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EVALUATION OF THE MINERAL COMPOSITION OF INFANT FORMULAS

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Abstract

The composition of modified milk for babies is based on the model of breast milk. Milk replacement formulas are produced on the basis of cow's milk so it is necessary to modify all the nutrients in order to make them resemble most closely the model. Determination of babies' nutritional requirements is based on the knowledge of women's breast milk, which is regarded the best possible food in the first period of infant life. The concentration of mineral elements in breast milk is low and the total content of ash amounts to $0.2\ g \cdot dl^{-1}$. The content of sodium, potassium and chlorine is three times as low as in cow's milk. The source of individual elements for babies is their food, though some elements are provided in drinking water and supplements. Typically, mineral elements are absorbed more effectively in the periods of intensive growth. It should be remembered that the mineral elements found in breast milk are characterised by much higher bioavailability than those present in modified milk. The major requirement for modified milk to be registered and authorised for sale in Poland is the conformity of its mineral composition with international recommendations.

The objective of the present work was to establish the content of mineral components in powdered milk used in the nutrition of infants in the first months of their lives. All the examined preparations were labelled as "a special nutrition product". They were purchased in different groceries in Lublin in October 2007, all before their use-by date. The shares of Mg, Zn, Cu, Ca, Mn, Na, Fe and K were marked in the samples.

It was demonstrated that all the examined milk samples contained much more Ca and Cu in comparison to recommended norms, whereas they were deficient in Mg and Mn.

Key words: child, infant formula, mineral components.

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OCENA SKŁADU MINERALNEGO MLEKA W PROSZKU

Abstrakt

Skład mleka modyfikowanego przeznaczonego dla niemowląt oparty jest na wzorcu pokarmu kobiecego. Preparaty mlekozastępcze są produkowane na bazie mleka krowiego, i dlatego konieczna jest modyfikacja wszystkich składników pokarmowych, aby je maksymalnie upodobnić do wzorca. Stężenie składników mineralnych w pokarmie kobiecym jest niskie, całkowita zawartość popiołu wynosi 0,2 g dl^{-1}. Zawartość sodu, potasu i chloru jest trzykrotnie niższa niż w mleku krowim (są to pierwiastki odpowiedzialne za osmotyczne obciążenie nerek). Źródłem poszczególnych pierwiastków dla niemowląt jest pożywienie, niektórych dostarczają woda pitna i suplementy mineralne lub witaminowo-mineralne. Zwykle składniki mineralne są wchłaniane efektywniej w okresach intensywnego wzrostu. Należy pamiętać, że składniki mineralne występujące w mleku matki charakteryzują się znacznie wyższą biodostępnością niż znajdujące się w mleku modyfikowanym. Głównym warunkiem rejestracji mleka modyfikowanego i dopuszczenia do obrotu w Polsce jest zgodność składu mineralnego i witaminowego z zaleceniami międzynarodowymi.

Celem pracy było ustalenie zawartości składników w mleku w proszku stosowanym w żywieniu niemowląt w pierwszych miesiącach życia. Materiał do badań stanowiły preparaty uznanych marek przeznaczone do żywienia niemowląt w pierwszych miesiącach życia. Wszystkie badane preparaty miały adnotację, że jest to „produkt specjalnego przeznaczenia żywieniowego". Mleka w proszku zakupiono w sklepach spożywczych na terenie Lublina w październiku 2007 r., w okresie jego przydatności do spożycia. W pobranych próbach oznaczono zawartość Mg, Zn, Cu, Ca, Mn, Na, Fe oraz K.

Wykazano, że badane próby mleka zawierały znacznie więcej Ca i Cu w porównaniu z normami, natomiast były niedoborowe pod względem zawartości Mg i Mn.

Słowa kluczowe: niemowlęta, preparaty mlekozastępcze, składniki mineralne.

INTRODUCTION

Long-term studies of the process of human growth indicate that no period is more significant to determining the health condition of an individual than the foetal stage and early childhood. Inadequate nutrition in infancy leads to development impairment. According to the latest recommendations, baby nutrition should be based on mother's breast milk and on manufactured preparations specially designed for this particular age group (ALDOUS 1999).

