A Critical Analysis of Breast Milk Enrichment in Distinct Bioactive Molecules: A Study of the Developmental Roles and Immunological Responses in the Newborn

Dr. Etini Aniekan Otumo,

Department of Obstetrics and Gynaecology,
Tamale Teaching Hospital (TTH)
Tamale, Ghana

ABSTRACT

The study aimed to analyze breast milk enrichment in distinct bioactive molecules as a study of the developmental roles and immunological responses in the new born. Breast milk is milk produced by mammary glands located in the breast of a human female. Breast milk is the primary source of nutrition for newborns, containing fat, protein, carbohydrates and variable minerals and vitamins. Human breast milk is a complex mixture of organic and inorganic compounds. Some compounds, such as conjugated linoleic acid (CLA), come partly from the mother's diet and are produced by the mother's body and secreted into the milk. The benefit of breast milk cannot be overemphasized; breast milk provides protection for the health of the infant during the first weeks of life, breastfeeding also improves the neuro development of children born immature. The paper reviewed the concept of breast milk, the concept of breast milk enrichment, the concept of bioactive molecules, and the roles of breast milk in the development of new born. It was this basis that the study concluded that Human milk is the best food for newborn nutrition. There is no ideal composition of human milk and also no easy way to control the complexity of its nutritional quality and the quantity received by breastfed infants. The benefits of breastfeeding have been quantified economically and increased breastfeeding rates bring substantial savings for any health system. One of the recommendations made was that women should appreciate the fact that breast milk provides distinct bioactive molecules that contribute to immune maturation, organ development, and healthy microbial gut colonization. Hence, they should encourage their babies with it regularly in order to protect newborn against infection, stomach bugs and inflammation.

Keywords: Breast Milk Enrichment, Distinct Bioactive Molecules, Developmental Roles, Immunological Responses and New Born

Introduction

The first 1,000 days in the life of a human being are a vulnerable stage where early stimuli may program adverse health outcomes in future lives. Proper maternal nutrition before and during pregnancy modulates the development of the fetus, a physiological process known as fetal programming. Breast milk is the best source of nutrition because it provides the energy and nutrients needed for the ideal growth and development of newborns and infants. Besides, breast milk includes various bioactive compounds, which protects infants against infectious agents and antigens and contributes to immune maturation, organ development and microbial colonization. Breast

milk is dynamic; the composition of the nutrients and the content of immunologically active compounds may change in each stage of lactation. During the early stages of lactation, biological and immunologically active compounds provide additional support to the development of the neonatal immune system.

Breast milk provides distinct bioactive molecules that contribute to immune maturation, organ development, and healthy microbial gut colonization, and also secures a proper immunological response that protects against infection and inflammation in the newborn. Breast milk (BM) is the normative source of nutrition for infants in the first six months of life. It is considered an essential source of nutrients, containing water (87%), fat (3.8%), proteins (1.0%), and lactose (7%), with both lactose and fat providing 40 and 50% of the total energy received from milk, respectively. Breast milk is an unbeatable food that alone meets the requirements of babies up to 6 months of age. The exclusively breastfed infants tend to have a satisfactory nutritional status. But the advantages of breastfeeding go beyond nutrition and are unanimously defended by all health establishments.

