Background Paper on
Dietary Exposure Assessment

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Toxicological and Health Aspects of Melamine and Cyanuric Acid

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CONTENTS

1. INTRODUCTION

Dietary exposure to melamine and its analogues can result from their "baseline presence" in food and drinking-water or from the deliberate adulteration of certain food items. Baseline dietary exposure to cyanuric acid, ammeline and ammelide in food other than drinking-water could not be estimated, because very limited concentration data were available.

This dietary exposure assessment considers separately the exposure arising from "baseline levels" and that arising from the adulteration of food products. Sources of "baseline levels" include migration from "melamine-ware" plastics, residues from the use of the pesticide cyromazine, the use of melamine as a component of food contact materials and as a by-product from the use of chlorine-containing disinfectants. Other potential sources of baseline levels not considered in this report due to lack of data include those from the use of melamine and/or cyanuric acid in animal feeds or from their addition to fertilizers, which may then result in low levels of residues in food.

This background paper draws upon existing national and regional exposure assessments where relevant and of sufficient quality. In a limited number of cases, new international dietary exposure assessments have been undertaken using the food consumption data outlined below and relevant occurrence data.

A brief summary of available national and regional risk assessments undertaken prior to the WHO Expert Meeting that include an estimate of dietary exposure from the possible adulteration of food and animal feed with melamine is also included in this paper.

2. FOOD CONSUMPTION

Where dietary exposure assessments have been undertaken de novo, relevant food consumption data have been utilized. There are no food consumption data that describe foods actually consumed by populations at a global or regional level. The Global Environment Monitoring System – Food Contamination Monitoring and Assessment Programme (GEMS/Food) cluster diets describe the amount of raw food commodities available for consumption in 13 regions (WHO, 2008). These data have been used for the estimation of baseline dietary exposure to melamine residues as a result of the use of cyromazine. For dietary exposures from the consumption of infant formula, estimates of baseline dietary exposure and exposure due to adulteration were based on food consumption data for specific countries. For other processed foods, estimates of dietary exposure at baseline and due to adulteration were undertaken for European populations only, using the Concise European Food Consumption Database, which contains food consumption data for 17 European countries (EFSA, 2008a).

3. UNCERTAINTY ASSOCIATED WITH THE DIETARY EXPOSURE ASSESSMENTS

The dietary exposure assessments, conducted de novo for this paper, for melamine from all sources of exposure other than infant formula are very conservative. The dietary exposure assessment for cyanuric acid in drinking-water is also very conservative. In addition, there is a high level of uncertainty associated with the exposure estimates owing to the limited number of data available.

4. EXPOSURE TO MELAMINE AND ITS ANALOGUES RESULTING FROM BASELINE LEVELS

4.1 Infant formula

In a draft health risk assessment, Health Canada (2008a) undertook a dietary exposure assessment using the results of a "snapshot" survey of 80 different infant formula products available on the Canadian retail market using a sensitive method of analysis. Melamine concentrations were <4–346 µg/kg in formula as purchased, with 75% of samples containing detectable levels. The equivalent concentrations on an "as received" basis were <0.5–69 µg/kg. Dietary exposure assessments were done for different infant age groups using published food consumption data for each group (Institut National de Santé Publique du Québec, 2001) or for premature infants using a Health Canada estimate of consumption (Health Canada, 2008a).

It was assumed that melamine concentrations were one half the limit of detection (LOD) in those cases in which no melamine had been detected. When maximum melamine concentration and maximum infant formula consumption values were used, the estimated baseline dietary exposures were 4.6–19.1 µg/kg body weight (bw) per day. However, this "worst-case" assessment is considered very conservative. A more realistic estimate was also presented, in which mean melamine concentration and mean infant formula consumption data were used to estimate baseline dietary exposures of **0.54–1.6 µg/kg bw per day**.

