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Contents of mineral elements in Swedish market basket diets

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ABSTRACT

The aim of this study was to estimate the average dietary exposure to toxic and essential mineral elements in the Swedish population (Cd, Pb, Zn, Cu, Ni, Cr, Fe, Mn, Co, Se, Ca, K, Mg, Na, I). Market baskets were purchased during March–May 1999 in four cities representing the major geographical regions and population centres in Sweden. The market baskets were based on food disappearance data representing more than 90% of annual supply, and were divided into 12 food groups.

Large variations between food groups were seen for the average concentrations of most essential elements. Differences between the four cities were relatively small (CoV < 10–20%), exceptions being e.g. Se in cereals and I in meat. Pb concentration varied considerably among food groups ranging from <0.001 mg/kg in soft drinks to 0.027 mg/kg in wine. Cd concentration varied from <0.001 mg/kg in soft drinks and dairy products to 0.024 mg/kg in cereal products. Average contents of the elements were (per/person/day) 1110 mg Ca, 2580 mg Na, 3320 mg K, 285 mg Mg, 11.3 mg Zn, 9.2 mg Fe, 3.5 mg Mn, 1.15 mg Cu, 0.20 mg I, 0.052 mg Se, 0.09 mg Ni, 0.025 mg Cr, 0.011 mg Co, 0.007 mg Pb and 0.010 mg Cd. Compared to a previous study in 1987 no or minor changes in the supply of Ca, Mg, Zn, Mn, Cu and Cd have occurred. The content of Fe was about 40% lower in the present study, mainly due to cessation of flour fortification. The content of Se was about 30% higher. The content of Pb was about 50% lower, probably due to the elimination of Pb from petrol and other measures taken to reduce Pb emissions in Sweden. The average content of essential mineral elements in the Swedish diet was close to or above daily recommended intakes for adults, except for Mg and Fe. The average Pb and Cd content corresponds to 3% and 17% of the JECFA PTWI, respectively. The content of Cd corresponds to 47% of the new TWI established by EFSA in 2009.

1. Introduction

The market basket study and the total diet study approaches are frequently used methods to estimate the average dietary exposure to contaminants as well as nutrients in the general population (Becker and Kumpulainen, 1987; Darnerud et al., 2006; Lombardi-Boccia et al., 2006; Leblanc et al., 2005; Müller et al., 1996, 1998; Iyengar et al., 2002; Egan et al., 2002; Muñoz et al., 2005; Rantakokko et al., 2006; Thomson et al., 2008; Voorspoels et al., 2006; Rose et al., 2010). The World Health Organization (WHO), through its Global Environment Monitoring System—Food Contamination Monitoring and Assessment Programme (GEMS/Food), is encouraging countries to undertake total diet studies as the most cost-effective method for assessing dietary exposure to chemical contaminants in the diet (WHO, 2007). Representative datasets on consumption of foods are combined with data on concentration in foods of the compounds of interest, to derive the average dietary exposure. The results can be used as a basis in risk assessments to determine if the exposure could pose a threat to public health. Also, the results from recurrent market basket studies can be used to assess the efficacy of risk management measures that have been undertaken. From that point of view, it is important that the studies are comparable with respect to representativity and design so that conclusions on changes in exposure or intake can be drawn.

In the non-occupationally exposed part of the population, the diet is the major source of exposure for many environmental contaminants like lead (Pb) and cadmium (Cd). The WHO/FAO Joint Expert Committee (JECFA) has performed risk assessments and established Provisional Tolerable Weekly Intakes (PTWI) for these contaminants (WHO, 2000, 2004). Recently the PTWI for Cd was evaluated by the European Food Safety Authority (EFSA, 2009) and the PTWI lowered from 7 to 2.5 μg/kg body weight. Similarly, dietary reference intakes (DRI) have been established for nutrients (Institute of Medicine, 2006; NNR, 2004). The PTWIs and DRIs can be used as benchmarks for evaluating if the estimated exposure or intake levels render concern for public health.

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Table 1
Foods included in market baskets purchased in four different cities in Sweden 1999.

