Meat as an Early Complementary Food for Infants: Implications for Macro- and Micronutrient Intakes

Nancy F. Krebs

Abstract

Optimal complementary feeding is recognized to be critical for prevention of infectious morbidity and mortality and for optimal growth and development. The nutrients which become limiting in human milk after approximately 6 months of exclusive breastfeeding are predictable based on the dynamic composition of human milk and the physiology of infant nutritional requirements. Iron and zinc are two micronutrients for which the concentrations in human milk are relatively independent of maternal intake, and for which the older infant is most dependent on complementary foods to meet requirements. Traditional feeding practices, including reliance on cereals and plant-based diets, do not complement these recognized gaps in human milk. Meats or cellular animal proteins are richer sources of these critical minerals as well as other essential nutrients. Yet, cellular animal proteins are often introduced only late in infancy in developed countries, and may be only rarely consumed by young children in developing countries. Plant-based diets result in a predominance of energy from carbohydrates, often including highly refined carbohydrates that are also likely to have a high glycemic index. This pattern of macronutrient intake is contrary to that of the period when the human genome evolved, and may influence the metabolic profile in young children, especially under conditions of nutritional abundance.

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Introduction

Optimal complementary feeding is recognized to be critical for meeting the nutritional needs of the older infant and young child who is still breastfed. Indeed, provision of nutritionally adequate complementary foods has been cited as one of the most important measures to prevent infectious morbidity.
and mortality in children under 5 years of age [1]. Furthermore, the period from birth to 24 months also represents a critical window of brain development, and thus of vulnerability to harm from micronutrient deficiencies that may have permanent effects on neurocognitive development [2]. In contrast to the universal and simple message of exclusive breastfeeding for the first 6 months which has yielded improvements in breastfeeding rates and exclusivity, guidelines and implementation strategies for complementary feeding are inevitably more complex, involving issues related to food availability and economics, cultural customs, preferences and norms, and the developmental readiness of the infant [3]. Thus, while the nutritional needs of the older infant have been extensively considered [4, 5], there is less consensus about the most feasible way(s) to meet energy and nutrient needs. Strategic options, many of which will be discussed in other articles in this series, include food-based approaches, food fortification, biofortification through plant breeding and agricultural practices, micronutrient ‘sprinkles’ added to local foods, and micronutrient supplements.

Here, the rationale for an approach to complementary feeding that encourages early and regular consumption of meat and flesh (cellular animal protein, CAP) for older infants and toddlers will be discussed, as well as some of the potential barriers to this approach.

**Adequacy of Exclusive Breastfeeding**

Human milk provides a biologically robust source of nourishment ideally suited for the human infant. The composition is also relatively consistent over a wide range of maternal dietary quality, although there are some exceptions. Regardless of the maternal nutritional status, however, the composition of human milk is dynamic, as are the infant’s nutritional requirements. The result of this is that at some point human milk alone will not adequately meet the infant’s nutritional needs. Although the exact timing of this point has been an area of some controversy [6], and it is certain to vary among individual infants, the recommendation to introduce complementary foods around 6 months of age recognizes the increasing risk thereafter for development of deficiencies of specific micronutrients for which intake from human milk alone will be marginal. This is not to imply that breastfeeding is not nutritionally important after 6 months, but rather that the combination of high quality complementary foods in addition to continued breastfeeding results in optimal growth, development and immunoprotection.

The concentrations of iron and zinc in human milk are minimally influenced by maternal intake. The relatively low concentration of iron in human milk is adequate for the first several months until the infant’s iron endowment at birth is expended. To provide adequate iron for active hematopoiesis and growth after the first 6 months of life, the infant is almost entirely dependent
on complementary foods as a dietary source [7, 8]. The situation for zinc is different in that the concentration of zinc in human milk is initially quite high but rapidly declines over the first 5–6 months postpartum; zinc intake by the exclusively breastfed infant follows a similar declining pattern [9, 10]. After this time, as for iron, the majority of the infant's requirement will also need to be provided by complementary foods [7, 8]. Iron deficiency is one of the most prevalent nutritional deficiencies on a global scale [2]. Likewise zinc deficiency, though more difficult to document, is also likely to be very common and to be a major causative factor for susceptibility to infectious morbidity and stunting [1, 11].

