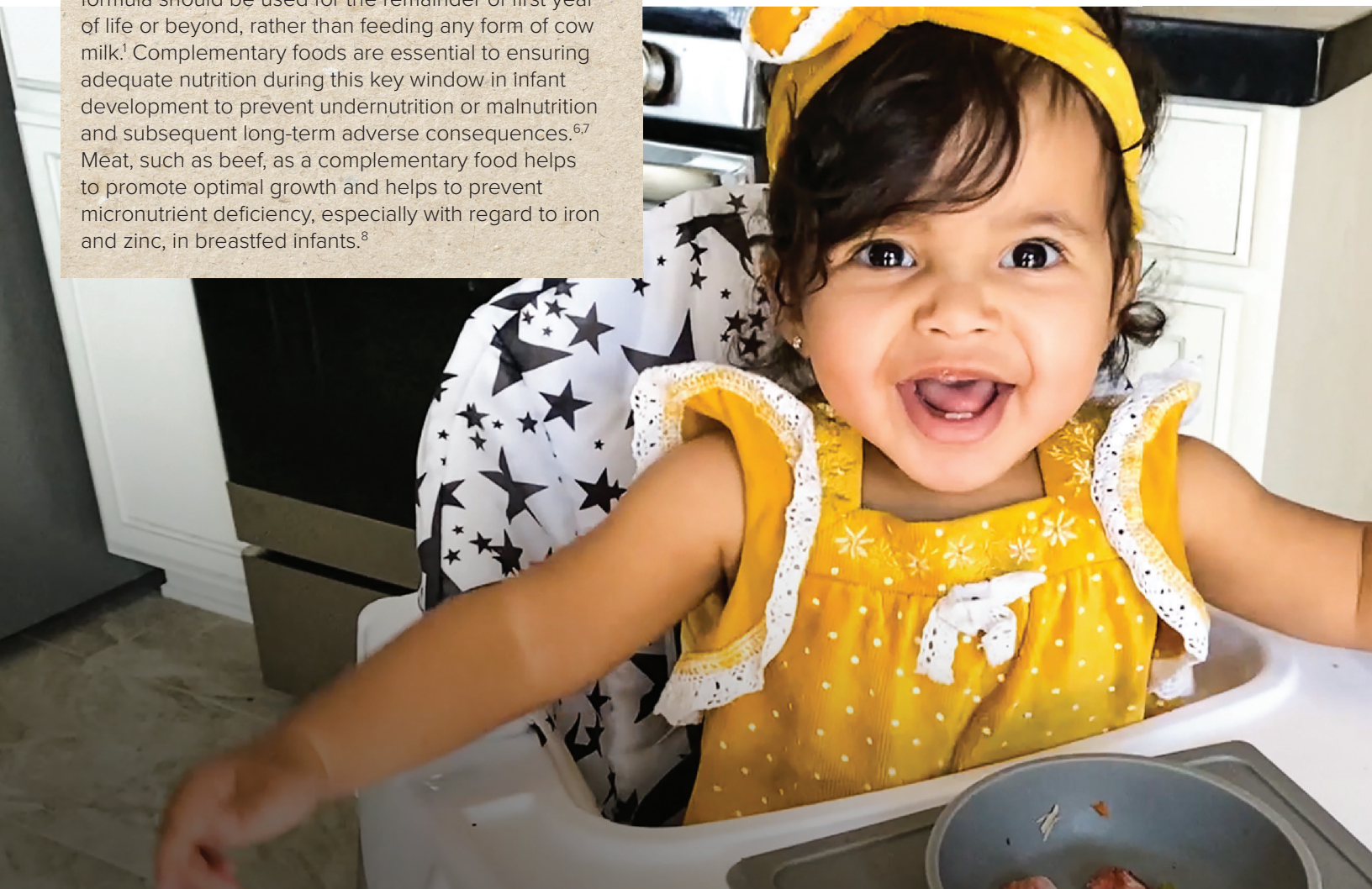
Certain key nutrients are important for infant growth and development, such as iron and zinc, particularly infants who are exclusively breastfed.[1] The transition from exclusive breastfeeding or formula feeding to the addition of complementary or solid foods, is referred to as complementary feeding, and marks greater risk of falling short of key nutrients, particularly for infants who are exclusively breastfed.[2] The introduction of complementary foods, that is, foods other than breast milk or infant formula, serves an important purpose in the daily diets of infants.[1,3] Complementary foods can take form as single-grain infant cereal, vegetables, fruits, and meats, and are modified to an appropriate texture (e.g., strained, pureed, chopped, etc.) for the infant's developmental readiness.[1,4,5]

Authoritative guidance from the American Academy of Pediatrics (AAP), the World Health Organization (WHO), and the U.S. Department of Agriculture (USDA), recommends the introduction of nutrient-dense complementary foods at approximately 6 months of age, based on the infant's developmental stage and nutritional status.[1,3,4] Prior to this, breast milk or formula provides all the calories and nourishment the baby needs. After 6 months, in addition to complementary foods, either breastfeeding or iron-fortified infant formula should be used for the remainder of first year of life or beyond, rather than feeding any form of cow milk.[1] Complementary foods are essential to ensuring adequate nutrition during this key window in infant development to prevent undernutrition or malnutrition and subsequent long-term adverse consequences.[6,7] Meat, such as beef, as a complementary food helps to promote optimal growth and helps to prevent micronutrient deficiency, especially with regard to iron and zinc, in breastfed infants.[8]

## Current Guidelines for Infant Feeding and Complementary Foods

Complementary foods help meet requirements for the energy and nutrients associated with growth and development during the first year of life. The AAP Committee on Nutrition, the WHO, and the USDA all recommend that infants be breastfed exclusively for approximately the first 6 months of life, progressing to breastfeeding combined with complementary foods from 6 months through at least the first year of life.[1,3,9] If breastfeeding is not possible or not elected, iron-fortified formula is recommended as the next best option.[10]