The composition of modified milk for infants is based on the model of human breast milk. Milk replacement formulas are manufactured on the basis of cow milk, so it is necessary to modify all nutrients in such a way that they resemble the original model to the maximum.

The determination of babies' nutritional requirements is based on the knowledge of women's breast milk which is regarded as the best possible food in the first period of infant life. The concentration of mineral elements in breast milk is low, the total content of ash amounts to 0.2 $g \cdot dl^{-1}$. The content of sodium, potassium and chlorine is three times lower in comparison to cow milk (these are the elements responsible for osmotic burden of the kidneys) (LYNCH, STOLTZFUS 2003). The source of individual elements for babies is their food, though some elements are provided in drinking water and supplements. Typically, mineral elements are absorbed more effectively in the periods of intensive growth (DROBNIK, LATOUR 2006). It should be remembered that the mineral elements found in breast milk are characterised by much higher bioavailability than those present in modified milk (SKRAJNOWSKA 2006).

The main requirement for registering and authorising the sale of modified milk in Poland is the compliance of its mineral and vitamin composition with international recommendations (STOLARCZYK 2001). Such compliance is confirmed by a certificate issued by Chief Sanitary Inspector (Główny Inspektor Sanitarny), which must be printed on the packaging of the product.

The aim of the present study was to determine the content of mineral elements, in powdered milk administered in infant nutrition in the first months of the children's lives.

MATERIALS AND METHODS

The material for the examinations was provided by milk replacement formulas representing well-known brands, used in baby feeding in the first months of their lives: A-1 (starter powdered milk for babies, enriched with iron, since the day of birth), A-2 (follow-on milk, with an addition of powdered rice cereal for babies, enriched, form the 4^{th} month of life), B-1 (from the day of birth until the 4^{th} month, enriched with iron), B-2 (containing a probiotic, bananas, above the 4^{th} month), C (with a probiotic, above the 4^{th} month), D (hypo allergic follow-on milk, enriched with iron), E-1 (with rice cereal, a formula for further baby nutrition above the 4^{th} month), E-2 (hypo allergic follow-on milk for babies above 4 months of life). All the examined preparations were labelled as "a special nutrition product". They had been purchased in grocery shops in Lublin in October 2007, before their use-by date.

The contents of dry matter and crude ash in the samples were determined with the use of the AOAC methods (1990). The content of Mg, Zn, Cu, Ca, Mn, Na, Fe and K was determined in the collected specimens, with the use of the AAS flame technique, in a Unicam 939 (AA Unicam Spectrometer).

All chemical analyses were performed in two replications. The results were statistically analysed. Arithmetic mean values and standard deviation (sd) were calculated with the use of STATISTICA 6.0 software. Taking into account energy concentration declared by the producer, proportions between individual mineral elements and energy (kcal) were calculated.

RESULTS AND DISCUSSION

The content of dry matter, crude ash and macroelements in the examined milk replacement formulas is presented in Table 1. It should be remembered that the concentration of certain mineral elements in modified milk is significantly higher in comparison with breast milk, which results from its lower assimilability (STOLARCZYK 2001).

The level of sodium in milk formulas ranged from 0.92 to 2.25 mg·g^{-1}. The highest share of sodium was found in B-1 formula and the lowest in A-2 milk. In reference to the content of sodium calculated per 100 kcal, the highest share of this element was recorded in C (51.4 mg) and D (nearly 50 mg) preparations, as well as in B-1, B-2 and E-2. Bearing in mind the norms, it should be noted that all formula types contained an acceptable amount of sodium.

The presence of 2.411 to 4.704 mg of potassium in 1 g (from 84.68 to 169.16 mg·100 kcal^{-1}) was observed in the analysed formulas. In reference to the norms, the acceptable limit of potassium was exceeded only in C preparation. Being the basic component of intracellular liquid, potassium influences the osmotic balance in the cell, participates in transmitting nerve impulses in the nervous and muscular systems, ensures the adequate course of reactions related to muscle contractions and activates a number of enzymatic reactions. Potassium takes part in carbohydrate transformations, energy transformations, systemic protein synthesis and amino acid transport in the cell (SHIMONI 2005).

