Beef as a First Food

Beginning around 6 months of age, infants are at risk of falling short of certain key nutrients for growth, especially infants who are exclusively breastfed. The transition from exclusive breastfeeding or formula feeding to the addition of solid foods, is referred to as complementary feeding. 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.

Authoritative guidance from the American Academy of Pediatrics (AAP) and the World Health Organization (WHO) recommends the introduction of complementary foods at approximately 6 months of age, based on the infant's developmental stage and nutritional status, even though breastfeeding may continue beyond two years.[1-3] These complementary foods are essential to ensuring adequate nutrition during this key window of opportunity in infant development to prevent undernutrition or malnutrition and subsequent long-term adverse consequences. Meat as a complementary food promotes optimal growth and helps to prevent micronutrient deficiency, especially with regards to iron and zinc, in breastfed infants.

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Today's Guidelines for Infant Feeding and Complementary Foods

At around 6 months of age, breast milk alone is no longer sufficient to meet the increasing needs for several nutrients, including iron, zinc, and calcium.[1-3]

The AAP Committee on Nutrition recommends infants be breastfed exclusively for approximately the first 6 months of life, continuing through the first year of life. If breastfeeding is not possible or not elected, iron-fortified formula is recommended as the next best option. Complementary foods should be introduced around 6 months of age, when the infant's digestive system has developed the enzymes necessary to digest a variety of foods.[1-3] Guidance emphasizes the importance of introducing solid foods during the right window of time for the infant. Indications of readiness may include holding up the head with good control, showing interest in table food, or opening the mouth when food is offered. Weight can also be used as a good indicator of readiness, according to AAP, with most infants being ready for solids when they double their birth weight and/or weigh at least 13 pounds. 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.

Developmental signs that a baby is ready for solids

- sits up well without support
- holds head up with good control
- shows interest in foods
- no longer has "extrusion reflex" or pushes solids out of mouth with the tongue
- moves food from front to back of mouth
- makes chewing motions
- closes mouth around a spoon
- shows significant weight gain (doubled birth weight) and weighs at least 13 pounds
- develops a "pincer" grasp, where he/she can pick up food or other objects between thumb and forefinger
- has a growing appetite

Sources USDA, AAP

According to USDA, no evidence of harm exists for introducing safe, nutritious complementary foods at 4 months when an infant is developmentally ready.[1-3] Starting too soon can affect future eating habits as the infant may reject the spoonfuls of solid foods initially, simply due to not being ready for them. The timing for introducing complementary foods to infants varies, but there is agreement that infants at about 6 months of age require increased iron and zinc intake beyond that available in breast milk alone.

Complementary foods help meet requirements for the energy and nutrients associated with growth and development during the first year of life. At around 6 months of age, breast milk alone is no longer sufficient to meet the increasing needs for several nutrients, including iron, zinc, and calcium.[1-3] The introduction of complementary foods by 6 months is also important for jaw and muscle development, which contributes to speech development. Additionally, complementary foods provide exposure to flavors and textures that may lead to acceptance of a wider variety of flavors and foods in later childhood. Infants who are not introduced to complementary foods when developmentally ready may reject foods introduced at a later age and may consume an inadequate variety and amount of food to meet their nutritional needs. 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.[1-3] The AAP and other nutrition experts note that there is no medical evidence for introducing solids in a specific order. Most often, single-grain cereals are introduced as a first complementary food; however, the AAP advises that meat, including beef, turkey, and chicken, should be added as early solids to the infant's diet.[1-3] This is especially important for breastfed infants, since both the infant's nutritional needs and the composition of breast milk change over time.

Once an infant learns to accept a complementary food and displays no signs of an allergic reaction after feeding for two to three days, another food can be introduced. Within a few months of introducing solid foods, an infant's diet should include a variety of foods each day, including meats, cereals, vegetables, fruits, eggs, and fish. Finger foods are appropriate once an infant can sit up and is able to pincer grasp and bring hands or other objects to the mouth, usually around 6 to 7 months of age.[1-3]

FYI

When introducing complementary foods, it is important to take into consideration the gestational age compared to the actual birth age of premature infants (born <37 weeks gestation). To improve nutritional iron status and growth rate, current evidence recommends introducing solids to premature infants at 3 months of their corrected age (the actual age minus the number of weeks premature), while also considering the individual readiness of each child.

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Essential Nutrients in Beef for Infants and Young Children

Experts agree that breastfed infants need a good dietary source of iron and zinc by 6 months of age, which cannot be met by breast milk alone. Adequate intake during this period is critical 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 cognitive development in infants and children. 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.