In a surveillance report of melamine contamination in infant formula (Chen & Kang, 2008), 341 samples from milk powder manufactured in 19 countries, other than China, were analysed. Only 1 of 341 samples analysed was identified positive with a trace amount of melamine (0.09 mg/kg). In another survey of 67 China-manufactured milk powder products from a single company, 63 contained detectable melamine at 0.17–0.28 mg/kg. The researchers from Taiwan, China, speculated that this "systemic existence" of low levels of melamine may be due to cross-contamination during milking and/or processing and migration from contact with utensils, processing facilities, packaging material and/or residues of sanitizers containing melamine.

The Food and Drug Administration (FDA) of the United States of America (USA) (USFDA, unpublished data, 2008) recently tested 44 domestically produced samples of infant formula. Three samples contained low levels of melamine (140–200 µg/kg), and a further sample contained cyanuric acid (250 µg/kg). The concentrations of melamine and cyanuric acid were reported as not detected in all other samples. The liquid chromatography/mass spectrometry method used was reported to have a limit of quantification (LOQ) of 0.25 mg/kg and 0.2 mg/kg for melamine and cyanuric acid, respectively. These results are within the range reported by Health Canada (2008a).

In Australia and New Zealand (J. Baines & L. Laajoki, personal communication, 2008; J. Reeve, personal communication, 2008), extensive tests have been undertaken by the industry on infant formula produced in each country, with no positive detections reported for melamine or cyanuric acid. However, these data utilized a limit of reporting of 1 mg/kg, whereas the Canadian "snapshot" survey utilized an LOD of 4 µg/kg in formula as purchased.

4.2 Foods other than infant formula

Estimates of baseline dietary exposure to melamine were undertaken for 17 countries in Europe, a region where processed foods form a significant part of the diet. Mean food consumption amounts for the whole population for foods of interest were taken from the European Concise Food Consumption Database, which reports food consumption amounts across 14 broad food categories (EFSA, 2008a). Baseline melamine concentration levels were derived from Health Canada data for foods available on the Canadian market (Health Canada, 2008b).

Where data were available for a single food only, the upper-bound mean level was taken to represent all foods in the category (non-detects assigned the LOD of 4 µg/kg). If more than one food had been analysed per food category, the highest mean baseline level was taken (data for cereal mixed dishes, sugar products including chocolate, coffee, tea, milk drinks, dairy-based products and cheese food categories).

Estimated dietary exposure to melamine at baseline ranged from **0.03 to 0.12 µg/kg bw per day** across the 17 European countries, assuming that melamine was present in all food groups included with a “positive result” for a food in the category and an average body weight of 60 kg. This is a conservative estimate, as the highest upper-bound mean baseline result for any one food group was used for all foods in that food category.

4.3 Dietary exposure arising from the use of chlorine-containing disinfectants

The USFDA (unpublished data, 2008) reported that trichloromelamine is approved for use as a disinfectant solution on food-processing equipment, utensils and other food contact articles, with the exception of milk containers and equipment. Trichloromelamine decomposes to melamine, and the USFDA estimated a melamine dietary concentration[1] of 0.14 mg/kg on the conservative assumption that all disinfectants contain trichloromelamine. Assuming consumption of 3 kg of food per day, the USA estimated baseline dietary exposure of melamine, from the use of the disinfectant trichloromelamine, as 0.42 mg/person per day, equivalent to **7 µg/kg bw per day.**

The disinfection of water with some chlorine-containing disinfectants may lead to residues of cyanuric acid in drinking-water. For example, sodium dichloroisocyanurate is widely used as a stable source of chlorine for the disinfection of swimming pools and in the food industry (WHO, 2007). It is also used as a means of disinfecting drinking-water, primarily in emergencies, when it provides an easy-to-use source of free chlorine.

Sodium dichloroisocyanurate decomposes in water to release free chlorine, available for the disinfection of drinking-water. The 61st meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA) concluded that the continued reaction of sodium dichloroisocyanurate–released free chlorine with organics in water would eventually result in residues of cyanuric acid in water (WHO, 2004).

