Human Health Risk Assessment

Appendix 4

Estimating Daily Intakes of Metals from Supermarket Food

Table of Contents
Human Health Risk Assessment - Appendix 4
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A4-1 Estimating Metal Intakes from Supermarket Food

Estimates of the dietary intakes of metals from supermarket food by the general Canadian population are limited. Daily dietary intake estimates for cadmium, cobalt, copper and nickel have been published by CEPA (Health Canada and Environment Canada), CCME and others (see Table A4-1). Information on dietary intakes for all age groups is not available for all metals. For example, information on dietary intakes of antimony and beryllium are limited to single estimates of daily intake by the general population (FSA, 1997; Vaessen and Szteke, 2000).

A4-2 Estimating Dietary Intakes of Metals for All Age Groups

The lack of dietary intakes for all age groups used in this assessment required that intake estimates for specific age groups be derived from available information. The shaded areas in Table A4-1 indicate where such derivations have been necessary. Cadmium intake rates were recalculated from CEPA (1994a and 1994b) values using current receptor characteristic values to obtain units in µg/day.

Table A4-1: Estimated Total Daily Intakes of Metals from Supermarket Food

Receptor	Daily Intakes of Metals from Supermarket Food (µg/day)					
	Antimony	Beryllium	Cadmium	Cobalt	Copper	Nickel
Infant	1.3	4.8	5.08	4.18	518	109.2 (72.2-146.2)*
Toddler	2.3	8.6	10.6	7.0	822	190
Child	3.5	13.2	16.8	10.0	1230	251
Teen	4.0	15.0	17.3	12.0	1520	313
Adult	3.4	12.7	14.8	11.0	1430	307
Reference	FSA, 1997	Vaessen & Szteke, 2000	CEPA, 1994a	Dabeka & McKenzie, 1995	CCME, 1997	Dabeka, 1989; Dabeka & McKenzie, 1995

Shaded cells represent calculated values (see text for explanations).
*see table A4-4.

CEPA and CCME provide daily dietary intake estimates for cadmium, and copper for all age groups. The age groups examined by Dabeka and McKenzie (1995) differ slightly from those used by CEPA and CCME. Dabeka and McKenzie (1995) do not report intakes for children age 0 - 1 year, and their toddler age group includes children aged 1 - 4 years rather than the 7 months to less than 5 years used by CEPA and CCME. Dabeka and McKenzie (1995), CEPA and CCME use the same age groupings for children (5 - 11 years), teens (12 - 19 years) and adults (20+ years). For the purposes of this assessment the intake estimates provided by Dabeka and McKenzie (1995) for cobalt for toddlers, have been applied to the toddler (7 months to less than 5 years) used in this assessment. The nickel and cobalt intakes for infants, shown in Table A4-1 have been estimated based on the intakes reported for toddlers. The ratios were determined by averaging the ratios of infant and toddler intakes for other metals as shown in equation A4-1.

Eq A4-1:

$$C_I = \left[\frac{\left(\frac{I_{As}}{T_{As}}\right) + \left(\frac{I_{Cd}}{T_{Cd}}\right) + \left(\frac{I_{Cu}}{T_{Cu}}\right) + \left(\frac{I_{Ni}}{T_{Ni}}\right)}{4} \right] = 0.598$$

Where: C_I = Correction factor for infant intake
I_x = Infant intake for arsenic, cadmium, copper, and nickel
T_x = Toddler intake for arsenic, cadmium, copper, and nickel

A4-3 Additional Information on Dietary Intakes for Antimony, Beryllium and Nickel

Dietary intake information for antimony and beryllium is limited to a single, general population estimate for each (FSA, 1997; Vaessen and Szteke, 2000). In order to develop likely total daily intakes from supermarket foods for all age groups of concern in this assessment, the single values have been used as a basis for estimating intakes in all age groups. A ratio process similar to the one outlined in Equation A4-1 was used. The estimated daily intakes of antimony and beryllium are 4 µg/day (FSA, 1997) and 15 µg/day (Vaessen and Szteke, 2000), respectively. A review of intake data for the other metals shows that the highest daily intakes of metals generally occurs in the “teen” age group for all metals considered (See Table A4-1). Therefore, the values reported for antimony and beryllium were assigned to this age group. Ratios for metal intakes between the teen age group and the other age groups were developed for arsenic, cadmium, cobalt and lead. The average of these values for each of the age groups was used to generate the intake estimates for antimony and beryllium for each of the age groups. The derivation of the ratios is shown in Table A4-2.

