ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 12 | December - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

BREAST MILK VS. INFANT FORMULA: A COMPREHENSIVE REVIEW OF NUTRITIONAL CONTENT, HEALTH OUTCOMES, AND PRACTICAL CONSIDERATIONS

Physiology

Dr. Keerti Katiyar* Junior Resident Department Of Physiology King George Medical University Lucknow, India *Corresponding Author

Prof. Shraddha Singh Professor& Head Department Of Physiology King George Medical University Lucknow, India

Dr. Sudipti Yadav Senior Resident Department Of Physiology King George Medical University Lucknow, India

Dr. Bindiya Verma Senior Resident Department Of Physiology King George Medical University Lucknow, India

ABSTRACT

Breast milk and infant formula are the two main sources of nutrition for infants, each with their own nutritional content, health effects, and practical factors. Breast milk has been widely researched and demonstrated to have various benefits over infant formula. It provides vital nutrients and bioactive components that help the infant's growth, immunological system, and cognitive development. Breast milk has been linked to a lower incidence of infection, illness, and mortality when compared to infant formula. Furthermore, breast milk has been shown to have a good impact on cognitive development, with studies demonstrating a significant improvement in cognition in premature newborns fed breast milk versus formula. When nursing is not possible, infant formula is seen to be an effective alternative. It is intended to imitate the nutritional makeup of breast milk, ensuring that infants' nutritional demands are met. However, it is crucial to note that infant formula may not give the same benefits as breast milk, such as the presence of pituitary hormones. Studies have also revealed that breast milk's decreased protein percentage compared to infant formula may have an impact on newborn growth and body composition. In practice, the decision between breast milk and infant formula may be influenced by a variety of circumstances, including maternal and newborn health, as well as feeding preferences. While breast milk is frequently regarded as the best source of nutrition for children, there are times when infant formula is required, such as when women are unable to nurse. It is critical to ensure that infants get enough nutrients, whether they are fed breast milk or formula. Finally, breast milk and infant formula have distinct nutritional properties, health consequences, and practical factors. Breast milk is widely considered the best source of nutrition for infants due to its unique composition and benefits. When nursing is not possible, infant formula can provide important nutrients to support infant growth and development.

KEYWORDS

Breast milk, Infant formula, Growth and development, Immune system, Nutritional content, Health outcomes

INTRODUCTION:

During the initial years of life, a child's development is highly significant, and nutrition plays a vital part in guaranteeing ideal growth and well-being. Parents frequently encounter the dilemma of selecting between breast milk and infant formula. Milk is crucial for infants. Human breast milk (HBM) is widely regarded as the optimal source of nourishment for infants. Human milk is the optimal source of nutrition for a newborn, providing the necessary nutrients for their daily growth and development. Human milk does not have a definitive composition that is considered superior, and there is no simple method to regulate the intricate nature of its nutritional value and the amount consumed by breastfed babies [1].

The initial half-year of an infant's existence is pivotal for their physical and cognitive advancement, as well as their general welfare. Infants in this stage have distinct dietary requirements that are mainly fulfilled by breastfeeding or formula feeding. Nevertheless, in specific instances, supplements can be crucial in promoting optimal health and bolstering particular areas of their development. Infant formulae share numerous similarities with human breast milk in various components, however, there is no flawless alternative to HBM [2]. As a result of this, the World Health Organization and the United Nations Children's Fund recommend that infants receive only HBM for a period of at least six months following birth, and this practice should be maintained for at least two years of age or longer [3,4]. It is also recommended by the American Academy of Pediatrics that mothers breastfeed their children for a minimum of one year [5]. Because of this, it is absolutely necessary to have a conversation about the factors that make HBM more suitable for consumption than infant formulae. Numerous research has been conducted to this day that have explored the immunologic components of HBM [2] as well as the nutritional components that are included in it. These components include a variety of macronutrients and micronutrients. When it comes to the nourishment of infants, breastfeeding is a powerful force that significantly contributes to the overall growth and development of a child in a sustainable manner. Breast milk is often referred to as a biological first food, as it provides nutritionally optimum sustenance that is perfectly tailored to the needs of newborns [6]. It is not only safe for consumption but also offers a range of health benefits that are crucial during the early stages of life. A significant benefit of breast milk is that it helps prevent newborns from a wide range of infections. This is one of the most recognized advantages about breast milk. The presence of antibodies and other immunological elements in breast milk helps to strengthen the immune system of the newborn, so providing a natural defense against ailments such as respiratory infections, diarrhoea, and ear infections. It is worth mentioning that breast milk contains many types of immune cells, including B and T lymphocytes, regulatory cells, monocytes/macrophages, neutrophils, natural killer cells, as well as IgA, IgG, and IgM antibodies.[7]. This immune protection is especially vital during the first few months of a baby's life, when the baby's own immune system is still developing. Although breastfeeding has benefits, it may not be suitable for every individual. Certain mother's may be incapable of lactating[8], whereas others may have a personal preference to abstain from breastfeeding. Various factors can hinder individuals from breastfeeding, such as undergoing breast reduction surgery, facing an unsupportive work environment, or experiencing medical conditions that make breastfeeding necessary. Alternatively, a mother might nourish their newborns with infant formula to aid their child's growth and development. Commercially manufactured infant formulae are a nourishing substitute for breast milk, and they also include some vitamins and elements that breastfed infants require from outside sources. Infant formula is designed to serve as a highly efficient replacement for Breast feeding [9]. While it is not possible to produce an exact replica of human milk [10], extensive measures have been implemented to replicate the nutritional composition of human milk in order to support the healthy growth and development of infants. This review aims to provide a detailed comparison of breast milk and infant formula, focusing on their nutritional content, health outcomes, and impact on the infant growth.

