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Threat or treat: Exposure assessment and risk characterisation of chemical contaminants in soft drinks and chocolate bars in various Polish population age groups

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Abstract

In the frame of the European Food Risk Assessment (EU-FORA) fellowship programme, two studies on chemical contaminants in food matrices were carried out in Warsaw, Poland, at the Department of Food Safety and Chemical Analysis, Institute of Agricultural and Food Biotechnology. The first study addressed health concerns about the dietary exposure to bisphenol A (BPA) contamination due to consumption of soft drink by Polish population. BPA is an organic additive used in the production of epoxy resins and polycarbonate plastics and because of this it is used in the internal coating of cans and in plastic bottle production. Depending on several factors, BPA can migrate from these materials to the soft drink and so, it can be ingested by consumers causing hormonal and reproductive disorders. To estimate the Polish population exposure to BPA, several soft drinks belonging to different brands were purchased from a supermarket in the city of Warsaw and analysed. The result of the analysis highlight that mean BPA exposure in the Polish population exceeds the tolerable daily intake proposed by the EFSA scientific opinion, raising health concerns. On the other hand, the second study, focused on cadmium exposure due to chocolate consumption by Polish population, did not raise any health concern. Cadmium is a heavy metal that naturally occurs in its inorganic form in the environment and its presence in chocolate derives only from the cocoa beans and not from contamination during processing. Its accumulation in the human body can create several adverse effects, including renal dysfunction and failure. To estimate the Polish population exposure to cadmium, several chocolate bars were purchased from a supermarket in the city of Warsaw and analysed. The results of the analysis show that cadmium exposure in the Polish population does not exceed the tolerable weekly intake proposed by the EFSA scientific opinion.

Keywords: bisphenol A, carbonated beverages, cadmium, cocoa, heavy metals, epoxy resin, food contact material

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1. Introduction

The European Food Risk Assessment (EU-FORA) fellowship programme is an initiative that aims to train a professional in the food risk assessment field in order to expand the pool of food safety experts and to build up a strong food risk assessment network all over Europe. Thanks to this European network, it will be possible to support a common risk assessment culture. The enrolled fellow has carried out for a period of 12 months, both remotely and in presence, the programme of activities offered by the hosting institute (competent organisation), according to the learning-by-doing concept. In parallel, this experience was integrated by several specific training modules distributed throughout the year for a total of 7 weeks that trained the fellow on a wide range of risk assessment-related topics.

The purpose of this paper is to report the activities that the fellow performed during the participation in the 6th EU-FORA cycle (2022–2023). The fellow, belonging to the Department for Life Quality Studies (QuVi) of the Alma Mater Studiorum - University of Bologna (Italy), spent 3 months at the Department of Food Safety and Chemical Analysis, Institute of Agricultural and Food Biotechnology – State Research Institute (IAFB) in Warsaw (Poland). During this period of time, the fellow worked on the exposure to different chemical contaminants present in food matrices and on the related risk for the Polish population. The working activities were related to the risk assessment that is a scientifically based process composed by four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation (European Commission, 2002). In particular, the working activities were focused on the last two steps. Of those, the former one is essential to estimate the probability that a hazard is present in food and how much of that food is consumed by the population (exposure assessment); the latter one defines whether the found exposure is below or above the recommended safety level (risk characterisation).

Chemical contaminants, that is substances that can potentially harm consumers health and for this reason are considered a hazard, are unwanted substances that may be present in food. Their presence in food might be the result of environmental contamination or can be due to various stages of production, processing, transport or storage of foodstuff. The presence of these contaminants may have some implication for the human health causing, for example: metabolic disruption, immune system disruption, neurotoxicity, hormonal disruption, reproductive disruption or cardiotoxicity. Since the contamination level in food as well as the dietary habits of the population are changing over time, it is important to collect up-to-date data on chemical contaminants in order to monitor and to estimate population exposure to these contaminants and the potential related risks. It is important to note that also the tolerable daily intake (TDI), that represents the safe limit of contaminant amounts that can be consumed over a lifetime, can change over time depending on the availability of new data that may change the hazard identification and characterisation. As a consequence, risk characterisation may change as well.

Good quality data together with a good risk communication are essential to have a well-informed risk assessment and risk management, to ensure a good risk analysis and to achieve a high level of protection of human life and health.

