Zeitschrift für
Ernährungswissenschaft Z Ernährungswiss 23:230–236 (1984)

The selenium content of infant food

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Summary

The selenium content of food exhibits great regional differences. Food samples of infants and young children from the North Rhine-Westphalia State in the Fed. Rep. of Germany were analysed by instrumental neutron activation analysis and showed that the average selenium content of local vegetable and fruit is below 5 ng/g wet weight. Only samples of potatoes and bananas exhibit higher selenium contents. The bananas, probably imported from different areas of the world, show an extremely high variance with values between 4 and 164 ng Se/g. Commercially available ready-for-use meals for infants or young children have a low Se content (median 24 ng/g) which is comparable to cow's milk. Besides eggs, cereals enriched with milk and some other cereal products contain more than 100 ng Se/g.

Zusammenfassung

Der Selengehalt der Nahrung weist große regionale Unterschiede auf. Nahrungsproben von Säuglings- und Kleinkinderkost aus Nordrhein-Westfalen wurden mit Hilfe der instrumentellen Neutronenaktivierungsanalyse untersucht und zeigten, daß der Selengehalt der hiesigen Gemüse und Früchte durchschnittlich etwa 5 ng/g beträgt. Nur Proben von Kartoffeln und Bananen weisen einen höheren Selengehalt auf. Bananen, importiert aus verschiedenen Gebieten der Erde, zeigen eine extrem hohe Schwankungsbreite mit Werten zwischen 4 und 164 ng Se/g. Fertiggerichte für Säuglinge und Kleinkinder haben einen der Kuhmilch vergleichbar niedrigen Selengehalt von durchschnittlich 24 ng/g. Außer Eiern enthalten nur Milchbreie und einige andere getreidehaltige Produkte mehr als 100 ng Se/g.

Key words: selenium, vegetable, fruit, cereals, infant food

Introduction

There are great regional differences of the selenium content of soils. Selenium is passed directly up the food chain through plants to animals and humans. Therefore, the amount of selenium in different foods is highly variable, depending upon the area where the plants are grown or where the animals are raised. There are areas in the world where the soil selenium content is either so high or so low that naturally intoxications or deficiencies happen to occur in animals.

The dose of selenium needed to cause chronic intoxications in humans is poorly defined because of the lack of specific criteria for selenosis in humans. Symptoms reaching from dermatitis, loss of hair and nails,

discoloration of the teeth, to gastrointestinal symptoms and psychological disturbances were described.

A variety of different clinical symptoms can be associated with low selenium blood values. In 1979 (2, 12), two instances of selenium-responsive diseases were reported in humans living in areas, where selenium deficiency diseases also occur in lifestock. White muscle disease – a degeneration of the skeletal muscle – is one of the predominant selenium deficiency symptoms in animals. In humans a naturally occurring Se-responsive cardiomyopathy – Keshan disease – was observed, mainly in children from the People's Republic of China (2). In New Zealand weakness and stiffness of skeletal muscles disappeared in a patient on parenteral nutrition after supplementation with selenomethionine (13).

Not only in parenteral fluids but also in special diets the selenium content can be extremely low (9). In the last decades in industrialised countries dietary habits have changed and more processed food instead of home-prepared meals are consumed especially by young children and infants. Food processing can also lower the selenium content significantly (10). Because of the regional variations, different fertilisations, and food processing techniques data based on analytical data of selenium content from one country cannot be used for another one.

The aim of the present work is to give figures of the selenium content of different infant foods available in the North Rhine-Westphalia State of the Fed. Rep. of Germany. This food comprises fresh fruit and commercially available infant meals. The data will be discussed and compared with data from other countries.

Material and methods

Food samples representing a cross section of the diet of 5–20-month-old children from North Rhine-Westphalia were chosen for analysis. Not only fresh fruit or infant teas were taken but also aliquots of mixed food after heating or cooking in the homes of the children. Non-homogenous samples were homogenised in silicon tubes. Aliquots of 1 to 2 g, or 1 to 2 ml, resp., were prepared by freeze-drying for analysis. Samples were analysed in duplicates. The Se content was estimated by instrumental neutron activation analysis (6); the activation time was 24 hrs. A close agreement between replicates with a variation of less than ± 10 percent from the mean was observed.