Nutritional Composition of Human Breast Milk:

a) Breast Milk:

Due to its distinctive and all-encompassing nutritional composition, breast milk is widely acknowledged as the gold standard [11] for nourishing infants. It offers a perfect equilibrium of macronutrients,

micronutrients, and bioactive compounds that are crucial for the growth and development of a newborn. Research indicates that these elements collectively contribute to the advancement of cognitive development, improvement of natural and adaptive immunity, regulation of the immune system, prevention of diabetes, maintenance of intestinal health, and possession of anti-inflammatory characteristics [12].

b) Macronutrients:

Breast milk delivers proteins, fats, and carbohydrates in proportions that are perfectly suited for an infant's needs. Human breast milk is an intricate mixture consisting of about 87 percent water, 3.8 percent fat, seven percent lactose and one percent protein. The fat and lactose contribute 50% and 40% of the overall energy content of the milk, respectively [16] .The protein content is composed of approximately 60-70% whey proteins and 30-40% casein proteins. Whey proteins are easily digestible and help in the rapid development of the infant's tissues. The fats in breast milk, which include essential fatty acids such as DHA (docosahexaenoic acid) and ARA (arachidonic acid) [13], are crucial for the development of the infant's brain and nervous system. The primary carbohydrate in breast milk is lactose, which aids in calcium absorption and promotes the growth of healthy gut flora, fostering a balanced intestinal microbiome [14]. Newborns obtain about fifty percent of their energy from fat during the initial month of life and play vital role for brain functioning [15].

c) Micronutrients:

Breast milk is rich in vitamins and minerals that have a high bioavailability, meaning they can be easily absorbed and utilized by the baby's body. However, the levels of several micronutrients in human milk might differ based on the mother's diet and the amount of nutrients stored in her body [17]. The substance includes lipophilic vitamins such as vitamins A, D, E, and K, which are essential for vision, bone integrity, immunological response, and blood clotting. In addition, breast milk contains water-soluble vitamins from the B complex group, such as B6, B12, and folate, which are essential for energy metabolism and the production of red blood cells. Breast milk contains essential minerals like as calcium, iron, and zinc, with the highest concentration found in colostrum. However, the levels of these minerals decrease as lactation continues [18]. Calcium is essential for the formation and strengthening of bones and teeth, iron aids in the manufacture of haemoglobin and cognitive development, and zinc is vital for immunological function and the growth of cells [19].

d) Bioactive Components

Beyond macronutrients and micronutrients, breast milk contains a range of bioactive components that contribute to the infant's overall development and immune protection. Bioactive constituents of human milk are characterized as constituents that influence biological processes and therefore have an effect on bodily function or state and ultimately health[19]. These include lactoferrin, growth factors, hormones, nucleotides, human milk oligosaccharides (HMOs), immunoglobulins, and cytokines enzymes, and growth factors [20]. Enzymes such as lipase aid in fat digestion, while hormones like prolactin and oxytocin support milk production and maternal bonding. Immunoglobulins, particularly IgA, provide passive immunity by protecting the infant against infections and pathogens[21]. Growth factors in breast milk promote the maturation of the infant's gut and other tissues, enhancing overall development and health[22].The extensive and well-balanced composition of breast milk makes it an unmatched source of nourishment for infants, promoting their growth, development, and immunological function during the crucial early stages of life [3].

