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ASSESSMENT OF INFANT EXPOSURE TO LEAD AND CADMIUM CONTENT IN INFANT FORMULAS

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Abstract

Infants and little children are the highest risk group as far as the exposition to toxic metals is concerned. Newly born babies do not have effectively functioning regulatory mechanisms and the absorption of mineral elements, including toxic ones, is higher than in older children and adults. Separate, more rigorous requirements have been determined for food products for infant nutrition. Special attention is required in the case of toxic metals, including lead and cadmium, which are regarded as particularly harmful to the organism.

The objective of the present work was to establish the content of lead and cadmium in powdered milk used in the nutrition of infants in the first months of their lives. Moreover, on the basis of surveys, the popularity of using milk replacement formulas was determined, as well as factors affecting this situation. All the examined preparations were labelled as "a special nutrition product". They had been purchased in different groceries in Lublin in October 2007, all before their use-by date. The shares of Pb and Cd were marked in the samples.

It was demonstrated that only two preparations did not comply with the recommendations regarding the content of cadmium, while in the other samples the maximum value was not exceeded. It was also noted that the analysed preparations were not safe for babies as far as the content of lead was concerned. At the same time, it was observed that as many as 87% babies were breast-fed, which is a positive phenomenon, whereas 40% women used combined nutrition for their children (breast feeding alternately with powdered milk). The choice of a particular preparation resulted in the first place from the doctor's recommendations, and next from babies' preferences and friends' opinions.

Keywods: child, infant formula, cadmium, lead.

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OCENA STOPNIA NARAŻENIA NIEMOWLĄT NA POBIERANIE OŁOWIU I KADMU W PREPARATACH MLEKA W PROSZKU

Abstrakt

Niemowlęta oraz małe dzieci to grupa populacji o najwyższym ryzyku narażenia na toksyczne działanie metali. U noworodków zaraz po urodzeniu brak jest sprawnie działających mechanizmów regulacyjnych, a wchłanianie składników mineralnych, w tym także pierwiastków toksycznych, jest większe niż u dzieci starszych i osób dorosłych. Ustalono odrębne, bardziej rygorystyczne wymagania dla produktów spożywczych przeznaczonych do żywienia niemowląt. Szczególnej uwagi wymagają metale szkodliwe, do których zalicza się m.in. ołów i kadm, uznawane za szczególnie niebezpieczne dla organizmu.

Celem pracy było ustalenie zawartości ołowiu i kadmu w mleku w proszku stosowanym w żywieniu niemowląt w pierwszych miesiącach życia. Ponadto na podstawie badań ankietowych określono popularność stosowania preparatów mlekozastępczych oraz czynniki wpływające na ten stan. Materiał do badań stanowiły preparaty uznanych marek, przeznaczone do żywienia niemowląt w pierwszych miesiącach życia. Wszystkie badane preparaty miały adnotację „produkt specjalnego przeznaczenia żywieniowego". Produkty zakupiono w sklepach spożywczych na terenie Lublina w październiku 2007 r., w okresie ich przydatności do spożycia. W pobranych próbach oznaczono zawartość Pb i Cd.

Jedynie dwa preparaty nie spełniały wymagań odnośnie do zawartości kadmu, w pozostałych wartość dopuszczalna nie została przekroczona. Ponadto stwierdzono, że analizowane preparaty nie są bezpieczne dla niemowląt pod względem zawartości ołowiu. Jednocześnie stwierdzono, że aż 87% dzieci było karmionych piersią, co jest zjawiskiem pozytywnym, przy czym 40% kobiet stosowało żywienie mieszane (karmienie piersią naprzemiennie z mlekiem w proszku). Największy wpływ na zakup danego preparatu miała porada lekarza, następnie upodobania dziecka oraz opinia znajomych.

Słowa kluczowe: niemowlęta, preparaty mlekozastępcze, kadm, ołów.

INTRODUCTION

Food may contain different harmful substances which, when absorbed, may present a serious hazard to health (TONG et al. 2000), especially in children, whose excretion processes are generally slower than in adults. Children have a low body weight and lower immunity. Mother's milk should not be treated as a potential source of toxic metals, since the milk producing gland creates a natural biological barrier which prevents their passing from the mother's organism into the food (GULSON et al. 1998). However, toxic metals may be passed to infants with other solid food products. Separate, more rigorous requirements have been determined for food products for infant nutrition. Special attention is required in the case of toxic metals, including lead and cadmium, which are regarded as particularly harmful to the organism. Both lead and cadmium are characterised by a high accumulation factor in living organisms. The circulation of heavy metals in the environment is linked to the food chain: soil – plant – animal – man. When metals pass to a higher link, their content accumulates increasingly (BRAD-

STREET et al. 2003). It should be noted that a positive correlation has been observed between the concentration of toxic metals in children's organisms and the incidence of autism (BRADSTREET et al. 2003). International organisations focused on children's health recommend that food products for babies and little children should be continuously monitored (UNEP/UNICEF 1999).