**Complementary Foods to Meet the Micronutrient Gaps of Exclusive Breastfeeding**

Despite knowledge of the nutrient gaps for the older breastfed infant, complementary feeding practices common in both developed and developing countries often do not emphasize foods which fill these gaps. For at least the past century, cereal gruels have been a common early food offered to infants in the US [6, 12]. With the recognition of the relatively high iron requirements of the older infant, iron fortification of infant cereal has provided a major vehicle to meet iron needs [13], thus further promoting the value of cereal as a first food for infants in the US. Fruits and vegetables are typically offered next, despite the fact that these are poor sources of the nutrients most likely to be limiting in older breastfed infants. Specific protein sources are gradually introduced, often not until late in the first year of life. This pattern is not unique to the US. Review of the complementary feeding guidelines described for the six sites participating World Health Organization Multicenter Growth Reference Study also indicates this a similar pattern in other affluent cultures [14].

In developing countries, various types of plant-based gruels or thin soups are common early foods offered to infants. These gruels are made from cereal grains or starchy roots and tubers [3, 4, 8], which not only are low in energy and nutrient content but also contain phytic acid and polyphenols, factors which impair the bioavailability of zinc and iron. Not only are these foods less than ideal, lack of diversity of complementary foods further compromises nutritional adequacy for older infants.

In contrast to the plant-based complementary foods, meats and flesh foods are excellent sources of bioavailable iron and zinc, as well as vitamins B₁₂ and B₆, micronutrients which may also be marginal in the diets of older infants and young children. Liver is an excellent source of most micronutrients, and is particularly high in vitamin A, deficiency of which is also very common in developing countries. These animal-source foods also provide high quality protein and typically have a higher caloric density. Thus meats provide a
nutrient profile more consistent with and ‘complementary’ to the nutritional needs of the older breastfed infant. Furthermore, as described by Cordain et al. [15], prior to the agricultural revolution, cereals, especially refined grain flours, were likely to be a relatively small part of the ‘hominin diet’, presumably including infants’ diets. Rather, the human diet was primarily reliant on animal flesh and fruits. Historical review of complementary feeding practices suggests that minced or pre-masticated meats were among early weaning foods prior to the 1800s [12]. Even 50–60 years ago in the US, common practice was to introduce meats, as well as the other major food groups, within the first 2 months of life [12]. Although such early introduction of any complementary foods is now considered undesirable, this illustrates the precedent for acceptance of meats much earlier than is typical in contemporary infant feeding.

**Evidence for Benefits of Cellular Animal Protein Intake**

A few studies have reported the benefit of meats, or CAPs, on growth and iron status in young children. For example, in a surveillance study of breastfed infants and toddlers in Peru, linear growth was positively associated with intake of animal-product foods (including meats) in those children with low intakes of complementary foods, and in those who had low breastfeeding frequency. Similarly, at low energy intakes, intake of animal source foods was positively associated with linear growth [16]. A cross-sectional survey of 12- to 23-month-old children in Delhi, India, reported higher length-for-age scores associated with parental education and non-vegetarian diets [17]. A nutrition intervention trial targeting improved complementary feeding in Peru, and specifically including a message to offer liver, eggs or fish every day, demonstrated a significant improvement in nutritional intakes and, importantly, a reduction in stunting [18]. In contrast, a similar intervention trial in India, which promoted consumption of higher quality plant-based complementary foods, including legumes and thickened gruels, was not associated with improvements in growth [19].