Nutritional Composition of Infant Formula:

A) Infant Formula:

When breastfeeding is not possible, infant formula can be used as a good nutritious substitute for breast milk in infants. Infant Formula is formulated to precisely replicate the nutritional composition of breast milk, although there are inherent disparities. Infant formula is formulated to closely resemble the composition of breast milk, incorporating additional vitamins, minerals, and other essential ingredients to promote the well-being of infants [23]. Food items that have been processed and contain a standard composition of milk proteins, lactose or other sugars, vegetable oils, minerals, and a few other ingredients are known as milk formulae [24]. Infant formula is only intended for the well-being of infants who do not have any exceptional medical or nutritional issues. The production process is subject to rigorous regulation and surveillance to ensure compliance with national and international quality standards [25].

b) Types of Formula:

There are several primary categories of infant formula, the most common of which are formulas made from cow's milk, soy, and hydrolysed protein [26]. Additionally, there are specialised formulas designed for infants who have particular medical requirements. Types may include Formula made from cow's milk, which is a source of protein: The vast majority of newborn formulae are made from cow's milk, which has been changed to be more comparable to human milk. Formula made from soy: parents and carers have the option of using soy-based formula if their child is unable to take lactose, which is a type of carbohydrate that is included in cow's milk formulations [27]. Formula for protein hydrolysate: Protein hydrolysate formulas are created from proteins that have been hydrolysed, which means they have been broken down into smaller sizes. To accommodate infants who are unable to digest formulas made from cow's milk or soy, several formulae have been developed [27]. Formulae that are specialised are formulae that are designed to suit infants who were born prematurely or infants who have certain medical issues.

There are three Specialised forms that infant formula can be found in, in addition to the various types of infant formula that are currently available. These include [10]: There are three different types of infant formulae available: One type of baby formula is powder, which is the least expensive form of infant formula and must be mixed with water before feeding. Another type of infant formula is liquid, which is a concentrated liquid that must be mixed with an equivalent amount of water. Finally, ready-to-feed infant formula is the most expensive form of infant formula that does not require mixing.

c) Macronutrients and Micronutrients:

Formulas for infants are formulated in such a way that they preserve a healthy equilibrium of macro elements and microelements. Formulae made from cow's milk that are considered standard contain proteins, lipids, and carbs in proportions that are comparable to those found in breast milk; however, in order to fulfil the nutritional requirements of newborns, these formulae frequently require fortification with additional vitamins and minerals [11,27]. The fat source is primarily comprised of vegetable fats; however, animal milk fats are also capable of serving as a suitable substitute [28]. Even if the macro and micro elements are segregated in different locations, they will still have an effect on the physiological features of the IF that is going to be formed [29]. The nutritional content of many formulae is increased by the use of additives like as probiotics, and DHA/ARA[30,31]. These additions also help the development of the brain and the digestive system.

Health Outcomes

a) Benefits of Breast Milk

Research has demonstrated that breastfeeding provides a number of benefits, not only for the mother but also for the newborn. Infants who are breastfed have a lower chance of developing a number of childhood metabolic illnesses [32], and the benefits of this parenting style may continue into adulthood. Also, according to the World Health Organisation [33], children who are breastfed have better IQ scores. The practice of breastfeeding is a global food production system that has an unrivalled capacity to improve the health of mothers and children as well as the food security status of children [6,34]. Some benefits are:

- **Short-term Benefits**: Due to the presence of immunoglobulins and other immune-protective components in breast milk, infants who are breastfed have a lower risk of contracting diseases such as gastroenteritis, respiratory infections, and otitis media [35,37]. There is a significant protective effect on infant mortality, with a 12% reduction [36]in the risk of mortality when compared to infants who are not nursed.
- **Long-term Benefits:** Long-term benefits include improved cognitive development [38], a lower risk of obesity and type 2 diabetes [39], with a significant impact on the length of time a woman breastfeeds [40], and a decreased risk of breast and ovarian malignancies [41]. Other research has demonstrated that nursing helps to improve the attachment that exists between a mother and her kid [10].

b) Advantages and Limitations of Infant Formula

- **Nutritional Adequacy:** Formula for infants is nutritionally

sufficient and helps to maintain normal growth and development in situations where nursing is either not possible or not desired. Providing all of the essential nutrients that infants require, baby formula is designed to be a successful substitute for infant feeding [41]. baby formula is intended to be used as a substitute for infant eating. Despite the fact that infant formula is derived from cow's milk or soymilk, it makes an effort to replicate the nutritional profile of breast milk as precisely as possible. It is imperative that the nutritional content of newborn formula has the appropriate quantities of water, carbohydrates, protein, fat, vitamins, and minerals [10,42]. The composition of infant formula is subject to stringent regulations and thorough evaluation by government organisations. For example, the effectiveness of all of the primary components that are added to formula, such as protein and fat, might range from a minimum to a maximum value according to their specifications. In order to be considered safe, these components must have a proven track record of use [43].

- **Potential Health Risks and Benefits:** Even while infants who are fed formula can reach normal growth, there is a possibility that they are at a little increased risk of infections and chronic diseases when compared to infants who are breastfed. However, specialised formulations have the potential to reduce the likelihood of some problems, such as digestive disorders and allergic reactions. Also, the incidence of sudden infant death syndrome (SIDS) [44]was much lower in infants who were breastfed as opposed to infants who were fed formula. newborn formula does not provide this level of protection or the flexibility to adapt to the requirements of the newborn [45].

