Exploring Optimal Nutrition for Infants: A Comprehensive Review of Infant Food and it’s Nutritional Considerations

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Students

Abstract: The maturity that take place throughout an infant’s first year of life depend on healthy diet. It is appropriate to let the infant decide how much food to eat based on their hunger. Give your child the essential fatty acids they need for strong hair, healthy skin, normal eye development, healthy brain development, and resistance to disease and infection. In this review paper we have tried to cover all the topics related to “Infant Nutrition” like how much food should be introduced to infants; proper feeding techniques can improve brain development throughout the critical first years of life, first food for baby, traditional foods for infants, instant infant foods, protective foods, energy density of infant foods, modified family food. And also how much quantity of nutrients should be given to infants. The nutrient intake varies for the age group from 0-6 months and 7-12 months. It includes the nutrients like carbohydrates, proteins, lipids, folate, iron, calcium, zinc, fluoride and vitamin (A, C, D, E, K, B1, B3, B6, B12). A study on comparison of nutritional antioxidant content in breast milk, donor milk and infant formulas.

Keywords: Infant Nutrition, brain development, first food, traditional food, instant infant food, modified food.

I. Introduction

Growth and maturation are significantly influenced by nourishment through the life cycle.[8] For the first four to five months of life, the baby can only be fed breast milk or an appropriate formula designed to replace milk. For this reason, it is suggested to include extra meals in the diet to ensure that the body is obtaining enough minerals.[43] Having meal mixes or a range of foods that meet the baby's requirements for macro and micronutrients is essential for providing supplemental diets that are balanced and nutritionally adequate.[37] During the initial year of life, an infant's growth and maturation depend heavily on a healthy diet. When developing babies are fed the right kinds and amounts of food, their health is enhanced. Through the use of positive and encouraging feeding techniques, carers teach infants suitable attitudes towards food, themselves, and others. A newborn may chew and eat a wide range of complementary foods as their mouth, tongue, and digestive tract grow. They were only able to swallow, nurse, and consume liquid foods such as baby formula or breast milk in the past. [42]

By incorporating a wide variety of fresh foods, complementary feeding should ideally provide a basis for the formation of well-rounded taste preferences. Newborns are well recognized to have an innate taste preference for sweet flavours and an instinctive dislike of bitter flavours, which evolved from an evolutionary standpoint to reject toxins and seek out energy. [29] Baby food formulation, handling, and storage are crucial for maintaining the foods' physicochemical qualities and nutritional value. Baby meals' physicochemical and nutritional qualities vary due to certain interactions and changes that occur during storage. [36]

Initial half-year For the newborn child's immune system and brain development to improve, breastfeeding is crucial. Consequently, the exclusive for about six months, breastfeeding is advised. Breastfeeding should be continued with the supplemental feed until the child is at least 1 year old. Notably, using expressed maternal milk is safe and feasible as long as the expressed milk is preserved properly to minimize the chance of bacterial growth. [30]

How much food should be introduced?

It is appropriate to let the infant decide how much food to eat based on their hunger. Parents and carers should feed each child 1-2 tablespoons of each food once a day, and then gradually increase the amount based on appetite.

• From 8 to 9 months, the infant can receive a maximum of 2-3 small meals daily, depending on hunger.

• Before turning one year old, 3 small meals and 1-2 snacks might be provided each day.
• While breast milk and formula consumption naturally decline in the age of 6 and 12 months. [19]

Proper feeding techniques can improve brain growth over the critical first three years of life by establishing avenues for purposeful education through attentive care giving.[25] Children should be given new meals every day until they get used to them, so parents should be persistent in this regard. It's advisable to avoid introducing new foods to a child who is unwell, such as during a cold or episode of diarrhea. When their parents eat a new cuisine, toddlers are more likely to accept it as well. Refusing children their favorite meal in a try to make them eat "healthy" food seems to have the opposite effect. Babies shouldn’t be caressed unduly, burped, or wiped. Rather, feeding should begin as soon as they cease crying for more than 30 minutes.[7] The infant is first introduced to solid foods when they begin to wean. It is often advised to start complementary feeding around six months or so. Though some contend that weaning can happen as early as four or six months. After three or four years, the child learns to feed itself independently.[35]

