Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Children's Food Project

2012-2013 Report on Sampling

RDIMS# 4482509 v3

Canada

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Executive Summary

The main objectives of the 2012 – 2013 Children's Food Project (CFP) were to:

- assess the compliance status for pesticide residues in infant formula;
- assess the level of veterinary drug residues in infant formula;
- obtain baseline data for arsenic species and aflatoxin M1 in infant formula; and
- provide data on multiple hazards to Health Canada that can be used for the health risk assessment of infant formula.

In the 2012 – 2013 CFP, a total of 148 milk-based, soy-based and specialized infant formula samples were purchased nationally. Formulas tested included stage one to follow-up or toddler formulas. Samples were analyzed for pesticide residues, veterinary drug residues, aflatoxin M1 and metals. A total of 2 002 analytical tests were performed which corresponded to over 39 000 results.

Pesticide residues were not detected in any of the 148 samples tested. One hundred milk-based samples were tested for veterinary drug residues. Fifteen samples contained detectable levels, five of which were considered violations detected at levels above the method limit of quantitation. Veterinary drug maximum residue limits are established for primary animal products (e.g., milk) but are not applicable to processed products that may contain these edible products (e.g., milk-based formula). As such, the detection of a quantifiable level of any drug residue in milk-based infant formula at or above the method limit of quantitation is interpreted as a violation. All violations were assessed by Health Canada and it was determined that the levels observed were unlikely to cause any adverse health consequences in infants. The overall compliance rate of the infant formula samples tested for pesticide and veterinary drug residues was 96.62%. As none of the violations represented a concern to infant health, no recall was initiated.

There are few Canadian maximum levels established for metals in food. Metals of high toxicological risk, including arsenic, cadmium, lead and mercury, were discussed in further detail. Arsenic can exist in both organic and inorganic forms in food with the inorganic forms generally being considered more hazardous. Arsenic speciation analysis was completed on all samples of infant formula to determine the levels of various organic and inorganic species; inorganic arsenic (As III and As V) were the only species detected. The concentrations of metals in the food samples were assessed by Health Canada and were not expected to pose a concern to infant health.

All milk-based and some specialized infant formula samples were analyzed for aflatoxin M1. Aflatoxins are mycotoxins produced by the fungal species, *Aspergillus*, that can contaminant grains and nuts. When dairy cows are fed aflatoxin-contaminated feed,

aflatoxin B1 is converted to aflatoxin M1, which is subsequently secreted in the milk. Detectable levels of aflatoxin M1 were found in 12% of samples. All results were below the *Codex Alimentarius Commission* maximum limit of 0.5 ppb aflatoxin M1 in milk.

Data obtained from studies like the CFP are useful in the assessment of the dietary exposure of Canadian children to pesticide residues, veterinary drug residues, metals and other contaminants. The 2012 – 2013 CFP represents an overview of the nature of pesticide and veterinary drug residues, aflatoxin M1 and metals in the infant formula available on the Canadian market.

1 The Children's Food Project

1.1 Purpose

The Children's Food Project (CFP) was initiated by the Canadian Food Inspection Agency (CFIA) with funding from the 'Building Public Confidence in Pesticide Regulation and Improving Access to Pest Management Products' initiative. In January 2003, the CFIA initiated the 'Young Children's Food Chemical Residues Project' (later renamed the 'Children's Food Project') to test children's foods for pesticide residues. In 2012-2013, the analytical testing conducted on children's food samples was expanded to include veterinary drug residues, aflatoxin M1 and speciated arsenic. The overall objective of the CFP continues to be to ensure compliance of pesticide residues as well as to obtain veterinary drug residue, aflatoxin M1 and arsenic species baseline data in children's foods. Specifically, the CFP aims to:

- gather data to determine the prevalence of pesticide and veterinary drug residues and aflatoxin M1 in imported and domestically produced children's foods;
- identify children's foods that may represent a potential health risk from illegal or inappropriate uses of pesticides and veterinary drugs; and
- determine compliance with pesticide, veterinary drug and metal established maximum levels.

1.2 Rationale

On an annual basis, the CFIA conducts a number of different monitoring programs and targeted surveys for chemical residues and contaminants in food. For example, the National Chemical Residue Monitoring Program (NCRMP) targets food commodities such as meat, eggs, honey, dairy products, maple products, processed products, and fresh fruits and vegetables. Alternatively, the CFP collects information on chemical residues in manufactured foods frequently consumed by and targeted to children (e.g., infant formula, cereal-based products, fruit juices and beverages, etc.). Manufactured and imported foods are also the focus of targeted surveys, deliverables of the Food and Consumer Safety Action Plan. However, targeted surveys conducted as part of the Food and Consumer Safety Action Plan do not focus on the level of chemical residues and contaminants in foods targeted to children as does the CFP. Targeted surveys focus mainly on chemical residues or contaminants or food products not tested under the CFP and NCRMP. Together, the data from these programs help health authorities assess potential exposure to chemical residues, contaminants and metals in a number of foods consumed by Canadian children. The results from these ongoing activities can be found

at the following CFIA web address:
http://www.inspection.gc.ca/english/fssa/microchem/resid/reside.shtml

1.3 Acts and Regulations Relating to Chemical Residues and Contaminants

The *Canadian Food Inspection Agency Act* stipulates that the CFIA is responsible for enforcing restrictions on the production, sale, composition and content of foods and food products as outlined in the *Food and Drugs Act* (FDA) and the corresponding *Food and Drug Regulations* (FDR).

Health Canada establishes Maximum Residue Limits (MRLs) for pesticide residues in food. The MRL is the maximum amount of residues that are expected to remain in or on food products when a pesticide is used according to label directions and is regulated under the *Pest Control Products Act* (PCPA). Pesticide MRLs apply to the identified raw agricultural commodity as well as to any processed food product that contains the commodity. However, where a processed product requires a higher MRL than that specified for its raw agricultural commodity, separate MRLs are specified. In the absence of a MRL, pesticide residues must comply with the General MRL (GMRL) of 0.1 ppm as stated in section B.15.002(1) of the FDR. The process for establishing an MRL is initiated through the publication of a Proposed Maximum Residue Limit (PMRL) on Health Canada's website. Established MRLs appear in Health Canada's MRL Database. The CFIA recognizes that there is no difference between an MRL and a proposed MRL in terms of scientific validity, therefore both MRLs and proposed MRLs are used to assess compliance.

Health Canada also establishes MRLs for veterinary drugs for edible tissues of food animals as well as milk, eggs and honey, but not for any processed food that may contain these edible products (e.g., cheese, yogurt, milk-based infant formula).Recent amendments to the FDA have allowed for MRLs for veterinary drug residues to be added or updated directly into the List of Maximum Residue Limits (MRLs) for Veterinary Drugs in Food published on Health Canada's website. Upon the completion of a scientific assessment for a veterinary drug, the MRL promulgation process is initiated through the posting of Proposed Maximum Residue Limits on Health Canada's website. The CFIA recognizes that there is no difference between an MRL and a proposed MRL in terms of scientific validity, therefore both MRLs and proposed MRLs are used to assess compliance.