Practical Considerations

Breastfeeding

- **Maternal Factors:** There are a number of factors that can have an effect on the nutritional makeup of breast milk, including the mother's diet, her health, and the stage of lactation [14]. Colostrum, which is the first milk that is generated in the first few days after birth, is especially abundant in antibodies and nutrients, and it offers the baby a crucial immune protection [37]. In order to fulfil the requirements of the developing newborn, the composition of breast milk undergoes a transformation as the process of lactation develops, with the levels of fat and energy content increasing [14].

Nommsen found that the volume and composition of breast milk can be influenced by a variety of maternal characteristics, including age, parity, and body mass index by the mother. For instance, moms who are older and have a greater parity likely to produce more breast milk, whereas mothers who are overweight or obese may have a lower milk production [46].

Formula Feeding

- **Accessibility and Convenience:**

In situations where breastfeeding is not an option, formula feeding can be a more practical option for working parents and offers an alternative that can be considered successful. Nevertheless, in order to guarantee the child's safety, it necessitates meticulous preparation and storage, which leaves room for flexibility for the parents and carers [47].

- **Cost Implications:**

In situations where breastfeeding is not an option, formula feeding can be a more practical option for working parents and offers an alternative that can be considered successful. As a result of the fact that it necessitates proper preparation and storage in order to guarantee safety, it provides parents and carers with a degree of flexibility [47]. There will also be an increase in the use of formula in countries where there is a greater prevalence of poor healthcare assistance, aggressive marketing [48]. On the other hand, breastfeeding can result in indirect costs, such as the amount of time spent breastfeeding or pumping, the cost of breastfeeding supplies (such as nursing bras and breast pumps), and the cost of seeking professional lactation support. Despite these expenditures, breastfeeding is frequently touted as the alternative that is more advantageous to both the mother and the infant in the long run, as well as the option that is more cost-effective [3,14].

- **Public Health Policies:**

Numerous measures have been undertaken to encourage breastfeeding by means of legislative support and instruction, while also ensuring that formula feeding is both safe and accessible for individuals who have a requirement for it [49]. These efforts include the Baby-Friendly Hospital Initiative, which encourages hospitals to embrace evidence-based practices that support breastfeeding [50], as well as rules on the marketing and labelling of infant formula [51]. Both of these initiatives are examples of measures intended to assist breastfeeding.

Comparative Analysis

- **Nutritional Comparison:**

Breast milk is a biologically active and flexible substance that automatically adjusts to meet the evolving nutritional requirements of the developing baby [47,52]. The composition of breast milk changes throughout lactation, with the ratios of macronutrients (carbohydrates, proteins, and fats) and micronutrients (vitamins and minerals) adapting to fulfil the developmental needs of the newborn [37]. On the other hand, infant formula is a synthetic milk [53] created to imitate the general nutritional characteristics of breast milk. However, it is incapable of completely duplicating the intricate and individualised composition of human milk[23]. Infants have a greater ability to absorb and utilise nutrients from breast milk compared to infant formula due to its better bioavailability [54]. The distinctive composition and structure of breast milk, which contains elements like digestive enzymes and immunoglobulins, contribute to improved nutrient absorption.

- **Health Outcomes Comparison:**

Indeed, women are the solely producers of this highly precious 'health food', Human Breast Milk. Multiple studies have shown that breastfed newborns typically exhibit superior immune defence [55] and have better long-term health results in comparison to formula-fed infants. Research has shown that breastfeeding is linked to a decreased likelihood of contracting infectious disorders such diarrhoea, respiratory infections, and otitis media. It also reduces the occurrence of chronic conditions such as obesity, diabetes, and some types of carcinomas [56].

Although current newborn formulae have made considerable progress in terms of nutritional composition and have reduced the differences in growth and development measures, they still do not possess the distinctive bioactive components and immune-modulating capabilities present in human milk. The non-nutritive chemicals present in breast milk have a vital role in the growth and maturation of the infant's immune system and gut microbiome[57,58]. Although, Breastfeeding has been linked to numerous child Physical health benefits, including the promotion of proper oral motor development, which improves growth and craniofacial development [59,60].

- **Practical Considerations Comparison:**

Breastfeeding is widely regarded as the most cost-effective and environmentally responsible method of infant feeding because it eliminates the need for formula production, packing, and transportation [61]. Breastfeeding, on the other hand, necessitates a major commitment and assistance from the mother because it is time-consuming [62]and might bring obstacles such as difficulty latching, poor milk supply, or the need to pump and preserve breast milk [63], Formula feeding, on the other hand, provides greater flexibility and convenience because it allows other carers to join in feeding the newborn and is easier to incorporate into the family's routine [64]. However, the cost of formula can be prohibitively expensive [65], particularly for low-income families [66], and formula preparation and storage necessitate careful attention to maintain safety and sanitation [67].