Human exposure to cyanuric acid was evaluated by assuming that 1 mol of sodium dichloroisocyanurate results ultimately in 1 mol of cyanuric acid. The daily dietary exposure to cyanuric acid from the consumption of water by adults, assuming a maximum application of sodium dichloroisocyanurate of 3.2 mg/l (equivalent to 2 mg/l free chlorine) and consumption of 2 litres of water per day, would be equivalent to 6.4 mg/person per day, expressed as sodium dichloroisocyanurate, or 4.2 mg/person per day as cyanuric acid. Assuming a 60-kg body weight, this is the equivalent of **70 µg/kg bw per day** for cyanuric acid. This dietary exposure assessment was a conservative overestimate of the actual exposure, because of the assumptions that were incorporated in the exposure estimate.

[1] Dietary concentration = consumption factor × concentration of melamine in the food; dietary concentration = 0.14 × <50 µg/kg = <7 µg/kg melamine weight of all food packaged. The term consumption factor, as used by the USFDA, describes the fraction of the daily diet expected to contact specific packaging materials. The consumption factor represents the ratio of the weight of all food contacting a specific packaging material to the weight of all food packaged.

4.4 Dietary exposure as a result of the migration of melamine and cyanuric acid from food contact materials

Melamine is a raw material in the production of some plastic products used for serving food. Low-level migration of melamine into the food has been reported. EFSA (2008b) reported that in a study by Ishiwata et al. (1987), melamine was detected at levels of 0.54, 0.72, 1.42 and 2.2 mg/kg in coffee, orange juice, fermented milk and lemon juice, respectively. These levels resulted from migration from the cup made from melamine–formaldehyde resin under hot and acidic experimental conditions (95 °C for 30 min). Melamine concentrations are therefore likely to be considerably higher than that which would occur in practice.

In more recent research, the United Kingdom Food Standards Agency (2004) undertook a compliance survey of chemical migrants from food contact materials. Fifty samples of "melamine-ware" food contact articles were sampled from retail outlets in England, including cups, plates, bowls and spoons. Testing for migration was undertaken using the European Committee for Standardization (CEN) method EN1186 Part 9 for fillable items and EN1186 Part 3 for non-fillable articles. Three sequential exposures to 3% (weight by volume) aqueous acetic acid for 2 h at 70 °C were carried out. The concentrations of melamine determined using this method were <0.06–0.90 mg/dm^2. For the two articles with a capacity in the range 0.5–10 litres, the concentrations were 0.96 and 3.8 mg/kg. The European Union (EU) specific migration limit (SML) in food or in food simulant for melamine from packaging materials is 30 mg/kg (European Commission, 2002).

The Government of Japan (T. Igarashi, personal communication, 2008) provided a reference for the elution of melamine in boiling water from plates and utensils. Melamine resin–made plates were submerged in boiling water for 30 min. Eluted melamine concentrations in the water were 0.08–0.29 mg/kg.

The Government of China provided unpublished data on melamine from food packaging materials purchased in China that were consistent with other findings. After treatment with 3% acetic acid, *n*-hexane and 15% ethanol for 30 min at 60 °C, melamine was detected in three of six melamine packages at concentrations ranging from 0.18 to 0.85 mg/kg and in no other packaging materials (Chinese Centre for Disease Control and Prevention, unpublished data, 2008).

The USFDA (unpublished data, 2008) reported that melamine is regulated as a component of an adhesive used in food contact materials. In addition, there are several regulations for melamine–formaldehyde resins. As the melamine is incorporated in the resin, only residual melamine would be available for migration. In addition, melamine–formaldehyde resins are typically used on the exterior of cans. The USFDA (unpublished data, 2008) estimated the baseline dietary exposure to melamine from its use in adhesives presuming "virtually nil" migration (<50 μg/kg), USFDA's standard assumption for adhesive exposure. This migration value was multiplied by the standard consumption factor of 0.14 for adhesives. This resulted in a dietary concentration of melamine from its use in adhesives of <7 μg/kg diet, equivalent to **<0.35 μg/kg bw per day**. A similar calculation was undertaken for the use of melamine in paper and paperboard, yielding a melamine dietary concentration of 0.038 μg/kg diet, equivalent to **0.0019 μg/kg bw per day**.