In developed countries, a handful of studies have examined the potential benefits of meats in the diets of older infants and toddlers. In one prospective observational study, infants were enrolled at 4 months and followed through 24 months of age; dietary intakes were documented by 7-day food diaries. Modest meat intake (<28.3 g/day) was positively associated weight gain in the first year of life, and with psychomotor development at 24 months [20]. An intervention study in Denmark randomized 8-month-old breastfed infants to receive high or low meat diets for 2 months. Despite having a total iron intake from fortified foods similar to the intake of the high meat group, the low meat group had a significantly greater decline in hemoglobin compared to the high meat group [21].
A trial in Denver randomized breastfed infants to either commercial pureed meat (beef) and gravy or iron-fortified rice cereal as the first complementary food [22, 23]. At 7 months, intake of zinc was significantly higher in the meat group, and the amount of zinc absorbed from a test meal was approximately 16-fold greater in the meat group [22]. The mean intake of \( \sim 56.6 \text{ g meat and gravy/day} \) provided the estimated average requirement of 2.5 mg zinc/day [7]. Infants in the meat group had a significantly greater increase in head circumference from 7 to 12 months; no other significant differences in functional outcomes between the groups were observed. The iron and zinc status at 9 months was suboptimal in over 1/3 of the infants, regardless of the group. Since the feeding intervention ended at 7 months, it is not possible to know whether outcomes, including iron and/or zinc status, would have been improved if the emphasis on meats had been sustained [23].

**Macronutrient Intakes with Plant- versus Animal-Based Complementary Feeding Patterns**

As the focus on the prevalence of micronutrient deficiencies in older infants and toddlers has emerged over the past decade, somewhat less attention has been directed to the macronutrient distribution of the typical weanling diet [3]. The reliance on cereals, with or without micronutrient fortification, results in a low fat, low energy dense diet. Although continued reliance on human milk will contribute to the quantity and quality of lipid intakes, as the percentage of energy from this source gradually declines, the composition of complementary foods contributes substantially to the macronutrient distribution in the total diet. At a time of development when a high energy dense diet, including high fat intake, is considered to be beneficial, the emphasis on cereals and other plant foods counters this pattern.

In the study described above on breastfed infants in Denver, at 7 months the group assigned to rice cereal as the first weaning food (with ad libitum introduction of fruits and vegetables) consumed more than 80% of the calories from complementary foods as carbohydrate, predominantly refined, and only 8% of calories were from fat. Assuming an average intake of human milk, the overall contribution of fat intake to energy would be only \( \sim 35\% \). Although the study design dictated the introduction of cereal as the first complementary food, it is worth noting that this represents typical feeding patterns for US infants. The intake of calories, iron, and zinc for the cereal group were essentially identical to intakes reported a decade earlier for 7-month-old breastfed infants in Denver [10].

In contrast, the infants assigned to start with meat (also with ad libitum introduction of fruits and vegetables) consumed 50% of energy from complementary foods as carbohydrate and 22% as fat. At 9 months, when the
majority of infants were still predominantly breastfed but complementary feeding was entirely ad libitum, carbohydrate continued to dominate, providing 64–75% of energy from complementary foods for the two groups, while energy from fat was <20% for both groups. Data from the Feeding Infants and Toddlers Study of US infants, the majority of whom were formula-fed, showed a similar pattern [24], with the mean percent of total calories from fat of about 35% for 7- to 11-month-olds [24].

The long-term effects of different macronutrient distributions during the critical developmental period of late infancy are unknown. Data from the STRIP Baby Project, in which infants randomized at 7 months to diets low in total fat (~30% of energy), and specifically low in saturated fat, indicated no adverse effects on growth or development after 3 years [25]. On the other hand, an analysis of food balance data in young Latin American children concluded that diets providing <22% of energy from fat, including low animal fat content, were associated with underweight and stunting, and that animal food products were critical to support normal child growth [26].