Table A4-2: Dietary Intake Ratios for Different Age Groups for Arsenic, Cadmium, Cobalt and Lead

Receptor	Daily Intakes of Metals from Supermarket Food (µg/day)								Averaging Ratio
	Arsenic[1]		Cadmium		Cobalt		Lead[2]		
	Intake	Ratio	Intake	Ratio	Intake	Ratio	Intake	Ratio	
Infant	19.70	0.28	5.08	0.29	4.18	0.35	8.97	0.37	0.32
Toddler	33.00	0.46	10.60	0.61	7.00	0.58	15.00	0.63	0.57
Child	62.50	0.87	16.80	0.97	10.00	0.83	20.00	0.83	0.88
Teen	71.60	1.00	17.30	1.00	12.00	1.00	24.00	1.00	1.00
Adult	42.40	0.59	14.80	0.86	10.50	0.88	25.70	1.07	0.85

[1] Dietary intake information for arsenic was taken from Yost et al., (1998).
[2] Information on lead in the diet comes from Dabeka and MacKenzie (1995).

Because nickel and copper can be added during food processing operations, it was felt that the levels of these metals would not provide a true reflection of trace metal levels in foods. Therefore nickel and copper were not considered in the development of the ratios used to estimate the daily intakes of the trace metals antimony and beryllium.

A4-3.1 Antimony

There is very limited data on dietary intakes of antimony in general/supermarket food. ATSDR (1990) estimated that the antimony concentration in the diet of a typical adult male was 9.3 µg/kg dry weight. The WHO used the information cited by the ATSDR to develop an estimate of the daily intake of antimony from food of 18 µg/day (WHO, 1996). Two studies that post date the work cited by ATSDR and the WHO have also examined dietary intakes of antimony (FSA, 1997 and Miahara et al., 1998). Miahara et al., (1998), examined antimony intakes in preschool children and the elderly in Brazil. Estimates of dietary intake ranged between 1.1 µg/day and 2.3 µg/day. The Food Standards Agency (1997) in Great Britain estimated dietary intakes of antimony in the British population. The study found a mean daily intake of 3 µg/day with a 97.5 percentile estimate of 4 µg/day. The study further noted that these values are approximately ten fold lower than the previous estimate of 29 µg/day that was based on a 1976 survey. The difference was attributed to a significant lowering of analytical detection limits between the time of the two studies (FSA, 1997). Although the WHO suggested a daily intake of 18 µg/day in 1996, this value was based on estimates developed before changes in analytical techniques allowed for better estimates of antimony levels in foods. As a result, the WHO value is likely to overestimate daily dietary intakes of antimony. For the purposes of this assessment, the upper estimate of 4 µg/day suggested by the FSA has been used to estimate dietary intakes of antimony for the residents of Rodney Street in Port Colborne. The upper FSA estimate (4 µg/day) was assumed to be a lifetime daily intake for a typical Rodney Street teen and was prorated to average estimates of supermarket food intake for other age classes as shown in Table A4-3.

A4-3.2 Beryllium

Information on the dietary exposure to beryllium is limited. Recently, a review of the worldwide literature on the occurrence of beryllium in food and drinking water and estimates of daily dietary exposure was sponsored by the Food Chemistry Commission of the International Union for Pure and Applied Chemistry (IUPAC) (Vaessen and Szteke, 2000). Beryllium levels in food were found to range from <1 to approximately 20 µg/kg fresh weight. In the US, the average beryllium concentration in drinking water is 0.2 µg/L. Estimates of beryllium intake from food consumption for the UK and the US ranged from 12 to 15 µg/day, however, these food intakes were considered to be rough estimates. The 15 µg/day estimate was assumed to be a life-time daily intake for a typical Rodney Street teen and was prorated to average estimates of supermarket food intake for other age classes as shown in Table A4-3.