A primary function of iron is to make red blood cells which carry oxygen from the lungs to the

Why are iron and zinc important for babies?

Iron—an essential nutrient for growth and development

- makes red blood cells that transport oxygen throughout the body
- supports the infant's brain development
- plays a role in the infant's developing immune system

Iron deficiency is associated with anemia which can affect growth and may lead to learning and behavioral problems.

Zinc—an essential mineral for growth and cognitive development

- improves recall skills, reasoning, and cognitive development
- supports metabolism of carbohydrates, fats, and protein for energy, boosting immunity, helping the body heal wounds, and maintaining normal blood glucose levels

Zinc deficiency is associated with growth stunting, loss of appetite, impaired immune function and, when severe, dermatitis.

muscles and brain. Emerging evidence also indicates that iron plays a role in the infant's developing immune system. 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.[4, 5] The form of iron 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.[6]

Eighty percent of the iron present in a newborn term infant is accreted during the third trimester of pregnancy.[7] After birth, as the baby grows and its 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.[7, 8] Due to the depletion of the iron stores present at birth and the low concentration of iron in human milk, exclusively breastfed infants will become dependent on complementary foods to avoid iron deficiency at approximately 6 months of age.[9] Among infants and children worldwide, iron is the most common nutrient deficiency.[9] Despite a decline in prevalence of iron deficiency anemia in developed countries, it still remains a particular concern for high-risk populations including infants and children.[10, 11]

The AAP and USDA report that full-term, breastfed infants need approximately 1 mg/kg/day of supplemental iron at 6 months of age, preferably from complementary foods (e.g., iron-fortified infant cereal and/or meats).[1, 7]

At this time, national data on the rate of iron deficiency in infants under 12 months of age are not available for the United States,[7] but two relatively small studies of breastfed infants in Denver observed rates of iron deficiency close to 30%, suggesting that iron deficiency continues to be a concern.[6, 12] Attention to preventing and diagnosing iron deficiency in breastfed 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.[13-17]

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Compared to iron-fortified cereals, meats generally contain less iron per serving; however, research has shown that the high bioavailability of iron in meat makes this complementary food more effective in helping to meet iron requirements and prevent deficiency.[6] Beef contains more than twice as much iron as chicken or pork. For older infants and toddlers, the AAP advises feeding meat, shellfish, and legumes, along with vegetables and fruits containing iron, as well as iron-fortified cereals. 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.[18]

Zinc

Zinc is an essential mineral for growth and development, and existing evidence shows its cognitive role in improving recall skills, reasoning, and attention in children. 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. 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.[19] Prevalence data for zinc deficiency are lacking; however, available data and clinical experience suggest that zinc deficiency is relatively common in older breastfed infants and young children.[20-22] Zinc deficiency is associated with growth stunting, loss of appetite, and zinc deficiency dermatitis.[21]

While zinc levels are initially high in breast milk, a sharp decline occurs in the early postpartum months.[1-3] Thus, around 6 months of age, the exclusively breastfed infant becomes strongly dependent on complementary food sources for zinc. 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.[20] Meat products 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. Beef contains twice as much zinc as turkey, chicken or pork. Additionally, cereals and certain vegetables contain components such as phytates and fiber, which can hinder absorption of both iron and zinc.[18, 23, 24]

The Case for Introducing Meat as a First Food

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. Meats, in particular beef, have been shown to be well tolerated and accepted as a first complementary food and help improve iron and zinc levels.[6, 12, 20, 25-29, 31, 35]

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.[6, 20] The infants were randomized to receive either a commercially available meat puree composed of mostly beef, an iron and zinc–fortified infant cereal, or an infant cereal fortified with iron only, as the first

Infants 6 to 12 months of age who are exclusively breastfed are at a high risk for iron and zinc deficiency because of extraordinary requirements for growth.[18]

complementary food for at least four months (**Table 1**). Infants were consuming 1 serving (15g dry cereal or one 71g jar of meat) per day by 7 months and gradually increased to 2 servings per day by 9 months.[6, 20]

Between 9 and 10 months of age, the infants who received iron- or iron and zinc-fortified cereals had twofold to threefold greater daily iron intakes compared to the group receiving pureed meats.[6] 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. Surprisingly, iron deficiency and iron deficiency anemia were common in the study's infants, with approximately one-third of the study participants mildly anemic, independent of feeding group. 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.[6]

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.[20] 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 0.03mg Zn/g while the rice cereal contained 0.02mg Zn/g.[26]