Guidance emphasizes the importance of introducing solid foods during the right window of time for the infant. Complementary foods should be introduced around 6 months of age, when the infant shows signs of readiness. Typically, between age 4 and 6 months, infants develop the gross motor, oral, and fine motor skills necessary to begin to eat complementary foods.[1,3] Signs of developmental readiness may include holding up the head with good control, showing interest in table food, opening the mouth when food is offered, ability to grasp small objects, and sitting up without support.[1,3,5] Weight can also be used as a good indicator of readiness, with most infants being ready for solids when they double their birth weight and/or weigh at least 13 pounds.[1] It is also important to monitor the infant's ability to swallow, noting whether the infant is able to move the food to the back of the mouth and swallow.[1,3,5] Additionally, by 6 months of age, the infant's digestive system has developed the enzymes necessary to digest a variety of foods.[1,11,12]



The ideal time to introduce complementary foods can vary based on the infant's developmental stage and nutritional status, however there is agreement throughout pediatric nutrition authorities that introduction of complementary foods should not occur before 4 months of age, before infants are developmentally ready.[5] Starting too soon or too late can affect future eating habits. Research has suggested that introducing complementary foods too early can increase the risk of choking, decrease intake of breast milk or formula resulting in malnutrition, as well as displace beneficial infant-associated microbes, altering the metabolic functionality of the gut microbiota.[5,13]

On the other hand, infants who are introduced to complementary foods after 6 months of age may miss the period of developmental readiness leading to rejection of foods and risk consumption of an inadequate variety and amount of foods to meet their nutritional needs.[5] Complementary foods provide exposure to flavors, textures and different types of foods, that may lead to acceptance of a wider variety of flavors and foods and reduce picky eating behavior in later childhood.[14,15] For example, once infants are 8 or 9 months, they may be more set in their ways and reluctant to try new foods or have trouble developing skills to eat independently.[1,16]

Additionally, the introduction of complementary foods is also important for jaw and muscle development, which contributes to speech development.[5] Research suggests that different textures of foods are better suited for different stages in the development of chewing, thus it is important to offer developmentally appropriate foods to the infant.[17]

The AAP and other nutrition experts note that there is no medical evidence for introducing solids in a specific order. Most often, iron-fortified single-grain cereals are introduced as a first complementary food; however, the AAP and USDA advises that meat, including beef, should be offered as early solids to provide heme-iron and zinc to the infant's diet, especially breastfed infants.[1,3,5]

### Developmental signs that a baby is ready for solids[1,3,5]

- Being able to control their head and neck
- Sitting up alone or with support
- Bringing objects to their mouth
- Trying to grasp small objects, such as toys or food
- Swallowing food rather than pushing it back out
- Shows significant weight gain (doubled birth weight) and at least 13 lb
- Shows interest in foods
- Has a growing appetite

Once an infant learns to accept a complementary food and displays no signs of an allergic reaction after feeding for 3 to 5 days, another food can be introduced.[1] Due to the new textures and flavors, it may take up to 8 to 10 exposures for an infant to accept a new food.[5,16] Within a few months of first introducing solid foods, an infant's diet should include a variety of foods each day, including meats, cereals, vegetables, fruits, eggs, and fish. The first 24 months is a critical window of opportunity to shape subsequent dietary patterns and eating habits. Early dietary patterns are critical to growth and development and play an important role in development of food preferences and healthy feeding habits.[3,18] The 2020-2025 Dietary Guidelines for Americans highlight that children in this age group consume small quantities of food, so it is important to make every bite count.[3]

## Essential Nutrients for Infants

Complementary foods should provide sufficient energy, protein, and micronutrients to cover a child's energy and nutrient gaps, so when combined with breast milk or formula, the infants are able to meet all his or her needs. Good nutrition is critical for the rapid growth and brain development that occurs in the first year of life.[5] Although all nutrients are necessary, the AAP highlights the key nutrients: zinc, iron, protein, choline, folate, iodine, vitamins A, D, B6 and B12 and long-chain polyunsaturated fatty acids to support optimal physical growth and brain development.[1,5,7]

The ideal time to introduce complementary foods can vary based on the infant's developmental stage and nutritional status, however pediatric nutrition experts agree that by 6 months of age, infants are often developmentally ready. This is especially important for breastfed infants, since both the infant's nutritional needs and the composition of breast milk change over time.[1,8] However adequate intake during this period is critical for all infants to protect against iron and zinc deficiencies which are associated with long-lasting negative effects on a child's development, learning, behavior, and growth.[1]

### *Iron*

Iron is an essential nutrient for various metabolic processes and supports neurologic development and immune function in infants and children.[3] A primary function of iron is to make red blood cells which carry oxygen from the lungs to the muscles and brain.[19]

Dietary iron is available in two forms — heme and nonheme iron. Heme iron is more bioavailable and has higher rates of absorption compared to nonheme iron.[19] Plants and iron-fortified foods like single-grain cereals only contain nonheme iron, whereas meat, seafood, and poultry contain both heme and nonheme iron.[1]

Exposure to iron has been shown to support the growth of healthful bacteria in an infant's gastrointestinal tract, also referred to as the enteric microbiome, which plays an important role in enhancing immune function.[20] The form of iron (naturally-occurring vs. synthetic) may influence the developing enteric microbiome in infants, with a greater abundance and diversity of

healthful bacteria associated with heme iron from meat as a first complementary food compared to iron fortified cereal, which supplies nonheme iron.[20]

Eighty percent of the iron stores present in a newborn term infant is accumulated during the third trimester of pregnancy.[21] After birth, as the baby grows and blood volume expands, red blood cells help provide iron, allowing the infant to be self-sufficient with regard to iron for the first 6 months of life. When the infant's birth weight has doubled (around 6 months of age), higher amounts of iron are required, which can be provided with the introduction of complementary foods such as red meats and vegetables with high iron content.[21,22]