2. Work programme description

2.1. Aim

The aim of the fellow work programme was to transfer knowledge and experience in how to define the occurrence of different chemical contaminants in different food matrices in the Polish market and how to estimate the exposure to these contaminants in different population groups. In particular, the fellow had the opportunity to gain hand-on experience and competence in:

- development and validation of an instrumental analytical method;
- solid phase extraction and microwave-assisted mineralisation protocols to recover the investigated analytes;
- spectrometric analysis by means of liquid chromatography–mass spectrometry (LC–MS) and inductively coupled plasma-mass spectrometry (ICP-MS) to detect and quantify the investigated analytes;
- statistical analysis and result interpretation;
- current legal regulation of food safety.

2.2. Activities/methods

To learn and achieve the above goals, the fellow performed all the laboratory activities at the IAFB (Poland), taking part in the working activities of the hosting institute, while data analysis was performed at the QuVi Department (Italy). In this way, the fellow estimated the risk of chemical dietary exposure related to some specific food consumption in different Polish population groups.

Specifically, the fellow's work was focused on:

i) bisphenol A (BPA) exposure in different Polish population groups consuming carbonated soft drinks;
ii) cadmium exposure in different Polish population groups consuming chocolate bars.

2.2.1. Bisphenol A exposure in different Polish population groups consuming carbonated soft drinks

In order to work on this topic, two assessment questions were posed:

'What is the occurrence of BPA in carbonated soft drinks?';
'How high is the dietary exposure of different Polish population groups to BPA?'

Food matrix

Soft drinks are water-based drinks widely consumed by the world population during the day in many occasions, since they provide refreshment, satisfaction, enjoyment and other benefits. These aspects made soft drinks one of the most popular and consumed products in the modern diet. Due to this high consumption rate, it could be interesting to estimate the risk associated to the consumption of this drink category, and in particular, the research was focused on carbonated soft drinks. Several carbonated soft drinks from different brands were purchased from supermarkets in the city of Warsaw, Poland. The sampling included both canned beverages and beverages in plastic bottles.

According to the EFSA's standardised food classification and description system FoodEx2 (catalogue FoodEx2 Matrix hierarchy (MTX) version 12.0), the selected matrices are labelled as 'Soft drinks with minor amounts of fruits or flavours [A0EQN]', 'Cola-type drinks [A03FQ]' and 'Energy drinks [A03GA]'. The first two matrices belong to the macro category 'Soft drinks [A03DZ]' that is defined as 'Group/item including e.g. Soda Pop or Fizzy drink. The group includes any type of Soft drinks. The part consumed/analysed is by default the whole marketed unit or homogenous representative portion'. The third matrix belong to the broad category 'Functional drinks [A03FZ]' that is defined as 'The group includes any type of Functional drinks, such as energy drinks and isotonic drinks. The part consumed/analysed is by default the whole marketed unit or a homogenous representative part'. All the purchased drinks were stored at room temperature according to market storage conditions.

Soft drinks consumption

Due to the huge economic changes that Poland experienced since 1989, the Polish lifestyle and the access to food drastically changed. For this reason, the Polish government needed a precise assessment on the nutritional situation of the Polish population. Hence, in 2000, the Polish Ministry of Health, together with the National Food and Nutrition Institute – Instytut Żywności i Żywienia (IŻŻ) – and with the technical assistance of the Food and Agriculture Organization of the United Nations (FAO), improved the previous nutrition information system. To do that, from September to November 2000, data on food and nutrient intakes were collected and examined with 24-h recall. To help the assessment of the portion size, a picture book of 201 food items, dishes, soft drinks and alcoholic beverages commonly consumed in Poland was used (Szponar et al., 2001; Sekula et al., 2004). The results of this survey are available in the EFSA Comprehensive European Food Consumption Database with the survey code IZZ FAO 2000.

In this risk assessment, the consumption data for the food category 'Soft drinks' (Exposure hierarchy level 3) for different population groups are based on the IZZ-FAO 2000 survey (Szponar et al., 2001; Sekula et al., 2004). The data, taken from the EFSA Comprehensive Food Consumption Database, are shown in Table 1.