CONCLUSION:

In conclusion, breast milk is an excellent source of nutrition for your child and transmitting the child-mother link and can truly be dubbed 'filled with love', nevertheless, both breast milk and infant formula have distinct advantages and disadvantages. Breast milk is nutritionally superior and has distinct health benefits, but infant formula is a practical and nutritionally acceptable substitute, particularly when breastfeeding is not an option. Parents must make informed decisions, guided by healthcare professionals, to ensure the best possible outcomes for their infants. Future research and technologies will further improve our understanding and practices of newborn feeding. Remember that every drop of breast milk you give is a gift to your baby's health and well-being. Governments and public health organisations will also develop policies to safeguard and encourage breastfeeding, such as maternity leave rules, workplace lactation support, and limitations on the marketing of breast milk substitutes. These programmes seek to establish an atmosphere that allows and empowers women to make educated decisions about newborn feeding. Future research and technologies will further

improve our understanding and practices of newborn feeding.

REFERENCES:

1. Boquien, C. (2018). Human milk: an ideal food for nutrition of preterm newborn. Frontiers in Pediatrics, 6. https://doi.org/10.3389/fped.2018.00295
2. Kim, S. Y., & Yi, D. Y. (2020). Components of human breast milk: from macronutrient to microbiome and microRNA. Clinical and Experimental Pediatrics, 63(8), 301–309. https://doi.org/10.3345/cep.2020.00059
3. World Health Organization; United Nations Children's Fund. Global strategy for infant and young child feeding. Geneva: World Health organization, 2003.
4. Eidelman, A. I., Schanler, R. J., Johnston, M., Landers, S., Noble, L., Szucs, K., & Viehmann, L. (2012). Breastfeeding and the use of human milk. Pediatrics, 129(3), e827–e841. https://doi.org/10.1542/peds.2011-3552
5. Eidelman, A. I. (2012). Breastfeeding and the use of human milk: An analysis of the American Academy of Pediatrics 2012 Breastfeeding Policy Statement. Breastfeeding Medicine, 7(5), 323–324. https://doi.org/10.1089/bfm.2012.0067
6. Smith, J. P. (2015). Markets, breastfeeding and trade in mothers' milk. International Breastfeeding Journal - Electronic Edition -, 10(1). https://doi.org/10.1186/s13006-015-0034-9
7. Godhia, M., & Patel, N. (2013). Colostrum - its composition, benefits as a nutraceutical : A review. Current Research in Nutrition and Food Science, 1(1), 37–47. https://doi.org/10.12944/crnfsj.1.1.04
8. MedlinePlus . Bethesda (MD): National Library of Medicine (US); [updated Jun 24; cited 2020 Jul 1]. Available from: https://medlineplus.gov/.
9. Institute of Medicine of the National Academics. Infant Formula: Evaluating The Safety of New Ingredients; The National Academics Press: Washington, DC, USA, 2004.
10. Martin, C. R., Ling, P. R., & Blackburn, G. L. (2016). Review of infant feeding: Key features of breast milk and infant formula. Nutrients, 8(5), 279. https://doi.org/10.3390/nu8050279
11. Luo, G., Zhu, Y., Ni, D., Chen, J., Zhang, W., & Mu, W. (2023). Infant formulae – Key components, nutritional value, and new perspectives. Food Chemistry, 424, 136393. https://doi.org/10.1016/j.foodchem.2023.136393
12. Cacho, N. T., & Lawrence, R. M. (2017). Innate immunity and breast milk. Frontiers in Immunology, 8. https://doi.org/10.3389/fimmu.2017.00584
13. Salem, N., & Van Dael, P. (2020). Arachidonic acid in human milk. Nutrients, 12(3), 626. https://doi.org/10.3390/nu12030626
14. Ballard, O., & Morrow, A. L. (2013). Human milk composition. Pediatric Clinics of North America/ the Pediatric Clinics of North America, 60(1), 49–74. https://doi.org/10.1016/j.pcl.2012.10.002
15. Purkiewicz, A., Czaplicki, S., & Pietrzak-Fiećko, R. (2022). The occurrence of squalene in human milk and infant formula. International Journal of Environmental Research and Public Health/International Journal of Environmental Research and Public Health, 19(19), 12928. https://doi.org/10.3390/ijerph191912928
16. Guo, M.(2014) Human Milk Biochemistry and Infant Formula. In Manufacturing Technology; Elsevier: Cambridge, UK.
17. Valentine, C. J., Morrow, G., Pennell, M., Morrow, A. L., Hodge, A., Haban-Bartz, A., Collins, K., & Rogers, L. K. (2013). Randomized controlled trial of docosahexaenoic acid supplementation in midwestern U.S. human milk donors. Breastfeeding Medicine, 8(1), 86–91. https://doi.org/10.1089/bfm.2011.0126
18. American Academy of Pediatrics (AAP). (2012). Breastfeeding and the Use of Human Milk. Pediatrics, 129(3), e827-e841. Retrieved from https://doi.org/10.1542/peds.2011-3552
19. Brockway, M., Daniel, A. I., Reyes, S. M., Gauglitz, J. M., Granger, M., McDermid, J. M., Chan, D., Refvik, R., Sidhu, K. K., Musse, S., Patel, P. P., Monnin, C., Lotoski, L., Geddes, D. T., Jehan, F., Kolsteren, P., Bode, L., Eriksen, K. G., Allen, L. H., . . . Azad, M. B. (2024). Human milk bioactive Components and Child Growth and Body Composition in the first 2 years: A Systematic review. Advances in Nutrition, 15(1), 100127. https://doi.org/10.1016/j.advnut.2023.09.015