Breast milk contains hundreds to thousands of distinct bioactive molecules that protect against infection and inflammation and contribute to immune maturation and proper organ development (Saavedra, 2017). Notably, breastfeeding also provides a source of bacterial colonization of the gut of the infant. A healthy microbiota allows proper immune training in the newborn and immunogenic response under a future challenge in adulthood. In contrast, using milk formula during lactation favors inadequate immune response and susceptibility to metabolic and immune-related pathologies in the newborn. Also, maternal exposure to energy-dense foods might negatively change the immune composition of the milk and promote defective activation of the immunogenic response and immune maturation in the newborn (Cortes-Macías, 2021). Overall, breastfeeding is a critical intervention that defines selective immunogenic programming settings and microbial colonization in the gut of the newborn, and prepares them to face several future health risks. Breastfeeding provides immunological programming in the newborn. Breast milk is also rich in many immunological factors that provide the first adaptive immunity in the gastrointestinal tract of infants. Breastfeeding not only provides the ideal nutrient composition for the newborn but also maintains excellent immunological integration between the mother and infant. The composition of immune components in breast milk may vary due to maternal factors. Accordingly, although all mechanisms for the association between breastfeeding and the prevention of the development of allergic diseases have not been fully understood, it has been demonstrated that breast milk has beneficial effects on some immune-mediated diseases. Recent technological developments continue to reveal possible mechanisms for better identification of breast milk composition and the beneficial effects of breast milk on both short- and long-term health.

Concept of breast milk

Breast milk is milk produced by mammary glands located in the breast of a human female. Breast milk is the primary source of nutrition for newborns, containing fat, protein, carbohydrates (lactose and human milk oligosaccharides), and variable minerals and vitamins (AAB, 2017). Breast milk (BM) is the normative source of nutrition for infants in the first six months of life. It is considered an essential source of nutrients, containing water (87%), fat (3.8%), proteins (1.0%), and lactose (7%), with both lactose and fat providing 40 and 50% of the total energy received from milk, respectively. BM also contains immune cells, microRNAs, hormones, and bioactive compounds with anti-inflammatory and anti-infective properties. These include cytokines, chemokines, immunoglobulins, hormones, growth factors, oligosaccharides, and antimicrobial peptides.

Breast milk also contains substances that help protect an infant against infection and inflammation while also contributing to the healthy development of the immune system and gut microbiome. Breastmilk is the ideal food for infants. It is safe, clean, and contains antibodies

that help protect against many common childhood illnesses. Breastmilk provides all the energy and nutrients that the infant needs for the first months of life, and it continues to provide up to half or more of a child's nutritional needs during the second half of the first year and up to one third during the second year of life. Breastfed children perform better on intelligence tests, are less likely to be overweight or obese, and are less prone to diabetes later in life. Women who breastfeed also have a reduced risk of breast and ovarian cancers.

Breastfeeding offers health benefits to mother and child even after infancy. These benefits include proper heat production and adipose tissue development, a 73% decreased risk of sudden infant death syndrome, (Yu, 2019) increased intelligence, decreased likelihood of contracting middle ear infections, cold and flu resistance, a tiny decrease in the risk of childhood leukemia, lower risk of childhood onset diabetes, decreased risk of asthma and eczema, decreased dental problems, decreased risk of obesity later in life, and a decreased risk of developing psychological disorders, including in adopted children (Hauck, 2011). In addition, feeding infant breast milk is associated with lower insulin levels and higher leptin levels compared to feeding an infant via powdered formula. Many of the infection-fighting and immune system-related benefits are associated with human milk oligosaccharides (Bode, 2012). Breastfeeding also provides health benefits for the mother. It assists the uterus in returning to its pre-pregnancy size and reduces post-partum bleeding, through the production of oxytocin. Breastfeeding can also reduce the risk of breast cancer later in life (Gillego 2012). Lactation may also reduce the risk of both types of diabetes for mother and infant. Breast milk is the only nutrition source for newborns. It is highly nutritious and also contains antibodies that help newborns fight infections. The functional constituents include fatty acids, glycoproteins, immunocompetent cells, immunoglobulins, and oligosaccharides. In addition to the above, breast milk also contains growth factors that aid with the growth and development of the newborn's gut, vasculature, and endocrine and nervous systems.

According to Kate (2021), breast milk is composed of many essential substances for optimal growth and development, including carbohydrates, fats, and proteins. The bioactive functions of the proteins in breast milk are especially important during critical periods of brain, gut, and immune development. As a result, breastfed babies have lower rates of otitis media as well as respiratory and intestinal infections. In addition to these short-term benefits, there are many long-term advantages to breastfeeding, including improved cognitive development and a reduced risk of cardiovascular disease, obesity, and diabetes. Studies have shown that mothers also benefit from breastfeeding, with favorable maternal metabolic changes including lower rates of hypertension, hyperlipidemia, and cardiovascular disease. Moreover, some studies show that breastfeeding can reduce the risk of breast and ovarian cancer.

