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Breast milk – a living superfood. Review of current knowledge

1. Patrycja Figurowska, MD
    a. Independent Public Healthcare Center in Mińsk Mazowiecki, Szpitalna 37, 05-300 Mińsk Mazowiecki, Poland
    b. https://orcid.org/0009-0003-7269-6916, patrycja.figurowska@gmail.com
2. Natalia Małek, MD
    a. Central Clinical Hospital in Warsaw, Banacha 1a, 02-097 Warsaw, Poland
    b. https://orcid.org/0009-0005-9602-2929, n.malek2609@gmail.com
3. Sara Emerla, student
    a. Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland
    b. https://orcid.org/0009-0007-2229-9145, emerlasara@gmail.com
4. Aleksandra Brożyna, student
    a. Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland https://orcid.org/0009-0000-9403-6212, ola.brozyna@icloud.com
5. Anita Kwiatkowska, MD
    a. Military Institute of Medicine - National Research Institute, Szaserów 128, 04-141 Warsaw, Poland
    b. https://orcid.org/0009-0009-7250-6194, aw.kwiatkowska@gmail.com
6. Arkadiusz Bydliński, student
    a. Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland
    b. https://orcid.org/0009-0001-4230-661X, bydlinskiarkadiusz@gmail.com

7. Konrad Karłowicz, MD
    a. Central Clinical Hospital in Warsaw, Banacha 1a, 02-097 Warsaw, Poland
    b. https://orcid.org/0009-0008-4610-6456, konrad.karlowicz@uckwum.pl
8. Maria Hermanowska, student
    a. Jan Kochanowski University, Collegium Medicum, al. IX Wieków Kielc 19A, 25-317 Kielce, Poland
    b. https://orcid.org/0009-0007-5673-6403, marysiah05@gmail.com
9. Julia Lubomirska, student
    a. Jan Kochanowski University, Collegium Medicum, al. IX Wieków Kielc 19A, 25-317 Kielce, Poland
    b. https://orcid.org/0009-0008-8557-5108, lubek1999@poczta.onet.pl
10. Łukasz Ciulkiewicz, MD
    a. Independent Public Healthcare Center in Mińsk Mazowiecki, Szpitalna 37, 05-300 Mińsk Mazowiecki, Poland
    b. https://orcid.org/0009-0005-4531-7532, lukasz.ciulkiewicz@onet.eu
11. Patryk Pluta, MD
    a. Stanisław Rybicki Regional Polyclinical Hospital in Skierniewice, Rybickiego 1,
    b. 96-100 Skierniewice, Poland
    c. https://orcid.org/0009-0005-3251-2267, patrykpluta15@gmail.com

Corresponding author: Patrycja Figurowska, MD, patrycja.figurowska@gmail.com

Breast milk – a living superfood. Review of current knowledge

ABSRTACT

Introduction: Breastfeeding is considered the best nutrition for infants, including born preterm due to containing optimal ingredients for development and growth. Breast milk is a rich source of nutrients, it also contains diverse types of bacteria, which play a role in infant's gastrointestinal tract colonization and preserving mammary health. Composition of human milk varies depending on numerous maternal and infant factors.

Aim of the study: The aim of the study was to summarize the current knowledge about the content of nutrients, bioactive factors and microbiota diversity in human milk depending on various factors.

Materials and methods: The work is a review of 26 mainly English-language scientific publications from 1989-2024 posted on the PubMed platform.

Results: Milk composition changes in addition to several factors. Depending on postnatal age: preterm milk has higher content of protein, fat and immunological factors and lower concentration of lactose than term milk. Depending on milk maturity: Colostrum is higher in protein but lower in lactose, fat and energy than mature milk. Human milk is also a source of viable bacteria important for developing infant's gut microbiota, but the diversity of bacterial strains in milk may vary. Depending on mode of delivery: milk of mothers after spontaneous labour contents more probiotic vaginal- and enteric-associated bacteria, while milk of mothers after C-section has more skin-associated microbiota. Depending on mother's weight: milk of overweight mothers is lower in probiotic- and higher in pathogenic bacteria. Alcohol, nicotine, and some medications also have negative impact on produced milk.

Conclusions: Human milk varies from woman to woman and its composition depends on several factors. Postnatal and gestational stage, delivery mode, mother's weight and certain substances have been found to be important factors influencing the constitution of breast milk, including nutrients, microbiota and volume of milk.