It was observed that, in comparison to the norms, the content of calcium was significantly exceeded in all the analysed preparations. In formula D, the amount of this element was 3.5 times higher than the acceptable limit, in B-2 and E-1 its share was 3 times higher than the norm, whereas in C, E-2 and A-2 preparations there was 2.5-fold more calcium than the acceptable value. The demand for calcium amounts to 600 mg per day during the first six months, and 800 mg per day in the following six months (ZIEMLAŃSKI et al. 1998). According to the Polish regulations, the ratio of Ca to P in baby milk formulas cannot be lower than 1.2 or higher than 2 (Journal of Laws 2002). Calcium and phosphorus are more easily assimilable from breast milk than from milk formulas, so the content of these components in modified milk is higher than the baby's demand indicates (ALDOUS 1999).

Our studies showed that all the examined preparations contained too little magnesium, compared to the recommendations. The currently obliging norms recommend that the share of magnesium in babies' and little children's diet should range from 50 to 150 mg per day (ZIEMLAŃSKI et al. 1998). Magnesium assimilability is increased by vitamin D, sodium, galactose and animal protein. Magnesium deficiency leads to disorders in the circulation and the functioning of the heart, irritability, convulsions, behaviour disor-

Table 1

Contents of macroelements in the infant formulas, mean ± SD (n=3)

Trade mark	Dry matter (%)	Crude ash (%)	Contents of macroelements								kcal 100 g^{-1}*
			$mg \cdot g^{-1}$				$mg \cdot 100\ kcal^{-1}$				
			Na	K	Ca	Mg	Na	K	Ca	Mg	
A-1	97.9±9.3	2.09±0.003	1.065±0.002	2.862±0.005	0.087 ±0.0002	0.042±0.0001	23.12	88.63	61.66	6.94	519
A-2	97.5±8.9	2.68±0.009	0.924±0.001	2.411±0.007	1.274±0.002	0.050±0.0001	27.22	84.68	119.96	7.66	496
B-1	98.1±9.0	2.63±0.02	2.247±0.005	3.313±0.01	0.098±0.0001	0.046±0.0001	45.99	99.80	76.32	7.83	511
B-2	95.0±9.0	3.79±0.04	1.551±0.006	4.331±0.02	0.167±0.001	0.616±0.002	46.22	136.55	157.56	11.13	476
C	97.0±8.9	3.58±0.03	1.632±0.005	4.704±0.02	0.141±0.001	0.067±0.0002	51.39	169.16	128.91	12.01	467
D	96.2±8.5	3.15±0.005	1.617±0.004	3.776±0.02	0.135±0.001	0.049±0.0001	49.78	138.58	165.95	11.42	463
E-1	97.3±9.3	3.15±0.02	1.500±0.004	3.173±0.009	0.148±0.002	0.059±0.0001	40.09	118.49	149.89	11.36	449
E-2	96.4±7.1	3.05±0.01	1.613±0.006	3.536±0.01	0.126±0.001	0.047±0.0001	46.74	130	122.61	9.35	460
Norms (2002)							20-60	60-145	50	25-90	

SD – standard deviation
* values as declared by the manufacturer

ders, anaemia, brittleness of the bones, higher neoplasm incidence and protein synthesis disorders (GRIFFIN et al. 2008).

The content of microelements in the s formulas is presented in Table 2.

The content of zinc ranged from 0.85 mg to 0.99 mg·100 $kcal^{-1}$. Bearing in mind the norms, it was concluded that the share of this element was adequate in all the studied preparations. The required zinc consumption in breastfed babies is 1mg per day (zinc assimilability from breast milk reaches 60%), and in children fed cow's milk or a combined diet these requirements are much higher since zinc absorption from such a diet does not exceed 40%, and is frequently at the level of 10-20%. The demand for zinc with such a diet and 20% zinc assimilability is 5-5.5 mg per day, yet a high percentage of babies fed a mixed diet or after discontinuing breast feeding receive too little zinc (MARZEC, ZARĘBA 2003a). Currently, zinc is regarded as one of the most important trace bioelements. It affects the human organism on many planes, though its role has not been fully described yet. Zinc bioavailability from a diet depends on its composition. In women's breast milk this element occurs in combination with low-molecular-weight proteins, which makes it very easily assimilable. In healthy adults zinc deficiency hardly ever occurs. However, it is frequent in new-born babies and little children. It was determined that the problem concerns about 50% of the whole population (HAMBIDGE, KREBS 2007). The digestive, central nervous, immune and bone systems all react to zinc deficiency.