Results

The selenium content of fluids was in general low (table 1). Infant teas contained between less than 0.1 and 3.2 ng/g, 4 samples contained less than 1.0 ng/g, four more less than 2.0 ng/g. All 18 samples of carrot or fruit juice which had been analysed, contained less than 5.5 ng/g. The median selenium content of cow's milk infant formulae amounted to 12.9 ng/g, the 20 analysed samples comprised 6 different follow-up formulae with a protein content higher than 1.9 g/100 ml.

The selenium content of fresh vegetables and different fruit, like apples, oranges, or apricots, was comparably low with a median value below 5 ng/g. Locally grown potatoes were in general richer in selenium than

Table 1. Se content of infant food [ng/g w.w.]

Kind of food	Number	Median	Range
Fluid food			
Teas	9	1.7	<0.1– 3.2
Fruit juices	18	2.6	0.4– 5.4
Milk formulae (follow-up f.)	20	12.9	9.2– 25.8
Cow's milk	11	21.5	17.4– 29.0
Fresh fruit			
Apple	5	4.9	1.1– 6.0
Oranges	2	1.5	1.4– 1.5
Apricots	5	2.9	0.3– 5.4
Bananas	11	(31.8)*	5.1–164.4
Fresh vegetable			
Carrots	11	2.9	1.4– 6.6
Cucumbers	2	2.5	2.0– 2.9
Beans (green)	2	2.4	1.7– 3.0
Potatoes	8	16.3	3.2– 40.0
Canned food			
Fruit	14	4.1	0.8– 9.9
Yogurt + fruit	2	19.8	14.6– 25.0
Vegetable	11	2.5	1.4– 3.7
Vegetable + meat	15	23.9	8.2– 87.4
White cheese	1	69.0	
Food incl. cereals			
Fruit + cereals	3	22.1	22.0– 34.0
Cereals enriched with milk	10	125.1	89.7–192.3
Biscuits	7	113.0	61.6–150.0
Various food			
Chocolate	3	48	37 53
Whole egg	1	179	
Egg yolk	1	500	

* broad variation and heterogeneity of values

other vegetables, but 2 samples had only a selenium content of 3.2 and 5.5 ng/g, 5 samples contained 15.2 to 28.2 ng/g, and 1 sample 40 ng/g, resp.

The selenium values of bananas, sold in West Germany, were even more heterogenous. The origin of the test samples is not known, 5 samples had a selenium content between 4.3 and 14.7 ng/g, 4 samples of 31.8 to 34.4 ng/g, 2 samples of 87.3, and 164.0 ng/g, resp.

The selenium content of canned fruit or vegetables was comparably low as in fresh ones. Yoghurt plus fruit contained about 20 ng Se/g, and white cheese 69 ng/g.

Commercially available infant meals with vegetables and 11 to 12% meat had only a median selenium content of 23.9 ng/g. Meals with chicken did not differ from those with pork or beef with respect to the selenium values. 2 samples containing vegetable plus egg (22.5 ng Se/g, 28.8 ng Se/g, resp.) were not richer than those with meat, although whole egg contained 179 ng/g and egg yolk 500 ng Se/g. Cereals enriched with milk and bread or biscuits were besides eggs the richest source of selenium for small chil-

dren and contained usually more than 100 ng Se/g. The addition of cereals to a milk formula leads to a tenfold increase of the selenium content of the meal.

Discussion

After the 5th to 6th months of age the feeding regimen of infants is changed, and the milk is partially replaced by other liquids or by solid foods. These foods called with the German term "Beikost" comprise infant teas, fruit juices, fresh or canned fruits, vegetables, and cereals.

Milk in general is a poor source of selenium, and milk formulae have even less selenium than cow's milk or human milk (8, 18). The comparison of the median selenium values of milk formulae (adapted and follow-up formulae) from 1978 (8) and 1983 (follow-up formulae) do not show a significant difference, 9.3 ng/g versus 12.9 ng/g. Follow-up formulae are richer in protein than adapted ones and, therefore, the trend to higher selenium values is understandable. With the exception of bananas and potatoes, vegetables and fruit contain only traces of selenium (less than 5 ng Se/g). Vegetables although enriched with smashed meat are not rich in selenium. This may result, firstly, from the low content of meat and, secondly, from processing. Morris and Levander (1) showed a 40 to 50 % reduction of selenium content of strained baby foods by processing if they are compared with the fresh raw samples.