Table 1: 'Soft drinks' consumption in the three different population groups considered (Other children, adolescent and adult)

Population group	g/kg bw
Other children – from 36 months up to and including 9 years of age	1.76
Adolescent – from 10 up to and including 17 years of age	1.89
Adult – from 18 up to and including 64 years of age	0.52

bw: body weight.

Bisphenol A and bisphenol derivatives

2,2-Bis(4-hydroxyphenyl)propane (CAS No 80–05-7), known as bisphenol A (BPA), is an organic additive used in the production of epoxy resins and polycarbonate (PC) plastics. Epoxy resins are widely used as coating material in canned beverages because they create a protective layer that separates drinks from the metal foil used to make the cans. PC plastics, on the other hand, are used to produce common plastic bottles. Residual BPA could potentially migrate from the coating material to the beverage. The migration rate depends from different factors such as temperature, pH, contact time, food composition and packaging material (Russo et al., 2019; Vilarinho et al., 2019; Wang et al., 2019). BPA can alter the functioning of endocrine regulation and cause biochemical changes on proteins, hence, the human exposure to BPA could affect hormone levels and fertility, nervous system, immune system and liver metabolism. Because of these effects on the human health and given the likelihood of such migration, the presence of BPA in food is regulated by the European legislation which allows a maximum of 0.05 mg per kg of food (European Commission, 2018). This strict limit pushed can and bottle manufacturing companies to use other alternative chemicals, known as bisphenol F (BPF – CAS No 620-92-8) and bisphenol S (BPS – CAS No 80-09-1). These are compounds structurally similar to BPA, that can in turn alter the functioning of the endocrine regulation similarly to BPA, but that are not regulated by law (Chen et al., 2016). To avoid adverse health effect in the population due to BPA exposure, in the 2023 EFSA's CEP Panel (EFSA, 2023) established a new TDI of 0.0002 μg/kg body weight (bw), replacing the old temporary tolerable daily intake (t-TDI) of 4 μg/kg bw established by EFSA opinion in 2015 (EFSA, 2015).

BPA and bisphenol derivatives occurrence in soft drinks

To assess the occurrence and, consequently, the levels of BPA, BPF and BPS in carbonated soft drinks, an extraction protocol based on the work of Cao et al. (2021) was optimised. To validate the optimised protocol, the recovery for each one of the considered analytes was evaluated using different fortification levels in the sample. Hence, 10 mL of each sample, fortified with dBPA as internal standard, was subjected to ultrasound treatment followed by solid-phase extraction (SPE) using a C18 sorbent cartridge (500 mg, 6 cc). The elution solvent was removed by evaporation under reduced pressure, and the resulting extract was re-dissolved in 2 mL of a 1:4 (v/v) MeOH:H_2O mixture. To analyse the extracted analytes, a method validated during the study was used. For the ultra-performance liquid chromatography–high-resolution mass spectrometry (UPLC-HRMS) analysis, 2.5 μL of extract were injected into a Vanquish LC system (Thermo Fischer Scientific, Waltham, MA, USA) connected to a Q Exactive Focus Orbitrap mass spectrometer (Thermo Fischer Scientific, Waltham, MA, USA). The LC system was composed by autosampler, oven and reverse phase column (Acquity UPLC BEH C18 1.7 μm, 2.1 mm × 100 mm). The analysis was performed using electrospray ionisation (ESI) on negative mode. Hence, the analytes were separated exploiting a gradient elution with a mobile phase consisting of a 9:1 (v/v) H_2O:MeOH mixture with 1 mM of ammonium fluoride (solution A) and of a 8:2 (v/v) MeOH:H_2O mixture with 1 mM of ammonium fluoride (solution B). The gradient elution, with a flow rate of 0.3 mL/min, was composed as follows: 0–3 min, isocratic elution 0% B; 3–12 min, linear gradient from 0% B to 100% B; 12–20 min, isocratic elution 100% B. Each analyte of interest was quantified using a linear regression model.

The left-censored data were handled according to the upper bound (UB) approach that is the most conservative one. Hence, the occurrence was calculated by replacing all the left-censored data with the limit of quantification (LOQ).

