Regulatory Toxicology and Pharmacology 73 (2015) 478–483

Contents lists available at ScienceDirect

Regulatory Toxicology and Pharmacology

journal homepage: www.elsevier.com/locate/yrtph

# Impact of a modification of food regulation on cadmium exposure

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ARTICLE INFO

*Article history:*
Received 5 June 2015
Received in revised form
30 July 2015
Accepted 31 July 2015
Available online 5 August 2015

*Keywords:*
Cadmium
Dietary exposure
Maximum limits
Regulation

ABSTRACT

The 2nd French Total Diet Study demonstrated that 0.6% of adults and 14.9% of children exceeded the tolerable weekly intake set by EFSA. The overexposure of several consumers (adults and children) can be partially due to the high consumption of bread and dried bread products, of bivalve mollusks and of potatoes. Except for mollusks, these foods are the main contributors identified for the general population. On this basis, the French agency for food, environmental and occupational health and safety (ANSES) assessed whether a decrease of the European maximum limits in foodstuffs could significantly reduce the level of exposure of French consumers. Applying ML set at P90 of the main contributors would neither significantly reduce exposure levels to cadmium for the general population, nor the percentage of subjects exceeding the TWI. To reduce background consumer exposure to cadmium, actions to be taken include efforts on sources that are at the origin of the soil contamination and the efficacy of consumption recommendations.



## 1. Introduction

Cadmium (Cd) is a widespread metallic trace element, naturally present in the environment but also found in high concentrations at certain sites as a result of human activities (metalworking, mines and other industries) and is of potential concern as a contaminant in the food chain.

Consequently, the European Union has passed and amended a series of Regulations on cadmium. These are based on setting maximum levels (ML) of cadmium in several foodstuffs (EU, 2006) and are, among others, 1 mg/kg fresh weight (fw) for mollusks, 0.2 mg/kg fw for bran and durum wheat and 0.1 mg/kg fw for flour. However, since EFSA lowered the health based guidance value (tolerable weekly intake or TWI) by a factor of almost three in 2009 (From 7 to 2.5 μg/kg bw/week, EFSA, 2009) and since new data became available concerning food contamination and the exposure and body burden of different population groups, the European Commission and the Member States have put in motion a revision of the ML for cadmium in foodstuffs.

In the adult population (between 18 and 74 years old) studied in the French biosurveillance study (ENNS) (Fréry et al., 2011) the mean and median concentrations of urine cadmium in France were both equal to 0.29 μg Cd/g creatinine, and the 95th percentile to 0.91 μg Cd/g creatinine. Those recent data for body burden suggest that 3.6% of French adults exceed the 1 μg Cd/g creatinine threshold of toxicological concern set by EFSA (EFSA, 2009). It is of importance to note that none of the subjects in the study exceeded the action threshold proposed by the German Human Biomonitoring Commission (5 μg Cd/g creatinine, Fréry et al., 2011).

These mean levels are in agreement with those found in France during previous investigations carried out by the French institute of surveillance (InVS) in 1997, 2000 and 2005 in different French cities (about 0.3 μg Cd/g creatinine at Salsigne and its surrounding area; RNSP, 1997) as well as in Marseilles (ORS PACA, 2011) and 0.27 μg Cd/g creatinine in the national study on incineration plants (Afssa, 2009).

Mean human urinary cadmium levels measured in the ENNS study were similar to those observed in the National Health and Nutrition Examination Survey (*NHANES*) carried out in 2003–2004 (CDC, 2009) on a representative sample of the population of the

*Abbreviations:* TWI, Tolerable Weekly Intake; EFSA, European Food Safety Authority; ANSES, French agency for food environmental and occupational health and safety; ML, Maximum Limits; NHANES, National Health and Nutrition Examination Survey; TDS, Total Diet Study; BMI, Body Mass Index.

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http://dx.doi.org/10.1016/j.yrtph.2015.07.027
0273-2300/

United States, in the Canadian Health Measures Survey performed in 2007–2009 (Health Canada, 2010) and in the population of the Czech Republic in 2005 (NIPH, 2006, 2010). On the other hand, the levels observed in Germany in the adult population ten years ago were slightly lower (Becker et al., 2003): 1.5 times lower than the mean in the adult French population and 1.25 times lower at the 95th percentile.

In 2006, the French agency for food, environmental and occupational health and safety (ANSES) showed that high consumers of seafood (fish, mollusks and crustaceans) had a higher body burden than the national average, with mean cadmium levels of 0.65 μg Cd/g creatinine and 1.19 μg Cd/g creatinine at 95th percentile (Sirot et al., 2008). In this study, subjects over the age of 64 years had mean body burden of 0.95 μg Cd/g creatinine and 1.94 μg Cd/g creatinine at P95. Fifteen percent of subjects in the study had body burden exceeding the threshold of concern. On the other hand, none exceeded the level of 5 μg Cd/g creatinine.