20. Geddes, D., & Kakulas, F. (2018). 7 Human Milk: Bioactive Components and Their Effects on the Infant and Beyond. In Breastfeeding and Breast Milk – from Biochemistry to Impact, (Ed, Family Larson- Rosenquist Foundation) Georg Thieme Verlag KG. The Global Health Network. https://doi.org/10.21428/3d48c34a.de115c2a
21. Janeway CA Jr, Travers P, Walport M, et al. Immunobiology: The Immune System in Health and Disease. 5th edition. New York: Garland Science; 2001. The distribution and functions of immunoglobulin isotypes. Available from: https://www.ncbi.nlm.nih.gov/books/NBK27162/
22. Levine, A., & Zuckerman, B. (2001). Breastfeeding: A Pediatrician's Guide. Pediatrics in Review, 22(4), 124-131. Retrieved from https://doi.org/10.1542/pir.22-4-124
23. Koletzko, B., Shamir, R., & Ashwell, M. (2012). Quality and safety aspects of infant nutrition. Annals of Nutrition & Metabolism, 60(3), 179–184. https://doi.org/10.1159/000338803
24. Baker, P., Santos, T., Neves, P. A., Machado, P., Smith, J., Piwoz, E., Barros, A. J. D., Victora, C. G., & McCoy, D. (2020). First.food systems transformations and the ultra.processing of infant and young child diets: The determinants, dynamics and consequences of the global rise in commercial milk formula consumption. Maternal and Child Nutrition, 17(2). https://doi.org/10.1111/mcn.13097
25. Lönnerdal, B. (2012). Preclinical assessment of infant formula. Annals of Nutrition & Metabolism, 60(3), 196–199. https://doi.org/10.1159/000338209
26. Website, N. (2024, May 8). Types of formula. nhs.uk. https://www.nhs.uk/conditions/baby/breastfeeding-and-bottle-feeding/bottle-feeding/ types-of-formula/
27. Masum, A. K. M., Chandrapala, J., Huppertz, T., Adhikari, B., & Zisu, B. (2020). Production and characterization of infant milk formula powders: A review. Drying Technology, 39(11), 1492–1512. https://doi.org/10.1080/07373937.2020.1767645
28. Hageman, J. H., Danielsen, M., Nieuwenhuizen, A. G., Feitsma, A. L., & Dalsgaard, T. K. (2019). Comparison of bovine milk fat and vegetable fat for infant formula: Implications for infant health. International Dairy Journal, 92, 37–49. https://doi.org/10.1016/j.idairyj.2019.01.005
29. Lund, P., Bechshøft, M. R., Ray, C. A., & Lund, M. N. (2021). Effect of processing of whey protein ingredient on maillard reactions and protein structural changes in powdered infant formula. Journal of Agricultural and Food Chemistry, 70(1), 319–332. https://doi.org/10.1021/acs.jafc.1c05612
30. Lien, E., Richard, C., & Hoffman. (2018). DHA and ARA addition to infant formula: Current status and future research directions. Prostaglandins, Leukotrienes and Essential Fatty Acids/Prostaglandins, Leukotrienes, and Essential Fatty Acids, 128, 26–40. https://doi.org/10.1016/j.plefa.2017.09.005
31. Pérez-Escalante, E., Alatorre-Santamaría, S., Castañeda-Ovando, A., Salazar-Pereda, V., Bautista-Ávila, M., Cruz-Guerrero, A. E., Flores-Aguilar, J. F., & González-Olivares, L. G. (2020). Human milk oligosaccharides as bioactive compounds in infant formula: recent advances and trends in synthetic methods. Critical Reviews in Food Science and Nutrition, 62(1), 181–214. https://doi.org/10.1080/10408398.2020.1813683
32. Moszak, M., Szulińska, M., & Bogdański, P. (2020). You Are What You Eat—The Relationship between Diet, Microbiota, and Metabolic Disorders—A Review. Nutrients, 12(4), 1096. https://doi.org/10.3390/nu12041096
33. World Health Organization. (n.d.). Breastfeeding. Retrieved from https://www.who.int/health-topics/breastfeeding#tab=tab_1
34. Salmon, L. (2015). Food security for infants and young children: an opportunity for breastfeeding policy? International Breastfeeding Journal - Electronic Edition -, 10(1). https://doi.org/10.1186/s13006-015-0029-6
35. Ladomenou, F., Moschandreas, J., Kafatos, A., Tselentis, Y., & Galanakis, E. (2010). Protective effect of exclusive breastfeeding against infections during infancy: a prospective study. Archives of Disease in Childhood, 95(12), 1004–1008. https://doi.org/10.1136/adc.2009.169912
36. Sankar, M. J., Sinha, B., Chowdhury, R., Bhandari, N., Taneja, S., Martines, J., & Bahl, R. (2015). Optimal breastfeeding practices and infant and child mortality: a systematic review and meta.analysis. Acta Pædiatrica, 104(S467), 3–13. https://doi.org/10.1111/apa.13147
37. Victora, C. G., Bahl, R., Barros, A. J. D., França, G. V. A., Horton, S., Krasevec, J., Murch, S., Sankar, M. J., Walker, N., & Rollins, N. C. (2016). Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. Lancet, 387(10017), 475–490. https://doi.org/10.1016/s0140-6736(15)01024-7
38. Der, G., Batty, G. D., & Deary, I. J. (2006). Effect of breast feeding on intelligence in children: prospective study, sibling pairs analysis, and meta-analysis. BMJ. British Medical Journal, 333(7575), 945. https://doi.org/10.1136/bmj.38978.699583.55
39. Gunderson, E. P., Lewis, C. E., Lin, Y., Sorel, M., Gross, M., Sidney, S., Jacobs, D. R., Shikany, J. M., & Quesenberry, C. P. (2018). Lactation duration and progression to diabetes in women across the childbearing years. JAMA Internal Medicine, 178(3), 328. https://doi.org/10.1001/jamainternmed.2017.7978
40. Chowdhury, R., Sinha, B., Sankar, M. J., Taneja, S., Bhandari, N., Rollins, N., Bahl, R., & Martines, J. (2015). Breastfeeding and maternal health outcomes: a systematic review and meta.analysis. Acta Pædiatrica, 104(S467), 96–113. https://doi.org/10.1111/apa.13102