The New Zealand Food Safety Authority (NZFSA, 2008a) has undertaken a literature review on the migration of melamine from melamine plastics into foods. Of four key papers identified, none indicated that the EU SML of 30 mg/kg for the migration of melamine into food would be exceeded. In most tests, the migration was around the LOQ. Migration was highly dependent on the temperature and pH of the food placed into a melamine resin container or in contact with melamine plastic. The review concluded that melamine "does leach out of plastics and this continues over time. Initially, migration of the monomer was the most important, but as time went on it was the breakdown of the plastic that lead to the availability of the melamine and subsequent migration."

Available migration data indicate that concentrations in food are likely to be ≤1 mg/kg. Although there are some limited data with concentrations >1 mg/kg, the assay used harsh migration conditions (typically 3% acetic acid, 70 °C for 2 h) that would not be encountered in practice. Using a concentration of 1 mg/kg and applying an assumption that the migrant may be present in 25% of the diet[2] (i.e. 750 g/person per day for an adult), a conservative estimate of baseline dietary exposure of melamine for adults would be **13 µg/kg bw per day**.

4.5 Dietary exposure as a result of the application of the pesticide cyromazine

Melamine residues in food can result from the use of cyromazine as an agricultural insecticide. The Joint FAO/WHO Meeting on Pesticide Residues (JMPR) (FAO, 2007) summarized Good Agricultural Practices for cyromazine on a range of vegetables in Greece, Spain, France, Switzerland, Italy, Mexico and the USA. Direct cyromazine use on farm animals was also reported in the USA (poultry) and Australia (poultry and sheep). The JMPR meeting concluded that melamine is the main metabolite found in all crops and most animal products. The plant and animal metabolism data reviewed by the meeting indicated that levels of melamine were lower than levels of parent cyromazine, with the exception of mushroom and liver. The 2007 meeting agreed that for practical purposes, the definition of residues (for compliance with maximum residue limits [MRLs] and for estimation of dietary exposure) for plant and animal commodities should be the parent cyromazine only. As a consequence, the JMPR only summarized the residues of cyromazine in their evaluation of the trials, with the exception of mushrooms, where melamine was present at levels similar to those of the parent cyromazine. In mushrooms, residues of melamine were in the range 1.5–6.6 mg/kg at a compost of 5 mg active ingredient (ai)/kg and in the range 3.1–17 mg/kg at a compost of 10 mg ai/kg. The MRLs estimated by the JMPR for parent cyromazine included those of 7, 0.2, 0.3 and 0.01 mg/kg in mushrooms, eggs, edible offal and milks, respectively.

Following media concerns about levels of melamine in mushrooms and other vegetables grown in China, Food Standards Australia New Zealand (J. Baines & L. Laajoki, personal communication, 2008) tested 15 samples of mushrooms and mushroom products imported from China, with no positive detections for cyromazine, melamine or cyanuric acid (limit of reporting of 1 mg/kg).

The United States Environmental Protection Agency (USEPA, 1999) reported a dietary exposure estimate for cyromazine of 0.0013 mg/kg bw per day for the population in the USA. They have also stated that approximately 10% of cyromazine is converted to melamine in vivo.

The Government of Japan (T. Igarashi, personal communication, 2008) provided summary information on residues arising from the treatment of tomato, celery and lettuce with cyromazine. In most of these trials, the concentrations of melamine were lower than the concentrations of cyromazine.

