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.\textsuperscript{1,3,4}
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.\textsuperscript{1,3,9} If breastfeeding is not possible or not elected, iron-fortified formula is recommended as the next best option.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{11,12}

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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{13} 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{7} 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.\textsuperscript{5,7} 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.\textsuperscript{8}
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. 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.

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. 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. 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.

Additionally, the introduction of complementary foods is also important for jaw and muscle development, which contributes to speech development. 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.

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.

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. 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.

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. 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.

Iron

Iron is an essential nutrient for various metabolic processes and supports neurologic development and immune function in infants and children. A primary function of iron is to make red blood cells which carry oxygen from the lungs to the muscles and brain. 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. Plants and iron-fortified foods like single-grain cereals only contain nonheme iron, whereas meat, seafood, and poultry contain both heme and nonheme iron.

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. 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.39-41 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.20,23 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.25 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.26 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.3,38 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.13,33 Additionally, cereals and certain vegetables contain components such as phytates and fiber, which can hinder absorption of both iron and zinc.34
**Key Nutrients in Beef**

Evidence suggests that many infants are falling short on nutrients found in animal-source foods, that can result in irreversible complications. However, meats, such as beef, are a good source of high-quality protein, iron, zinc, vitamin B₁₂ and choline, and should be added as one of the first solid foods.⁶⁴

### Protein

**Protein**

Essential for physical growth and development

### Zinc

**Zinc**

Essential for growth, cognitive development, appetite regulation, and immune function

### Vitamin B₁₂

**Vitamin B₁₂**

Supports brain development and producing healthy red blood cells

### Choline

**Choline**

Essential for physical growth and development

### Heme Iron

**Heme Iron**

Essential for various metabolic processes for growth, neurologic development and immune function

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**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.¹⁵ 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. 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

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.1,28 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.1,2,20,39,47,52 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.25 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.43

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%.1,4,54 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. Heat processing, blending, and homogenization may reduce reactivity in beef-sensitive children to help improve digestibility and reduce antigenicity of meat-based baby foods.

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.

### 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. 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. 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.

### 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. 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). By 12 months of age, most healthy, full-term infants are able to feed themselves chopped foods from the table with their fingers.

### 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. 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). By 12 months of age, most healthy, full-term infants are able to feed themselves chopped foods from the table with their fingers.

### 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. 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


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