As noted above, the human genome adapted to an environment, including diet, profoundly different from that of the past 10,000 years when agriculture and animal husbandry were introduced. Not only were cereal grains not routinely consumed prior to this, until only 150–200 years ago the grains that were consumed were unrefined. In the late 1800s, milled grains came to dominate and the germ and bran were routinely removed and discarded [15]. Although the cereals and grains consumed by young children in developing countries in rural areas may be relatively unprocessed, this is likely not the case in urban and peri-urban areas where more refined products are more readily available.

Refined carbohydrates are generally associated with higher glycemic load and have been proposed to cause chronic hyperglycemia and hyperinsulinemia. These metabolic conditions have been proposed to predispose to obesity, type 2 diabetes, cardiovascular disease, and chronic elevation of inflammatory markers [27]. To date, few studies have examined the effects of infant feeding beyond breastfeeding versus formula feeding on obesity and metabolic profiles, but it is possible that the early introduction of a ‘westernized diet’, with predominance of refined carbohydrates predisposes to risk of later chronic diseases. If a high carbohydrate load is concurrent with micronutrient deficiencies, there may be further exacerbation of adverse metabolic effects. There are many potentially confounding factors, including genetic risk of insulin resistance, birth weight (reflecting intrauterine exposure), early weight gain and subsequent weight status, in addition to the impact of type of feeding. The theoretical issues raised about the relationship of current complementary feeding practices to the later risk of chronic diseases of westernization warrant further consideration and research in view of global concerns about rising rates of childhood obesity and its comorbidities, including insulin resistance.
Acceptability and Safety of Meats as an Early Complementary Food

Although a common perception about the introduction of meats and liver as an early complementary food is that infants will not accept them, our experience does not support this. We found no difference in parents’ ratings of infants’ acceptance between cereal and meat groups in the Denver study described above [23]. In unpublished observations, we have also found no hesitation to eating pureed cooked liver in 7- and 12-month-old infants in rural Guatemala.

Theoretical concerns may also be raised about the potential for allergic sensitization from different complementary feeding patterns. A recent consensus document cites the major foods posing allergy risks are bovine milk, egg, peanut, tree nuts, fish, and seafood [28]. Wheat especially is associated with both food allergies and celiac disease (gluten enteropathy), and rice is stated to be an important allergen in Asia. The consensus document concludes that well-cooked or freeze-dried meats have low allergenicity [28].

Recognition of the nutritional value of animal source foods, especially meats and flesh foods, for complementary feeding has been noted by several organizations, including the American Academy of Pediatrics, World Health Organization, and the Centers for Disease Control and Prevention [6, 13, 29–30]. Thus, in developed countries, the main barrier to broader adoption of these recommendations seems to be primarily one of education of physicians and care providers who advise breastfeeding mothers on complementary feeding. The lack of a definitive evidence base for optimal feeding for predominantly breastfed infants, however, and the relatively small numbers of these infants also contribute to the lack of consensus in practice.

In developing countries, the issues are quite different, and the availability of meat and flesh foods may be much more limited, due at least in part, to the relative expense of animal source foods. However, this is clearly not the only issue. In many settings, customs rather than availability are the major barrier. Offering the older infant meat is simply not recognized as an appropriate or valuable practice. In some cultures, religious beliefs prohibit the consumption of CAP, although some accept the use of eggs and dairy products. Several initiatives from non-governmental organizations have been undertaken to increase production, accessibility and consumption of animal source foods in efforts to combat coexisting micronutrient deficiencies. These programs have not been universally successful, and emphasize the importance of formative research to characterize and understand a population’s perceptions about nutrition, health and infant and child feeding prior to undertaking major interventions. Critically needed are also efficacy studies of meat consumption as part of overall improved complementary feeding practices for older infants and toddlers. At present, the lack of a strong evidence base may foster
ambivalence about the benefits of advancing a feeding strategy that has broad sociocultural and economic implications contrary to the status quo.