Maximum levels for chemical contaminants in foods may be expressed as either regulatory tolerances or standards. Regulatory tolerances are listed in the FDR whereas standards can be viewed on Health Canada's website. A limited number of tolerances

and standards are established for metals in food. There are, at present, metal tolerances established in the FDR (Section B.15.001-Table I) for arsenic, lead and tin in specific commodities. It should be noted that Health Canada has been reviewing the regulatory tolerances in Table I of Division 15 and has proposed updated tolerances for arsenic and lead in fruit juice, fruit nectar, beverages when ready-to-serve and water in sealed containers.[1]

All chemical residues or contaminants detected in food products are evaluated to determine if there has been a violation of applicable Canadian MRLs or maximum levels. In cases where there is not an established MRL or maximum level, foods presented for sale in Canada must be compliant with sections 4(1) (a) and (d) of the FDA. These sections state that no person shall sell an article of food that (a) has in or on it a poisonous or harmful substance or (d) is adulterated. Residues detected at or below established levels are in compliance and do not require enforcement or follow-up action. When a violation is identified, or if no MRL or maximum level has been established but an elevated result is observed, the result is assessed on a case-by-case basis to determine the appropriate follow-up action. Follow-up actions can include notification of the producer or importer, follow-up inspections, further directed sampling, or recall of products if Health Canada determines that the product could pose a health risk to consumers or certain segments of the population. Follow-up actions vary according to the magnitude of the health risk, with the objective of preventing any repeat occurrence or further distribution of items still in the marketplace.

1.4 Limitations of the Children's Food Project

The CFP is designed to provide a snapshot of the concentrations of pesticide, veterinary drug, metal, and aflatoxin M1 residue levels in infant formula. It is not designed to gather statistically valid information on the type and levels of chemical residues and metals in children's foods. This would require a significant increase in the number of samples.

The sampled foods are chosen based on the market availability of manufactured foods frequently consumed and marketed towards children and do not necessarily correspond to the relative importance of this type of food in their diets. No statistical methods are used to determine the types and numbers of samples selected.

2 2012 – 2013 Children's Food Project Design

2.1 Sample selection

The 2012-2013 CFP was designed to provide a snapshot of the levels of pesticide residues, veterinary drug residues, aflatoxin M1 and metals found in milk-based, soy-based and specialized infant formulas. In the past, the CFP has focused solely on pesticide residues and metals in foods available and targeted to children (0 – 15 years of age). In 2012-2013 the analysis of veterinary drug residues, aflatoxin M1 and arsenic species was included in an effort to expand the scope of the CFP.

The multitude of food available targeted to children, as well as the different consumption patterns of children of different age groups, makes it impractical for the CFIA to test all of these on an annual basis. To address this challenge, different foods for different age groups are sampled each year. In 2011 – 2012, foods for children aged 2 – 15 years were targeted. In 2012 – 2013, only infant formulas were sampledformulas as these had not been targeted since the 2008-2009 CFP. Please consult Appendix A for web links to previous CFP reports.

The samples in the 2012-2013 CFP included milk-based, soy-based and specialized infant formula (e.g., powdered, ready-to-feed and concentrate). The formulas tested included stage one to follow-up or toddler formulas. Samples were packaged in a variety of formats (e.g., glass and plastic bottles, cans, boxes, and cartons) and were purchased from several national grocery chains and drugstores.

2.1.1 Sample breakdown

A total of 148 infant formula samples were included in the 2012-2013 CFP. The samples were further subdivided into three broad categories based on ingredient similarities between products: milk-based, soy-based, and specialized infant formula (Table 1). The category of specialized formula includes those infant formulas that are processed for special dietary needs (e.g., hypoallergenic, lactose-free) and thickened formulas. Samples of powdered, ready-to-feed and concentrate were sampled in most of the categories. All infant formula samples were imported and originated from either Ireland (11 samples), the Netherlands (5 samples), Switzerland (25 samples), or the United States (107 samples). Many of these infant formula products were manufactured for Canadian companies.

Table 1 Breakdown of products sampled in the 2012 – 2013 CFP

Infant Formula Type	Number of Samples	Percent of Total
Milk-based	87	59%
Concentrate	*2*	*1%*
Powder	*75*	*51%*
Ready-to-feed	*10*	*7%*
Soy-based	36	24%
Powder	*36*	*24%*
Specialized	25	17%
Powder	*22*	*15%*
Ready-to-feed	*3*	*2%*
Total	**148**	**100%**

2.2 Analysis

All analytical testing of infant formula samples is completed 'as sold', meaning concentrates and powders are not reconstituted prior to analysis. Analytical testing was performed using multi-residue methods. These cost-effective methods are capable of detecting large numbers of pesticides, or veterinary drug residues or metals. Samples in the CFP were analyzed by accredited laboratories under contract with the Government of Canada as well as CFIA laboratories. The laboratories must be ISO 17025 accredited and the analytical methods used must be listed on their Scope of Accreditation and meet the performance criteria set out by the CFIA. Regardless of the choice of method, it must be fit for the intended purpose, and adequately sensitive to enforce MRLs.

2.2.1 Pesticide analysis

Pesticides and other agricultural chemicals are commonly used in large scale agricultural systems. These chemicals help to protect crops from damage by pests, increase yields and expand the geographical location in which crops can be grown. A consequence of using agricultural chemicals during food production is that foods can sometimes retain chemical residues which may be of concern to Canadian consumers. Additionally, residues present in feed and forage can be transferred to the milk of lactating dairy cattle. The infant formula samples were tested by by accredited laboratories for pesticide residues using three multi-residue analytical methods. The analytical scope for the multi-residue methods used is provided in Appendix B, Tables B-1 to B-3.

2.2.2 Veterinary drug analysis

Food-producing animals in conventional production systems may be treated with veterinary drugs. Some drugs are administered to individual animals to treat specific disease conditions, while other drugs are administered to groups of animals, usually

through medicated feed or water, for the prevention or treatment of disease or for the purpose of growth promotion. The infant formulas in the CFP were analyzed for a variety of veterinary drug residues, including antibiotics, parasiticides and growth promoters. The analytical scope is provided for the multi-residue methods in Appendix B, Table B-4.

2.2.3 Metals and elements analysis

Although many metals occur in food as a result of their natural presence in the environment, they may also be present in food as a result of the use of pesticides or other agricultural chemicals, environmental contamination or processing. While some metals are essential nutrients, exposure to others may be harmful to human health (e.g., arsenic, cadmium, mercury, lead).

Arsenic has been used in the past as a component of pesticides directly applied to crops, but this use has been discontinued in many countries, including Canada. Chromium, copper and arsenic are used together as a wood preservative but can leach out of pressure treated wood products. The CFIA has advised livestock producers not to use chemically treated wood near livestock feed or food-producing animals to avoid the transfer of potentially harmful levels of these metals and other chemicals from the wood into animal products such as meat, milk and eggs. Cadmium is a common contaminant of chemical fertilizers, and may accumulate in certain types of plants as a result of plant uptake. If these plants are fed to animals, cadmium can accumulate in animal tissues. The processing of foods with lead-contaminated water or using lead-containing equipment can introduce lead into foods.