For the dietary exposure assessment, melamine concentration levels were derived from the supervised trial median residue levels (STMR) for cyromazine (agricultural trial data; FAO, 2007) for all products for which an MRL for cyromazine was estimated by the

[2] USFDA commonly uses a model diet, which assumes 3 kg total food consumption, of which 1.5 kg is solid foods.

2007 JMPR (FAO, 2007). Melamine residue concentration levels were assumed to be 10% of the cyromazine residue levels[3] for the purpose of the dietary exposure assessment. However, JMPR data indicate that for edible offal (mammalian meat offal and poultry offal) and mushrooms, levels of melamine were of a similar magnitude to those of parent cyromazine. For these latter commodities, it was assumed that melamine residue concentration levels were at the STMR of 0.01 mg/kg and 2.2 mg/kg, respectively,

Food consumption amounts for the products likely to contain melamine from the legitimate pesticide use of cyromazine for 13 different regions were derived from the GEMS/Food cluster diets (WHO, 2008). Estimated baseline dietary exposure to melamine from use of cyromazine as a pesticide ranged from 0.04 µg/kg bw per day (diet A) to 0.27 µg/kg bw per day (diets E and M). It was assumed that residues were present in all commodities for which an MRL was estimated by the 2007 JMPR (FAO, 2007) in all 13 regions in the world. A body weight of 60 kg was also used. This is a conservative estimate, as it assumes that all crops have been treated, that cyromazine has been applied at the maximum use pattern[4] and that it will be used in all regions.

Cyromazine is also used as a veterinary drug. However, no data on residue levels of cyromazine or its metabolites from this use were available. Levels arising from veterinary use were therefore not included in the dietary exposure assessment.

4.6 Animal feed

No data were available on the baseline levels of melamine in animal feed.

The USFDA (2008a) permits the presence of cyanuric acid (≤30%) as a by-product in feed-grade biuret. Biuret is an approved additive for ruminant feed products to provide non-protein nitrogen with specific labelling. The label must state the maximum percentage of equivalent crude protein from non-protein nitrogen. Information on the levels of cyanuric acid in the products of animal origin, arising from the presence of cyanuric acid as a by-product in feed-grade biuret, were not available.

4.7 Other potential sources of “baseline melamine” in food

In the USA, there are some reports of fertilizer companies adding melamine to their products to help control the rate at which nitrogen seeps into the soil (United States Patent Office, 1988; McWilliams, 2008).

5. EXPOSURE TO MELAMINE AND ITS ANALOGUES AS A RESULT OF ADULTERATION OR MISUSE

5.1 Infant formula

In a Chinese dietary exposure assessment specific to adulterated Sanlu infant formula products, four age groups of infants and young children (3, 6, 12 and 24 months) were chosen. The maximum amount of infant formula consumption was used based on the recommended usage level on the package label of Sanlu infant formula and other brands. In

[3] The Expert Meeting recognized that the 10% value was a rough approximation of the ratio between cyromazine and melamine residues. For some residue trials, melamine residues were less than 10% of the cyromazine levels, and for others, they were greater than 10%.

[4] Commonly referred to as “Good Agricultural Practice”.

estimating dietary exposure for the four groups, the body weight and infant formula consumption values used were in the ranges 5.5–14 kg and 120–150 g dried powder, respectively. The concentration data from 111 samples of Sanlu infant formula were used, as summarized in Table 1 (Chinese Centre for Disease Control and Prevention, unpublished data, 2008). The calculated estimates of dietary exposure are summarized in Table 2.

Table 1. Melamine concentrations in Sanlu infant formula samples (dried powder)

Sample	No. of samples	Mean (mg/kg)	Median (mg/kg)	90th percentile (mg/kg)	Maximum (mg/kg)	Range (mg/kg)
A	111	1212	1000	2600	4700	<0.05–4700
B	52	1674	1700	2880	4700	<0.05–4700

Notes: Sample A: all samples; Sample B: samples collected from affected area in China. LOQ = 0.05 mg/kg.