Around 6 months of age, the nutritional gap between the nutritional composition of breast milk and nutritional needs of iron widens, thus the need to introduce iron-rich solid foods to complement the micronutrient requirement.[1] Human breast milk is distinctly low in iron (0.4 mg/L), but has high bioavailability of iron, which enhances the absorption of iron by infants, compensating for the low levels present in the milk.[23] For infants who are not breastfed or are partially breastfed, the AAP recommends providing an iron-fortified formula from birth to one year of age.[1] The iron content of infant formulas has typically been substantially greater than in human milk; standard term infant formulas in the U.S. contain 12 mg/L.[21] Previous research have suggested that there are small differences in iron absorption between human milk and infant formulas until 6 months of age.[24]

Among infants and children worldwide, iron is the most common nutrient deficiency.[21] In the U.S., iron deficiency continues to be a concern. The Dietary Guidelines for Americans 2020-2025 highlights iron as a nutrient of public health concern among older infants ages 6 through 11 months who are fed primarily human milk and consume inadequate iron from complementary foods.[3] According to the Nestlé Feeding Infants and Toddlers Study (FITS), the largest dietary intake study focused on infants, toddlers and preschoolers in the U.S., the number of infants with inadequate iron intakes has more than doubled between 2002 to 2016, with nearly 1 in 5 (18%) infants age 6-12 months currently falling short on dietary iron.[25-28] Specific to exclusively breastfed infants in the U.S., an estimated 77% have inadequate iron intake during the second half of infancy (6-11 months)[3] Declining consumption of key iron-rich foods among older infants and young children, including beef and iron-fortified cereal are, at least in part, responsible for the high rates of iron deficiency.[28] Therefore, attention to preventing and diagnosing iron deficiency in infants has increased due to growing evidence that iron deficiency and iron deficiency anemia in infants may have long term effects on behavior and neurodevelopment, which can persist for decades after the deficiency occurs, even when corrected.[29-32]

For healthy infants from birth to 6 months, the Institute of Medicine (IOM) determined an adequate intake for iron at 0.27 mg/d and a recommended dietary allowance of 11 mg/d from 7-12 months of age.[19,21] On average, two servings of complementary foods providing iron, such as meat or iron fortified cereal are sufficient to meet the daily iron requirement.[1] Compared to iron-fortified cereals, meats generally contain less iron per serving; however, the bioavailability of the heme iron in meat is higher, making it more effective in helping to meet iron requirements and preventing deficiency.[20,33] Fruits rich in vitamin C are recommended to help increase iron absorption from non-heme sources. Some plant-based sources of iron, including soy foods, contain phytates that inhibit iron absorption.[34]

***Zinc***

Zinc is an essential mineral for growth and development, and existing evidence shows its role in cognitive function such as improving recall skills, reasoning, and attention and motor functioning in children.[35] Zinc also has critical functions in several body processes, including forming DNA, the metabolism of carbohydrates, fats, and protein for energy, boosting immunity, helping the body heal wounds, and maintaining normal blood glucose levels.[36] Zinc deficiency in infants and children presents a special challenge, as recognition of the public health importance of inadequate intakes of zinc and its effects on morbidity and mortality in young children is growing.[37] The Dietary Guidelines for Americans 2020-2025 notes that older infants (6-11 months), approximately half (54%) of U.S. infants fed human milk have inadequate zinc intake.[3]

Similar to iron, the nutritional gap between the nutritional composition of breast milk and nutritional needs of zinc widens, thus the importance to introduce zinc-rich solid foods to complement the micronutrient requirement in breastfed infants. The zinc content of human milk is well documented to start at high concentrations (>3 mg/L) and is efficiently absorbed by the infant, but then a sharp decline occurs over the early months postpartum to <1 mg/L by 6 month, resulting in exclusively breastfed infants to be strongly dependent on complementary food sources for zinc.[8,38] Some infant cereals are fortified with zinc in addition to iron, though the bioavailability of the zinc is modestly lower than that in meat. Traditional emphasis on infant cereals, vegetables, and fruits as complementary foods is unlikely to meet zinc requirements of the older breastfed infant.[39] The AAP and USDA recommend zinc-rich complementary foods such as meat products which are considered a superior source of zinc because they contain higher amounts of zinc in a more bioavailable form compared to cereals, vegetables, and fruits.[1,3,33] Additionally, cereals and certain vegetables contain components such as phytates and fiber, which can hinder absorption of both iron and zinc.[34]