The multi-metal analytical method used in the CFP analyzes for 20 different metals and elements including: aluminum, antimony, arsenic, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, tin, titanium and zinc.

Arsenic speciation

In addition to part of the metals analysis, speciated arsenic analysis was also completed. Although arsenic can be found in its elemental form, in biological and environmental media, it is more commonly found in combination with other elements. Inorganic arsenic refers to elemental arsenic and arsenic combined with elements other than carbon (e.g., oxygen, chlorine and sulphur). Organic arsenic refers to a broad set of arsenical compounds that include carbon in their structure (e.g., arsenocholine (AsC), arsenobetaine (AsB), monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA)). Organic arsenic compounds may be formed as the result of plant or animal metabolism. Generally speaking, inorganic arsenic species (e.g., As III and As V) are considered more

hazardous than organic arsenic species. Most cases of human toxicity from arsenic have been associated with exposure to elevated levels of inorganic arsenic in drinking water.

In the 2012-2013 CFP, samples were analyzed by two different methods: total arsenic and speciated arsenic. The results of the two methods are discussed separately as the two methods are not directly comparable. The method used for arsenic speciation quantifies key inorganic arsenic (As III and As V) and organic arsenic species (AsB, AsC, MMA and DMA) present in the samples but not all of the arsenic species that may potentially be present. As such, the sum of the individual arsenic species measured by the speciation method may not correspond to the total arsenic concentration measured by the multi-element analytical method. The analytical scope for the arsenic speciation method is provided in Appendix B, Table B-5.

2.2.4 Aflatoxin M1 analysis

Mycotoxins are secondary toxic metabolites of some fungal species that may contaminate food. Aflatoxins are mycotoxins produced by the fungal genus *Aspergillus*, which may contaminate grains and nuts. Exposure to mycotoxins vary in the hazards that they pose to human health, but can affect the liver, kidney, nervous, endocrine and immune systems. Aflatoxin B1 has been classified by the International Agency for Research on Cancer (IARC) as carcinogenic to humans.[2] The fungi that produce aflatoxins thrive in hot, humid climates and are not typically detected in Canadian crops. When dairy cows are fed aflatoxin-contaminated feed, aflatoxin B1 is converted to the metabolite aflatoxin M1, which is subsequently secreted in the milk. There is sufficient evidence in experimental animals indicating that aflatoxin M1 may be carcinogenic by a similar mode of action as aflatoxin B1.[2, 3] All samples of milk-based infant formula were analysed for aflatoxin M1.

3 Results and discussion

3.1 Pesticides

A total of 432 tests for pesticide residues were carried out on 148 samples. No pesticide residues were detected in any of the samples. Similar results were observed in the 2008-2009 CFP Report on Sampling.[4] In the 2008-2009 CFP study, 35 milk- and soy-based infant formula samples were tested for pesticide residues; no residues were detected in any of the samples.

3.2 Veterinary drugs

As stated previously, veterinary drug MRLs established for milk are not applicable to milk-based processed products. Therefore, any level of a drug residue in milk-based infant formula is considered a violation if it exceeds the limit of quantitation (LOQ) for the method.

A total of 1200 tests for veterinary drug residues were carried out on 100 samples of milk-based and specialized infant formula. Out of the 100 samples tested for veterinary drugs, residues were detected in 15 samples. Of these, five samples had residues above the LOQ and were in violation of the FDR (Figure 1) (95% compliance). Five different types of drug residues were detected, two of which resulted in the observed violations (Table 2). Compliance rates for individual veterinary drug residues detected ranged from 96 to 100%. All violations in infant formula were assessed by Health Canada. It was determined that the residues in violation were unlikely to have any adverse health consequences.

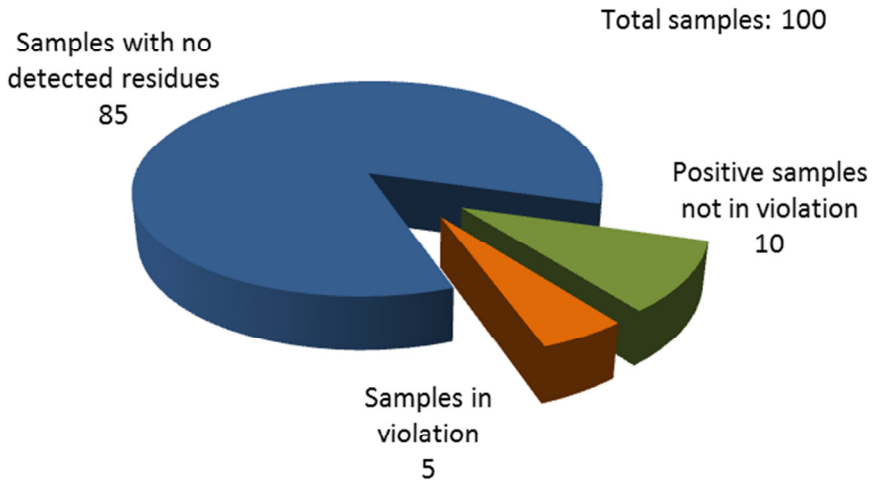

Figure 1. **Distribution of veterinary drug residue results by sample**

Table 2. **Veterinary drug residues detected and compliance rate (by residue) in infant formula**

Residue	No. Tests	No. Positives	% Positive	No. Violations	% Compliance
Florfenicol	100	11	11.00%	4	96%
Sulfamethazine	100	5	5.00%	2	98%
Monensin	100	1	1.00%	0	100%
Chlortetracycline	100	1	1.00%	0	100%
Moxidectin	100	1	1.00%	0	100%

Of the five veterinary drug residues that were detected in milk-based infant formula, florfenicol had the highest positive rate at 11% and lowest compliance rate at 96% (Table 2). Florfenicol is a broad spectrum antibiotic approved for use in Canada in food-producing animals; however, it is not approved for use in lactating dairy cattle and therefore no MRL is established for florfenicol in milk. There were five samples positive for sulfamethazine, two of which were violations (98% compliance). Sulfonamides are primarily used in the prevention and treatment of bacterial infections and are also used as a growth promoter. Sulfamethazine is approved for use in dairy cattle and there is an MRL for milk of 0.01 ppm. Single samples were positive for monensin, chlortetracycline and moxidectin at levels below the LOQs of the methods and as a result were not considered violations. MRLs are established in milk for monensin (0.01 ppm), chlortetracycline (0.1 ppm) and moxidectin (0.04 ppm).

Although MRLs are established in milk for all veterinary drug residues detected except florfenicol, the MRLs are not extended to secondary products such as infant formula. All positive results were sent to Health Canada for assessment. For the highest levels of each of the veterinary drugs residues detected, VDD estimated residue levels in infant formula 'as consumed' by reconstituting the infant formula as directed. All estimated veterinary drug residue levels were well below the acceptable daily intakes for each residue and were unlikely to cause any adverse health consequences.