BPA exposure

To estimate chronic exposure to BPA for each population group, the BPA P95 UB occurrence determined in the analysed soft drinks, expressed as μg/g of food, was multiplied by the average soft drink consumption, expressed as g/kg bw per day, of each population group (see below the reported equation).

$$\text{Exposure}\left[\frac{\mu\text{g of BPA}}{\text{kg bw}}\right] = \text{Occurence}\left[\frac{\mu\text{g of BPA}}{\text{g of food}}\right] \times \text{Consumption}\left[\frac{\text{g of food}}{\text{kg bw}}\right]$$

Risk characterisation

To understand if there is health concern about the exposure to BPA through the consumption of soft drinks, the BPA TDI was compared with the chronic dietary exposure values obtained for each of the considered groups. In all the groups, the exposure to BPA exceeds the TDI set by EFSA in 2023, raising health concerns. It has to be noted that the BPA quantity in the soft drinks is below the maximum limit of 0.05 mg per kg of food allowed by the European legislation (European Commission, 2018).

2.2.2. Cadmium exposure in different Polish population groups consuming chocolate bars

To work on this topic, two assessment questions were posed:

'What is the occurrence of cadmium in chocolate bars?';
'How high is the dietary exposure of different Polish population group to cadmium?'

Food matrix

Chocolate is eaten all over the word and its consumption is associated with pleasure and happiness. Poland is one of the European countries with the highest chocolate consumption. For this reason, it could be interesting to estimate the risk associated with the consumption of chocolate bars. Hence, several chocolate bars, produced from different brands and with different percentages of cocoa, were purchased from supermarkets in the city of Warsaw, Poland.

According to the EFSA's standardised food classification and description system FoodEx2 (catalogue MTX version 12.0), the selected matrices are labelled as 'Bitter chocolate [A034G]' and 'Milk chocolate [A034J]' both of them belonging to the broad category 'Chocolate and similar [A0EQD]'. The Bitter chocolate matrix is described as 'The group includes any type of Bitter chocolate, such as Dark chocolate and Plain chocolate, usually containing at least 35% total dry cocoa solids, with no milk or much less than milk chocolate and with no sugar or small amount of sugar. The part consumed/analysed is by default the whole or a portion of it representing the observed heterogeneity'; the Milk chocolate matrix is described as 'The groups includes any type of Milk chocolate, i.e. a sweet chocolate obtained from cocoa products, sugar and milk or milk products. According to EU legislation (Directive 2000/36/EC; European Parliament and European Union Council, 2000) milk chocolate has to contain not less than 14% dry milk solids and not less than 3.5% milk fat. The part consumed/analysed is by default the whole or a portion of it representing the observed heterogeneity'. All the purchased chocolates were stored at room temperature according to market storage conditions.

Chocolate consumption

As for the 'Soft drinks', the consumption data for the two food categories 'Milk chocolate' and 'Bitter chocolate' (Exposure hierarchy level 5) for different population groups are based on the IZZ-FAO 2000 survey (Szponar et al., 2001; Sekula et al., 2004). The data, taken from the EFSA Comprehensive Food Consumption Database, are shown in Table 2.

Table 2: 'Milk chocolate' and the 'Bitter chocolate' consumption in the three different population groups considered (other children, adolescent and adult)

Population group	Exposure hierarchy (L5)	g/kg bw
Other children – from 36 months up to and including 9 years of age	Milk chocolate	0.18
Adolescent – from 10 up to and including 17 years of age	Milk chocolate	0.07
Adult – from 18 up to and including 64 years of age	Milk chocolate	0.02
Other children – from 36 months up to and including 9 years of age	Bitter chocolate	0.06
Adolescent – from 10 up to and including 17 years of age	Bitter chocolate	0.03
Adult – from 18 up to and including 64 years of age	Bitter chocolate	0.01

bw: body weight.

Cadmium

Cadmium (Cd – CAS number 7440-43-9) is a heavy metal that naturally occurs in its inorganic form in the environment. In parallel to the natural sources of Cd, its anthropogenic sources contribute to increase the level of Cd in the environment. Cd does not have any known biological function in humans, it can be absorbed from diet and accumulates in kidneys and liver, with a biological half-life of 10–35 years. Over time, its accumulation can create several health adverse effects including renal dysfunction, renal failure and osteomalacia (EFSA Panel on Contaminants in the Food Chain (CONTAM), 2009).