In 2006, Anses launched the second French total diet study (TDS2) to assess the dietary exposure of the general population to 445 substances of public health interest, including cadmium. The TDS consisted in three major steps: (i) food sampling and sample preparation as consumed by the population, (ii) analysis of the samples, and (iii) dietary exposure assessment by combining the occurrence data with the national consumption data. The food sampling methodology has already been described in details elsewhere (Sirot et al., 2009) as well as results for the substances measured in the TDS (Nougadère et al., 2012; Bemrah et al., 2012; Sirot et al., 2012; Rivière et al., 2014; Sirot et al., 2012b). The results for trace elements (including cadmium) can also be found (Millour et al., 2011; Arnich et al., 2012). The French population's mean exposure to cadmium was estimated at 1.12 μg/kg bw/wk in adults (18–79 years old) and 1.68 μg/kg bw/wk in children (3–18 years old). At the 95th percentile, exposure was estimated at 1.89 μg/kg bw/wk in adults and 3.15 μg/kg bw/wk in children. The main contributors to cadmium exposure both in adults and children were bread and dried bread products (22% and 13%, respectively) and potatoes and potato products (12% and 14%, respectively). Detailed data show that adults with the highest estimated intakes are high consumers of mollusks and crustaceans, bread and potatoes. EFSA's TWI of 2.5 μg/kg bw/wk (EFSA, 2009) is exceeded by 0.6% [$CI_{95\%}$ 0.3–1.0] of adults and by 14.9% [$CI_{95\%}$ 13.0–16.7] of children.

The difference between the proportion of subjects exceeding the reference values set for body burden (3.6%) on one hand, and set for food consumption on the other (0.6%), can be explained, leaving aside methodological differences, by the fact that diet accounts for 90% of exposure of non-smokers (UNEP, 2008) and that part of the general population's body burden can be attributed to other contamination vectors (mainly tobacco). Moreover, body burden reflect past exposure, whereas TDS reflects current dietary exposure, and data suggest that cadmium concentrations in foods and exposure tend to decrease for several years (Béchaux et al., 2014).

Moreover, dietary exposure data suggest that 1.4% of adults are exposed to more than 90% of the TWI. For these individuals the exposure margin is low if other potential sources of cadmium are taken into account.

The results generated by these two approaches concur, emphasizing that a small part of the French adult population is over-exposed to cadmium, largely through dietary intake, and that high consumers of seafood appear to be more exposed than the general population. The level of overexposure remains moderate and it would be helpful to compare it to a future action threshold to decide on the most appropriate reduction measures to be taken.

As a small fraction of the French population is overexposed to cadmium and since foods are the main source of contamination (excluding smoking and occupational exposure), dietary regulations could be an effective way of reducing exposure. Since cadmium is a ubiquitous metal found in a large number of foods, it is important to identify the food groups to be regulated. The present work focuses on the evaluation of strategy that could help decreasing cadmium exposure of adults via foodstuffs. The impact on cadmium dietary exposure of new ML has been assessed as well as the impact on the percentage of individuals exceeding the TWI.

## 2. Material and methods

### 2.1. Consumption and exposure profiles

Exposure data used in the present work have already been described elsewhere (Arnich et al., 2012). Briefly, total individual exposures were assessed by combining consumption and contamination data. The national and individual food consumption survey (INCA2) was carried out in between December 2005 and May 2007 (Dubuisson et al., 2010). The survey included 2624 adults (aged 18–79), these random sample were drawn using a multistage cluster sampling technique. After exclusion of the under-reporters, the analysis was done with 1918 adults. Food and beverages consumptions were assessed in detail using a 7-day food record. The amounts consumed were estimated by using a photograph manual of portion size or household measures or grams per unit. Individual data such as body weight were also recorded. Contamination data were those from the 2nd French TDS. Briefly, food samples representative of the whole French diet were collected in 2007–2009, prepared as consumed by the population. In all, 1319 composite corresponding to 212 core foods were analyzed for cadmium. The analytical method has already been described (Arnich et al., 2012).

In the present work, in order to have a statistically more robust and larger population sample, it was decided to investigate the 5% most exposed adults (95th percentile of exposure, or P95, N = 90) instead of the 0.6% exceeding the TWI (N = 16).

Consumption levels of this subgroup were compared to the general population by mean of a t-test. Alpha (two-tailed) was set at 5%. Adjustments were performed to compensate for the multiple t-tests: 0.001 = 0.05/number of tests (n = 43). Data analyses were performed using the Statistical Analysis System statistical software package version 9.1.3 (SAS Institute, Cary, NC, USA).

### 2.2. Simulations of new ML

The contribution of each foodstuff and food group to the total exposure was calculated as the part (%) of the exposure resulting from the consumption of this foodstuff or food group. The major contributors to the exposure have been identified in the general population as well as in the 5% most exposed to choose some foods for which the impact of a new ML could be tested. The simulations finally concerned some of those main contributors, i.e. products based on wheat flour, mollusks and crustaceans, and potatoes.

To evaluate the impact of new ML on contamination data and on exposure levels, concentration data from the 2009–2010 French monitoring programs for the selected food groups and 2000–2010 data from the main operators in the cereals industry were used, in order to have a general distribution of the contamination levels per food. The P90 and P95 values for these foodstuffs have been chosen as possible new ML for the simulations, and then the contamination values above those limits were then excluded from the calculations. The impact on the mean concentration of these exclusions was applied to the TDS data in order to calculate the new exposure. For example, if the exclusion of 10 values of oyster samples implied a decrease of 5% in the general cadmium mean concentration, the mean TDS concentration of oysters was also reduced by 5% for the