3.3 Metals and elements

Appendix C contains a detailed summary of the positive results from the metals and elements analysis observed in the infant formula types sampled. All samples had detected levels and as mentioned in section 2.2, metals are expected to be present in most food products. The results presented in Appendix C report the total metal concentration present in the samples and do not distinguish between various organic and inorganic forms, except in the case of arsenic. The CFIA continues to develop and validate methods to enable quantitation of metal species of toxicological importance to complement the current approach. In the 2012-2013 CFP, arsenic speciation was conducted on the infant formula samples and results are discussed in the arsenic section below.

The following discussion focuses on the four detected metals of high toxicological importance (e.g., arsenic, cadmium, mercury and lead).

Arsenic

Arsenic can be found in a variety of different foods at low levels generally due to accumulation from the environment as a result of weathering of soils, industrial processes, and pollution.[5] There are no established arsenic tolerances or maximum levels for infant formula in Canada. It should be noted that the distribution of arsenic levels illustrated in Figure 2 for the three types of infant formula tested are reported as total arsenic only. Total arsenic was detected in all samples except one milk-based infant formula. Detected concentrations ranged from 0.0014 ppm to 0.0227 ppm in milk-based, 0.0045 ppm to 0.027 ppm in soy-based and 0.0013 ppm to 0.0292 ppm in specialized infant formula. In Figure 2, the distribution of data points for the different product types are comparable.

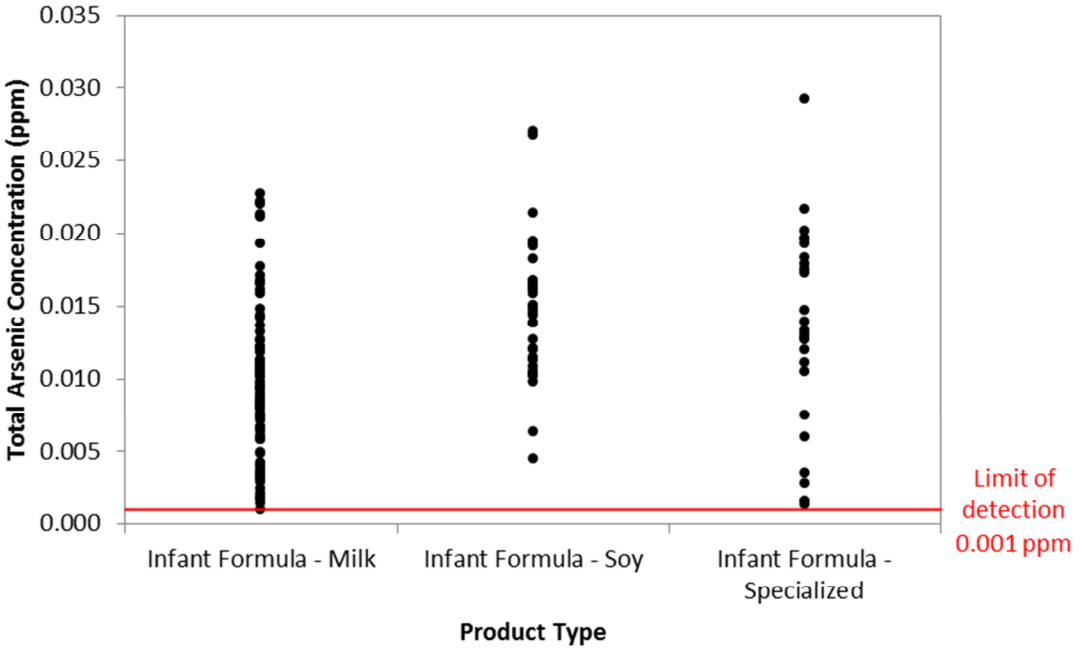

Figure 2. Distribution of total arsenic levels detected by product type

Total arsenic in milk- and soy-based infant formulas tested in a targeted survey for metals conducted by the CFIA in 2011-2012 ranged from not detected (<0.005 ppm) to 0.063 ppm for milk-based and not detected to 0.068 ppm for soy-based infant formula (unpublished). In the 2008-2009 CFP total arsenic levels in milk-based formula ranged from 0.0154 – 0.0847 ppm and in soy-based infant formula from 0.0157 – 0.0955 ppm.[4] Total arsenic levels detected in the CFP were all within the ranges observed in the CFIA targeted survey and 2008-2009 CFP. Health Canada did not consider that any of the samples represented a concern to infant health with respect to the total arsenic levels observed.

As described in section 2.2.4, the arsenic speciation method detects six forms of arsenic, including four organic species (DMA, MMA, AsC, AsB) and two inorganic species (As III and As V). Inorganic arsenic is a known human carcinogen.[6] Exposure to inorganic arsenic in drinking water has been casually associated with carcinogenic (e.g., lung, skin and bladder cancer) and non-carcinogenic outcomes (e.g., ischemic heart disease and skin lesions).[7] In the case of organic arsenic, the gastrointestinal tract, and the renal and urinary systems appear to be the most sensitive targets in animals.[8] There are no epidemiological studies describing chronic exposure to organic arsenic.

The inorganic arsenic species were the only species detected in any of the infant formula samples (Figure 3). In the CFP of the infant formula samples tested, As III was detected in 36.9% and As V in 8.7% of samples. As III and As V ranged from 0.0007 ppm to 0.00522 ppm and 0.0048 ppm to 0.00862 ppm, respectively (Figure 3). The distribution of As III and As V was similar between infant formula product types. Health Canada was notified of all levels of inorganic arsenic found and did not consider that these levels represented a concern to infant health. Jackson et al. (2012) also reported that arsenic species present in infant formula were almost exclusively inorganic. The major species detected was As V and low concentrations of As III and DMA were also detected at levels near the limit of detection.[9] Specific levels of the inorganic species detected were not reported in the study.