Conclusion

Optimal complementary feeding is recognized to be critical for optimal growth and development during early childhood. The nutrients which become limiting in human milk after approximately 6 months of exclusive breastfeeding are predictable based on the dynamic composition of human milk and the physiology of infant nutritional requirements. Iron and zinc are two micronutrients for which the concentrations in human milk are relatively independent of maternal intake, and for which the older infant is most dependent on complementary foods to meet requirements. Traditional feeding practices, including reliance on cereals and plant-based diets, do not complement these recognized gaps in human milk. CAP sources are rich in these critical trace minerals as well as other essential nutrients, and limited intervention studies have suggested good acceptance by the infants and beneficial outcomes. The distribution of macronutrients also varies greatly between plant-based diets and those including CAP, which may have implications for metabolic predisposition toward obesity and insulin resistance, both of which are increasingly prevalent in developing countries. Thus, although there is a strong theoretical rationale for the earlier introduction of CAP, there is a great need for both efficacy and effectiveness studies.

References

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Meat and Complementary Feeding


Discussion

Dr. Michaelsen: You compared meat and liver and there was much more zinc and iron in liver. But the meat factor that is enhancing iron absorption, is that mainly in muscle foods? I got the impression that the meat factor, although it is not well
identified, is more in muscle food than in liver. So does meat perhaps have a better capacity to enhance iron absorption?

Dr. Krebs: As I said the iron in liver, though it is a very high isn't all heme. So if you were going to predict you would not predict that the absorption would be efficient. Whether it is efficient enough to make use of all that is there has not been done in a head-to-head comparison. The liver of course is richer in several nutrients.

Dr. Kruger: I haven’t seen many studies that looked at head circumference and it was a very important result that the zinc status actually predicted head circumference and also the Bayley scores. That to me was one of the really important observations that you made.

Dr. Krebs: I want to be very cautious about this, especially on the Bayley testing, as it is just a trend and the behavior score on that version of the Bayley is still a fairly rudimentary score, but nevertheless it was done blinded and so on. As far as the head circumference is concerned, there has actually been a difference in head circumference according to the amounts of zinc that breastfed infants get depending on what the mother’s secretion was. I am beginning to think that this actually may be a real finding. It was a surprise but it was actually the only anthropometric measure that was different. I have become very attuned to measuring that now in any of our intervention trials.

Dr. Solomons: It is really unfortunate that there was only one month of intervention and perhaps there are other populations in which you could increase the amount of time in which the randomized comparison is continued. But in the one month that you had, was there any differential effect on the consumption of breast milk across the two groups? I ask this because these women were presumably still breastfeeding. In the study in Denver you could have chosen a cereal with any amount of fortification with zinc and iron; you could have designed a cereal that was like meat, or a cereal that was like Guatemalan cereals. The real comparison then is in the real world of places where the complementary food, cereal, a grain product, is not a prepared processed infant cereal but is rather something mixed with water. Such a cereal would not have any fortification. So in the real world there would not be the option for the iron- and zinc-fortified cereal side to the equation, so that the contrast between meat and cereal in Pakistan or Guatemala would be much more dramatic than it could be with whatever fortified cereal you used.

Dr. Krebs: You are right, the cereals actually weren’t fortified at that time with zinc. So this was a non-fortified cereal and there was very little zinc. There was a lot of electrolytic iron and it is not very well absorbed. Yes, a longer intervention would have been very good. I was actually very nervous about doing the study at the time and I felt it was probably unethical to withhold meat, not really recognizing that many infants go much longer without really having meat introduced. If I did it now I would probably put them on dinners that are low in zinc and iron but actually have enough protein. Regarding the breast milk intake, we didn’t do test weighing but they were all exclusively breastfed and none of them used a formula at the 7-month point. By 9 months about 50% were on a formula up to between 110 and 225 g/day. We didn’t see any difference between the two groups.

Dr. Mello: What is the amount of the meat necessary?

Dr. Krebs: The average intake was over 2 mg/day of zinc and that was from about 57 g of a commercial product. It would actually only take about 28 g/day of beef and gravy, a pureed product, and so if you are actually just using straight meat, we predict that they actually take less than 57 g.