A comparison of the values obtained with the norms resulted in a conclusion that the share of copper was exceeded in all the studied formulas. The demand for copper in early childhood is not high because of significant copper reserves in the liver, acquired during foetal life (SZOTOWA 1993). After birth, babies fed their mother's milk reveal negative copper balance, yet the reserves accumulated in the liver during their foetal life are sufficient to ensure the proper functioning of copper-dependent enzymes. Assuming 50% copper absorption with food and endogenic copper reserves in the liver, 40 μg·kg^{-1} per day of this element is recommended for babies during the initial three months of their lives. The daily copper recommendation for infants is 0.65mg (MARZEC, ZARĘBA 2003b).

The content of iron ranges from 0.036 mg to 0.31 mg in 1 g. It should be noted that among the preparations enriched with iron none was characterised by a high content of this component. Bearing in mind the iron content per 100 kcal, the highest amount of this element, above the limit, was observed in A-2, E-1 and D, preparations. The content of iron in B-2 and E-2 formulas also exceeded the acceptable norm. In the remaining preparations the share of this element was adequate. Iron content in breast milk is *ca* 0.3-0.5 mg·l^{-1}. The assimilability of this element from mother's milk reaches 70%, whereas in modified milk this value does not go beyond 25% (STOLARCZYK 2001). During the initial three months after birth the baby uses iron reserves accumulated in the organism, which is absolutely sufficient.

Table 2

Content of microelements in the infant formulas, mean (n=3)

Trade mark	Contents of macroelements								kcal 100 g^{-1}*
	mg·g^{-1}				mg·100 $kcal^{-1}$				
	Na	K	Ca	Mg	Na	K	Ca	Mg	
A-1	0.006	0.005	0.066	0.00	0.75	0.06	1.19	0.00	519
A-2	0.004	0.007	0.053	0.002	1.21	0.12	1.69	0.05	496
B-1	0.012	0.004	0.052	0.002	1.00	0.06	1.00	0.04	511
B-2	0.029	0.009	0.310	0.002	0.99	0.12	1.58	0.05	476
C	0.009	0.004	0.073	0.0008	0.75	0.04	1.35	0.04	467
D	0.003	0.004	0.074	0.001	0.91	0.06	1.66	0.06	463
E-1	0.005	0.006	0.036	0.002	1.02	0.102	1.69	0.04	449
E-2	0.003	0.004	0.074	0.0009	0.85	0.05	1.54	0.02	460
Norms (2002)					0.5-1.5	0.002-0.008	0.5-1.5	5-15	

* values as declared by the manufacturer

However, from the fifth month the baby must be administered iron in the diet and milk replacement formulas become its important source for children who are not breastfed (STOLARCZYK 2001). It is believed that anaemia caused by iron deficiency is the reason for mental retardation (HURTADO et al. 1990). At the same time, iron excess in the diet blocks zinc and copper absorption and stimulates the growth of certain strains of intestinal bacteria (STOLARCZYK 2001).

Our study revealed that all the examined preparations contained too little manganese, in reference to the norms. The share of this element in the analysed milk replacement formulas ranged from 0.0008 mg to 0.002 $mg \cdot g^{-1}$. Manganese deficiency is particularly hazardous to infants and little children because it can result in growth and development disorders (LJUNG, VAHTER 2007). The symptoms of manganese deficiency are rare in older children and adults because manganese is commonly present in the food. Manganese participates in carbohydrate and fat transformations, it is an activator of numerous enzymes, affects the processes of connective tissue formation and reproductive processes. If its insufficiency occurs, it may lead to disorders of the growth and development in children (LJUNG, VAHTER 2007).

SUMMARY

The source of individual elements for babies is their food, though some elements are provided in drinking water and supplements. In all the formulas the content of Ca and Cu exceeded the recommended norms. In contrast, the products were deficient in Mg and Mn. It should be remembered that the concentration of certain mineral elements in modified milk is significantly higher in comparison with breast milk, which results from its lower assimilability (SKRAJNOWSKA 2006).

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