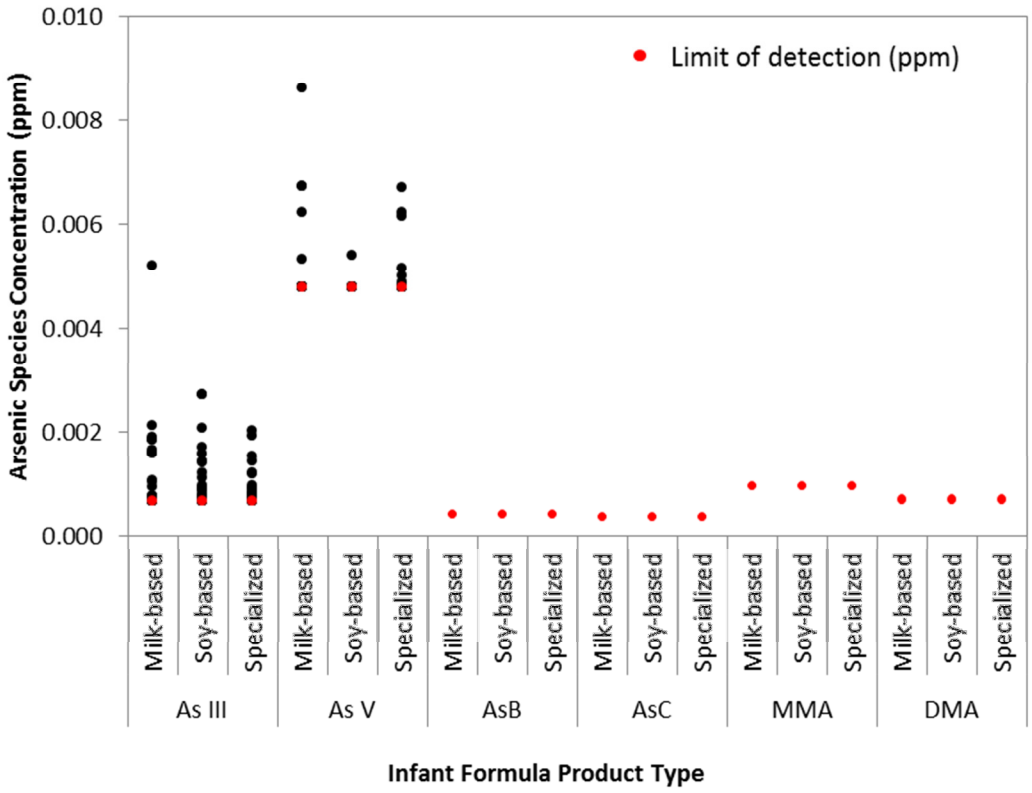

Figure 3. Distribution of speciated arsenic levels detected by product type

Cadmium

There are no Canadian tolerances or standards established for cadmium levels in infant formula. Cadmium can be present in water and soils. Soil may become contaminated with cadmium by the use of phosphate fertilizers or sewage sludge. Food grown in cadmium-containing soils is the primary source of cadmium exposure in the general

population.[10] The target organ for cadmium toxicity via the oral route is the kidney.[11] According to IARC cadmium is carcinogenic to humans following inhalation exposure.[6] Figure 4 illustrates the distribution of cadmium levels detected in the three infant formula types tested with approximately 59% of the samples containing a detectable level of cadmium. In Figure 4, the range of cadmium in soy-based infant formula (0.004 – 0.044 ppm) was higher than in milk-based and specialized infant formulas (0.001 – 0.009 ppm and 0.002 – 0.009 ppm, respectively). Detectable levels of cadmium were only observed in powdered infant formulas with the highest level was observed in a powdered soy-based infant formula.

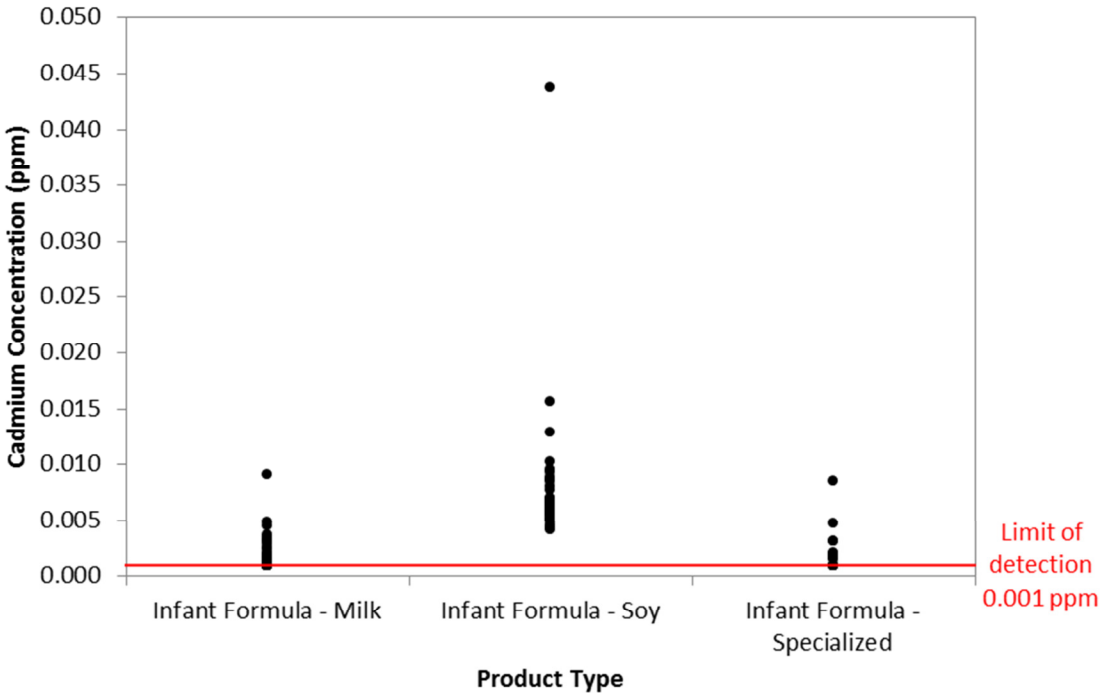

Figure 4. Distribution of cadmium levels detected by product type

Cadmium levels tested under a Health Canada survey of trace metals in infant formula ranged from 0.00076 – 0.00347 ppm in soy-based infant formula and 0.00001 – 0.00126 ppm in milk-based infant formula.[12] Also cadmium levels reported in Canadian Total Diet Studies between 2000 and 2007 ranged from 0.00009 ppm to 0.00043 ppm in milk-based and 0.00054 ppm to 0.00173 ppm in soy-based infant formula.[13] In a European study, the mean cadmium levels ranged from 0.0011 – 0.0235 ppm in concentrated infant formula, with soy-based formulas containing approximately six times more cadmium than milk-based formulas.[14] Previously in the 2008-2009 CFP, milk-based and soy-based infant formulas were tested for metals where cadmium levels ranged from 0.0025 – 0.0082 ppm in milk-based and 0.005 – 0.0127 ppm in soy-based infant

formulas.[4] In all of these cases, soy-based formula contained higher levels of cadmium when compared to milk-based formula. Although some of the cadmium levels observed in the 2012-2013 CFP were higher than what was seen previously, Health Canada indicated that levels observed in infant formulas were not expected to pose a safety concern to infant health.

Lead

Lead exposure may occur from a number of environmental and food sources. Chronic exposure to low levels of lead can be harmful to human health. Children are particularly susceptible to the adverse neurological effects of lead exposure. There are several tolerances for lead in food that are specified in Division 15 of the FDR that apply to concentrated infant formula and infant formula when ready-to-serve. Health Canada has informed industry and the CFIA that as part of Health Canada's risk management strategies for lead, the lead tolerances in Table I of Division 15 are being updated.[15, 16]

Figure 5 illustrates the distribution of lead levels detected in the three product types tested. Approximately 88% of the infant formula samples tested for lead contained detectable levels (>0.001 ppm). The majority of the lead levels for the different products are comparable as much of their distribution falls below 0.02 ppm. Higher lead levels were found in two samples of milk-based infant formula (0.0348 ppm and 0.107 ppm) and one sample of soy-based infant formula (0.035 ppm) when compared to the rest of the distribution of levels in Figure 5.

