*BioMetals* 1997, **10**, 299–302

# Selenium levels in infant milk formula

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Received 16 May 1997; accepted for publication 18 June 1997

**Twenty-four brands of commercial infant milk formula were collected and analysed for selenium by inductively coupled plasma spectrometry with the hydride t-system after an acid digestion procedure. The mean selenium concentration was 49.0 ± 11.55 μg l$^{-1}$, with a range from 26–68 μg l$^{-1}$, resulting in an adequate daily selenium intake for infants aged from zero to six months consuming 0.75 l milk daily as set by the US National Research Council in 1989.**

**Keywords:** infant milk formula, Saudi Arabia, selenium

## Introduction

Selenium is an essential nutrient for humans and animals. Keshan disease, endemic cardiomyopathy of children and women of childbearing age, occurring in China in regions where dietary selenium intake is very low (Keshan Disease Research Group 1979, Chen *et al*. 1980 Xia *et al*. 1989) was the first human disease shown to be related to selenium deficiency.

Selenium acts as a protective agent against heavy metal toxicity (Magos & Webb 1980, Johansson 1991, Anderson & Nielsen, 1993), cancer (Willett *et al*. 1983, Helzlsouer *et al*. 1989) and cardiovascular diseases (Salonen *et al*. 1988, Korpela *et al*. 1989, Korpela 1993).

The major sources of Se in most diets are meat and cereal products, which contribute approximately 50% and 25–35%, respectively, of the total Se intake of Americans (Litov & Combs 1991). In addition, dairy products and eggs provide 10–20%, while fruits and vegetables provide less than 5% of the total Se intake. For infants and children, however, the core of Se-providing foods may be much smaller. The selenium intake of infants is of interest because of their rapid growth rate and their heavy reliance on milk, a food that has a highly variable selenium content, depending on its geographical origin. In Canadian infants, estimates of Se intake by dietary records showed milk to supply 98% and 89% of total Se intakes at one and three months of age, respectively (Gibson & DeWolfe 1980). At six months of age, milk provided only 35%, whereas cereals provided 34% of the total dietary Se. By 12 months of age, the introduction of a variety of foods further decreased the relative contributions of milk and cereal to the Se nutrition of the infants. Selenium concentration in formula milk is generally lower than in breast milk (Lombeck 1980, Litov *et al*. 1987). Levels of Se in young infants (one to four months) were even lower than levels in cord blood samples; higher levels were found in older infants (Lombeck *et al*. 1977, Verlinden *et al*. 1983). Others have also shown that selenium levels double from early infancy to adult life (Hatano *et al*. 1984). Plasma selenium changes have been studied in healthy, full-term infants fed with human milk by mothers given no added selenium, fed with human milk by mothers given selenite or yeast tablets high in selenium, or fed with commercial formula to which sold foods were added from three months of age. Plasma selenium values increased in the human milk-fed infants but dropped in the formula-fed infants. The greatest increase was seen in infants of yeast-supplemented mothers, indicating that intake is the primary factor affecting neonatal plasma selenium levels (Kumpulainen *et al*. 1985).

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In Saudi Arabia, a study by Al-Saleh *et al*. 1997 revealed that Se daily intake in 77.8% of breast-fed infants ranged from 0.9–15 μg. This was considered to be low when compared with the US National Research Council recommendation in which Se daily intake for infants of zero to six months should be 10–40 μg (National Research Council 1989). About 56% of the screened lactating women were giving their infants additional milk formula. The Se content of infant formulas varies as a result of differences in the amounts of intrinsic Se ingredients. A study in Finland (Kumpulainen *et al*. 1987) showed the Se concentrations of a locally produced milk-based infant formula to be as low as 3–5 μg $l^{-1}$. Since there is little information available on the Se content of commercial infant milk formula (Zabel *et al*. 1978, Smith *et al.* 1982), this study was undertaken to determine the extent of variation in the Se content of different brands of infant milk available in the Saudi markets.

## Materials and methods

Seventy-one cans, from 24 infant powdered formulas on sale, were randomly collected from different supermarkets in Riyadh, capital of Saudi Arabia.

*Analytical procedure*

Selenium measurements were performed using the ATI-701 inductively coupled plasma emission spectrometer (ICP) equipped with the hydride generation system.

Samples were oven-dried overnight at 100–105°C. A weighed sample of approximately 1.0 g milk powder was reacted with 3 ml of concentrated 'selectipur' nitric acid (E. Merck, Darmstadt, (Germany) into a 100 ml reflux Pyrex digestion tube. An automated Digestion system 12 0019 with a 1012 Autostep Controller (Tecator AB, Hoganas, Sweden) was programmed as follows: 10 min ramp to 120°C and hold for 5 min. When the digestion was complete, and the tubes cooled, 2 ml of 5 M hydrochloric acid (Fisher Scientific Co. Springfield, USA, A.C.S.) was added to each sample converting the selenium to the selenium (IV) state. The mixture was heated to 90°C for 5 min and held for 20 min. After cooling for 90 min at 4°C, the digestate was filtered through filter paper (Whatman No. 541). The clear supernatant was transferred to polypropylene tubes and diluted to 10 ml with deionised water. The sample analysis was performed five times in duplicate. Selenium contents were expressed as μg $l^{-1}$. The sample was then ready for analysis.