Concept of bioactive molecules

Betrice (2009) sees bioactive compounds as naturally occurring essential and non-essential compounds that can positively influence human health. Nutritionally, they have also been called nutraceuticals since 1979 because, when ingested, they provide health benefits beyond basic nutrition. Bioactive compounds make up a highly heterogeneous set of molecules with different chemical structures and distributions in nature. According to Gengatharan, (2015) Bioactive compounds are defined as components of food that have an impact on physiological or cellular activities in the humans or animals that consume such compounds. It can also be define as a compound having some biological activity. As the name suggests (Greek 'bios' means life and Latin 'activus' means dynamic or full of energy), a bioactive compound (or substance) has its direct physiological or cellular effects on a living organism. Such effects may be positive or negative, depending on the nature of the substance, its dose, and its bioavailability. They include flavonoids, anthocyanins, tannins, betalains, carotenoids, plant sterols, and

glucosinolates. They are mainly found in fruits and vegetables; have antioxidant, anti-inflammatory, and anti-carcinogenic effects; and can be protective against various diseases and metabolic disorders. Such beneficial effects make them good candidates for development of new functional food with potential protective and preservative properties. Various fruits and vegetables provide a range of nutrients and different bioactive compounds including phytochemicals (phenolics, flavonoids, and carotenoids).

Bioactive compounds are primarily found in fruits and vegetables, and include flavonoids, anthocyanins, tannins, betalains, carotenoids, plant sterols, and glucosinolates. Various fruits and vegetables provide a range of nutrients and different bioactive compounds including phytochemicals (phenolics, flavonoids, and carotenoids) which may exert their peculiar physiological and cellular effects. Bioactive molecules comprise many soluble molecules, including growth factors, angiogenic factors, cytokines, hormones, DNA, siRNA, and immunosuppressant drugs, which interact with and modulate the activity of a cell.

A bioactive compound is a compound that has an effect on a living organism, tissue, or cell, usually demonstrated by basic research in vitro or in vivo in the laboratory. While dietary nutrients are essential to life, bioactive compounds have not been proven to be essential, either because the body can function without them or because their actions are obscured by nutrients fulfilling the function. Bioactive compounds lack sufficient evidence of effect or safety, and consequently, they are usually unregulated and may be sold as dietary supplements (Lupton, 2014). Examples of plant bioactive compounds are carotenoids, polyphenols, or phytosterols. Examples of fatty acids in animal products are those found in milk and fish. Other examples are flavonoids, caffeine, choline, coenzyme Q, creatine, dithiolthiones, polysaccharides, phytoestrogens, glucosinolates, and prebiotics (Lupton, 2014). Microorganisms, plants, and animals offer many bioactive products of great interest for application in the food and pharmaceutical industries (Sinha, 2021). According to Ren (2013), more than 80% and 30% of the active compounds used in food and medicine, respectively, are obtained from natural sources.

Roles of breast milk in the development of new born

Breast milk provides the ideal nutrition for infants. It has a nearly perfect mix of vitamins, protein, and fat everything your baby needs to grow. And it's all provided in a form more easily digested than infant formula. Breast milk contains antibodies that help your baby fight off viruses and bacteria. Breastfeeding lowers your baby's risk of having asthma or allergies. Plus, babies who are breastfed exclusively for the first 6 months, without any formula, have fewer ear infections, respiratory illnesses, and bouts of diarrhea. They also have fewer hospitalizations and trips to the doctor.