Dr. Guno: For practical clinical application, it appears from the data that only on the days that liver is fed will the iron and zinc requirements be met. We also say that the babies should be fed a variety of foods on the days that the mother gives a fish or
a vegetable source of protein. Is it prudent to say that the mothers should also use other iron-fortified products or give an iron supplement?

Dr. Krebs: That is an interesting question. It is always hard to match reality with the daily requirements, and I don't know if you have to have meat every single day. In many populations if meat were available several times a week, we would be doing much better than we had been. It probably becomes too complicated to recommend a supplement on the days that you don't have meat. By consuming meats you are getting a better iron intake, but it may be difficult to fine tune recommendation of alternating meat with supplementation.

Dr. Brown: One comment about real world situations. The last time I looked at this in Bangladesh using the FAO food balance sheets, the per capita availability of meat was about 4 g/person/day. So even if we are talking about adjusting an ounce of meat, we are far away from being able to meet that requirement in much of the developing world in terms of availability, so there is a big challenge there. I have two questions. In Dr. Ferguson's presentation the other day, it was very interesting to me that with the cereal-based fortified processed complementary foods there has been very little impact on any indicator of physical growth, but in several studies in which mixed diets usually with animal source foods were provided, there has been a growth impact. I am not quite sure what might explain that, you looked at protein and zinc but I also note that there are differences in fat intake. I wonder if you might comment on that. The second question is just for my information. When you looked at the exchangeable zinc for size in relation to zinc intake, did you also look back at the serum zinc concentration?

Dr. Krebs: It was a small subgroup in which we did the isotope that I doubt we would have seen a relationship. The other question was about the fat intake. The calories were so remarkably close, but whether the fat in itself could have had some effect, besides just straight energy, I guess possibly.

Dr. Brown: I raised the question because in the study I presented 2 days ago from Ghana, we saw no differences in the energy intake in the 3 groups that received the different micronutrient supplements, but there was a difference in the weight gain and linear growth in the group that received the 'Nutributter'. We also found a significant increase in the α-linoleic acid concentration in plasma which was directly associated with the differences in growth and explained about 50% of the differences in growth across groups. It is not the ideal study design to address this question, but I was curious if anybody else has experience in that area.

Dr. Krebs: Until we have a really important initiative involving NGOs or ministries of health, it is difficult to say whether there is a true benefit to using animal source foods, meat and flesh. The data are accumulating anyway and that is really why we need controlled trials. So much has been invested in trying to figure out appropriate supplementation and fortification programs, if an equal amount of energy went into how we can deliver meat to the population, that might actually be time well spent. I know it is the norm that there is very little meat available, but it doesn't mean that it has to be that way.

Dr. Agostoni: May I add two comments regarding fat composition. Arachidonic acid is supposed to be a growth promoter, not directly but through eicosanoid synthesis to improve the cell to cell talking. On the other hand, an association of DHA with growth has been observed, even if it is difficult to explain in terms of biologic plausibility. So in both cases we are dealing with fat quality more than quantity. As a further hypothesis on growth promotion with some supplements, we should keep in mind a possible role for branched chain amino acids, even if supplied in minimal amounts, as this could also increase the biologic value of vegetal proteins supplied together.

Dr. Fewtrell: One of the reasons mothers in the UK don't use much meat is they start complementary feed before 6 months and they find it quite difficult to puree
foods into a suitable consistency. The alternative is to use jars that actually have very little meat. We don't actually have commercially available single meat products which might actually help. Liver is very unpopular among mothers in the UK, and it is a hard job to persuade them to adopt it. In developing countries where calcium intake may not be good, I wonder whether we should have any concern about giving a lot more meat and increasing calcium excretion in urine, and whether that might potentially have any downsides? It is not something that we particularly thought about before, and I guess in developed countries it is not going to be an issue, but in certain areas of the world I imagine that could be a potential problem.