First food for Infants

Meals offered to young children with maternal milk during the weaning process are known as complementary meals. Children from six months to three years old should consume approximately 100 kcal/kg of required daily calories. Twelve-month-old newborns ingested about 80 kcal/kg of calories, most of which came from breast milk. Compared to babies between the ages of 5 and 11, toddlers between the ages of 12 and 17 months only consumed eight extra calories. Sixty-nine percent of the children's calories between the ages of nine and eighteen months (average age of thirteen months) came from breast milk.[22] The study aims to investigate the relationship between the introduction of solid foods early in infancy, gastrointestinal problems, allergies during the first two years of life, and neonatal weight in addition to the effects of diet, weight, and respiratory infections, gastrointestinal problems, and nappy rash incidence in newborns at different intervals; two weeks, two, three, four, six, nine, twelve, fifteen, eighteen, and twenty-four months of age. Babies who are given solid foods between the ages of 8 and 12 weeks typically weigh more than those who are introduced later. [16]

Traditional foods for infants

When the child is comfortable eating cereal porridge, you can serve them mixed dishes that include cooked cereal, lentils, and one or more vegetables. Most traditional infant diets in the country are mixed foods, such khichdi, Dalia, sujikheer, upma, idli, dhokla, bhaat-bhaji, etc.[33]

Instant Infant Foods

Infant meal mixtures can be prepared at home by using food grains that you already have on hand. These are sattu-like concoctions, which are popular among Indians. One part of any pulse (moong, channa, or arhar), three parts of any cereal (rice, wheat), or millet (ragi, bajra, jowar), and half of groundnuts or white til, if available, can be consumed. After each component is separately roasted, the ingredients should be well combined, crushed, and kept in airtight receptacles.[33]

Protective Foods

Protective foods such milk, curd, lassi, eggs, fish, and fruits and vegetables are also crucial to aid in the healthy growing of the infants, and to adapted family cuisine and reconstituted infant food mixes.[33]

Energy Density of Infant Foods

Due to their small stomach capacity, infants consume almost three times as much energy per kg of body mass as adults do.[30] Compared to conventional cereal porridges, which have an energy density of 1.5 kJ/g, and oil-fortified porridges, which can have an energy density of up to 6 kJ/g, FS has an energy density of 22 kJ/g. It is unknown how a supplemental food this high in energy might affect the amount of breast milk consumed. [17]

Modified Family Food

The pieces of chapatti could be soaked in a half-katori of dal and some vegetables. After adding a little oil, the blended food may be well mashed and fed to the infant. Changing the family's diet is one of the right way to ensure that newborns are receiving complementary feedings.[33]
How much amount of nutrients should be given to infants? [42]