41. Stevens, E. E., Patrick, T. E., & Pickler, R. (2009). A history of infant feeding. the Journal of Perinatal Education, 18(2), 32–39. https://doi.org/10.1624/105812409x426314
42. Cook, D. A. (1989). Nutrient levels in infant formulas: technical considerations. the Journal of Nutrition/ the Journal of Nutrition, 119, 1773–1778. https://doi.org/10.1093/jn/119.suppl_12.1773
43. Koletzko, B., Baker, S., Cleghorn, G., Neto, U. F., Gopalan, S., Hernell, O., Hock, Q. S., Jirapinyo, P., Lonnerdal, B., Pencharz, P., Pzyrembel, H., Ramirez Mayans, J., Shamir, R., Turck, D., Yamashiro, Y., & Zong Yi, D. (2005). Global Standard for the Composition of infant Formula: recommendations of an ESPGHAN coordinated international expert group. Journal of Pediatric Gastroenterology and Nutrition, 41(5), 584–599. https://doi.org/10.1097/01.mpg.0000187817.38836.42
44. Vennemann, M., Bajanowski, T., Brinkmann, B., Jorch, G., YüCesan, K., Sauerland, C., & Mitchell, E. (2009). Does breastfeeding reduce the risk of sudden infant death syndrome? Pediatrics, 123(3), e406–e410. https://doi.org/10.1542/peds.2008-2145
45. Tomaszewska, A., Jeleniewska, A., Porębska, K., Królikowska, K., Rustecka, A., Lipińska-Opałka, A., Będzichowska, A., Zdanowski, R., Aleksandrowicz, K., Kloc, M., & Kalicki, B. (2023). Immunomodulatory effect of infectious disease of a breastfed child on the cellular composition of breast milk. Nutrients, 15(17), 3844. https://doi.org/10.3390/nu15173844
46. Nommsen-Rivers, L. A., Chantry, C. J., Peerson, J. M., Cohen, R. J., & Dewey, K. G. (2010). Delayed onset of lactogenesis among first-time mothers is related to maternal obesity and factors associated with ineffective breastfeeding. The American journal of clinical nutrition, 92(3), 574-584.
47. Mohapatra, I., & Samantaray, S. R. (2023). Breastfeeding and Environmental consciousness: A narrative review of environmental implications and potential contributions to reduce waste and energy consumption. Curēus. https://doi.org/10.7759/cureus.45878
48. World Health Organization. (2019). Global breastfeeding scorecard, 2019: increasing commitment to breastfeeding through funding and improved policies and programmes. https://apps.who.int/iris/bitstream/handle/10665/326049/WHO-NMH-NHD-19.22-eng.pdf?sequence=1%26isAllowed=y
49. Rollins, N. C., Bhandari, N., Hajeebhoy, N., Horton, S., Lutter, C. K., Martines, J. C., ... & Victora, C. G. (2016). Why invest, and what it will take to improve breastfeeding practices?. The Lancet, 387(10017), 491-504.
50. Pérez-Escamilla, R., Martinez, J. L., & Segura-Pérez, S. (2016). Impact of the Baby-friendly Hospital Initiative on breastfeeding and child health outcomes: a systematic review. Maternal & child nutrition, 12(3), 402-417.
51. World Health Organization. (2017). Guidance on ending the inappropriate promotion of foods for infants and young children.
52. You are what you eat. . .and so is your baby | Blogs | CDC. (2017, August 11). https://blogs.cdc.gov/publichealthmatters/2017/07/you-are-what-you-eatand-so-is-your-baby/
53. Fomon, S. J. (2001). Infant feeding in the 20th century: Formula and Beikost. the Journal of Nutrition/ the Journal of Nutrition, 131(2), 409S-420S. https://doi.org/10.1093/jn/131.2.409s
54. Hamosh M. 1988. Fat needs for term and preterm infants. In: Tsang RC, editor; , Nichols BL, editor. , eds. Nutrition During Infancy . Philadelphia: Hanley and Belfus. Pp.133–159.
55. Goldman, A. S. (2012). Evolution of immune functions of the mammary gland and protection of the infant. Breastfeeding Medicine, 7(3), 132–142. https://doi.org/10.1089/bfm.2012.0025
56. Savino F, Benetti S, Liguori SA, Sorrenti M, Cordero Di Montezemolo L. Advances on human milk hormones and protection against obesity. Cell Mol Biol (Noisy-le-grand). 2013 Nov 3;59(1):89-98. PMID: 24200024.
57. Carr, L. E., Virmani, M. D., Rosa, F., Munblit, D., Matazel, K. S., Elolimy, A. A., & Yeruva, L. (2021). Role of human milk bioactives on infants' gut and immune health. Frontiers in Immunology, 12. https://doi.org/10.3389/fimmu.2021.604080
58. Iwasaki, A., & Medzhitov, R. (2015). Control of adaptive immunity by the innate immune system. Nature Immunology, 16(4), 343–353. https://doi.org/10.1038/ni.3123
59. Neiva, F. C., Cattoni, D. M., Ramos, J. L., & Issler, H. (2003). Early weaning: implications to oral motor development. J Pediatr (Rio J), 79(1), 7-12.
60. Limme, M. (2010). Diversification alimentaire et développement dentaire : importance des habitudes alimentaires des jeunes enfants pour la prévention de dysmorphoses orthodontiques. Archives De Pédiatrie, 17, S213–S219. https://doi.org/ 10.1016/s0929-693x(10)70930-1
61. Bartle, C. (2010). Breastfeeding and sustainability: Loss, cost,'choice', damage, disaster, adaptation and evolutionary logic. In Sustainability, Midwifery and Birth (pp. 186-199). Routledge.
62. Standard, G. (2010). Breastfeeding: A Bridge to the. BREASTFEEDING MEDICINE, 5(6).
63. Office of the Surgeon General (US); Centers for Disease Control and Prevention (US); Office on Women's Health (US). The Surgeon General's Call to Action to Support Breastfeeding. Rockville (MD): Office of the Surgeon General (US); 2011. Barriers to Breastfeeding in the United States. Available from: https://www.ncbi.nlm.nih.gov/