Working standard solutions were made up each day in the range 2.0–16.0 μg $l^{-1}$ using 5 M hydrochloric acid solution. A calibration curve of emission intensity versus concentration of selenium was drawn and the concentra-

**Table 1.** Se contents in commercially available infant formulas

| Brand of infant formula | Se content (μg $l^{-1}$) | Remarks | Country of origin |
|---|---|---|---|
| Pelargon | 47.0 (39.0–62.0) | Infant formula with iron | The Netherlands |
| Bebelac-1 | 47.0 (29.0–62.0) | | The Netherlands |
| Wyeth S-26 | 53.0 (40.0–67.0) | | Ireland |
| Nursie | 41.0 (35.0–48.0) | Infant formula with iron | France |
| Wyeth Promil | 68.0 (63.0–71.0) | High protein follow-on formula from six months old | Ireland |
| NAN | 53.0 (45.0–58.0) | Infant formula with iron | The Netherlands |
| Nutrilon Premium | 38.0 (27.0–45.0) | Complete infant formula | The Netherlands |
| Guigoz-1 | 37.0 (34.0–39.0) | Infant formula with iron | Switzerland |
| Babuna Prima | 30.0 (25.0–36.0) | Follow-on infant formula with iron from five months old | Switzerland |
| Guigoz-2 | 40.0 (36.0–43.0) | Follow-up infant formula with iron from six months old | Switzerland |
| Bebelac-2 | 62.0 (51.0–74.0) | Follow-up milk with iron from six months old. | The Netherlands |
| Nutrilon Follow-on | 63.0 (52.0–73.0) | Follow-up milk formula from six months old | The Netherlands |
| Babina Plus | 26.0 (22.0–32.0) | Infant formula from zero to four months old | Switzerland |
| GAIN | 65.0 (61.0–71.0) | Follow-on milk formula over six months old | Denmark |
| Enfamil | 48.0 (40.0–59.0) | Infant formula for first 12 months | The Netherlands |
| MAEIL-Mamma | 40.0 (35.0–43.0) | | Korea |
| Similac | 49.0 (43.0–52.0) | | USA |
| Enfapro | 64.0 (56.0–68.0) | Follow-up formula for older babies | The Netherlands |
| Mamil | 68.0 (63.0–72.0) | Follow-on milk from six months old | Denmark |
| All 110 | 54.0 (46.0–62.0) | Lactose-free infant formula | The Netherlands |
| Mamex | 44.0 (33.0–55.0) | | Denmark |
| Frisolac (H) | 48.0 (48.0–48.0) | | The Netherlands |
| Milupa Nektarmil-1 | 44.0 (36.0–51.0) | Infant formula from birth fortified with vitamins and minerals | Germany |
| Similac with Iron | 47.0 (42.0–56.0) | Infant formula with iron | Denmark |

tions of the unknown samples were read from the calibration graph. To check the accuracy of the method, a Standard Reference Material (SRM) 8435, 0.131 ± 0.014 $\mu g\ g^{-1}$ (National Institute of Standards and Technology, NIST, Gaithersburg, MD, USA) was used. Our results were in good agreement with the NIST certified level (0.13 ± 0.023 $\mu g\ g^{-1}$). Additionally, the analytical recovery for Se at various concentrations tested (0.025–0.1 $\mu g\ g^{-1}$) was 88–104%, which was thought to be satisfactory. The spiked powdered milk samples were run with the test samples and blanks using the same analytical procedure.

## Result and discussion

The Se analysis of 24 brands of milk-based powdered formulas for normal infants on sale in Saudi Arabia is presented in Table 1. The mean of Se content in different brands of infant milk formulas was 49.0 $\mu g\ l^{-1}$ (range 26–68 $\mu g\ l^{-1}$). This resulted in an average daily intake of 36.75 μg, in the range 19.5–51 μg. This is well within the safe and adequate daily intake range of 10–40 μg for infants aged from zero to six months consuming 0.75 l milk daily, set by the US National Research Council (1989). Selenium concentration in formula milk is generally lower than in breast milk (Lombeck 1980, Litov *et al.* 1987).

By contrast with other studies, where Se concentration in breast milk is higher than in cows' milk and infant formulas (Lombeck *et al.* 1978, Smith *et al.* 1982, Varo *et al.* 1984), the results of this study showed that the mean Se content in milk formulas (49.0 $\mu g\ l^{-1}$) was higher than the Se content in breast milk collected from Saudi lactating mothers (17.57 $\mu g\ l^{-1}$) and cows' milk (20.25 $\mu g\ l^{-1}$) in a previous study by Al-Saleh *et al.* (1997). This may be due to the fact that the Se content of milk is influenced by the Se intake of lactating mothers and dairy cows in Saudi Arabia. This is very disturbing, especially when multiparity and long lactation is characteristic among rural areas in Saudi Arabia. Consequently, further studies are needed to evaluate the selenium status in Saudi infants who are receiving breast milk as a sole source of nutrition and to consider whether or not low Se intakes can be detrimental to health of infants.

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