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Review article

Breast Milk Components and Factors that May Affect Lactation Success

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SUMMARY

Introduction. Breastfeeding is the most important way to feed a newborn, infant and a young child. Lactogenesis is the ability of secreting milk from the mammary gland and includes secretory initiation and activation. The birth of the placenta and decrease in progesterone levels stimulate an increase in prolactin levels and the secretion of milk from the breast. Human milk contains carbohydrates, lipids, proteins, vitamins, minerals, fatty acids, amino acids and trace elements. In addition, numerous cells, macrophages, bacteria, chemokines, cytokines, immunoglobulins, hormones, growth factors, and mucin are present. The composition of milk differs depending on the phase of secretion. Colostrum is secreted for the first five days after birth, then comes transitional milk, and mature milk two weeks after birth. During the very act of breastfeeding, there is a difference between pre-milk and last milk. In pre-milk, the fat content is low and increases with the duration of lactation, and in breast milk it is relatively high.
Aim: To point out the importance of milk composition and factors that are influential for breastfeeding.
Conclusion: Maternal parity, age or socioeconomic status and education can affect the concentration of certain components of breast milk. Adequate social policy and support, along with education related to early breastfeeding experiences, can be the key factors in initiating and maintaining breastfeeding. Besides the mother and the child, the entire social community would benefit from that.

Keywords: **breastfeeding, breast milk composition, exclusivity, infant, breastfeeding self-efficacy**

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INTRODUCTION

Breastfeeding is the most important way to feed a newborn, infant and young child. It is associated with numerous benefits for both mother and child. The World Health Organization recommends exclusive breastfeeding for the first six months of life, as well as continuing breastfeeding until the end of the second year with the addition of a non-dairy diet. Human milk (HM) is not always of constant composition; its components are variable, which fully corresponds and is adapted to the needs of the child at different ages (1). The low rate of breastfeeding in the world and in Serbia affects various social policy activities in order to improve the incidence of initiation and the optimal length of breastfeeding.

THE STRUCTURE OF THE MAMMARY GLAND AND LACTATION

The structure of the mammary gland and breast in the early phase of development consists of a network of mammary lobes and canals, surrounded by milk tissue. During puberty, changes in the structure of the breast occur due to the influence of hormones. During pregnancy, in the second trimester, the lobules of the mammary glands enlarge. They are located around the main branched canal, with further division and differentiation of cells involved in milk production (2). Lactogenesis is the ability of secreting milk from the mammary gland and includes secretory initiation and activation. High levels of progesterone inhibit prenatal milk synthesis. Birth of the placenta and a decrease in progesterone and estrogen levels stimulate an increase in prolactin, cortisol, insulin and breast milk secretion. The process occurs 2 - 3 days after birth and is accompanied by breast swelling (3, 4).

The process of lactation is achieved by the joint action of oxytocin and prolactin on cellular receptors. The hormone oxytocin plays a role in the release of milk from the breast. By stimulating the nipple, oxytocin is synthesized in the posterior lobe of the pituitary gland. The connection with the receptors of myoepithelial cells on the milk ducts and alveoli leads to contraction and expulsion of milk. With its secretion, oxytocin in the mother creates a feeling of calm and greater attachment to the child during the breastfeeding process (3). Prolactin is produced in the lactoferral cells of the anterior pituitary gland. Its role is in inducing the synthesis of milk proteins and lactose. When breastfeeding and breast milk extraction are absent, both milk production and breast size decrease. With epithelial cell apoptosis, the structure of the mammary gland is rearranged to the period before pregnancy (4, 3). Oxytocin and prolactin levels increase during breastfeeding. Higher plasma oxytocin values were observed in older mothers, with lower body mass index (BMI) values. There is also an association with less weight loss in the newborn in the first days of life (5).