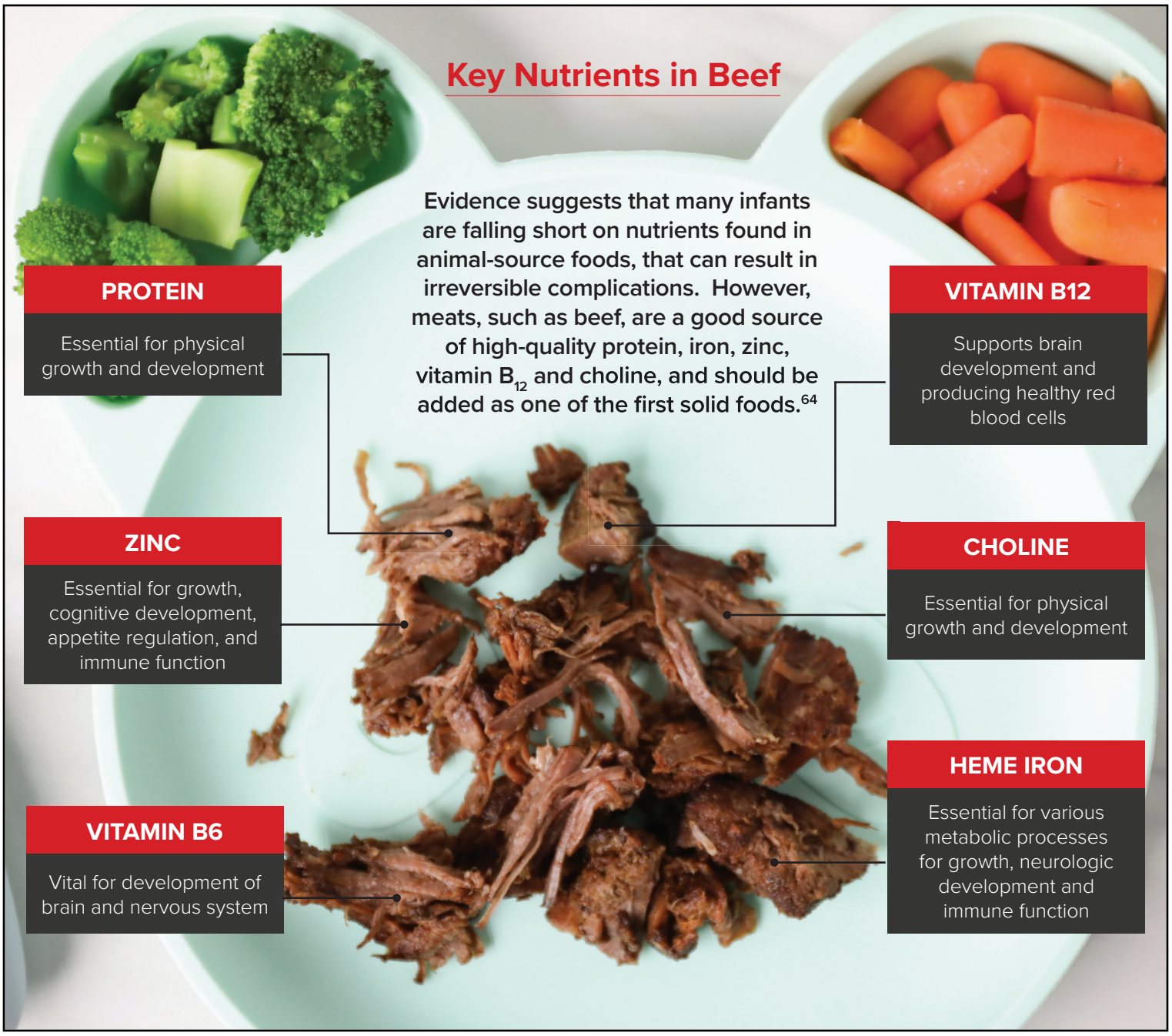
***Other key nutrients***

In addition to iron and zinc, other nutrients such as protein, choline and B vitamins, are also important when establishing early healthy dietary patterns.

Protein is an essential nutrient for physical growth and development. Food sources of protein including meat, poultry, eggs, cheese, yogurt, legumes, quinoa and tofu can be introduced as complementary foods. The USDA notes that it is important to consider animal-source foods which provide all essential amino acids necessary to meet protein requirements, whereas plant proteins tend to be lacking in at least one essential amino acid. Plant proteins can be combined together to provide all essential amino acids.[5]

Infants require high-quality protein from foods for optimal physical growth and development.[1,5] Previous research compared the effect of protein from infant cereal and meat-based complementary foods in breastfed infants, showing the protein from meats was associated with greater linear growth and weight gain but without excessive gain in adiposity, which was not seen in the infants who consumed cereal.[40] Additional research demonstrated improved linear growth without additional risk of rapid weight gain at 12 months of age in formula-fed infants who followed a meat-based complementary diet compared to a dairy-based complementary diet.[41] These different growth patterns persisted when infants were measured at 18 and 24 months of age.[42]

B vitamins play important roles in overall bodily function, impacting brain development, energy levels and cell metabolism. The concentration of B vitamins (including thiamin, riboflavin, niacin, vitamin B-6, vitamin B-12, pantothenic acid, biotin and choline) in human milk, is strongly related to the mother's dietary intake of these vitamins. Low maternal intake or stores of the B vitamins can result in lower concentrations present in human milk, which could adversely affect infant status and development. A well-nourished mother's breast



milk is generally adequate to meet breastfed infants' nutritional requirements.[43] As the infant grows, stores of the B vitamins are readily depleted, increasing reliance on complementary foods to provide B vitamins. One exception to this generalization is vitamin B12 for vegan mothers, especially if she has not taken supplements during pregnancy and lactation; her milk may be low in vitamin B12, resulting in the breastfed infant to be at risk of deficiency.[1,3]

Choline is a critical nutrient for overall brain development and function. Data from animal models suggest that fetal and infant demand is very high and maternal stores of choline are depleted during pregnancy and lactation.[44] Current research suggests that failing to meet recommendations of choline can be detrimental to health, particularly in regard to cognitive function in the developing fetus and infant.[44] Choline is present in various food items; however, animal products typically contain higher amounts of choline compared to plant foods.[45]

## The Case for Introducing Beef as a First Food

The AAP, the WHO and the USDA recognize the nutritional value of meats, including beef, as a source of nutrients that many older breastfed infants (6-11 months of age) are at risk of falling short on, including heme iron, zinc, protein, vitamin B6 and B12, and choline.[1,3,4] In a recently systematic review conducted by the USDA, the authors conclude that there is strong evidence that complementary foods containing iron, such as meat, can help maintain adequate iron status or prevent deficiency in the first year among infants at risk of insufficient iron stores or low intake.[46] Additionally, the authors note there is moderate evidence that complementary foods containing zinc, such as meat, supports zinc status in the first year."[46]

Meats, including beef, pork, chicken, and turkey, and vegetables are generally more nutrient-dense (contain more nutrients per calorie) compared to fruits or cereals, which are commonly the first complementary foods offered to infants.[5,28] Beef has been identified as a rich source of heme iron and zinc which has been shown to be well tolerated and accepted as a first complementary food and help improve iron and zinc levels in the infant.[3,20,39,47-52] Beef contains more than twice as much iron and zinc as chicken, turkey or pork.[53]