Table 2. Dietary exposure estimates of melamine from Sanlu infant formula (111 samples)

Age (months)	Melamine dietary exposure estimates (mg/kg bw per day) at following concentrations:			
	Mean (1212 mg/kg)	Median (1000 mg/kg)	90th percentile (2600 mg/kg)	Maximum (4700 mg/kg)
3	28.4	23.4	61.0	110.2
6	26.0	21.4	55.7	100.7
12	18.2	15.0	39.0	70.5
24	10.4	8.6	22.3	40.3

Based on the median melamine concentration (1000 mg/kg), the melamine dietary exposure for infants 3, 6, 12 and 24 months of age were 23.4, 21.4, 15.0 and 8.6 mg/kg bw per day, respectively. The researchers emphasized that the samples collected were not necessarily representative, that melamine concentrations in the adulterated Sanlu infant formula varied and that infants may not have consumed Sanlu product all the time.

5.2 Foods other than infant formula

Adulteration has been recently documented in milk powder, cereal products and ammonium bicarbonate. Foods that may contain milk powder include dairy foods, such as ice cream and yoghurt, meal replacements containing dairy ingredients, biscuits, cakes, chocolates, ice confection and milk-based drinks. Some of these foods also contain cereal. Although occurrence data were available for ammonium bicarbonate, eggs and egg powder, it was not possible to include this information in the model, other than to assume that where this additive had been used as a raising agent in products such as biscuits and cakes or egg products had been added, the contribution to overall melamine levels in that product would have been accounted for in the reported analytical results from the International Food Safety Authorities Network (INFOSAN) reports of contaminants and the EU Rapid Alert System for Food and Feed.

For the purpose of estimating dietary exposure to melamine for foods containing dairy products from China, estimates were undertaken using the EFSA Concise Food Consumption Database for adults (EFSA, 2008a). Melamine concentration levels for each relevant food category were derived from the maximum melamine concentrations from INFOSAN and other country data. It was assumed that 10% of each food category for which there were analytical results (data for cereal mixed dishes, other cereals, sugar products including chocolate, coffee and milk drinks food categories) may have contained milk powder from China and that coffee comprised 50% of the tea and coffee category. In cases where more than one food had been analysed per food category, the highest reported melamine level was taken.

Estimated dietary exposure to melamine from foods containing adulterated milk powder were **0.16–0.7 mg/kg bw per day**, assuming that melamine was present in all food groups with the highest reported result for a food in that group and an average body weight of 60 kg. This is a very conservative estimate, as in reality not all of the food in each food category is likely to contain milk powder, and less than 10% of foods are likely to contain adulterated Chinese milk powder. In addition, actual melamine levels are likely to be lower than the maximum reported result for any one food category.

Prior to the availability of testing results, EFSA published a theoretical estimate of melamine dietary exposure for high consumers of biscuits and confectionery, assuming a range of melamine in milk powder and various proportions of milk powder in biscuits and confectionery (EFSA, 2008b). Estimates of potential dietary exposure to melamine from biscuits ranged from 0.0002 to 0.3 mg/kg bw per day for a 60-kg adult and from 0.0006 to 0.9 mg/kg bw per day for a 20-kg child. Estimates of potential dietary exposure to melamine from confectionery ranged from 0.0007 to 0.45 mg/kg bw per day for a 60-kg adult and from 0.002 to 1.35 mg/kg bw per day for a 20-kg child.

5.3 Addition to animal feed

In 2007, following the adulteration of pet food with melamine, the USFDA (2007) published an interim risk assessment of melamine and its analogues that considered the potential risk to humans of consuming food derived from animals, such as pork, chicken and eggs or fish, where the parent animal had been fed with feed containing pet food scraps contaminated with melamine. Based on a worst-case scenario, assuming melamine and cyanuric acid were present in equal amounts in all solid food consumed by an individual each day, the potential dietary exposure was estimated to be ~250 times less than the tolerable daily intake (TDI) established by the USFDA of 0.63 mg/kg bw per day. This risk assessment could also be applied to animal feed contaminated by the direct adulteration of ingredients with melamine and its analogues.