The aim of the present study was to determine the content of lead and cadmium in powdered milk administered in infant nutrition in the first months of the children's lives. Additionally, the popularity of replacement milk formulas was evaluated on the basis of a questionnaire survey, as well as the factors responsible for their popularity.

MATERIAL AND METHODS

The material for the examinations comprised 8 milk replacement formulas representing well-known brands, used in baby feeding in the first months of their lives (Table 1). 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.

Table 1

Trade mark and characteristic of analysed infant formulas

Trade mark	Characteristic
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 4th month
E-2	hypo allergic follow-on milk for babies above 4 months of life)

The content of Pb and Cd was measured with the use of flameless AAS technique in a Varian Spectr AA-880. All chemical analyses were performed in two replications.

Questionnaire surveys were performed in Lublin and Podkarpacie regions, from October to December 2007. The questionnaire consisted of 11 questions, whose purpose was to determine the consumption volume of milk replacement formulas, depending on the place of residence (a village or a town), as well as the reasons for using and selecting a particular prepa-

ration (Table 2). Assuming that it is the mothers who most frequently buy food for their children, there were also questions about the mother's age and educational background. The study was carried out on 100 children's mothers.

Table 2

Questionnaire

1.	Age of children □ 1 month □ 2 months □ months □ 4 months □ 5 months □ above 5 months	7.	Trade mark of milk formulas used in the nutrition of infants □ Bebiko □ Humana □ HIPP □ NAN □ other ……..
2.	Place of residence □ village □ town	8.	Used milk formulas and breast feeding simultaneously □ yes □ no
3.	Education of mother □ primary □ vocational □ college □ higher	9.	Reasons for use of breast-milk substitutes □ lack of breast milk □ supplemental feeding □ discontinuing breast feeding □ other
4.	Age of mother □ to 20 □ 20-25 □ 26-30 □ above 30	10.	Only one type of formula was used in the infant's diet □ yes □ no
5.	Number of children □ 1 □ 2 □ 3 □ more than 3	11.	Factors affecting purchase of milk formulas □ family □ friends □ doctor's recommendations □ price □ advertising □ income □ baby's preference □ trade mark □ other……
6.	Time of breast-feeding □ to 5 months □ above 5 months □ not at all		

RESULTS AND DISCUSSION

Newly born babies do not have effectively functioning regulatory mechanisms and the absorption of mineral elements, including toxic ones, is higher than in older children and adults (Drobnik, Latour 2006). The results of marking the content of cadmium and lead in milk formulas are presented in Table 3.

Table 3

Contents of cadmium and lead in the infant formulas, mean ± SD (n=3)

Trade mark	Contents of	
	Cd (μg g^{-1} fresh matter)	Pb (μg g^{-1} fresh matter)
A-1	0.002	0.198
A-2	0.011	0.418
B-1	0.002	0.158
B-2	0.014	0.094
C	0.0004	0.120
D	0.002	0.450
E-1	0.002	0.161
E-2	0.002	0.289
Polish Norm (Journal of Laws 2003)	0.01	0.10

SD – standard deviation

Our studies also demonstrated that only two of the milk replacement products did not meet the requirements regarding the content of cadmium, namely A-2 and B-2. The acceptable value was not exceeded in the remaining formulas. The limit was determined by legal regulations and it amounts to 0.01 mg·kg^{-1} (0.01 μg·g^{-1}) of the product (Journal of Laws 2003).

The results of the above studies are alarming. Cadmium is regarded as an indicator of carcinogenic processes. It also impairs kidney functions (Waalkes 2000). Moreover, a relationship between the presence of cadmium in food and calcium (Staessen et al. 1999) and iron (Ĺkesson et al. 2000) metabolism disturbances was demonstrated. Cadmium is a metal to which babies are exposed continuously, since its source may be water, air, food and cigarette smoke. Studies proved that this element accumulates in babies' organisms during their foetal lives to a much higher degree than in their mothers' organisms (Razagui, Ghribi 2005). As it was demonstrated, cadmium's half-life in the human organism is *ca* 30 years (Castelli et al. 2005), which explains why exposing children to this element is particularly hazardous.

The acceptable amount of lead was also determined by the law and it is 0.1 mg·kg^{-1} (0.1 μg·g^{-1}) of the product (Journal of Laws 2003). Our studies revealed that the acceptable limit of lead was not exceeded only in B-2 brand (0.094 μg·g^{-1}). In C formula a slightly higher amount of this element was determined, whereas in all the remaining formulas the content of lead was significantly higher than the norms. In D and A-2 preparations the limit was exceeded fourfold.