MILK COMPOSITION

Breast milk is a very complex substance in its composition. It has the necessary nutrients for the prevention of infections, adequate growth and development of the organism, colonization by intestinal microbiota and affects the proper maturation of the immune system. It is rich in carbohydrates, lipids, proteins, vitamins, minerals, fatty acids, amino acids, and trace elements. In addition, numerous cells, macrophages, bacteria, chemokines, cytokines, immunoglobulins, hormones, growth factors, and mucin are present. The importance of understanding the composition of human milk is important because of

Table 1. *Composition of milk macronutrients (7)*

Variable	Colostrum	Mature milk	AMF
Energy (kcal / 100 ml)	50 - 60	65 - 70	60 - 70
Carbohydrate (g / l)	50 - 62	60 - 70	9,0 - 14,0 g / 100 kcal
Lactose (g / l)	20 - 30	67 - 70	
Oligosaccharides (g / l)	20 - 24	12 - 14	
Total protein (g / l)	14 - 16	8 - 10	1,8 - 3,0 g / 100 kcal
Total fat (g / l)	15 - 20	35 - 40	4,4 - 6,0 g / 100 kcal

kcal - kilocalories; AMF - adapted milk formula

Table 2. Composition of milk trace elements (7)

Micronutrient	Colostrum	Mature milk	AMF (min - max)
Iron	0.5 – 1.0 mg/l	0.3 – 0.7 mg/l	0.45 – mg/100 kcal
Calcium	250 mg/l	200 – 250 mg/l	50 – mg/100 kcal
Phosphorus	120 – 160 mg/l	120 – 140 mg/l	25– mg/100 kcal
Magnesium	30 – 35 mg/l	30 – 35 mg/l	5– mg/100 kcal
Sodium	300 – 400 mg/l	150 – 250 mg/l	20 – 60 mg/100kcal
Chloride	600 – 800 mg/l	400 – 450 mg/l	50 – 160 mg/100kcal
Potassium	600 – 700 mg/l	400 – 550 mg/l	60 - 180 mg/100kcal
Manganese	5 – 12 μg/l	3 – 4 μg/l	1 – μg/100 kcal
Iodine	40 – 50 μg/l	140 – 150 μg/l	10 – μg/100 kcal
Selenium	25 – 32 μg/l	10 – 25 μg/l	1 – μg/100 kcal
Copper	0.5 – 0.8 μg/l	0.1 – 0.3 μg/l	35 – μg/100 kcal
Zinc	5 – 12 μg/l	1 – 3 μg/l	0.5 – mg/100 kcal

AMF - adapted milk formula

its connection with numerous developmental processes of the newborn (6).

The largest share in the composition of human milk is water, up to 87 - 88%. The osmolarity is 286 mOsm/l, the specific gravity is 1.030, and the energy value is 65 - 70 kcal per 100 ml. The basic macronutrients are: carbohydrates (7%), fats (3.8%) and proteins (1%) (Table 1), while micronutrients are present in much lower concentrations (Table 2) (7).

Carbohydrates are represented in HM in the form of lactose, which is a disaccharide composed of lactose and galactose. The highest concentrations of lactose are found in HM, which corresponds to the developmental needs of the human brain. Lactose is broken down on the upper surface of small intestine enterocytes by the enzyme lactase. In the newborn, it is easily digestible and important for maintaining the constant values of HM osmolarity (8). The levels of free glucose and its metabolites are small and nutritionally negligible for the newborn's diet. Human oligosaccharides (HMOs) are the second most represented carbohydrates. There are more than 200 different structures. They consist of glucose, galactose, N - acetylglucozoamine, fructose and sialic acid (9).

Fats represent a significant source of energy of 40 - 55% of the total energy intake through HM. They are present in the form of triglycerides which comprise 98% of the fractions of lipids, cholesterol with 0.5% and phospholipids with 0.8% of the total fat fraction. Lipids contain the essential fatty acids, linoleic and alpha linoleic acid, as well as fat-soluble vitamins. Their role is to form the structures of the nervous system and retina but also as for inflammatory and immune processes. HM fats are easily digested due to the presence of lipase enzymes (7, 8).

Proteins are represented in the form of whey, casein and a mixture of various peptides (lactoferrin, alpha lactalbumin, lysozyme, secretory immunoglobulins, serum albumins). Casein is sparingly soluble, affects intestinal peristalsis and facilitates calcium absorption. In HM, it is present in lower concentrations compared to whey which is liquid, easily digestible and is mostly found in HM, unlike other types of milk. Alpha lactalbumin is important for the supply of essential amino acids. It participates in anti-inflammatory reactions, immune role and absorption of microelements in newborns. It is specific for HM, while beta lactalbumin is found in beef milk and is mainly responsible for allergic reactions in newborns. Protein concentrations gradually decrease from colostrum to mature milk (7).