In a study based in the Denver metropolitan area, the effects of different complementary food regimens on iron and zinc status were evaluated in 45 five-month-old breastfed infants.[20,39] The infants were randomized to receive either a commercially available meat puree composed of mostly beef (1.0 mg iron and 2.1 mg zinc per serving), an iron and zinc–fortified infant cereal (7.8 mg iron and 1.2 mg zinc per serving), or an infant cereal fortified with iron only (6.2 mg iron and 0.3 mg zinc per serving), as the first complementary food for at least four months. Infants were consuming 1 serving (15 g dry cereal or one 71 g jar of meat) per day by 7 months and gradually increased to 2 servings per day by 9 months.[20,39]

Between 9 and 10 months of age, the infants who received iron- or iron and zinc-fortified cereals had two to threefold greater daily iron intakes compared to the group receiving pureed meats.[20] However, biomarkers of iron status did not differ by feeding regimen. Although iron intake from pureed meat was much less than the total iron intake from the fortified cereals, due to the heme iron content, the iron in the meat was more readily absorbed and able to meet the physiologic demands of the growing infant. This highlights the fact that dietary intake alone does not predict iron status, and other factors such as bioavailability, growth rates and iron endowment at birth, are also important.[20]

On the other hand, daily zinc intakes as well as zinc absorption were significantly greater for the pureed meat and iron and zinc-fortified cereal groups than for the cereal group fortified with iron only. The iron-only cereal had both a low zinc content and a high phytate:zinc ratio; thus, the iron-only cereal group was the only group that did not meet the physiologic requirements for zinc (0.84 mg/day for infants 7 to 12 months), which is the amount required to be absorbed to replace losses and to be retained for growth.[39] The body is unable to increase absorption of zinc when consuming a low-zinc diet, and adequate amounts of zinc are necessary in foods to ensure the absorption of zinc is sufficient to meet physiologic requirements. In a similar study, nine 7-month-old breastfed infants who consumed beef puree had more than double the zinc intake of infants receiving iron-fortified infant rice cereal, but 16-fold greater absorbed zinc. The infants were fed the complementary foods ad libitum, without specifications of amounts. Energy intakes were the same between the two groups. The beef puree contained 0.03 mg Zn/g while the rice cereal contained 0.02 mg Zn/g.[49]

Overall, these results support that meat is an appropriate first food, in particular for breastfed infants who may have lower iron status and that meat is a better source for zinc than infant cereals that are not zinc-fortified. The incorporation of meats during complementary feeding is well accepted and provides an intake of zinc that meets estimated dietary requirements in a form that is well absorbed.

Infants have high iron requirements and highly bioavailable forms of dietary iron are needed to ensure optimal iron status and to help prevent a decrease in hemoglobin levels in late infancy.[48] The absorption of iron from iron-fortified cereal is relatively low, estimated at less than 5%, while meats provide more bioavailable heme iron with absorption up to 35%.[1,47,54] Additionally, when meat is consumed with other foods, the absorption of non-heme iron from other food sources is enhanced.[52,55] Despite the potential value of meats as a source of iron, zinc and other nutrients, most infants are not introduced to meat until around 8 months of age.[56] It has been reported that in 2008, approximately 1% of the surveyed infants consumed beef.[57] In a more recent survey in 2016, beef intake increased to 2.5% of the surveyed infants consumed beef.[28]

The low meat content of complementary food combinations, such as mixtures of meat and vegetables, does not significantly impair iron status in well-nourished infants, but may increase the risk of developing marginal iron status in infants older than 6 months after exclusive breastfeeding.[51,58] Therefore, some commercially prepared combinations of meat and vegetables may not contain enough meat to supply adequate amounts of iron.

Beef is not a major allergen and is generally well tolerated by most infants. However, a beef allergy has been observed with incidence estimated between 3.3% and 6.5%, among children with atopic dermatitis.[59] Heat processing, blending, and homogenization may reduce reactivity in beef-sensitive children to help improve digestibility and reduce antigenicity of meat-based baby foods.[60]

While the AAP and USDA recommends lean meats as first foods for infants, they discourage foods that are higher in sodium such as processed meat products, as well as those with added sugars, honey or are unpasteurized.[3]

## Offering Beef as a first food

Foods prepared at home can be equally nutritious as commercially prepared options. Offering foods in the age- and developmentally appropriate size, consistency, and shape will allow an infant to learn to eat, swallow easily and minimize choking.[3] There are two styles of complementary feeding: conventional spoon-feeding and baby-led weaning. For the conventional or spoon-fed style feeding, it is recommended to start with thin and smooth pureed foods at ~6 months and advance to more complex textures including lumpy foods, chopped foods, finger foods and family food by the end of the first year.[61] For baby-led weaning, whole foods are introduced at ~6 months of age, which are modified to different shapes, sizes and textures, so babies can hold the food and feed themselves, with minimal choking hazards. Pre-loaded spoons with purees can also be provided to encourage self-feeding. It is important to note that feeding styles are not exclusive and can be combined.[62]

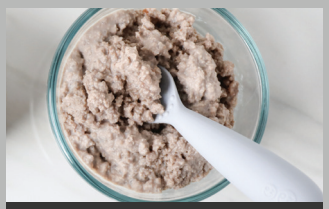
A top concern for parents, caregivers and healthcare professionals when introducing solid foods, in particular using the baby-led weaning technique, is the increased risk of choking.[5,63,64] However, recent studies have found that baby-led weaning is not associated with an increased risk of choking, compared to conventional spoon-feeding.[65,66] Therefore it is important to offer foods in the age- and developmentally appropriate size, consistency, and shape to allow an infant to develop the skills to safely learn to eat solid foods.[3] As well as for parents and caregivers to closely supervise during mealtimes.