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>0-6 months</th>
<th>7-12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>60g/day of carbohydrate</td>
<td>95g/ day of carbohydrate</td>
</tr>
<tr>
<td>Protein</td>
<td>9.1g/ day of polypeptides</td>
<td>11g/ day of polypeptides</td>
</tr>
<tr>
<td>Lipids</td>
<td>31g/ day of lipid</td>
<td>30g/ day of lipid</td>
</tr>
<tr>
<td>Linoleic Acid (n-6 Polysaturated fatty acids)</td>
<td>4.4g/ day of Linoleic acid</td>
<td>4.6g/ day of Linoleic acid</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>400µg Retinol</td>
<td>500µg Retinol</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>2.0µg/ day of Phytonadione</td>
<td>2.5µg/day of Phytonadione</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>4mg/day of α-tocopherol</td>
<td>5mg/day of α-tocopherol</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>40mg/ day L-ascorbic acid</td>
<td>50mg/ day L-ascorbic acid</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>0.4µg/ day of Cobalamin</td>
<td>0.5µg/ day of Cobalamin</td>
</tr>
<tr>
<td>Folate</td>
<td>65µg/ day dietary folate</td>
<td>80µg/ day dietary folate</td>
</tr>
<tr>
<td>Vitamin B6 (Pyridoxine)</td>
<td>0.1mg/ day of Pyridoxine</td>
<td>0.3mg/ day of Pyridoxine</td>
</tr>
<tr>
<td>Vitamin B1 (Thiamin)</td>
<td>0.2mg/ day of B1</td>
<td>0.3mg/ day of B1</td>
</tr>
<tr>
<td>Vitamin B2 (Riboflavin)</td>
<td>0.3mg/ day of B2</td>
<td>0.4mg/ day of B2</td>
</tr>
<tr>
<td>Niacin</td>
<td>2mg/ day of B3</td>
<td>4mg/ day of B3</td>
</tr>
<tr>
<td>Calcium</td>
<td>210mg/ day of Ca</td>
<td>270mg/ day of Ca</td>
</tr>
<tr>
<td>Iron</td>
<td>0.27mg/ day of Fe</td>
<td>11mg/ day of Fe</td>
</tr>
<tr>
<td>Zinc</td>
<td>4mg/ day of Zn</td>
<td>5mg/ day of Zn (UL)</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.01mg/ day of fluoride</td>
<td>0.5mg/ day of fluoride</td>
</tr>
</tbody>
</table>

How much amount of nutrient should be given to 0-12 months infants?

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>0-12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-3 polyunsaturated fatty acids</td>
<td>0.50g/ day of n-3 fatty acid</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>5µg (200IU)/ day</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>600µg/ day of Retinol</td>
</tr>
<tr>
<td>Iron</td>
<td>40mg/ day of Fe</td>
</tr>
</tbody>
</table>

➢ All of these consumption values correspond to the Adequate consumption (AI) suggested for infants.
➢ Acceptable Upper Limit of Intake (UL)

Sources and some crucial points about different nutrients:

Carbohydrates:
Sugar alcohols, such as sorbitol and mannitol, are significant sources of carbohydrates that need to be considered for newborns. Lactose, the primary carbohydrate found in mother’s milk and infant formula manufactured from cow’s milk, is typically digested by babies.
A baby’s diet must include carbohydrates since they are a vital source of energy and minerals.
• Give food energy for development, exercise, and body functions;
• Dietary protein helps the body produce new tissue more quickly and effectively.
• Give the body the ability to regularly use lipids and
Give the components needed to create a few key bodily substances.[42] Almost all consumed carbs are transformed into glucose during digestion. The main oxidative fuel used by the brain is glucose.[23] During infancy and childhood, digestible carbohydrates are a vital source of energy for growing and developing newborns and children. By the time a baby is two years old, carbohydrates—mostly lactose—should provide 40% of its energy.[41]

Proteins:
Breast milk, infant formula, and/or supplemental foods include high-quality protein that is necessary for the development, maintenance, and repair of new tissues in infants, including skin, eyes, muscles, the heart, lungs, brain, and other organs. They also need high-quality protein to produce essential enzymes, hormones, antibodies, and other components take part in extremely specialised activities to manage your body's processes. Over the past 35 years, a large number of published assessments of human protein requirements—including those for infants and newborns—have been made available. A study has been conducted of the protein requirements for maintenance and for growth of children about 1 year old who had recovered from malnutrition. The diets adopted provided 120 kcal/kg per day; dry skim milk was the only source of protein. The average maintenance requirement, measured by nitrogen balance, was found to be 100 mg N/kg day.[10]

Lipids:

Lipids are necessary for a baby's diet because:

- Promote the body's retention of fat, which lowers body temperature and acts as insulation; fat accounts for more than 50% of the energy in breast milk and infant formula;
- bodily heat loss, in addition it provides cushioning to safeguard internal organs;
- Permit the fat-soluble vitamins A, D, E, and K to be absorbed. Give the body the vital fatty acids it needs to develop healthy skin, hair, eyes, and brain tissue while also strengthening its defences against disease and infection.[42] Babies get the majority of their energy from lipids. The bulk of the fat in human milk is composed of triglycerides; cholesterol and phospholipids are present in very small amounts.[27] For neonates to fulfill their high energy needs and to perform a range of metabolic and physiological functions essential to their growth, development, and general well-being, they must consume dietary lipids.[12]

Vitamin D:

The amount of sunshine a baby receives influences how much vitamin D they need.