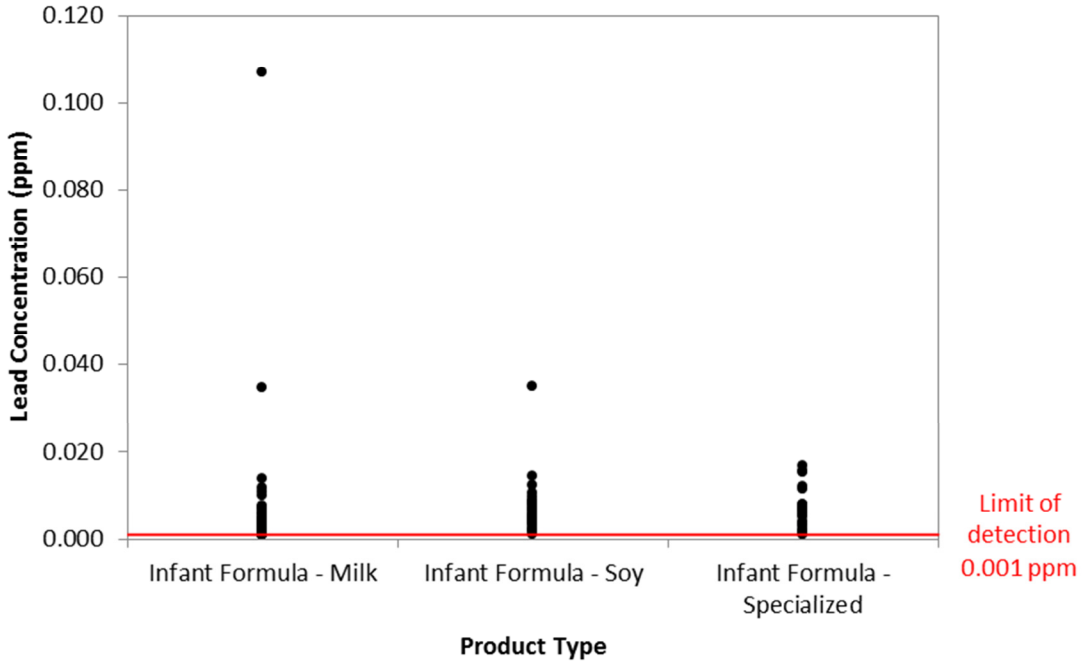

Figure 5. Distribution of lead levels detected by product type

Lead occurs naturally in the environment and has many industrial uses, such as in mining, smelting and battery manufacturing.[17] After the implementation of measures to reduce exposures to lead through the inhalation route (e.g., use of unleaded gasoline), oral exposure from food and water along with ingestion of house dust and soil contaminated with lead are the greatest sources of a child's environmental exposure to lead.[17]

A study completed by Health Canada examined the levels of lead in a variety of infant formula samples.[18] The range of values for milk-based and soy-based infant formula was 0.00014 – 0.00246 ppm and 0.0011 – 0.0021 ppm, respectively. All Health Canada results were reported on an 'as consumed' basis and are not directly comparable to all results in this study as they are reported 'as sold'. The range of lead in ready-to-feed samples tested in the CFP ranged from 0.00189 – 0.00662 ppm. Lead levels in infant formula tested in a targeted survey conducted by the CFIA in 2011-2012 ranged from not detected (<0.002 ppm) to 0.034 ppm [unpublished] and from <0.002 ppm to 0.015 ppm under the 2008-2009 CFP.[4] Although the range of lead levels observed in infant formula samples tested in the 2012-2013 CFP were higher than other Canadian studies, Health Canada did not consider these lead levels to represent a concern to infant health. One powdered infant formula sample containing 0.107 ppm of lead was considered atypical in Health Canada's assessment. This result was sent to the appropriate program for follow-up.

Mercury

Although mercury is released naturally from rocks, soils and volcanoes, industrial activities have increased the amount of mercury in the environment.[19] Mercury contamination is a concern because it is toxic, persists in the environment, and can bioaccumulate in the food chain. The health effects of mercury depend on its chemical form (elemental, inorganic, organic) and the route and level of exposure. Methyl mercury is easily absorbed and can cross the blood-brain barrier. Children and the developing fetus are particularly susceptible to the harmful neurological effects of methyl mercury. The most common source of human exposure to mercury is the consumption of certain types of predatory fish. Health Canada has established maximum levels for mercury in different types of fish; however there are no mercury standards established for infant formula. All infant formula samples were tested for mercury. No mercury levels above the limit of detection (LOD) for the method were detected. LODs were different depending on the sample type; powdered infant formula was 0.00068 ppm and liquid infant formula was 0.00017 ppm.

3.4 Aflatoxin M1

Aflatoxin M1 is the main metabolite of aflatoxin B1 excreted in milk when lactating animals are fed aflatoxin B1 contaminated feed.[20] Aflatoxin-producing fungi can contaminate animal feed if grown, transported, stored, or processed under hot, humid conditions for prolonged periods of time. A total of 100 milk-based and specialized infant formula samples were tested for aflatoxin M1. There are few Canadian maximum levels established for mycotoxins. The results obtained in this study were compared to the Codex maximum level of 0.5 ppb for aflatoxin M1 in milk. Aflatoxin M1 was detected in 12 samples at levels below this maximum level. Levels ranged from 0.01 ppb to 0.136 ppb in ready-to-feed, concentrate and powdered formulas (12% positive) (Table 3).

Table 3. Levels of aflatoxin M1 observed in milk-based infant formula

Infant Formula Type	Infant Formula Format	Total Number of Samples	Number of Positive Samples	Minimum (ppb)	Maximum (ppb)	Average (ppb)
Milk-based	Concentrate	2	1	0.069	0.069	0.069
	Powder	75	4	0.013	0.069	0.032
	Ready to Feed	10	4	0.010	0.136	0.085
Specialized	Powder	13	3	0.021	0.055	0.033

There are a limited number of studies that have investigated the presence of aflatoxin M1 in infant formula. Many studies in the literature that focus on aflatoxin M1 in milk are centred in Europe and the Middle East. A survey of aflatoxin M1 in dairy products marketed in Italy included 92 samples of powdered infant formula. Fifty-four percent of powdered infant formula samples tested positive for aflatoxin M1; levels ranged from <0.001 ppb to 0.0796 ppb.[20] Aflatoxin M1 levels in 18 infant formula samples marketed in India ranged from 0.143 ppb to 0.770 ppb (94% positive rate).[21] As Canada does not have an established maximum level for aflatoxin M1 in milk or milk-based products, compliance was not assessed. All results were below the Codex maximum level of 0.5 ppb for aflatoxin M1 in milk.

4 Conclusion

The results of the 2012-2013 CFP indicate that none of the 148 infant formula samples analyzed contained detectable levels of pesticide residues. Out of 100 infant formula samples tested for veterinary drugs, residues were detected in 15 samples. Of these, five were in violation as the levels were above the LOQ of the method. All results were assessed by Health Canada and it was determined that the residues detected were unlikely to cause any adverse health consequences. The overall compliance rate of the infant formula samples tested for pesticide and veterinary drug residues was 96.62%.