According to the AAP, approximately 2 servings of meat (1-2 oz/day or 1-2 small jars of commercially prepared meat/day) can be provided to help meet key nutrients and energy needs.[1] The AAP and the USDA recommend starting with 0.5 to 1 ounce of meat, increasing to 1 to 2 ounces of meat by 8 months of age. Babies 6-8 months of age should consume 1-2 ounces of protein-rich foods per day, by 8-12 months of age should consume 2-4 ounces of protein-rich foods per day.[5]

### If feeding by spoon:

At around 6 months of age, introduce pureed beef (which can be mixed with breastmilk to develop a thin consistent taste and texture while maintaining nutrient-density). As the infant grows, lumpy texture purees should be introduced to increase food acceptance.[61] By 8 months of age, the baby should develop the pincer grasp and some teeth and have the ability to pick up and chew on shredded or thin slivers of beef (rather than cubed or chunks).[5] By 12 months of age, most healthy, full-term infants are able to feed themselves chopped foods from the table with their fingers.[5]


Puree


Lumpy Mashed Texture

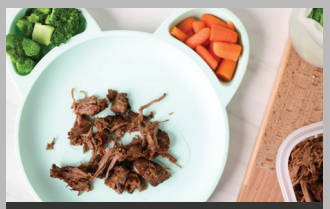
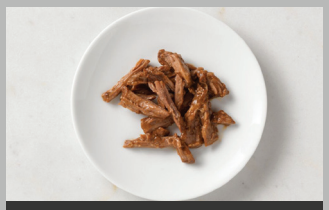

Soft Finger Food


Table Food

### If using baby-led weaning method:

At around 6 months of age, ~2 inch in length, log-shaped pieces of well-done beef can be introduced. Using the palmar grasp, the baby can pick up and hold larger strips of food. Although the baby will not have the ability to chew the steak strips, the baby can suck on the juices to get much-needed iron.[67] By 8 months of age, the baby should develop the pincer grasp and some teeth and have the ability to pick up and chew on shredded or thin slivers of beef (rather than cubed or chunks).[5] By 12 months of age, most healthy, full-term infants are able to feed themselves chopped foods from the table with their fingers.[5]


Log-Shaped Finger Food


Thin Slivers of Steak

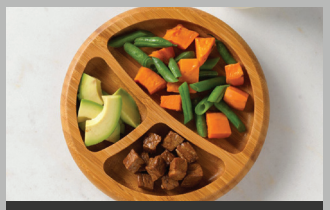

Combined Finger Foods


Table Food

**When preparing food for an infant, it is important to follow USDA established food safety guidelines.**

**For more information, visit:** *beefitswhatsfordinner.com/cooking/food-safety* and *beefitswhatsfordinner.com/cooking/determining-doneness*

## Summary and Conclusions

Meeting iron and zinc requirements (as well as other essential nutrients) during key stages of growth and development in the first year of life is crucial. Infants 6 to 12 months of age who are exclusively breastfed are at high risk for iron and zinc deficiency because of extraordinary requirements for growth coupled with low or declining levels of these essential nutrients in breast milk, but these nutrients are important for all infants.[34] A growing body of evidence indicates that inadequate intakes of iron and zinc may exert lasting negative effects on an infant's central nervous system development, with potential for irreversible effects on learning, recall skills, attention span, and behavior. Research supports the effectiveness and acceptance of meats, such as beef, as a first complementary food that supplies iron and zinc in a bioavailable form to help prevent the significant and potentially long-term effects of iron and zinc deficiency. Although single grain cereals have been traditionally introduced as a first complementary food, authoritative guidance from the AAP, the WHO and the USDA recommends offering nutrient-rich complementary foods, such as beef as a good source of high-quality protein, iron, and zinc, and other key nutrients for optimal growth and development.

## Key Takeaways

- Pediatric nutrition experts recommend the introduction of complementary foods around 6 months of age, based on the infant's developmental stage and nutritional status.
- At around 6 months of age, breast milk alone is no longer sufficient to meet the infant's increasing needs for several nutrients, including iron and zinc.
- The main indicators of whether a baby is ready for solid foods is the maturity of the digestive tract and the baby's developmental readiness.
- However adequate intake during this period is critical for all infants to protect against nutrient deficiencies which can impact long-lasting negative effects on a child's development, learning, behavior, and growth.
- Meat, such as beef, as a complementary food reduces micronutrient deficiency, especially with regards to iron and zinc.
- Introducing a variety of complementary foods with varying flavors and textures, help ensure adequate nutrition.
- Infants should be given age- and developmentally appropriate foods to help prevent choking.