Among the food constituents consumed by small children, only those containing cereals like bread, biscuits, or cereals enriched with milk have a high selenium content. In whole egg and egg yolk we estimated the highest selenium content. Usually egg is included in the food after the 6th month of life.

Table 2 shows a comparison of the selenium content of different foods which are or can be consumed by young children in West Germany, Japan, North America, United Kingdom, and USSR. The general trend that vegetables and fruit are low in selenium and cereals higher is remarkable but known already from adult food. Food rich in selenium like fish, seafood and kidney is usually lacking in the food table of infants.

Comparing our values with literature data they are similar but somewhat lower than the values from Japan (14). There is a good agreement with the values from Berlin (5).

The several fold differences between the values of some food constituents are partially due to regional variations, or to food processing techniques. Methodical problems should not have played a major role during the last decade, since more than 3 reliable methods for selenium estimations in food are available.

Already in 1961 Hadjimarkos and Bonhorst (4) pointed at the great difference between the selenium content of milk or egg samples in selenium-poor or selenium-rich country sides of Oregon, varying between 5 and 49 ng/g of milk, and between 56 and 202 ng/g of egg, resp. In our study, the best example for regional variations are the selenium values of bananas varying between 4.3 and 164.0 ng/g.

Even the selenium contents of locally produced food can be changed substantially by fertilisation of the soil, which may increase the selenium

Table 2. Comparison on the Se content, ng/g w. w. of infant foods from different countries.

Country	W.Germany NRW+	Germany Berlin	W.Germany Stuttgart	Japan	Japan	USA	USA	Canada	United Kingdom	USSR
(Reference)	present data	5	12	14	11	10	7	1	17	15·
Year	1983	1980	1969	1971	1980	1970	1983	1972	1978	1971
Method	NAA§	AAS§§	AAS	FM**	NAA	FM	FM	FM	FM	
Cow's milk	22	15	16	30		13			10	13
Milk formulae	13									
Fruit juices	3					2				
Apples	5	2		9	1	5		4		1
Oranges	2		34·	3	2	13		15		
Apricots	3									
Peaches						4		4		
Bananas	32*		42·		10	10		4		
Carrots	3	2	3	10		22		6	10	11
Cucumbers	3	10		2						
Spinach	7	20	17				15			
Beans (green)	2	11				6		5		
Cauliflowers		33				6		4		
Cabbages		22		10		22		30		5
Potatoes	16			20		5		23	10	28
Canned fruit	4	2					24	2		
Yogurt + fruit	20									
Canned vegetables	3	7				2	3			
Vegetables + meat	24									
Fruit + cereals	22					25				
Cereals enriched with milk	125									
Biscuits	113						24			
Whole egg	179			240				390		
Egg yolk	500					180		690	200	25

\+ State of North Rhine-Westphalia
* broad variation
· converted from dry weight basis
NAA& Neutron Activation Analysis
AAS&& Atomic Absorption Spectrophotometry
FM** Fluorometry

content several fold within some years. Supplementation of animal food with selenite, selenate or selenoamino acids is less effective in increasing the selenium content of animal tissues or meat.

The values published on processed infant food are limited and should be extended. Only for cow's milk, some vegetables and fruits comparable figures are available, however, not for typical meals of young children in Central Europe or North America like cereals enriched with milk, yoghurt plus fruit, fruit plus cereals, canned vegetables plus meat.

The bioavailability of selenium may also differ between children's food and adult's food. The bioavailability of selenium in human milk versus cow's milk is not known. Selenium in wheat exhibits a higher bioavailability than selenium in fish (3); however, it is less available than the selenite-selenium with respect to GSHPx activity of young red cells or liver. In plants a high percentage of selenium exists as selenomethionine. The availability of seleno-methionine is dependent on the methionine content of the food and the methionine state of a person (16).

As young children eat mianly a lactovegetarian diet, the selenium content of their meals is more prone to regional variations and changes of the bioavailability than those of adults.

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Received March 21, 1984

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