All levels of metals and other elements were assessed and considered not to be a concern to infant health. Arsenic speciation analysis was completed on all samples of infant formula. Only the inorganic arsenic species were detected. Health Canada did not consider the levels observed to be a concern to infant health.

Aflatoxin M1 was detected in 12% of samples of milk-based and specialized infant formula. All levels of detected aflatoxin M1 were below the 0.5 ppb Codex maximum level for aflatoxin M1 in milk.

Due to the limited scope and number of samples collected in the project, no clear relationships can be made between product type and country of origin. The data obtained from annual studies like the CFP are useful in the assessment of the dietary exposure to pesticide residues, veterinary drug residues, aflatoxin M1 and metals in infant formula consumed by Canadian children.

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Appendix A

Table A-1 Summary of results obtained in previous Children's Food Projects

Age Group Targeted	Remarks and pesticide residue results	Sampling Year	Sample Size
0 – 18 months	• Overall compliance rate of 99.76%	*2002 - 2003*	412
2 – 10 years	• Scope expansion to include some veterinary drug residues and metals • Overall compliance rate of 100%	*2003 - 2004*	594
0.5 – 15 years	• Overall compliance rate of 98.8%	*2004 - 2006*	1523
0.5 – 15 years	• Overall compliance rate of 100%	*2006 - 2007*	350
3 – 15 years	• Overall compliance rate of 98.6%	*2007 - 2008*	836
0 – 24 months	• Pesticide residue scope expansion from 300 to 400 residues • Overall compliance rate of 99.7%	*2008 – 2009*	382
2 – 15 years	• Overall compliance rate of 98.6%	*2009 – 2010*	821
0 – 24 months	• Overall compliance rate of 100%	*2010 – 2011*	879
2 – 15 years	• Overall compliance rate of 99.7%	*2011 – 2012*	710

Appendix B

Table B-1 List of analytes (142) included in the CFIA liquid chromatography electrospray ionization tandem mass spectrometry (LC/ESI-MS-MS) pesticide method (PMR-006-V1.0)

3-Hydroxycarbofuran	Diniconazole	Isocarbamide	Pyrifenox
Acetochlor	Dioxacarb	Isoprocarb	Pyrimethanil
Aclonifen	Dipropetryn	Isoxathion	Pyriproxyfen
Aldicarb	Diuron	Mepanipyrim	Quinoxyfen
Aldicarb sulfone	Dodemorph	Mephosfolan	Quizalofop
Aldicarb sulfoxide	Emamectin	Methabenzthiazuron	Quizalofop-ethyl
Azaconazole	Epoxiconazole	Methiocarb	Schradan
Benomyl	Ethiofencarb	Methiocarb sulfone	Spinosad
Benoxacor	Ethiofencarb sulfone	Methiocarb sulfoxyde	Spirodiclofen
Bitertanol	Ethiofencarb sulfoxyde	Methomyl	Spiromesifen
Bromuconazole	Ethirimol	Methoxyfenozide	Spiroxamine
Butafenacil	Ethoprop	Metolcarb	Sulfentrazone
Butocarboxim sulfoxide	Etofenprox	Metoxuron	Tebufenozide
Cadusafos	Etoxazole	Molinate	Tebufenpyrad
Carbaryl	Fenamidone	Napropamide	Tebupirimfos
Carbendazim	Fenazaquin	Naptalam	Tepraloxydim
Carbofuran	Fenhexamid	Neburon	Tetraconazole
Carbosulfan	Fenoxanil	Ofurace	Thiabendazole
Carfentrazone-ethyl	Fenpropidine	Oxamyl	Thiacloprid
Chlorimuron-ethyl	Fenpropimorph	Oxamyl oxime	Thiamethoxam
Chloroxuron	Fenpyroximate	Paclobutrazol	Thiazopyr
Chlortoluron	Fentrazamide	Pencycuron	Thiodicarb
Clodinafop-propargyl	Fluazifop-butyl	Penoxsulam	Thiofanox
Cloquintocet-mexyl	Flucarbazone-sodium	Picolinafen	Thiofanox sulfone
Clothianidin	Flutolanil	Picoxystrobin	Thiofanox sulfoxyde
Cyanofenphos	Flutriafol	Piperophos	Thiophanate methyl
Cycloxydim	Forchlorfenuron	Pretilachlor	Tralkoxydim
Cycluron	Formetanate	Primisulfuron-methyl	Trichlorfon
Demeton-s-methyl sulfone	Fosthiazate	Prodiamine	Trietazine
Demeton-s-methyl sulfoxyde	Fuberidazole	Propoxur	Trifloxysulfuron
Desmedipham	Furathiocarb	Pymetrozine	Triforine
Diclocymet	Haloxyfop	Pyraclostrobin	Trimethacarb
Diethofencarb	Imazamethabenz-methyl	Pyraflufen-ethyl	Zinophos
Difenoconazole	Imidacloprid	Pyridalyl	Zoxamide
Dimethametryn	Indoxacarb	Pyridaphenthion	
Dimethomorph	Iprovalicarb	Pyridate	

Table B-2 List of analytes (32) included in third party method for pesticide analysis in dairy products

Alachlor	Beta-Endosulfan	o,p-DDE
Aldrin	Endosulfan sulphate	o,p-DDT
Alpha-BHC	Endrin	Oxychlordane
Beta-BHC	Fenchlorophos	p,p-DDD
Cis Chlordane	Heptachlor	p,p-DDE
Trans Chlordane	Heptachlor epoxide endo	p,p-DDT
Chlorpyrifos	Hexachlorobenzene	Cis-Permethrin 1
Cyfluthrin	Lindane	Trans-Permethrin 2
Dicofol	Methoxychlor	Quizalofop-ethyl
Dieldrin	Mirex	Tefluthrin
Alpha-Endosulfan	o,p-DDD	

Table B-3 Analytes (16) included in the third party method for carbamate analysis

Aldicarb	oxamyl
aldicarb sulfone	methiocarb
aldicarb sulfoxide	carbofuran
dioxacarb	carbaryl
isoprocarb	bufencarb
propoxur	bendiocarb
promecarb	methiocarb sulfoxide
methomyl	3-hydroxycarbofuran

Table B-4 Analytes included in veterinary drug multi-residue methods

Program	Analytes
Benzimidazoles	albendazole, albendazole-2-aminosulfone, albendazole sulfoxide, albendazole sulfone cambendazole, carbendazim, fenbendazole, flubendazole, levamisole, mebendazole, oxfendazole, oxibendazole, thiabendazole, 5-hydroxythiabendazole
Endectocides	abamectin, doramectin, emamectin, eprinomectin, ivermectin, moxidectin
Fluoroquinolones	ciprofloxacin, danofloxacin, difloxacin, enoxacin, enrofloxacin, flumequine, marbofloxacin, nalidixic acid, norfloxacin, ofloxacin, orbifloxacin, oxolinic acid, pipemidic acid, sarafloxacin, sparfloxacin
Glycosides	amikacin, apramycin, dihydrostreptomycin, gentamicin, hygromycin, kanamycin, neomycin, spectinomycin, streptomycin, tobramycin
Ionophores/Nicarbazin	lasalocid, maduramicin, monensin, narasin, nicarbazin, salinomycin
Macrolides / Lincosamides	clindamycin, desmycosin, erythromycin, josamycin, lincomycin, neospiramycin, oleandomycin, pirlimycin, spiramycin, tilmicosin, tulathromycin, tylosin
Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)	flunixin, phenylbutazone