## References


1. American Academy of Pediatrics Committee on Nutrition. Pediatric Nutrition. 7th ed. Elk Grove, IL: American Academy of Pediatrics, 2014.
2. Fewtrell M, Bronsky J, Campoy C, et al. Complementary Feeding: A Position Paper by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) Committee on Nutrition. J Pediatr Gastroenterol Nutr 2017;64(1):119-132.
3. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025. 9th Edition. December 2020. Available at DietaryGuidelines.gov.
4. Pan American Health Organization/World Health Organization. Guiding principles for complementary feeding of the breastfed child. Washington DC: Pan American Health Organization/World Health Organization, 2003.
5. USDA, Food and Nutrition Service. Infant Nutrition and Feeding Guide: A Guide for Use in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) [FNS-826]. 2019.
6. Theurich MA, Grote V, Koletzko B. Complementary feeding and long-term health implications. Nutr Rev 2020;78(Supplement_2):6-12.
7. Schwarzenberg SJ, Georgieff MK, Committee on Nutrition. Advocacy for improving nutrition in the first 1000 days to support childhood development and adult health. Pediatrics 2018;141(2).
8. Krebs NF. Dietary zinc and iron sources, physical growth and cognitive development of breastfed infants. J Nutr 2000;130(2S Suppl):358S-360S.
9. National Academies of Sciences, Engineering, and Medicine. Vibrant and Healthy Kids: Aligning Science, Practice, and Policy to Advance Health Equity. Washington, DC: The National Academies Press. . 2019.
10. American Academy of Pediatrics Committee on Nutrition. Iron fortification of infant formulas. Pediatrics 1999;104(1 Pt 1):119-23.
11. Were FN, Lifschitz C. Complementary Feeding: Beyond Nutrition. Ann Nutr Metab 2018;73 Suppl 1:20-25.
12. USDA, Food and Nutrition Service. Infant Nutrition and Feeding Guide: A Guide for Use in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) [FNS-288]. 2009.
13. Differding MK, Benjamin-Neelon SE, Hoyo C, Østbye T, Mueller NT. Timing of complementary feeding is associated with gut microbiota diversity and composition and short chain fatty acid concentrations over the first year of life. BMC Microbiol 2020;20(1):56.
14. Mennella JA, Trabulsi JC. Complementary foods and flavor experiences: setting the foundation. Ann Nutr Metab 2012;60 Suppl 2:40-50.
15. Taylor CM, Emmett PM. Picky eating in children: causes and consequences. Proc Nutr Soc 2019;78(2):161-169.
16. Spill MK, Johns K, Callahan EH, et al. Repeated exposure to food and food acceptability in infants and toddlers: a systematic review. Am J Clin Nutr 2019;109(Suppl_7):978S-989S.
17. Simione M, Loret C, Le Révérend B, et al. Differing structural properties of foods affect the development of mandibular control and muscle coordination in infants and young children. Physiol Behav 2018;186:62-72.
18. Reidy KC, Deming DM, Briefel RR, Fox MK, Saavedra JM, Eldridge AL. Early development of dietary patterns: transitions in the contribution of food groups to total energy—Feeding Infants and Toddlers Study, 2008. BMC Nutr 2017;3:5.
19. National Institutes of Health Office of Dietary Supplements. Iron: Fact sheet for health professionals. Available at https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/.
20. Krebs NF, Sherlock LG, Westcott J, et al. Effects of different complementary feeding regimens on iron status and enteric microbiota in breastfed infants. J Pediatr 2013;163(2):416-23.
21. Baker RD, Greer FR, Committee on Nutrition American Academy of P. Diagnosis and prevention of iron deficiency and iron-deficiency anemia in infants and young children (0-3 years of age). Pediatrics 2010;126(5):1040-50.
22. Domellöf M, Braegger C, Campoy C, et al. Iron requirements of infants and toddlers. J Pediatr Gastroenterol Nutr 2014;58(1):119-29.
23. Friel J, Qasem W, Cai C. Iron and the Breastfed Infant. Antioxidants (Basel) 2018;7(4).
24. Lonnerdal B, Georgieff MK, Hernell O. Developmental Physiology of Iron Absorption, Homeostasis, and Metabolism in the Healthy Term Infant. J Pediatr 2015;167(4 Suppl):S8-14.
25. Bailey RL, Catellier DJ, Jun S, et al. Total Usual Nutrient Intakes of US Children (Under 48 Months): Findings from the Feeding Infants and Toddlers Study (FITS) 2016. J Nutr 2018;148(9S):1557S-1566S.
26. Butte NF, Fox MK, Briefel RR, et al. Nutrient intakes of US infants, toddlers, and preschoolers meet or exceed dietary reference intakes. J Am Diet Assoc 2010;110(12 Suppl):S27-37.
27. 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(1 Suppl 1):s22-30.
28. Roess AA, Jacquier EF, Catellier DJ, et al. Food Consumption Patterns of Infants and Toddlers: Findings from the Feeding Infants and Toddlers Study (FITS) 2016. J Nutr 2018;148(suppl_3):1525S-1535S.
29. Georgieff MK. The role of iron in neurodevelopment: fetal iron deficiency and the developing hippocampus. Biochem Soc Trans 2008;36(Pt 6):1267-71.
30. Lozoff B, Beard J, Connor J, Barbara F, Georgieff M, Schallert T. Long-lasting neural and behavioral effects of iron deficiency in infancy. Nutr Rev 2006;64(5 Pt 2):S34-43; discussion S72-91.
31. Lozoff B, Jimenez E, Smith JB. Double burden of iron deficiency in infancy and low socioeconomic status: a longitudinal analysis of cognitive test scores to age 19 years. Arch Pediatr Adolesc Med 2006;160(11):1108-13.
32. McCann JC, Ames BN. An overview of evidence for a causal relation between iron deficiency during development and deficits in cognitive or behavioral function. Am J Clin Nutr 2007;85(4):931-45.
33. Hunt JR. Bioavailability of iron, zinc, and other trace minerals from vegetarian diets. Am J Clin Nutr 2003;78(3 Suppl):633S-639S.
34. Dewey KG. The challenge of meeting nutrient needs of infants and young children during the period of complementary feeding: an evolutionary perspective. J Nutr 2013;143(12):2050-4.
35. Black MM. The evidence linking zinc deficiency with children's cognitive and motor functioning. J Nutr 2003;133(5 Suppl 1):1473S-6S.
36. National Institutes of Health Office of Dietary Supplements. Zinc: Fact sheet for health professionals. Available at https://ods.od.nih.gov/factsheets/Zinc-HealthProfessional/.
37. Hambidge KM, Krebs NF. Zinc deficiency: a special challenge. J Nutr 2007;137(4):1101-5.
38. Krebs NF. Update on zinc deficiency and excess in clinical pediatric practice. Ann Nutr Metab 2013;62 Suppl 1:19-29.