A large number of minerals have been identified in lower concentrations in HM than in AMF. Their concentrations decrease from colostrum to mature milk, but they are characterized by high bioavailability. Calcium, phosphorus, magnesium stand out as well as trace elements such as iron, copper, zinc. Trace elements are found in low concentrations in HM and can be affected by the mother's diet. Vitamins, especially vitamin D and vitamin K, are present in insufficient concentrations in HM, so their

replacement is recommended in the first days after the birth of a child (7, 8).

The composition of milk differs depending on the phase of secretion. Colostrum is secreted for the first five days after birth, then comes transitional milk, and mature milk for 14 days after birth. Colostrum is rich in immunoglobulins (IgA), lactoferrin and minerals that help protect neonatal infections. It is relatively low in fat (1 – 2 %) and rich in protein (10 % and 20 - 30 g/l, respectively). High levels of chlorine, sodium and magnesium are present, and lower levels of calcium and potassium. The transition of colostrum to mature milk is associated with an increase in the concentration of lactose and glucose, and a decrease in protein concentrations to 7 - 8 g/l. Such a composition of HM correlates with a smaller increase in body weight of breastfed children during their second half of the first year (from 6th to 12th month) (6).

During the very act of breastfeeding, pre-milk is different, i.e. first milk at the beginning of the act of breastfeeding. The fat content in it is relatively low and increases with the duration of lactation. Rear milk is characterized by a higher percentage of fat and a higher caloric value. The amount of lactose and protein differs slightly between them (7).

The volume of HM gradually increases, reaching the highest amount around 6 - 7 months in order to satisfy the nutritional requirements of the infant. Fat content and energy value increase in HM during lactation. Concentrations of carbohydrates increase during the first four months, while the concentrations of protein from colostrum, transition milk to mature milk gradually decrease. At the beginning of the act of breastfeeding, the ratio of whey protein and casein is 90:10, in transitional milk 70:30, and in mature milk 60:40. In the period after 6 months, the values of the ratio of whey protein and casein reach 50:50 (6).

Besides micro and macronutrients, HM also contains bioactive components that perform their basic function in the formation of an adequate immune response in the newborn.

Immunoglobulins IgA make up 90 % of all immunoglobulins in HM. The highest concentrations are in colostrum, making a significant immune defense of the newborn. Immunoglobulins bind pathogenic microorganisms, prevent their motility, stop adhesion and penetration into the epithelium of the intestinal mucosa. Epidermal growth factor, in addition to other specialized growth factors, is important for the activity of intestinal enzymes, healing of the intestinal mucosa, and better transport of nutrients. Numerous cytokines, which function as small peptides and intercellular transporters, are responsible for the regulation of immunity, inflammatory processes and hematopoiesis. Lactoferrin is a protein that binds iron in the intestinal lumen and prevents the growth of bacteria. It also shows a cytotoxic effect on pathogenic microorganisms, prevents their adhesion to the intestinal epithelium, and is important for limiting excessive immune responses (9).

Breast milk contains a large number of various microbes that are the main source of bacteria in the intestines of a breastfeeding neonate. The importance is reflected in the formation of the innate immunity of the newborn, owing to the creation of its own intestinal microflora. In 44 studies that examined the microbiome of breast milk, among other things, it was reported that bacterial diversity was higher in breast milk compared to the feces of newborns or mothers. The most commonly discovered genera were *Staphylococcus, Streptococcus lactobacillus, Pseudomonas, Bifidobacterium, Corynebacterium, Enterococcus, Acinetobacter* and many others. The composition of the microbiome is influenced by the mode of birth, sex of the child, gestational age, parity, lactation phase, BMI of the mother, geographical position (10). Every day for a month, they take in about 107 bacteria or over 700 different types of bacteria (9).

MicroRNAs are non-coding small molecules essential for the regulation of gene expression. They can be found in extracellular fluids, where they serve as biomarkers of disease. Of the body fluids, most microRNAs are found in breast milk, where their most important role is in the development of the immune system and metabolic functions of the newborn (4).

Oligosaccharides in HM have a strong antimicrobial effect and belong to the group of glycans. Higher concentrations of HMOs in HM have been observed in premature infants than in term neonates. Their prebiotic role is important, when in the distal part of the small intestine, undigested oligosaccharides in food support the growth of bacteria. Glycans and HMOs, by acidifying the intestinal lumen, inhibit the development of intestinal infections. By producing bacteriocins and organic acids, they prevent the growth of pathogens. Together with glycans, HMOs inhibit the binding of

pathogens and, with their antiadhesive and prebiotic role, reduce inflammation in the intestines (9).