Program	Analytes
Penicillins	amoxicillin, ampicillin, cloxacillin, dicloxacillin, nafcillin, oxacillin, penicillin V, penicillin G
Phenicols	chloramphenicol, florfenicol, thiamphenicol
Sulfonamides	dapsone, ormetoprim, sulfabenzamide, sulfacetamide, sulfachloropyridazine, sulfadiazine, sulfadimethoxine, sulfadoxine, sulfaethoxypyridazine, sulfaguanidine, sulfamerazine, sulfameter, sulfamethazine, sulfamethizole, sulfamethoxazole, sulfamethoxypyridazine, sulfamonomethoxine, sulfamoxole, sulphanilamide, sulfaphenazole, sulfapyridine, sulfaquinoxaline, sulfathiazole, sulfisomidine, sulfisoxazole, trimethoprim
Tetracyclines	chlortetracycline, doxycycline, epi-chlortetracycline, epi-oxytetracycline, epi-tetracycline, oxytetracycline, tetracycline

Table B-5 Arsenic species included in the arsenic speciation method

Species	Form	Synonym	Chemical formula
As III	Inorganic	Arsenious acid, Arsenite	$As(OH)_3$
As V	Inorganic	Arsenic acid, Arsenate	H_3AsO_4
AsC	Organic	Arsenocholine	$C_5H_{14}AsBrO$
AsB	Organic	Arsenobetaine	$C_5H_{11}AsO_2$
MMA	Organic	Monomethylarsonic acid	CH_3AsO_3Na
DMA	Organic	Dimethylarsinic Acid, Cacodylic acid	$C_2H_7AsO_2$

Appendix C

Table C-1 Levels of metals observed in the product types tested

Metal Analyte	Infant Formula Type	Total Number of Samples	Total Number Negative	Total Number Positive	Minimum (ppm)	Maximum (ppm)	Mean (ppm)
Aluminum	Milk-based	87	1	86	0.003	4.410	0.817
	Soy-based	36		36	0.717	5.860	3.032
	Specialized	26		26	0.460	5.420	2.404
Antimony	Milk-based	87	29	58	0.001	0.015	0.004
	Soy-based	36	11	25	0.001	0.011	0.004
	Specialized	26	5	21	0.001	0.007	0.003
Total Arsenic	Milk-based	87	1	86	0.001	0.023	0.010
	Soy-based	36		36	0.004	0.027	0.014
	Specialized	26		26	0.001	0.029	0.013
Arsenobetaine	Milk-based	87	87	-	-	-	-
	Soy-based	36	36	-	-	-	-
	Specialized	26	26	-	-	-	-
Arsenocholine	Milk-based	87	87	-	-	-	-
	Soy-based	36	36	-	-	-	-
	Specialized	26	26	-	-	-	-
Dimethyl Arsenic Acid	Milk-based	87	87	-	-	-	-
	Soy-based	36	36	-	-	-	-
	Specialized	26	26	-	-	-	-
Inorganic Arsenic (III)	Milk-based	87	70	17	0.001	0.005	0.002
	Soy-based	36	15	21	0.001	0.003	0.001
	Specialized	26	9	17	0.001	0.002	0.001
Inorganic Arsenic (V)	Milk-based	87	82	5	0.005	0.009	0.007
	Soy-based	36	35	1	0.005	0.005	0.005
	Specialized	26	19	7	0.005	0.007	0.006
Monomethyl Arsenic Acid	Milk-based	87	87	-	-	-	-
	Soy-based	36	36	-	-	-	-
	Specialized	26	26	-	-	-	-
Beryllium	Milk-based	87	48	39	0.001	0.015	0.002
	Soy-based	36	6	30	0.001	0.004	0.002
	Specialized	26	7	19	0.001	0.007	0.002
Boron	Milk-based	87	11	76	0.008	2.170	0.531
	Soy-based	36		36	0.396	3.280	1.425
	Specialized	26	7	19	0.044	1.780	0.760
Cadmium	Milk-based	87	52	35	0.001	0.009	0.002
	Soy-based	36		36	0.004	0.044	0.008
	Specialized	26	8	18	0.002	0.009	0.003

Metal Analyte	Infant Formula Type	Total Number of Samples	Total Number Negative	Total Number Positive	Minimum (ppm)	Maximum (ppm)	Mean (ppm)
Chromium	Milk-based	87		87	0.002	0.188	0.034
	Soy-based	36		36	0.037	0.098	0.062
	Specialized	26		26	0.008	0.132	0.055
Copper	Milk-based	87		87	0.475	9.890	4.410
	Soy-based	36		36	2.860	7.020	5.323
	Specialized	26		26	0.413	9.580	4.361
Iron	Milk-based	87		87	10.700	151.000	84.271
	Soy-based	36		36	88.500	145.000	109.178
	Specialized	26		26	13.200	122.000	82.169
Lead	Milk-based	87	14	73	0.001	0.107	0.005
	Soy-based	36	1	35	0.002	0.035	0.007
	Specialized	26	2	24	0.001	0.017	0.007
Magnesium	Milk-based	87		87	42.200	1190.000	425.089
	Soy-based	36		36	350.000	851.000	584.917
	Specialized	26		26	0.501	737.000	383.115
Manganese	Milk-based	87		87	0.079	32.200	2.901
	Soy-based	36		36	1.930	5.440	3.078
	Specialized	26		26	0.086	3.060	1.155
Mercury	Milk-based	87	87	-	-	-	-
	Soy-based	36	36	-	-	-	-
	Specialized	26	26	-	-	-	-
Molybdenum	Milk-based	87		87	0.022	0.978	0.204
	Soy-based	36		36	0.127	0.790	0.370
	Specialized	26		26	0.012	0.239	0.107
Nickel	Milk-based	87	10	77	0.002	0.206	0.031
	Soy-based	36		36	0.107	0.540	0.209
	Specialized	26	3	23	0.003	0.067	0.036
Selenium	Milk-based	87	2	85	0.005	0.375	0.220
	Soy-based	36		36	0.168	0.416	0.271
	Specialized	26	1	25	0.002	0.404	0.245
Tin	Milk-based	87	20	67	0.003	0.317	0.063
	Soy-based	36	8	28	0.002	0.202	0.045
	Specialized	26	10	16	0.002	0.109	0.026
Titanium	Milk-based	87	8	79	0.002	1.300	0.085
	Soy-based	36		36	0.054	0.396	0.211
	Specialized	26		26	0.013	0.437	0.163
Zinc	Milk-based	87		87	4.180	93.300	46.757
	Soy-based	36		36	42.800	90.900	68.283
	Specialized	26		26	5.490	96.300	53.105