Keywords: breast milk, breast milk analysis, breast milk macronutrients, breast milk composition, human milk variability

INTRODUCTION

Due to its unique composition, breast milk is the optimal and best nutrition for infants. Exclusively breastfeeding followed by introducing complementary foods and continuation of breastfeeding for at least 1 year is unanimously recommended for the first 6 months of life by World Health Organisation (WHO) and American College of Obstetricians and Gynaecologists (ACOG) and American Academy of Pediatrics (AAP) [1-3]. Breast milk contains almost all the nutrients, growth factors and immunological factors that are necessary for a healthy term and pre-term infant to grow and develop. Moreover, human milk contains various skin and non-skin types of viable bacteria genera, which probably play a part in colonization of the infant

alimentary tract [4], intestines development, digestion, dental health, immune system development, and pathogen resistance [5]. The immediate and long-term benefits for child resulting of breastfeeding includes also reduction risk of allergic diseases, inflammatory bowel disease, obesity, hypertension, diabetes mellitus type 2 for child [6-8]. Breastfeeding also has a positive impact on cognitive development in early and middle childhood. IQ test results showed a positive correlation with duration of breastfeeding [9]. Health advantages for breastfeeding mothers include early uterus involution, reduction risk of breast and ovarian cancer, reduction risk of mastitis, enabling weight loss after childbirth and decreasing risk of postpartum depression [10, 11].

NUTRITIONAL CONTENT

Human milk macronutrients provide energy for development and growth of infant. 87% of the composition of breast milk is water, the remaining 13% consist mostly of carbohydrates, fats and proteins. The first two macronutrients constitute the main source of energy for infant (45% and 44%, respectively), while proteins contribute only about 8% [12]. Breast milk contains optimal proportions of nutrients, with the exception of vitamin K, which should be administered after birth to prevent vitamin K deficiency bleeding (VKDB), and vitamin D, which should be supplemented in the appropriate dose until the diet becomes its main source [13].

MATURITY EFFECTS

Milk composition changes with postnatal age. Compared to mature milk, colostrum contains higher concentration of protein and lower concentration of fat and lactose, in both term and preterm milk. With milk maturation increase also the energy value. [14]

TERM VERSUS PRETERM MILK

In case of preterm infants, mother’s milk contains higher concentrations of protein, fat and sodium and lower concentrations of carbohydrates, especially lactose, calcium and phosphorus. [13]. In comparison to term milk, preterm mature milk characterizes also with the higher energy contents, while the preterm colostrum has lower energy than term colostrum. [14]

BIOACTIVE AGENTS

Human milk consist of different types of bioactive factors, such as hormones (e.g. thyroid hormones, cortisol), enzymes (peptide and non-peptide), growth factors (e.g. erythropoietin, IGF-1), transporters, anti-inflammatory agents and immune cells (T and B lymphocytes, monocytes, macrophages secreting lactoferrin and lysozyme), as well as stem cells [15]. Breast milk contains also antimicrobial factors, such as immunoglobulins (mostly secretory IgA, but also IgG, IgM, IgD, IgE), which are produced by mammary glands and secreted into milk as a result of contact of microorganisms with the respiratory and digestive system of the mother. Additionally, breastfeeding promotes the structural and functional maturation of the gastrointestinal mucosa, increase the motor activity of the gastrointestinal tract and influences on development of the immune system of the infant. Moreover, nipple receptors remain in constant contact with the infant's saliva, recognise its composition, bacterial flora and, as a result, the milk produced is adapted to the individual needs of the infant. This makes breastfeeding possible both the newborn and the older siblings, and each of them will receive appropriate content of the nutrients and bioactive agents. [16]