- Fat-soluble vitamin D is necessary for the normal development of teeth and bones. Infants who receive little vitamin D are more probable to experience inadequate bone mineralization and eventually develop rickets. In full-term infants, rickets is rare, but in very preterm infants, the risk is increased. [1] Early onset osteopenia is a danger element for premature infants, which emphasizes the significance of getting enough minerals and vitamin D to maintain good bone health.[32]

Vitamin A:

The two main dietary sources of vitamin A are thought to be breast milk and baby formula. For neonates on supplemental foods, liver, egg yolks, leafy greens, and yellow and dark green fruits (such as spinach, greens, sweet potatoes, apricots, melons, and peaches) are additional sources of vitamin A, or carotenes.

- The development and growth of healthy mucous membranes, skin, and hair, as well as proper vision, depend on vitamin A. Growth and development, also strong reproductive and immunological system.[42] Additionally, through the first six months of life, the Vitamin A Consultative Group (IVACG) advises that three 50,000-international unit (IU) doses of vitamin A be administered concurrently with newborn vaccinations.[38]

Vitamin K:

Vitamin K metabolism indicates that not much vitamin K really crosses the placenta from mother to kid. Preterm babies are given high quantities of vitamin K by prophylaxis, TPN solutions, infant formula, and breast milk fortifiers. Consequently, vitamin serum concentrations in preterm neonates can be up to 100 times larger in preterm newborns than in adults and 10–20 times higher in babies fed formula.[20] The gastrointestinal system was most frequently the site of the hemorrhage, which typically started on the second or third day of life. The efficiency of vitamin K administration in preventing vitamin K-deficiency bleeding was established, and hemorrhagic illness caused by vitamin K deficiency was subsequently distinguished from bleeding related to other causes.[26] During the first week of life, infants often face a significant decrease in their plasma prothrombin levels, which can pose a serious risk. However, by giving vitamin K prophylactically to the newborn or to the mother before delivery, this drop can be lessened or even avoided.[39]

Vitamin E:
Breast milk and infant formula are the two main sources of vitamin E for babies. As infants get older, a variety of foods can provide them with vitamin E, such as butter, liver, egg yolks, wholegrain breads, cereals, leafy green vegetables, vegetable oils and their byproducts, wheat germ, and other grain products that have been enhanced or fortified with vitamin E.

- The main purpose of vitamin E include protecting the body's supply of vital fatty acids and vitamin A. Prevents tissue deterioration.[42] \( \alpha \)-tocopherol, or vitamin E, has been associated to numerous advantageous outcomes for premature newborns. Anaemia, which typically develops four to six weeks following a premature birth, is partially caused by a vitamin E deficiency, and regular vitamin E supplements are usually advised.[6] Due to their medical needs, premature babies may experience delays in starting feeding for a few days and restrictions on food intake for several weeks. As a result, addressing low plasma vitamin E levels in premature newborns may require a substantially longer period.[24]

**Vitamin C:**

The two main food sources of vitamin C are believed to be nursing moms and infant formula. The body needs ascorbic acid, a water-soluble vitamin, for the following essential functions:

- Producing collagen, which keeps bones, muscles, and cartilage structurally intact; shielding blood vessels, teeth, and other connective tissues;
- Healing injuries influencing the body's capacity to fight off diseases; and improving iron absorption.[42] Since this is the lowest known intake of vitamin C for infants, it is advised that newborns receive about 20 mg per day throughout the first year of their lives.[18] To get the concentrations of ascorbic acid (vitamin C) in preterm neonates closer to those in utero during the third trimester, the dosages should be increased to 25–31 mg/kg/day.[11]