Table A4-3: Sample Calculation of Estimated Dietary Intakes for Each Age Class Using Averaging Ratios

Receptor	Averaging Ratio	Daily Intakes of Metals from Supermarket Food (µg/day)			
		Antimony		Beryllium	
		Reported	Calculated	Reported	Calculated
Infant	0.323	-	1.3	-	4.8
Toddler	0.571	-	2.3	-	8.6
Child	0.878	-	3.5	-	13.2
Teen	1.00	4.0	4.0	15.0	15.0
Adult	0.848	-	3.4	-	12.7

A4-3.3 Nickel

Interpreting information from dietary intake studies requires assessing a whole range of information from levels of nickel in specific food items to how this information is integrated into overall population intakes by age class and averages and percentiles for each age class. Some agencies report just average intakes for the adult population, others indicate upper ranges of intake, as well, and sometimes just a range of intakes is reported. Consequently, the full range of intakes reported by various agencies is tabulated in Table A4-4.

Several studies have attempted to estimate the daily intake of nickel from supermarket or processed food in the Canadian and North American populations. Based on the US Food and Drug Administration's Total Diet Study of 1984, the mean nickel consumption of infants and young children was 69 to 90 µg/day (Pennington and Jones, 1987). Average daily dietary intake of nickel in the US has been reported as 168 µg/day (Myron et al., 1978; cited in ATSDR, 1997). A more recent review of dietary intake has included nickel intakes from dietary supplements and estimates that adults consume 76 to 105 µg/day of nickel from diet and supplements (IOM, 2001). The US dietary intake data formatted to match the Canadian age class groups is shown in Table A4-4.

A 1984 market basket survey of dietary nickel intake in England determined an intake of 154-166 µg/day (Smart and Sherlock, 1987). More recently, the results of the 1997 UK Total Diet Study were published (Ysart et al., 2000). The average dietary exposure for UK adults was 120 µg/day and the 97.5th percentile was 210 µg/day, similar to their 1994 survey. This information was prorated to Canadian age class intervals using the averaging ratios in Table A4-3 and is shown in Table A4-4.

CEPA, provides estimates of daily nickel intakes from food for the general Canadian population (CEPA, 1994b). These estimates are based on a survey of nickel concentrations in various foods conducted by National Health and Welfare, 1992 (unpublished, cited in CEPA, 1994b) and estimates of age specific food intakes derived from a Nutrition Canada, Environmental Health Directorate survey (CEPA, 1994c). More detailed information on dietary intakes of nickel by Canadians was reported in Dabeka and McKenzie (1995). The Canadian dietary intake of nickel for all ages, male and female, is 286 µg/day (Dabeka and McKenzie (1995)). It is not indicated whether the Canadian dietary intakes are averages or some upper range, however, inspection of the tables of nickel levels in various food categories indicates that the reported Canadian dietary intakes are average values.

Inspection of Table A4-4 shows that Canadian dietary nickel intakes are higher than US and UK estimates. Dabeka and McKenzie (1995) comment on this situation and indicate that the highest nickel intakes were for meat and poultry (about 40%), bakery goods and cereals (about 19%), soups (about 15%) and vegetables (about 11%). These data are felt to provide the best representation of likely nickel intakes from food for the Canadian population as a whole. Therefore these values have been used to represent the intake of nickel from non-home grown food sources for the residents of Rodney Street (Table A4-1).