**Dr. Krebs:** The protein-calcium relationship is very complicated. In our meat study, the actual increase in protein isn't that huge an intake, it wasn't to fortify 4 g/kg/day. I would not worry about that, and in terms of what is holding up growth and what is affecting meal status and so on, it's really iron and zinc, it is not calcium. There is no evidence that in general the bone status of breastfed infants differs in formula-fed infants even though the formula-fed infants absorb a lot more calcium and so on. So to me calcium hasn't been really such a compelling issue in terms of how we think about complementary feeding. It is hard to get it from the plant-based diet and you do need to supplement them, but I don't think it is as critical. I find it hard to believe that the amount of meat these babies were eating would have affected their calcium homeostasis.

**Dr. Solomons:** There are a lot of fully available studies on electrolytic iron in adults [1]. Electrolytic iron is the source in infant formulas before 6 months and follow-up formulas and cereals, and children in the United States are not iron-deficient. In your study, although the difference was small and the sample size was small, there was more anemia in the meat-fed than in the cereal-fed children. Recent data on anemia rates in a national representative sample show that the United States is so very different from the rest of the world in anemia that it is bizarre to the point where we have overcorrected anemia in young children.

**Dr. Krebs:** That is a fair comment. It is not that we never see iron deficiency in older breastfed infants who have been on cereals, but in general, absolutely on a population basis, it seems to have done the job. In the US it is very hard to find just breastfeeders and know if it is really doing the job in breastfed infants because there are so few infants in the community who are still predominantly breastfed passed 6 months. So when you look at national data they are reflecting iron-fortified formula.

**Dr. Solomons:** The in vitro bioavailability of electrolytic iron has been found to be acceptable [2].

**Dr. Bulusu:** I liked it when you asked if we at all need non-vegetarian food or is there a need for meat. There are two issues here, as Dr. Brown mentioned one is the 4 g of meat in a Bangladesh diet. In India it is not necessarily a socioeconomic issue, it is also a cultural issue. So what would you recommend under those conditions? Secondly Dr. Agostoni mentioned that there are vegetarian bodybuilders. How do you explain that? I come from a Brahmin family. Brahmans are a specific caste that never touches meat, fish or eggs. One of my professors at university used to tease me saying that I was a grass-eating lady. Once I had finished my MSC and entered the PhD program, he was still one of my professors. After several such occasions I said, ‘For the last two years I have been hearing this from you, sir. We are all nutritionists in this department, can we have a real anthropometric, clinical, biochemical and intellectual study here?’ So among 14 research colleagues in the laboratory, and I was the tallest among the girls and scored 81% at my MSC level and had no clinical sign of any deficiency. The only test left was biochemical; my hemoglobin was 13.8, and that too being a vegetarian, the highest, not only among my female colleagues but also among the males. So how can you explain this? To date I have never touched any non-vegetarian food.
Dr. Krebs: There are probably a number of factors here. It is obviously a real dilemma in truly vegetarian communities where it is based on religious practices. I don't want to counter that, but I think we have to recognize, as the WHO has and as you discussed in your presentation, that if you are not going to use animal source foods then you may well need a micronutrient supplement to meet those needs in that vulnerable time period. With regard to the vegetarian bodybuilder, I don't know what that person or that population was fed as young infants, but once you have passed early infancy and toddlerhood your requirements go down, and all of us in this room can do just fine on a vegetarian diet as far as the zinc requirements. So infancy and early childhood are a very vulnerable time, and this is the time in life when it is going to be a challenge to be a vegetarian. But if you are vegetarian then you would be prudent to think about supplementation, again on a population basis as you talked about in your country. The other factor is that there are so many in the world who are not vegetarian for religious purposes, including the US where we simply just don't get this message out; it is just a custom not really a specific religious practice.

Dr. Bulusu: I would just like to add that through the Micronutrient Initiative I promote supplementation and fortification, but I always believe in diversification, a balance diet.

References