books/NBK52688/
64. MedlinePlus [Internet]. Bethesda (MD): National Library of Medicine (US); [updated Jun 24; cited 2020 Jul 1]. Available from: https://medlineplus.gov/.
65. Rothstein, J. D., Winch, P. J., Pachas, J., Cabrera, L. Z., Ochoa, M., Gilman, R. H., & Caulfield, L. E. (2021). Vulnerable families and costly formula: a qualitative exploration of infant formula purchasing among peri-urban Peruvian households. International Breastfeeding Journal - Electronic Edition -, 16(1). https://doi.org/10.1186/s13006-021-00356-6
66. Newhook, J. T., Ludlow, V., Newhook, L. A., Bonia, K., Goodridge, J. M., & Twells, L. (2013). Infant-Feeding among Low-Income Women: The Social Context that Shapes their Perspectives and Experiences. Canadian Journal of Nursing Research, 45(3), 28–49. https://doi.org/10.1177/084456211304500303
67. Losio, M. N., Pavoni, E., Finazzi, G., Agostoni, C., Daminelli, P., Dalzini, E., Varisco, G., & Cinotti, S. (2018b). Preparation of powdered infant formula. Journal of Pediatric Gastroenterology and Nutrition, 67(4), 543–546. https://doi.org/10.1097/mpg.0000000000002100