MICROBIOTA

Breast milk is one of the most important factors shaping the bacterial flora of the digestive system of the infant. Recent studies revealed that breast milk, especially colostrum, is the source of the commensal, mutualistic and probiotic bacteria in the infant's gut [17]. Human milk contains both skin and non-skin bacterial strains. Several bacteria typically present on adult's skin are gram-positive bacteria such as *Staphylococcus*, *Propionibacterium* and *Corynebacterium* [4]. The adult non-skin microbiota are more diverse and derives from the lower intestine and vagina. It is generally dominated by anaerobic bacteria such as *Enterococcus*, *Bacteroides* and *Prevotella* [18]. Human milk microbiota consist of over 200 bacterial genera. The most important strains are lactic acid bacteria: *Bacterioides*, *Lactobacillus* and *Bifidobacterium*, which are characteristic of colonizing the human lower digestive tract and comprise the main group of intestinal microflora of the infant (up to 85% of the entire population) [19]. The breast milk microbiota composition is dynamic, shifting from high diversity of skin- and enteric-associated bacteria in colostrum to less diverse but more numerous infant's oral microbiota during milk maturation [18]. There are three models, which are not mutually exclusive, determining the content of living, diverse microflora in human milk.. The first one is the intracorporeal translocation bacteria from the mother's intestinal microflora to

the mammary gland, using dendritic cells) [5, 20, 21]. The second way is the transfer of mother's bacteria from the mother's skin (found on the nipple and other parts of the mother's body) to breast milk during breastfeeding [20, 21]. Third hypothesis indicates the role of the mode of delivery [18, 20, 21]. On the skin and in the oral cavity of neonate born vaginally there are bacteria found in the birth canal and the mother's large intestine, which colonize nipple and ductal tissue during breastfeeding [5, 20, 21]. The way infant suckle allows breast milk to flow backward from the infant's oral cavity to the mammary gland [18]. Infants born by C-section display a bacteria strains more similar to human skin microbiota. However, the skin flora is no more related of mother than of a stranger, what indicates that most bacteria are transmitted to the infant from those handling the newborn [5], with underrepresentation of enteric species, such as *Bacteroides* and *Escherichia-Shigella* [22]. In breastfed children, the predominant flora of the gastrointestinal tract contains bacteria of the *Bifidobacterium* and *Lactobacillus* genera, with limited potential pathogens such as *Streptococcus spp.* or *Escherichia coli,* unlike those fed with formula [16] in which there is also an overrepresentation of *C. difficile [22]*. The other factors influencing gut microbial composition are mother's weight and weight gain during pregnancy. Infant's microbiota of overweight mothers and mothers with excessive weight gains characterize with lower numbers of *Bacteroides-Prevotella* and *Bifidobacterium* species and significantly higher numbers of *C. difficile* or *Staphylococcus aureus*. *Bifidobacteria* play a role in modulating intestinal microbiota, controlling of inflammatory processes and improving glucose tolerance and insulin secretion, so there is a link between the composition of *Bifidobacterium* species and certain diseases such as allergies, obesity and metabolic disorders [17]. These bacteria also contribute to digestion in infants by breaking down sugars and proteins, which improves intestinal function by increasing stool moisture, defecation frequency and stool volume [21]. Also *Staphylococcus* aureus may play a role in the development of weight gain and predict inflammatory diseases, as well as *Clostridium difficile*. High concentrations of these species during infancy may predispose to obesity in older children [17]. Moreover, virulent strains of *Staphylococcus spp.*, especially *S. epidermidis,* in breast milk play a role in pathogenesis of mastitis. It has been proven that the administration of probiotic strains derived from breast milk reduces the symptoms of mastitis and the number of virulent bacterial strains more effectively than the administration of antibiotics. Certain *Lactobacillus* strains can inhibit the multiplication of *Staphylococcus spp.* in epithelial cells of mammary gland, they also produce antimicrobial and anti-inflammatory factors [18]. The microbiota in breast milk can

also establish a healthy gut-brain axis, influencing the central nervous system parts associated with anxiety, mood, pain and cognitive function [23].

VARIABILITY OF THE COMPOSITION OF BREAST MILK

Human milk production is a complex and dynamic process. Some substances with small particles can cross the intestinal barrier and enter the mother's bloodstream, from where they can be secreted directly into breast milk and influence volume, nutritional content and microbial composition of the breast milk. These include, for example, allergens, caffeine, alcohol, nicotine and drugs.

PHYSIOLOGICAL VARIABILITY

Breast milk is characterized by certain physiological variability. Depending on the lactation period, protein concentration gradually decreases and fat concentration increases; Depending on the feeding phase, the composition of the milk changes from watery to more fatty. Food with a higher fat content is also produced at night and by mothers breastfeeding a male and preterm infants. Additionally, milk from mothers of prematurely born children is also more rich in proteins and immunological components and less in lactose [16].