**Vitamin B12:**

Breast milk or baby formula from women who get adequate vitamin B12 will be adequate to meet the needs of nursing babies. Complementary foods, such as dairy and egg yolks, can be offered to babies as they grow to help them acquire this essential vitamin. Water-soluble vitamin B12 is necessary to maintain normal brain function and to protect healthy red blood cells. [42] Low vitamin B12 concentrations in the mother's breast milk were the cause of the megaloblastic pancytopenia deficiency; further testing revealed maternal pernicious anaemia. [31]

**Folate:**

Some foods that give newborns folate include breast milk, infant formula, leafy greens, oranges, melons, whole-grain bread, cereals, lentils, lean meats, egg yolks, and liver. The following procedures require the water-soluble vitamin folate:

- Each body cell's production of genetic material, cell division, and the growth and maturation of healthy blood cells. [42] New research suggests that low maternal folate levels during pregnancy may result in low birth weight, which raises the risk of poor long-term health and developmental implications, even if the mother frequently uses her reserves to maintain the newborn's folate levels.[34]

**Vitamin B6:**

Potatoes, beans, meat, whole-grain breads, cereals, breast milk, baby formula, liver, and a variety of grain products enhanced or fortified with the vitamin are among the foods high in vitamin B6. The water-soluble vitamin B6 pyridoxine is required by the organism to help utilize protein for tissue synthesis; Promote fat metabolism.[42] Extra vitamin B6 is given to all newborns during their first six months of life. [9]

**Vitamin B1:**

Lean pork, potatoes, beans, and whole grain breads, cereals, and other grain items improved or fortified with thiamin are additional great sources of the vitamin.

- The water-soluble vitamin thiamin, often known as vitamin B1, is necessary for the body to help digest carbohydrates and provide energy in neonates. And play a crucial part in the neurological system's regular operation. [42] Aflatoxin B1 (AFB1), aflatoxin M1 (AFM1), and ochratoxin A (OTA), known to potentially lead to severe health problems in infants, were evaluated in several commonly consumed varieties of baby food.[5]

**Vitamin B2:**

Wholegrain breads, cereals, organ meats, dairy products, egg yolks, green vegetables (broccoli, asparagus, and turnip greens), breast milk, baby formula, and grain products enhanced or fortified with riboflavin are foods high in this
vitamin. During metabolism, the water-soluble vitamin riboflavin, also known as vitamin B2, helps to release energy from proteins, lipids, and carbs.[42] B1, B2, and B3 vitamins are crucial nutritious ingredients in baby feeds made with cereal. Understanding these vitamins' bioaccessibility is crucial for the nutrition of newborns and early children. [3]

**Niacin:**
Foods high in niacin include cereals, whole-grain breads, eggs, chicken, meat, fish, breast milk, baby formula, and secure or enriched grain products. Foods high in tryptophan, such as eggs, cheese, yoghurt, cattle, poultry, and fish, can be transformed by the body into niacin.

During metabolism, the body uses the water-soluble vitamin niacin to help break down protein, fat, and carbohydrates into energy. To aid in the taking up of niacin, the body frequently transforms the amino acid tryptophan present in food into niacin.[42] Over-nutrition during pregnancy resulting from maternal obesity or an unhealthy diet can lead to excess infant adiposity at birth. Specific dietary macronutrients and micronutrients increase fat cell development in both in-vitro and in-vivo models and may therefore link maternal diet to increased infant adiposity. We hypothesized that high maternal dietary niacin intake during pregnancy, especially in combination with a high-fat diet (HFD) would increase infant adiposity. [40]

**Calcium:**
By drinking sufficient quantity of breast milk or infant formula, a baby can get enough calcium. Supplemental meals including yoghurt, cheese, fortified or enhanced grain products, some green leafy vegetables (such collards and turnip greens), and tofu (if the food label specifies it was produced with calcium sulphate) can provide older infants with more calcium.