FACTORS AFFECTING THE COMPOSITION OF HUMAN MILK

Maternal obesity during pregnancy affects the supply of fatty acids to the fetus during lactation. Low concentrations of n-3 and elevated concentrations of n-6 polyunsaturated fatty acids have been reported, which is associated with a proinflammatory condition and oxidative stress in various fetal organs. The offspring are at higher risk of developing obesity, neuropsychiatric disorders, asthma and cancer (11).

Iodine supplementation (75 - 400 mg iodine/day) as well as selenium (20 μg/day) in the mother increase the concentrations of these elements in breast milk. Compensation of Zn, Fe or Ca to the mother through diet during pregnancy or lactation will not affect their concentration in excreted breast milk (6).

Numerous endocrine factors and melatonin affect the newborn's adequate night's sleep, reducing their neonatal colic. The reason for this is the higher concentration of melatonin in the nocturnal than in the daytime HM sample (7.3 pg/ml vs. 1.5 pg/ml) (6).

Reports on the relationship between maternal parity and HM structure differ between studies. A higher lipid concentration associated with higher parity was found in Lebanon, as opposed to Gambian rural women. Higher amounts of Fe and minerals were found in multiparous women, while immunoglobulin levels were usually higher in first - born colostrum among women from Bangladesh and Brazil (6).

Concentrations of macro and micronutrients differ slightly between adolescent mothers and older breastfeeding mothers. Research by Serbian authors indicate that the age of mothers greater than 35 years is more strongly correlated with the content of fat, retinol and β carotene than a diet rich in eggs, meat and dairy products (12). The socioeconomic status of the mother, such as education or occupation, has influenced the concentration of lipids and polyunsaturated fatty acids in India and Iraq (6). In China, there has been a positive association between the mode of delivery, BMI in highly educated mothers, and the concentration of carotenoids and tocopherols in HM (13).

The way of ending pregnancy also has an impact on the composition of human milk. The vaginal way of giving birth is associated with a higher concentration of protein in colostrum. Cesarean delivery will affect higher choline levels, iodine levels in transitional milk and IgA concentrations in colostrum compared to women who gave birth naturally (6).

Certain studies report the effects of harmful substances to which the mother has been exposed, which can also be found in breast milk. The analysis of the composition of HM in women from Serbia indicates a high risk of aflatoxin pollution. The milk of mothers who consumed numerous dairy products made from the milk of animals fed with corn contaminated with aflatoxin during the pregnancy period was examined. There is a high risk of aflatoxin exposure in neonates who are more susceptible to toxic contaminants in the first days of life. Aflatoxin contamination has been reported in colostrum and breast milk up to 8 months postpartum (14). Arsenic in the milk sample of Lebanese mothers was associated with their intake of fish and cereals, while cadmium pollution was significantly associated with maternal accidental exposure to smoke (15).

It is believed that the sex of the child may be related to the composition and volume of HM. In boys, mothers had 25 % higher caloric content and higher content of lipids such as linoleic acid, phospholipids, gangliosides, all in favor of the potentially higher energy needs of the male child (6).

FACTORS THAT MAY AFFECT THE ONSET AND MAINTENANCE OF LACTATION

Research shows that mothers usually have a negative experience related to breastfeeding or low breastfeeding self-efficacy a week after giving birth. These usually included: a short period of "skin-to-skin contact" after birth, a lack of social support, no or short education about breastfeeding, a previous negative experience of breastfeeding, or a short period of breastfeeding with previous children. Greater education related to early breastfeeding experiences and breastfeeding self-efficacy would enable more adequate qualifications for breastfeeding counseling and its extension, from which would benefit the mother, the child and society as a whole (16).

Galactogogues are substances that help in the

production of milk in different phases of secretion. Some research indicate the importance of plants such as fenugreek or nettle in initiating, continuing or increasing the secretion of breast milk. Herbal tea, which is dominated by nettle, increased lactation and prevented the lack of breast milk in premature mothers in intensive care units by 80% (17).

A survey of the population in Serbia indicates that exclusive breastfeeding for up to 6 months is represented by up to 13.3%. It had a higher prevalence among richer women, followed by women who gave birth to children weighing more than 2,500 g, multiparous than primiparous women. Of interest are the research data which show that the absence of a baby friendly program ("hospital friends of the baby") in the maternity hospital indicates a higher chance of the infant to be breastfed for up to 6 months. Attending childbirth preparation programs within schools for pregnant women increases the chances of such mothers breastfeeding their children for more than 18 times. Stronger support needs to be provided to mothers and medical staff in maternity hospitals (18).