The results are highly alarming. It should be noted that food is one of the factors which most frequently put infants and little children at risk of contact with lead. Numerous studies demonstrated that food addressed to this particular group of consumers is not safe as far as the content of this toxic element is concerned (Marzec, Zaręba 2003, Winiarska-Mieczan, Gil 2007, Winiarska-Mieczan, Kwiecień 2007). Hozyasz et al. (2004) showed that the mean content of cadmium in cow milk was lower in comparison with the mean share of this element in different milk replacement mixtures, whereas the mean content of lead was lower only in starter mixtures. Guidi et al. (1996) stated that the share of lead in mixtures for babies remained within quite a wide range: from 6 $\mu g \cdot l^{-1}$ to 600 $\mu g \cdot l^{-1}$ in standard formulas based on modified cow milk, and from 2 $\mu g \cdot l^{-1}$ to 45 $\mu g \cdot l^{-1}$ in lactose-free formulas, hyper allergic (HA type) ones and those containing milk cow protein processed by hydrolysis. This provided a vital argument in favour of the necessity to increase quality requirements for manufacturers regarding raw materials and improved technological processes. What should be remembered is the results of the studies indicating possibile occurrence of high cadmium and aluminium concentrations in soy mixtures. The average content of toxic metals in cow milk is higher than in human breast milk (Hozyasz et al. 2004).

Infants and little children are the highest risk group as far as the exposition to toxic metals is concerned (Mahajan et al. 2005, Razagui, Ghribi 2005). Lead finds its way to the child's organism through the respiratory or digestive system (Tong et al. 2000). This is a highly toxic element and the resulting poisoning may lead to anaemia (Mahajan et al. 2005), dysfunctions of different organs (liver, kidneys, stomach) and convulsions (Aldous 1999). A report from 1999 drafted by UNICEF and UNEP (UNEP/UNICEF 1999) states that exposing children to the risk of contact with lead leads to impaired functioning of the nervous system, which is manifested primarily in the disorder of motor functions, and also in behaviour problems or physical hyperactivity. Such children also revealed impaired brain functions and lower IQ (Chen et al. 2005). An excessive accumulation of lead in the organism leads to death. Preventing or relieving the toxic activity of lead is reduced to enriching the diet with calcium and iron (UNEP/UNICEF 1999) and with vitamin C (Committee on Environmental Health 2005). Studies revealed a lower level of cadmium concentration in the blood of lactating mothers after enriching their diet with calcium (Hernandez-Avila et al. 2003). Experiments using radioactive lead demonstrated that in primates the level of cadmium absorption into the brain tissue is conversely proportional to their age (Willes et al. 1977). The studies performed by Tsukahara et al. (2002) demonstrated that babies with anaemia caused by iron deficiency had a higher cadmium concentration than healthy infants. The level of lead and ferritin in the blood were conversely correlated, similarly to the level of lead in the blood and haemoglobin.

The survey revealed that 87% of the children in the studied group were breast fed. According to the recommendations determined by the World Health Organisation, infants and little children should be fed breast milk exclusively until the sixth month and later they should be administered supplementary products which must be nutritionally adequate and safe while continuing breast feeding until the second year or longer (KUNACHOWICZ, KUNDZICZ 2003). Breast milk is fully adapted to feeding babies, depending on the stage of their development (PAWLUS et al. 2005). Mother's milk is a specific quality food for a baby as it is adapted to the peculiar digestion, assimilation and metabolism of the infant's organism. It contains all indispensable nutritional and protective ingredients in proper amounts and adequately composed, adjusted to the needs of the baby's organism and not burdening the digestive and excretory systems, which are not fully mature yet. Breast milk completely satisfies the demand for nutrients throughout six months, except for vitamin D (SKRAJNOWSKA 2006). Mother's milk ensures proper physical and mental development of the child. Besides, breast feeding makes the baby feel secure and contributes to the mutual emotional relationship between the mother and the child.

Our studies revealed that some mothers did not breast feed their babies at all or decided to introduce milk replacement formulas for various reasons. According to the majority of the respondents, the reason why they decided to use milk replacement preparations was to provide supplemental feeding (53.9%), 30% declared the lack of breast milk, whereas 15% used a formula after discontinuing breast feeding. 60% of the women in the studied group did not use milk formulas simultaneously with breast feeding, while 40% chose a combined diet for their children. Unquestionably, the vast majority of the surveyed women (92%) used only one type of the formula and only 8% tried more than one. The place of residence did not have any influence on the frequency of using milk formulas.

The studies demonstrated that the choice of a given formula was dictated primarily by the doctor's recommendations (66.7%), while in 25% of the cases it was the baby's preference that was decisive. The advice offered by friends was effective in above 8%. Other factors did not have any influence on the purchase of milk formulas by the questioned women. Moreover, it was observed that the products offered by well-known brands were the most popular ones. Being familiar with the brand does affect the consumers' opinion concerning its quality. The prestige of a particular brand name is one of the determinants of the product's quality (GÓRSKA-WARSEWICZ 2003).

SUMMARY

The analyses showed that only two milk replacement formulas did not satisfy the requirements regarding the share of cadmium, namely A-2 and B-2. It was also observed that the analysed preparations were not safe for babies regarding the content of lead.

It was concluded that as many as 87% of the babies were breast fed, which is a positive phenomenon. The majority of women (60%) did not administer replacement formulas and breast feeding simultaneously, while 40% chose a combined diet for their babies. The purchase of particular milk formulas was largely affected by doctors' recommendations, and in the second place by babies' preferences or friends' advice.

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