No farm animal feeding studies were available that would allow a quantitative assessment of the carryover of melamine into foods from animal feed to be carried out. A dietary exposure assessment relating to the recent reports of adulteration of animal feed was therefore not possible.

6. REVIEW OF NATIONAL AND REGIONAL RISK ASSESSMENTS FOR MELAMINE

A number of national and regional risk assessments were available that included dietary exposure estimates that assumed that foods contained adulterated milk powder as an ingredient. Foods most likely to contain milk powder were infant formula, other milk formulas, dairy foods such as ice cream and yoghurt, meal replacements containing dairy ingredients and other foods with milk powder as an ingredient, such as biscuits, cakes, chocolates, ice confection and milk-based drinks.

6.1 USA

In an interim safety and risk assessment, the USFDA (2008b) used a worst-case scenario to determine the maximum level of melamine that could be in the food supply, assuming that half the food supply was contaminated with melamine and its analogues such that the reference health standard was not exceeded. A "back-calculation" was made from the TDI of 0.63 mg/kg bw per day (USFDA, 2007) with the application of an additional safety factor of 10 and assuming a body weight of 60 kg and a total daily food and liquid consumption of 3 kg. Using this methodology, it was calculated that the concentration in the contaminated food at which the TDI was reached would be 2.5 mg of melamine and its analogues per kilogram of food.

The USFDA assessment also calculated the theoretical dietary exposure resulting from melamine-contaminated milk and milk-derived ingredients from China, assuming that products with melamine levels over the action level of 2.5 mg/kg were no longer available for sale. Using a maximum melamine concentration of 2.5 mg/kg and using average per capita national consumption data, the assessment indicated that consumers in the USA would be exposed to only 1.1% of the adjusted reference health standard (TDI of 0.63 mg/kg bw per day with the additional 10-fold safety factor). In making this calculation, it was assumed that the following milk-derived ingredients contained melamine: casein, lactose, whey protein concentrate, dry whey, dry whole milk, non-fat dry milk, skim milk powders and dry buttermilk.

6.2 EFSA

The European Food Safety Authority (EFSA) has published a statement on the risks for public health relating to melamine in Chinese infant milk and milk products (EFSA, 2008b). This statement included an assessment of dietary exposure for EU consumers based on imported products and compared these potential dietary exposures with the TDI of 0.5 mg/kg bw per day established by EFSA for melamine. Based on European import statistics, EFSA identified that biscuits and chocolate products imported from China to the EU potentially contained contaminated milk and milk powder as an ingredient.

6.2.1 Biscuit consumption

Using an "assumed" high-percentile consumption value of double the average EU daily per capita consumption, several scenarios for the dietary exposure to melamine from biscuit consumption were presented. Two concentrations of melamine in milk powder were used (low: 29 mg/kg; and high: 2563 mg/kg), and the proportion of the milk powder in the biscuits was assumed to be 2, 3.5 and 16%. Calculations were done for adults at 60 kg bw and children at 20 kg bw.

Dietary exposure scenario estimates for adults were 0.0002–0.0034 and 0.0188–0.3007 mg/kg bw per day for the low and high concentrations of melamine, respectively. For children, the comparable dietary exposure estimates were 0.0006–0.0102 and 0.0564–0.9022 mg/kg bw per day, respectively. Dietary exposures for cyanuric acid were not calculated.

6.2.2 Confectionery consumption

The EFSA statement also included a hypothetical melamine dietary exposure estimate from the consumption of confectionery. An "assumed" high-percentile consumption value of 3 times the average EU daily per capita consumption for confectionery was used. Several scenarios for the dietary exposure to melamine from confectionery were calculated, assuming the same low and high concentrations of melamine in the milk powder (29 and 2563 mg/kg).