Bookman and the authors examined the frequency of breastfeeding among 20,000 primi- and multiparous women. The onset of breastfeeding in primiparous women was influenced by the mother's age, education, and obtaining information from a nurse or the hospital staff, family or friends. Primiparae will decide to practice breastfeeding rather than multiparae, but with a shorter breastfeeding period (19).

Prenatal advice on the importance of breastfeeding for mothers who have not breastfed their children in their previous pregnancies affects the growth of exclusive breastfeeding, children's growth and development. They showed randomized controlled clinical trials on 108 pregnant women in Iran (20). Other studies report an average duration of breastfeeding of about 17.5 months in that country. Children with younger mothers and primiparous women had shorter breastfeeding. Mothers with high school and college have previously stopped breastfeeding compared to more educated women (21).

British authors have estimated that counseling and monitoring of breastfeeding immediately after birth can affect the improvement of the breastfeeding rate in the first days and months, but this impact cannot be maintained in the long run. It is considered that more adequate breastfeeding support is needed with a more favorable national policy in order to increase the impact of breastfeeding (22).

A study in America showed the influence of the media and public attitudes towards breastfeeding. An analysis of the understanding of the importance of breastfeeding and its benefits, presented in the media, can have a positive effect on increasing support for breastfeeding as a common practice (23).

A review of data from a cohort study in China indicated an increase in the frequency of breastfeeding over the last decade compared to the previous ten years. It is known that China is a country with great diversity in culture and levels of economic development and education (24).

Skin-to-skin contact increases the rate of exclusive breastfeeding during the first hour after the birth of a child. Such a report can be used by health professionals to develop breastfeeding support programs (25).

CONCLUSION

Breast milk is a substance that does not provide only food for newborns and is much more than just feeding. The connection with the mother and the intimacy that comes with breastfeeding cannot be replaced by any other preparation. As a result of the variable composition of HM, during different periods, the infant is provided with the most necessary foods and ingredients. With her behaviour, diet and living habits, the mother could also influence many milk ingredients. Although breastfeeding rates are declining in some parts of the world, adequate social policies and support for breastfeeding provide opportunities for its early onset and long enough maintenance. This achieves benefits not only for the child and the mother, but also for society as a whole.

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Komponente majčinog mleka i faktori koji mogu uticati na uspešnost laktacije

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S A Ž E T A K

Uvod. Dojenje predstavlja najznačajniji način ishrane novorođenčeta, odojčeta i malog deteta. Laktogeneza je mogućnost izlučivanja mleka iz mlečne žlezde. Obuhvata sekretornu inicijaciju i aktivaciju. Izbacivanje placente i smanjenje nivoa progesterona stimulišu porast nivoa prolaktina i lučenje mleka iz dojki. Humano mleko sadrži ugljene hidrate, lipide, proteine, vitamine, minerale, masne kiseline, amino-kiseline i elemente u tragovima. Osim toga, prisutni su i makrofagi, brojne ćelije, bakterije, hemokini, citokini, imunoglobulini, hormoni, faktori rasta i mucin. Sastav mleka razlikuje se zavisno od faze lučenja. Prvih pet dana od porođaja luči se kolostrum, zatim prelazno mleko, a dve nedelje posle porođaja zrelo mleko. U toku samog akta dojenja razlikuje se predmleko i zadnje mleko. U predmleku sadržaj masti je nizak, povećava se sa trajanjem laktacije, a u zadnjem mleku, relativno je visok.
Cilj. Cilj rada bio je da se ukaže na značaj sastava mleka i faktora koji su od uticaja za dojenje.
Zaključak. Paritet majki, uzrast, socioekonomski status, kao i obrazovanje, mogu imati uticaja na koncentraciju određenih komponenti majčinog mleka. Adekvatna socijalna politika i podrška, uz edukaciju vezanu za iskustva ranog dojenja, mogu biti ključni faktori za započinjanje i održavanje dojenja. Koristi od toga, pored majke i deteta, imala bi i celokupna društvena zajednica.

Ključne reči: **dojenje, sastav majčinog mleka, ekluzivnost, odojče, samoefikasnost dojenja**