Cadmium in chocolate derives from the cocoa beans and not from processing contamination (Vanderschueren et al., 2021; Bravo et al., 2022). The cocoa tree (*Theobroma cacao* L.) is particularly effective in up taking Cd from soil. Hence, the Cd content in *T. cacao* depends on its presence in soil and on soil pH, which influences Cd availability (Vanderschueren et al., 2021; Bravo et al., 2022; Wade et al., 2022). Because Cd tends to accumulate in cocoa shells rather than in nibs, the processing steps where shells are removed from the nibs is essential to reduce Cd content in cocoa products (Bravo et al., 2022). Since after this step Cd content in chocolate depends only by the percentage, the quality and the origin of cocoa used (Kruszewski et al., 2018; Vanderschueren et al., 2021; Bravo et al., 2022; Wade et al., 2022), the European legislation (European Commission, 2006, 2021) set a maximum level of Cd allowed in different type of chocolate (Table 3).

Table 3: Maximum level of cadmium allowed in chocolate according to European legislation

Foodstuff	Maximum level (μg/g wet weight)
Milk chocolate with < 30% total dry cocoa solids	0.10
Milk chocolate with ≥ 30% total dry cocoa solids Chocolate with < 50% total dry cocoa solids	0.30
Chocolate with ≥ 50% total dry cocoa solids	0.80

bw: body weight.

To protect the population from adverse health effect, in the 2009 the EFSA's CONTAM panel (EFSA Panel on Contaminants in the Food Chain (CONTAM), 2009) established a tolerable weekly intake (TWI) of 2.5 μg/kg bw.

Cadmium occurrence in chocolate bars

According to the European standard EN 13805:2014 (European Committee for Standardization, 2014), to determine the occurrence of Cd in chocolate, 0.250 g of sample were weighted and subjected to microwave-assisted mineralisation after adding 5 mL of 67–69% nitric acid, 1 mL of 30% hydrogen peroxide and 200 μL of yttrium solution (10 μg/mL) as an internal standard. The microwave-assisted mineralisation was performed with a power of 1800 W to reach the temperature of 210°C in 20 min and to maintain it constant for other 20 min, for a total mineralisation time of 40 min using an Ethos Up high-performance microwave digestion system (Milestone). Two blank samples were subjected to the mineralisation process, as well. After the mineralisation process, real and blank samples were transferred and recovered into a 25 mL volumetric flask. The final volume was made up to 25 mL with water. In parallel, two standard mixtures were prepared in a final volume of 25 mL. The first solution was prepared by adding 1 mL of 67–69% nitric acid and yttrium to obtain a final concentration of 0.08 μg/mL. The second standard solution was prepared by adding 1 mL of 67–69% nitric acid, yttrium to obtain a final concentration of 0.08 μg/mL and cadmium to obtain a final concentration of 4 ng/mL.

To measure the cadmium level in chocolate, it was decided to use the ICP-MS analysis method, as it is one of the methods that fulfil the performance criteria set by Regulation No 333/2007 (European Commission, 2007). The Cd analysis was performed using an iCAP RQ ICP-MS (Thermo Scientific) according to an in-house method based on the European standard EN 15763:2009 (European Committee for Standardization, 2009). A kinetic energy discrimination (KED) module filled with helium was used and Cd quantification was performed with external standard calibration curve. Five readings for each sample were performed. The LOQ of this analysis method is 0.001 μg/g.

No left-censored data were present. The occurrences resulted from the analysis of the two different chocolate groups are reported in Table 4.

Table 4: Median and P95 of Cd occurrence in the two analysed chocolate matrices

Matrix	Median (μg/g wet weight)	P95 (μg/g wet weight)
Milk chocolate	0.018	0.029
Bitter chocolate	0.126	0.149

The cadmium occurrence in each chocolate group resulted to be lower than the maximum level of cadmium allowed in chocolate by the European legislation (European Commission, 2006, 2021). It has to be noted that the 'bitter chocolate' group can be subdivided into 'Chocolate with < 50 % total dry cocoa solids' and 'Chocolate with ≥ 50% total dry cocoa solids'. To compare the Cd level in chocolate with the maximum level of Cd allowed by the European legislation, the Cd level of each of these two subcategories was considered separately.