DRUGS INTAKE

Most drugs appear in human milk in small amounts and are safe for breastfed child. However, some drugs have a high excretion to milk and have a toxic effect on the infant, but mostly do not affect the composition of the breast milk, although bromocriptine may inhibit production of milk [13].

CIGARETTE SMOKING

Over the past decades, the frequency of smoking in women of child-bearing age has increased significantly. Infants of mothers who smoke cigarettes are exposed to harmful substances released into the milk. Nicotine reaches a concentration several times higher in the milk than in the mother's serum, blocks physiological rise of a prolactin induced by suckling, which provides to reduction of breast milk production. There is also no compensating mechanism which increase energy of smoking mother’s milk. The mean values for protein, fat and lactose do not

different significantly between milk of smoking and non-smoking mothers [24]. Moreover, it has been proven that Sudden Infant Death Syndrome (SIDS) is more common in infants of smoking mothers [16].

ALCOHOL INTAKE

It has been shown that the milk let-down reflex can be partially blocked by maternal alcohol consumption, depending on the ethanol dose. With relatively high doses of alcohol (above 1.0 g/kg of mother's body weight), the milk flow reflex may be completely blocked by inhibiting the release of oxytocin [25].

HORMONAL CONTRACEPTION

Most studies indicate that the use of combined oral contraceptives leads to a reduction in milk volume and a shorter duration of breastfeeding. Lower nitrogen content was observed in women taking combined estrogen-progestin pills, but there was no effect on lactose or fat levels. In contrast, progestogen-only pills showed no effect on milk volume and composition [25, 26].

DIET AND SUPLLEMENTATION

The diet of a breastfeeding mother does not have a significant impact on the composition of breast milk. Most of the components of breast milk are synthesized "de novo" by lactocytes, but some substances can be taken directly from the mother's blood and lymph and secreted into the milk. Minor modifications to the mother's diet may influence the content of certain elements (e.g. iodine, zinc, copper) or vitamins (B group, vitamin C, vitamin A), and especially the kind of fatty acids. With an incorrectly balanced diet, the value of breast milk will not change dramatically. Poor nutrition of the mother will mainly negatively affect her body. Most minerals, macronutrients and folate can be derived to breast milk at the expense of maternal stores or tissues. However, it has been documented that the amount of milk may decrease by up to 15% due to the consumption of less than 1,500 kcal/day by a breastfeeding mother [16, 25].

STRESS

Maternal stress and anxiety may reduce milk production by inhibiting the oxytocin-related milk ejection reflex. Milk production is higher in women who are relaxed while breastfeeding.

However, in stressed women who are unsure of their ability to breastfeed, the oxytocin level may decrease [25].

CONCLUSIONS

Exclusive breastfeeding is the preferred method of feeding for infants up to age 4-6 months. This applies to both full-term and premature babies. It is recommended to introduce complementary foods between the 17th and 26th week of life and to continue breastfeeding until the end of the first year of life or longer. Breastfeeding provides the infant with unique nutritional and health benefits, optimizes the infant's health and has a positive impact on the child development and growth. It also has a positive effect on the mother's organism. The composition and volume of breast milk vary depending on the infant's needs, providing the child with an adequate supply of macronutrients, energy and bioactive agents. Moreover, breast milk is a source of many strains of commensal and probiotic bacteria that are involved in the shaping of the infant's gut microbiota and the development of its immunity. However, there are several factors that can negatively impact the microbiome of breast milk, which may predispose the child to developing certain diseases in the future but also have implications on mammary health. There are also substances that, if taken by the mother, can be excreted in the milk, affects its composition and reduce milk production, which may lead to limited growth and impaired development of the infant. Therefore, special attention should be paid to educating pregnant women about the benefits of breastfeeding, both for the mother and child, and supporting them to breastfeed exclusively for first 6 months after giving birth.

DISCLOSURES

Author's contribution:

Conceptualization: Natalia Małek, Sara Emerla;

Methodology: Maria Hermanowska, Julia Lubomirska;

Formal analysis: Aleksandra Brożyna, Konrad Karłowicz, Arkadiusz Bydliński;

Investigation: Patrycja Figurowska, Łukasz Ciulkiewicz;

Writing-rough preparation: Anita Kwiatkowska, Patryk Pluta;

Writing-review and editing: Natalia Małek, Sara Emerla;

Supervision: Natalia Małek, Sara Emerla.

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