Overall these results support the premise that meat is an appropriate first food for breastfed infants 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.[27] 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, 28, 29] Additionally, when meat is consumed with other foods, the absorption of nonheme iron from other food sources is enhanced.[2, 30, 31] Despite the potential value of meats as a source of iron and zinc, most infants are not introduced to meat until around 8 months of age. It has

Table 1. Comparison of average iron and zinc content per serving size in complementary foods with recommended intakes

	Iron (mg)	Zinc (mg)
Adequate intake/day 0-6 months*	0.27	2.0
Recommended Dietary Allowance/day 7-12 months*	11.0	3.0
Meat puree (71 g)**	1.0	2.1
Iron only-fortified infant cereal (15g) **	6.2	0.3
Iron and zinc-fortified infant cereal (15g)**	7.8	1.2
3 oz cooked beef composite***	2.5	5.9
3 oz cooked pork composite***	0.85	2.46
3 oz cooked chicken composite***	1.03	1.78

*Recommended Dietary Allowances and Adequate Intakes, Elements. Food and Nutrition Board, Institute of Medicine, National Academies, 2001. Available at www.nap.edu

**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;96:30-5.

**Krebs NF, Sherlock LG, Westcott J, Culbertson D, Hambridge KM, Feazel LM, Robertson CE, Frank, DN. Effects of different complementary feeding regimens on iron status and enteric micronota in breastfed infants. J Pediatr 2013;163:416-23

***US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 28, 2015. (NDB No 13364 for beef, 10093 for pork, and 05013 for chicken)

been reported that in 2008, less than 10% of infants consume meat in their first nine months, with less than 0.4% consuming beef.[33] 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.[34, 35] Therefore, some commercially prepared combinations of meat and vegetables may not contain enough meat to supply adequate amounts of iron.

Acceptance and tolerance of meat as a first food has also been studied. Scientific research, as well as anecdotal evidence, suggests that the introduction of a variety of flavors and textures improves the acceptance of new foods in infants and young children.[10] Although beef is generally well tolerated by most infants, beef allergy has been observed, with incidence estimated between 3.3% and 6.5%, among children with atopic dermatitis.[36] Heat processing, blending, and homogenization may reduce reactivity in beef-sensitive children to help improve digestibility and reduce antigenicity of meat-based baby foods.[37]

Global Impact

Iron deficiency is the most common nutritional deficiency in the world, a significant concern in developing countries while also prevalent in developed countries such as the United States. In comparison, approximately 20% of children 0 to 4 years of age in developed countries are iron deficient, and approximately 8% of infants and toddlers in the United States are reported to have iron deficiency (**Table 2**).[38] The WHO and the United Nations International Children's Emergency Fund (UNICEF), recognize that lack of breastfeeding in the first six months is a major risk factor for infant/childhood morbidity and mortality, which may be compounded by inappropriate complementary feeding.[39] The WHO guidelines for complementary feeding

recommend daily intake of animal source foods after 6 months of age, noting that vegetarian diets cannot meet nutrient needs without nutrient supplements or fortified foods.[1-3] A randomized controlled trial was conducted in impoverished communities in four global sites, the Democratic Republic of Congo, Zambia, Guatemala, and Pakistan to evaluate the use of meat compared to a multimicronutrient-fortified cereal as a complementary food in infants and toddlers prone to high stunting rates.[40] Both complementary foods appear to improve iron status; however, due to the high rate of stunting at baseline, there was a lack of effect to reverse the stunting progression in the infants.[42, 43] Meat may be more readily available and affordable than micronutrient-fortified products for households. In addition, a protective effect of meat consumption was noted against stunting in toddlers.[42] Other global studies of infants from deprived socioeconomic backgrounds indicate that higher red meat intake is associated with positive effects on linear growth and serum levels of iron and zinc status.[43, 44]

Table 2. Iron deficiency anemia in children 0 to 4 years of age

WHO Region	Total affected population
Africa	45,228,000
Americas	14,200,000
Southeast Asia	111,426,000
Europe	12,476,000
Eastern Mediterranean	33,246,000
Western Pacific	29,793,000
Overall	**245,386,000**

World Health Organization (WHO), United Nations Children's Fund (UNICEF), United Nations University (UNU). Iron deficiency anaemia: assessment, prevention and control. Geneva, Switzerland: World Health Organization, 2001. [WHO/NHD/01.3]

Summary and Conclusions

Meeting iron and zinc requirements 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.[18] 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, evidence suggests that meats are a good source of high-quality protein, iron, and zinc, and should be added as one of the first solid foods for infants.

Key Takeaways

- Health 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.
- Meat as a complementary food reduces micronutrient deficiency, especially with regards to iron and zinc, in breastfed infants.

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