A significant number of studies provide evidences for the benefits of breast milk for infants. Protective effects of breastfeeding on gastrointestinal system and respiratory tract infections have already been indicated. However, it is stated that breast milk does not only provide passive protection, but can also directly change the immunological development of the infants. Various studies found that breastfeeding promotes cognitive development, decreases inflammation and reduces the risk of developing allergic and chronic diseases such as obesity, diabetes and cardiovascular diseases later in life (Goldman, 2017). Some of the epidemiological studies found that formula feeding increases the risk for diseases compared to breastfeeding (Wall, 2013). Consequently, it is considered that breast milk has the most protective and effective immunomodulatory activities among the other nutrients and infant formula. However, how some of the specific factors involved in breast milk contribute to both innate and adaptive immune functions of neonates and infants is still being investigated (Cacho, 2017).

Breastfeeding not only provides the ideal nutrient composition for the newborn but also maintains an excellent immunological integration between the mother and infant.

Breast milk includes various bioactive compounds, which protects infants against infectious agents and antigens and contributes to immune maturation, organ development and microbial colonization. The composition of breast milk continues to provide appropriate energy and nutrients according to the infant needs, in order to protect neonatal immune system and maintain the development and growth of infants.

Roles of breast milk in the immunological responses of new born

Breast milk provides distinct bioactive molecules that contribute to immune maturation, organ development, and healthy microbial gut colonization, and also secures a proper immunological response that protects against infection and inflammation in the newborn. Breast milk is a source that is known to be the richest in terms of immunomodulation. Breast milk is a source of bioactive molecules, bacteria, and immune cells (Ballard, 2013). Immunogenic cells in breast milk program the immunogenic response in the newborn and incentivize healthy microbial colonization of the gut of the infant by training the immune system (Andreas, 2015). In this new scenario, breast milk protects the newborn against infection and inflammation at earlier stages of life and contributes to immune maturation. Notably, the role of breast milk in assisting physiological microbial, and there is evidence that altered gut micro-biome in the newborn is found associated to metabolic compromise in children.

During the first weeks of postnatal life, the adaptative immune system of the newborn is immature, insufficient, and ineffective to protect against pathogens (Yu, 2018); multiple pathways have been proposed to explain defective immunity in the newborn, including immaturity of immune cells or lymphoid tissues. As a consequence, susceptibility to infections is elevated, and the probabilities of illness and death increase. In fact, birth is considered a dramatic and dangerous transition for the neonate, who is exposed to a new environment with a diverse microbial ecosystem compared with that in utero. Also, neonates experience enhanced susceptibility to infections while showing limited responsiveness to vaccination, particularly during the first months of life. Notably, the transfer of maternal immune components via breast milk allows the newborn to secure immunity to respond to any dangerous external pathogens, increasing their fitness for survival. Initial reports propose that women provide passive immune protection by transmitting antibodies in the colostrum during the first 2–4 days of breastfeeding (Hurley, 2011). In addition to nutritional biomolecules, human breast milk has many non-nutritional bioactive components that profoundly impact infant survival and health. Colostrum is particularly rich in immunologic components with anti-inflammatory and anti-infectious effects and known roles in regulating early intestinal colonization and immune development. Representative immunologic proteins include α-lactalbumin, lactoferrin, lysozyme, and secretory immunoglobulin.

Conclusion

The study concludes that breast milk is the best source of nutrition that provides the energy and nutrients needed for the ideal growth and development of newborns and infants. Besides, breast milk includes various bioactive compounds, which protects infants against infectious agents and antigens and contributes to organ development and microbial colonization. Breast milk also contains substances that help protect an infant against inflammation, whilst also contributing to healthy development of the immune system. Breast milk plays an important role by providing ideal nutrition for infants. Breast milk also protects the newborn against infection and inflammation at earlier stages of life and contributes to immune maturation.

Recommendations

1. Women should appreciate the fact that breast milk provides distinct bioactive molecules that contribute to immune maturation, organ development, and healthy microbial gut colonization. Hence, they should encourage their babies with it regularly in order to

protect new born against infection, stomach bugs and inflammation.