- Among other things, calcium is a mineral that is significant for the development of bones, teeth, blood coagulation, and Upkeep of strong muscles and nerves.[42] Calcium absorption in healthy preterm newborns ranges from approximately 50% to 60% of intake on average, which is comparable to what breastfed full-term infants absorb. [2]

**Iron:**
Infants require the mineral iron for proper growth, the production of healthy blood cells, and the prevention of iron deficiency anemia. Thus, the body iron content of two "normal" newborns can vary by 300 percent. The total body iron at 20 years old is 4 to 5 cm. Every balance must be obtained by food consumption.[42] During the initial few months of life, healthy, term, breastfed newborns are typically not advised to take iron supplements, or iron drops. Iron-rich supplementary foods are advised as an infant's iron stores often run out around the age of six months. Meat products, iron-fortified continuation formulae, and other iron-fortified foods, like cereals, fall within this category.[14]

**Zinc:**
Good sources of readily available zinc include meat, liver, and egg yolks, while whole-grain items have more inaccessible forms of the mineral. The following biological processes that zinc contributes to include:

- Protein synthesis, which promotes wound healing blood production
- The general development and upkeep of all tissues
  - Taste sensitivity and a strong immune system.[42] Between 6 and 24 months of age, supplemental foods must supply 84-689% of the zinc needed by newborns.[4]

**Fluoride:**
Fluoride is a valuable mineral, although it is not considered an essential vitamin. In the right dosages, fluoride lessens the teeth's vulnerability to dental caries, or tooth decay.

Numerous baby foods and beverages have the potential to elevate an infant's fluoride intake beyond the recommended optimal level (0.05–0.07 mg F/kg body weight) when prepared with fluoridated water, thereby heightening the risk of dental fluorosis.[44] Although many experts advocate fluoridating water as a safe and effective technique to prevent dental cavities, the maximum allowable day-to-day consumption of fluoride from all sources is a topic of contention in the scientific literature.[15]

**A study on comparing the amount of nutritional antioxidants in donor milk, breast milk, and baby formulas**
Donor milk is frequently seen as a suitable or even perfect substitute for the mother's own milk in the case that the mother of a hospitalized infant is unable to give breast milk. When the mother's milk is unavailable, donor milk is thought to be a useful substitute, with premature newborns being the main beneficiaries. Donor milk comes from breastfeeding, healthy women who agree to donate their excess, which is gathered, processed, and kept in reserve by specialized facilities like human milk banks. In order to prevent microbial growth and guarantee its safety for consumption, donor milk is pasteurized. Following pasteurization, significant drops in glutathione and
malondialdehyde, two antioxidant molecules, have been observed. Preterm newborns have heightened antioxidant levels at birth but comparatively weaker antioxidant defenses.[21] The flaws in the baby food market, where the primary “products” are: mother’s milk (expressed or fed from the breast); other mother’s milk (milk banks or wet nurses); commercial baby foods, such as infant milk formulas; and complementary foods and drinks. Since cow's milk proteins are the primary source of nutrition for newborns, the question of whether human milk can effectively replace it becomes necessary when the baby is formula-fed. Formulas with highly hydrolyzed milk proteins should be chosen in this situation, however even they run the risk of triggering allergic responses in individuals with heightened sensitivity. If six months of age, if there is evidence of cow's milk allergy with IgE-associated symptoms, a soy bean formula might be suggested, but only if a clinical challenge has established tolerance to soy protein. Testing whether proteins from the milk of different mammalian species may be utilised as a substitute for untreated cow milk may be accomplished through proteomic examination of the proteins from various mammalian species. [21]

19. Government of Western Australia Child and Adolescent Health Service (2023)


42. U.S. Department of Agriculture, Food and Nutrition Service (1994)