39. Krebs NF, Westcott JE, Culbertson DL, Sian L, Miller LV, Hambidge KM. Comparison of complementary feeding strategies to meet zinc requirements of older breastfed infants. Am J Clin Nutr 2012;96(1):30-5.
40. Tang M, Krebs NF. High protein intake from meat as complementary food increases growth but not adiposity in breastfed infants: a randomized trial. Am J Clin Nutr 2014;100(5):1322-8.
41. Tang M, Hendricks AE, Krebs NF. A meat- or dairy-based complementary diet leads to distinct growth patterns in formula-fed infants: a randomized controlled trial. Am J Clin Nutr 2018;107(5):734-742.
42. Tang M, Andersen V, Hendricks AE, Krebs NF. Different Growth Patterns Persist at 24 Months of Age in Formula-Fed Infants Randomized to Consume a Meat- or Dairy-Based Complementary Diet from 5 to 12 Months of Age. J Pediatr 2019;206:78-82.
43. Allen LH. B vitamins: proposed fortification levels for complementary foods for young children. J Nutr 2003;133(9):3000S-7S.
44. Wallace TC, Blusztajn JK, Caudill MA, et al. Choline: The Underconsumed and Underappreciated Essential Nutrient. Nutr Today 2018;53(6):240-253.
45. Wallace TC, Blusztajn JK, Caudill MA, Klatt KC, Zeisel SH. Choline: The Neurocognitive Essential Nutrient of Interest to Obstetricians and Gynecologists. J Diet Suppl 2020;17(6):733-752.
46. Obbagy JE, English LK, Psota TL, et al. Complementary feeding and micronutrient status: a systematic review. Am J Clin Nutr 2019;109(Suppl_7):852S-871S.
47. Davidsson L, Kastenmayer P, Szajewska H, Hurrell RF, Barclay D. Iron bioavailability in infants from an infant cereal fortified with ferric pyrophosphate or ferrous fumarate. Am J Clin Nutr 2000;71(6):1597-602.
48. Engelmann MD, Sandstrom B, Michaelsen KF. Meat intake and iron status in late infancy: an intervention study. J Pediatr Gastroenterol Nutr 1998;26(1):26-33.
49. Jalla S, Westcott J, Steirn M, Miller LV, Bell M, Krebs NF. Zinc absorption and exchangeable zinc pool sizes in breast-fed infants fed meat or cereal as first complementary food. J Pediatr Gastroenterol Nutr 2002;34(1):35-41.
50. Krebs NF, Hambidge KM. Complementary feeding: clinically relevant factors affecting timing and composition. Am J Clin Nutr 2007;85(2):639S-645S.
51. Dube K, Schwartz J, Mueller MJ, Kalhoff H, Kersting M. Complementary food with low (8%) or high (12%) meat content as source of dietary iron: a double-blinded randomized controlled trial. Eur J Nutr 2010;49(1):11-8.
52. Engelmann MD, Davidsson L, Sandstrom B, Walczyk T, Hurrell RF, Michaelsen KF. The influence of meat on nonheme iron absorption in infants. Pediatr Res 1998;43(6):768-73.
53. U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. FoodData Central, 2019. Available at fdc.nal.usda.gov (Beef composite, cooked - FDC ID: 170208, NDB Number: 13364; Turkey, whole, meat only, cooked, roasted - FDC ID: 171481, NDB Number: 5168; Pork, fresh, composite of trimmed retail cuts (loin and shoulder blade), separable lean and fat, cooked - FDC ID: 167906, NDB Number: 10227; Chicken, broilers or fryers, meat only, cooked, roasted - FDC ID: 171054 NDB Number: 5013).
54. Hurrell R, Egli I. Iron bioavailability and dietary reference values. Am J Clin Nutr 2010;91(5):1461S-1467S.
55. Hurrell RF, Reddy MB, Juillerat M, Cook JD. Meat protein fractions enhance nonheme iron absorption in humans. J Nutr 2006;136(11):2808-12.
56. Grummer-Strawn LM, Scanlon KS, Fein SB. Infant feeding and feeding transitions during the first year of life. Pediatrics 2008;122 Suppl 2:S36-42.
57. 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(12 Suppl):S38-51.
58. Cox KA, Parkin PC, Anderson LN, et al. Association Between Meat and Meat-Alternative Consumption and Iron Stores in Early Childhood. Acad Pediatr 2016;16(8):783-791.
59. Fiocchi A, Restani P, Riva E. Beef allergy in children. Nutrition 2000;16(6):454-7.
60. Restani P, Fiocchi A, Restelli AR, et al. Effect of technological treatments on digestibility and allergenicity of meat-based baby foods. J Am Coll Nutr 1997;16(4):376-82.
61. 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(1):75-85.
62. Castle J. The Smart Mom's Guide to Starting Solids: How to Introduce, Advance and Nourish Your Baby with First Foods. Nourished Child Press, 2018.
63. Cameron SL, Heath AL, Taylor RW. Healthcare professionals' and mothers' knowledge of, attitudes to and experiences with, Baby-Led Weaning: a content analysis study. BMJ Open 2012;2(6).
64. Ferraro K. The 5 Biggest Fears that Stop Parents from Doing Baby-Led Weaning. Available at https://www.fortifiedfam.com/home/2019/2/21/the-5-biggest-fears-that-stop-parents-from-doing-baby-led-weaning.
65. Brown A. No difference in self-reported frequency of choking between infants introduced to solid foods using a baby-led weaning or traditional spoon-feeding approach. J Hum Nutr Diet 2018;31(4):496-504.
66. Fangupo LJ, Heath AM, Williams SM, et al. A Baby-Led Approach to Eating Solids and Risk of Choking. Pediatrics 2016;138(4).
67. Purchas RW, Simcock DC, Knight TW, Wilkinson BHP. Variation in the form of iron in beef and lamb meat and losses of iron during cooking and storage. Int J Food Sci Technol 2003;38(7):827-837.


***If you have questions about starting solid foods, consult a physician or health care provider.***

Funded by the Beef Checkoff

© 2021 Cattlemen's Beef Board and National Cattlemen's Beef Association ARMS#042321-10