2. Considering the fact that every teaspoon of breast milk has 3,000,000 germ killing cells in it, mothers should encourage their babies with breast milk in order to help share their antibodies with the babies. This means that if mother ensures the baby gets at least one tsp. a day as it is very valuable
3. Mothers worldwide should exclusively breastfeed infants for the Childs first six month to achieve optimal growth, development and health.

References

1. Andreas J, Kampmann B, Mehring & Le-Doare K. (2015). Human breast milk: a review on its composition and bioactivity. *Early Hum Dev.* (2015) 91:629–35.
2. Association, Australian Breastfeeding (2017). "*Breastmilk composition*". Australian Breastfeeding Association.
3. Ballard O & Morrow L. (2013). *Human milk composition: nutrients and bioactive factors*. Pediatr Clin North Am.
4. Betrice H (2009). "*Bioactive compounds: Definition and assessment of activity*," Nutrition, vol. 25 (1) 11-12, pp.
5. Bode, L. (2012). "*Human milk oligosaccharides: Every baby needs a sugar mama*". Glycobiology. 22 (9): 1147–1162.
6. Cacho, T. & Lawrence, M. (2017) *Innate Immunity and Breast Milk*. Frontiers in Immunology, 8, 584. https://doi.org/10.3389/fimmu.2017.00584
7. Cortes-Macías E, Selma-Royo M, García-Mantrana I, Calatayud M, González S, Martínez-Costa C, (2021). *Maternal diet shapes the breast milk microbiota composition and diversity*: impact of mode of delivery and antibiotic exposure. J Nutr. 151:330–40.
8. Gengatharan A. (2015). "Betalains*: Natural plant pigments with potential application in functional foods*". LWT - Food Science and Technology 64.2 645-649.
9. Gillego A, Bernik S. (2016*)Breast-Feeding Might Cut Risk for Tough-to-Treat Breast Cancer: Study.*
10. Goldman, A.S. (2018) Future Research in the Immune System of Breast Milk. *The Journal of Pediatrics,* 206, 274-279.
11. Hauck R, Thompson M, Tanabe O, Moon Y, & Vennemann MM (July 2011). *Breastfeeding and reduced risk of sudden infant death syndrome: a meta-analysis*. Pediatrics. 128 (1): 103–10.
12. Hurley L, Theil K. (2011*). Perspectives on immunoglobulins in colostrum and milk*. Nutrients. 3:442–74. 10.3390/nu3040442
13. Kate, A. (2021). *Human Milk and Lactation*. Available at: https://emedicine.medscape. com/ article /1835675-overview
14. Lupton J, Atkinson A, & Chang N (2014). "Exploring the benefits and challenges of establishing a DRI-like process for bioactives". *European Journal of Nutrition*. 53
15. Ren, (2013). "Recent advances in separation of bioactive natural products," *Chinese J. Chem. Eng*., vol. 21, no. 9, pp. 937-952.
16. Saavedra M, Dattilo M. (2017).*Nutrition in the first 1000 days of life: society's greatest opportunity*. In: Saavedra J, Dattilo A. editors. Early Nutrition and Long-Term Health: Mechanisms, Consequences, and Opportunities. Oxford: Elsevier; p. 35–44.
17. Sinha & D. P. Häder, (2021). *Introduction*, Nat. Bioact. Compd., pp. 1-17, 2021,
18. Wall, G. (2013) *Outcomes of Breastfeeding versus Formula Feeding*.
19. Wang M, Monaco H, & Donovan M. (2016). *Impact of early gut microbiota on immune and metabolic development and function.*
20. Yu C, Khodadadi H, Malik A, Davidson B, Salles É da SL, & Bhatia J, (2018). *Innate immunity of neonates and infants*.
21. Yu H, Dilbaz S, Coßmann J, Hoang C, Diedrich V, & Herwig A, (2019). "Breast

milk alkylglycerols sustain beige adipocytes through adipose tissue macrophages". *The Journal of Clinical Investigation*. 129 (6): 2485–2499.