The available research indicates that the use of stainless-steel cookware does not appreciably add to the amount of nickel or chromium ingested. A study by Accominotti et al., (1998) found that the levels of metals released during cooking were still less than the tolerable daily intake (TDI) recommended by the World Health Organization. This was supported by other studies which found that certain acidic fruits could leach metals. A study by Kuligowski and Halperin (1992) found that stainless is readily attacked by organic acids at cooking temperatures and mildly acidic pH. As a result, iron, chromium, and nickel did leach from the material into the food being prepared. Nickel was a major corrosion product from stainless steel utensils and the authors recommend that nickel-sensitive patients switch to utensils made from a material other than stainless steel. Studies have indicated that the vast majority of the nickel available to the food would be leached out of the cookware on the first use. However, this situation did not recur in subsequent usage, even after the cookware had been cleaned via abrasion (Flint and Packirisamy, 1997). The study by Dabeka and McKenzie (1995) did indicate that stainless steel cooking utensils (e.g., oven pan and roasting pan) appear to contribute to the higher levels of nickel in cooked steak, ground beef, port, lamb, and poultry. This may provide some rationale as to why the intake concentrations reported by Dabeka and his colleagues were higher than those presented in our jurisdictions.

Table A4-4: Estimated Daily Dietary Intake of Nickel for Various Countries

Source	Daily Intake 0 - 6 months (µg/day)	Daily Intake 1-4 year (µg/day)	Daily Intake 5-11year (µg/day)	Daily Intake 12-19 year (µg/day)	Daily Intake Adult (µg/day)
CEPA, 1994b	154	208	270	325	308
Dabeka, 1989; Dabeka and McKenzie, 1995	109.2 (72.2-146.2)*	190	251	313	307
US FDA Total Dietary Study (95th %ile) (IOM, 2001)	9(37) (reported)	81(153) (recalculated)	107(199) (recalculated)	125(250) (recalculated)	119(233) (recalculated)
UK Total Dietary Study 1997(97.5th %ile) (Ysart et al., 2000)	39(68) (calculated)	68(120) (calculated)	105(184) (reported)	120(210) (reported)	102(178) (calculated)

* the CEPA and Dabeka (1989) infant diet is based on dietary surveys taken in the 1970s. A comparison of the infants exposures under the following scenarios is provided:

1. Diet A - assumes that the infant only consumes breast milk for six months;
2. Diet B - assumes that the infant only consumes formula for six months; and
3. Diet C - assumes that the infant consumes breast milk or formula only for the first three months, and this diet is then supplemented by vegetables, cereal and bread, and, fruit and fruit juices.

Diet A - Recent studies of nickel in human milk using the ICP-MS analytical method indicate low levels in European mothers. Biego et al., (1998) did not detect nickel in seventeen French breast milk samples at a reported detection limit of 2.9 µg/L. Krachler et al., (2000) analysed milk samples from 27 Austrian mothers and reported a median value of 0.79 µg/L (range - detection limit 0.13 µg/L to 6.35 µg/L). In a recent Canadian study, milk from 43 mothers living in Newfoundland was analysed during the first 12 weeks of breast feeding (Friel et al., 1999). Median values for nickel ranged from 0 to 28 µg/L. If an infant consumes 850 mL breast milk per day (Emmett et al., 2000), nickel intakes resulting from Diet A could range from 0.67 µg/day to 23.8 µg/day.

Diet B - Dabeka (1989) reported milk-based formulas as having half the nickel content of soy based formulas. For the zero - six month age group, reported nickel intakes from formula range from 35.7 µg/day (evaporated milk) to 74.7 µg/day (soy-based formula).

Diet C - The combination diet (Diet C) suggested above uses Nutrition Canada’s values for vegetable, cereal and fruit intakes for this age group (33g, 34.4g and 75.7g/day, respectively). Using the overall nickel intake for each of these food groups based on Dabeka and McKenzie

(1995) and the Nutrition Canada food intake factors, this results in a nickel intake estimate of 143 µg/day. Diet A and three months of vegetable, cereal and fruit intakes suggests overall intakes of 72.2 µg/day to 95.3 µg/day over the first six months. Similarly, Diet B and three months of vegetable, cereal and fruit intakes suggests overall intakes of 107.2 µg/day to 146.2 µg/day over this period. The mid point of this range (72.2 to 146.2 µg/day) is 109.2 µg/day.

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