Estimated dietary exposure to melamine for adults from the consumption of confectionery were 0.0007–0.0051 and 0.060–0.449 mg/kg bw per day for the low and high concentrations of melamine, respectively. For children, the comparable dietary exposure estimates were 0.0020–0.0152 and 0.179–1.346 mg/kg bw per day, respectively. Dietary exposures for cyanuric acid were not calculated.

For both biscuits and chocolate, it was noted that there was currently no information on whether such products were imported from China into Europe or how frequently such high levels of dietary exposure may occur in Europe. The EFSA statement did not include an assessment of dietary exposure to melamine or cyanuric acid as a result of their "baseline presence" at low levels in food; this was outside the scope of the question posed to EFSA by the European Commission.

6.3 Canada

Health Canada (2008b) has reviewed all the available data about the health effects of melamine and evaluated the health risks. Health Canada's risk assessment concluded that if powdered infant formula contained melamine at 1 mg/kg, the maximum level for melamine established by Health Canada and many other countries for that food, the subsequent consumption of infant formula would result in a melamine dietary exposure of less than 10% of the toxicological reference dose (TDI of 0.35 mg/kg bw per day established by Health Canada).

6.4 Australia

FSANZ (2008) published a risk assessment that included a "back-calculation" to determine the consumption of food that would lead to the exceedance of the TDI (0.63 mg/kg bw per day; USFDA, 2007) when different melamine concentration scenarios were used. For infant formula, at levels of adulteration of 100 mg/kg, an infant will quickly exceed the TDI, if fed exclusively on formula. In products containing 10% milk powder, at melamine concentrations of 10 mg/kg, unrealistic amounts of food would have to be consumed to exceed the TDI (e.g. 44 kg for a 70-kg adult). If food was contaminated with melamine at 100 mg/kg, a 20-kg child would have to eat more than 1 kg of that food before exceeding the TDI, and an adult, more than 4 kg of the food. Assuming heavy adulteration with 1000 mg melamine per kilogram of food, adults would still have to consume over 400 g of food to exceed the TDI, and a 20-kg child, 130 g of food.

FSANZ has also undertaken "preliminary dietary exposure assessments" based on the positive detections for melamine in Australia and elsewhere, assuming that only a single food containing melamine is consumed at any one time. For example, using food consumption data for Australians aged 2+ years and New Zealanders aged 15+ years, and assuming a concentration of melamine of 180 mg/kg in soft confectionery, as detected in sweets in New Zealand, for all adults and children 4–8 years, dietary exposure to melamine from soft confectionery was estimated to be below the TDI. For 2- to 3-year-old Australian children, dietary exposure was 115% of the TDI at the 90th percentile of melamine exposure. For a child weighing 30 kg, about 105 g of these sweets would have to be consumed per day before the TDI was exceeded. FSANZ recognized that the scenario considered was conservative, in that they concluded that "Chinese made sweets are likely to be infrequently consumed and in small amounts" (FSANZ, 2008). Similar calculations have been undertaken by the food authorities in Singapore and the Hong Kong Special Administrative Region and published on their respective web sites.

6.5 New Zealand

NZFSA (2008b) has undertaken a dietary exposure assessment as part of its toxicological opinion relating to infant formula. Using food consumption data published by a major infant formula manufacturer and infant body weight data from the United States National Health and Nutrition Examination Survey (NHANES), NZFSA (2008b) calculated the total of melamine that would lead to the exceedance of the EFSA TDI of 0.5 mg/kg bw per day. Residue concentrations that led to dietary exposure at the level of the EFSA TDI for four different infant age groups were 23–32 mg/kg. NZFSA (2008c) stated that it uses a TDI of 0.5 and 1.5 mg/kg bw per day for melamine and cyanuric acid, respectively, when found on their own. When both are detected in the same food, a lower TDI of 0.063 mg/kg bw is used.

7. REFERENCES

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