Food group	1% of annual consumption per person (g/ml)	No. of food items	Description of food items included in the food group
Cereal products	694	11	Flour, grain, corn flakes, pasta, bread incl. wholemeal bread
Pastries	137	4	Biscuits, buns, cakes
Meat products	567	16	Beef, pork, lamb, poultry, cured/processed meats
Fish	133	13	Fresh and frozen, canned products, shellfish
Dairy products	1685	12	Milk, sour milk, yoghurt, cream, hard cheese, processed cheese, cottage cheese
Egg	92	1	
Fats	175	6	Butter, margarine, cooking oil, mayonnaise
Vegetables, incl. root vegetables	548	19	Fresh and frozen, canned products
Fruit	641	15	Fresh and frozen, canned products, juice, nuts, cordials, jam
Potatoes	514	4	Fresh, French fries
Sugar and sweets	286	6	Sugar, chocolate, sugar sweets, mustard, ketchup
Soft drinks, beer	1188	4	Soft drinks, mineral water, beer (2.1-3.5% alcohol)
Wine	145	4	Red and white wine (2 varieties each)
Strong beer (>5% alcohol)	218	3	Different brands
Spirits	28	3	Different brands
Ice cream	68	2	Dairy and vegetable fat-based

The purpose of this study was to estimate the average dietary exposure to the environmental contaminant mineral elements Cd and Pb and the following essential mineral elements: Zn, Cu, Ni, Cr, Fe, Mn, Co, Se, Ca, K, Mg, Na and I. The results are compared with a previously reported Swedish market basket study (Becker and Kumpulainen, 1987) and other reports on exposure assessment in Sweden (Becker and Pearson, 2006; Jorhem et al., 1998). The study is a part of the ongoing market basket program monitoring trends in dietary exposure of essential and toxic compounds.

2. Materials and methods

2.1. Market baskets

The choice of food items included in the baskets was based on the food balance sheets for 1998 (SBA, 1999). The food balance sheets give information on annual market availability of food categories and foodstuffs. A shopping list was produced by breaking down the food categories into food items using data on their market shares. Food items consumed on average less than 0.5 kg/person/year were excluded from the list. The shopping list consisted of 116 foods and beverages and covered approximately 90% of the total annual consumption expressed in kg/person. Coffee and tea (as beverages), drinking water and household salt were not included.

The market baskets were purchased during the period March–May 1999 in the cities Sundsvall, Uppsala, Göteborg and Malmö, representing four major geographical regions and population centres in Sweden. The baskets were purchased in two major department stores in each of the four cities. Thus, the total number of baskets was eight. Staff from the local health authorities made the purchases, except in Uppsala where staff from the National Food Administration made the purchase. Each shopper was instructed to taking advantage of bargain prices. Immediately after purchase the baskets were transported to the National Food Administration in Uppsala. Due to practical reasons, ice cream, wines and spirits were purchased in Uppsala only.

2.2. Preparation of the food samples

The food items in each basket were divided into 14 groups (Table 1). From each food group a sample was prepared to represent 1% of the average annual food consumption for an average person. The food items in each food group were treated as they would be in a general household, e.g. meat and fish were freed from skin and bones, potatoes and root vegetables were peeled. The samples were then mixed and homogenized in an acid washed food blender with a bowl of acrylonitrile styrene plastic and equipped with a titanium blade. The samples were stored in acid washed containers at −20 °C until analysis (CEN, 2002).

For analysis of Ca, I, K, Mg, Na and Se the two baskets from each of the four cities was merged, resulting in one sample per food group and city. For analysis of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn

Table 2a
Analytical parameters for the graphite furnace programmes.

Step	Temp (°C)	Ramp sec.	Hold sec.	Ar, flow (ml/min)	Read
Pb					
Dry	90	5	0	300	
Dry	110	10	20	300	
Ash	500	20	10	300	
Cool	20	1	6	300	
Atomise	1700	0	3	0	x
Cleaning	2600	1	3	300	
Cd					
Dry	90	5	0	300	
Dry	130	20	20	300	
Ash	200	15	10	300	
Cool	20	5	5	300	
Atomise	1500	0	4	0	x
Cleaning	2600	1	3	300	
Ni					
Dry	90	5	0	300	
Dry	120	20	15	300	
Ash	1000	10	10	300	
Cool	20	5	5	300	
Atomise	2500	0	4	0	x
Cleaning	2700	1	3	300	
Cr					
Dry	90	5	0	300	
Dry	120	20	10	300	
Ash	700	10	10	300	
Cool	20	5	5	300	
Atomise	2200	0	3	50	x
Cleaning	2700	1	5	300	
Co					
Dry	90	5	0	300	
Dry	120	20	5	300	
Ash	1200	5	10	300	
Cool	20	5	5	300	
Atomise	2200	0	3	50	x
Cleaning	2600	2	2	300	