Cadmium exposure

As for BPA, to estimate the chronic exposure to Cd for each population group, Cd P95 occurrence determined in the analysed chocolates, expressed in μg/g of food, was multiplied by the average chocolate consumption, expressed in g/kg bw per day, of each population group. As Cd is a contaminant that accumulates in the body, the exposure was multiplied by 7 to have a weekly exposure. See below the reported equation. The weekly exposure values are reported in Table 5.

$$\text{Exposure}\left[\frac{\mu\text{g of Cd}}{\text{kg bw}}\right] = \text{Occurence}\left[\frac{\mu\text{g of Cd}}{\text{g of food}}\right] \times \text{Consumption}\left[\frac{\text{g of food}}{\text{kg bw}}\right] \times 7$$

Table 5: Weekly Cd exposure values for the two chocolate matrices for each of the three different population groups. Occurrence and consumption are also reported.

Population group	Foodstuff	Occurrence (μg/g ww)	Consumption (g/kg bw)	Weekly exposure (μg/kg)
Other children – from 36 months up to and including 9 years of age	Milk chocolate	0.029	0.18	0.037
	Bitter chocolate	0.149	0.06	0.063
Adolescent – from 10 up to and including 17 years of age	Milk chocolate	0.029	0.07	0.014
	Bitter chocolate	0.149	0.03	0.031
Adult – from 18 up to and including 64 years of age	Milk chocolate	0.029	0.02	0.004
	Bitter chocolate	0.149	0.01	0.010

Risk characterisation

To understand if there is health concern about the exposure to Cd through the consumption of milk chocolate and bitter chocolate, the Cd TWI was compared with the chronic dietary exposure values obtained for each of the considered groups. In all the groups, the exposure to Cd is lower than the TWI of 2.5 μg/kg bw set by EFSA in 2009. Hence, the Cd exposure by chocolate consumption does not currently raise any health concern.

3. Conclusion

During the year, the fellow had the opportunity to gain knowledge and experience in the chemical risk assessment field through a theoretical and a practical training. With the bibliographic research, the fellow stepped into the chemical risk assessment dealing with the regulatory part of food safety and understanding the chemical contaminant risk, the contaminant types and their possible negative health effects. During the laboratory work, the fellow gained a practical knowledge on ICP-MS and LC–MS analysis, on developing and validating an analytical method and on sample preparation for heavy metal analysis. All this was possible thanks to the learning-by-doing approach that allowed the fellow to use both the hosting site expertise and the new knowledge acquired during the EU-FORA training modules to deal with practical problems and to perform BPA and Cd risk characterisation in different Polish population groups. The data produced during the internship will be exploited for scientific paper writing, that will contribute to reinforce cooperation between research institutes and to develop and define the fellow's future career.

In addition, the programme allowed the fellow to grow from a professional point of view giving a scientific base and all the necessary tools to understand and critically analyse food-related toxicity issues. All in all, the EU-FORA programme was an important meeting point where to network with international experts and fellows to exchange ideas and build useful scientific connections.

4. Other activities

In addition to the work activities carried out at the hosting site, the opportunity to attend several conferences during this year was important in order to share with the scientific community the collected data and ideas developed in the framework of this project. The main relevant conferences are listed in Table 6.

Table 6: Main conference attended by the fellow during the EU-FORA programme

Type of event	Title	Contribution	Date	Place
Conference	21th National Congress of Italian Society of Toxicology (SITOX)	Poster presentation: Determinazione del livello di contaminazione di bisfenolo A e dei suoi derivati in bibite gassate in lattina presenti sul mercato polacco	From 20 February 2023 to 22 February 2023	Bologna, Italy
Conference	9th EBF Young Scientist Symposium	Poster presentation: BPA exposure in different population groups consuming canned carbonated beverages	From 11 May 2023 to 12 May 2023	Hasselt, Belgium

Disclaimer

To avoid copyright issues, all BPA data were not showed in this technical report as these data are intended to be published in a peer-reviewed journal.

References

Bravo D, Santander M, Rodríguez J, Escobar S, Ramtahal G and Atkinson R, 2022. “From soil to chocolate bar”: identifying critical steps in the journey of cadmium in a Colombian cacao plantation. Food Additives & Contaminants. Part A, Chemistry, Analysis, Control, Exposure & Risk Assessment, 39(5), 949–963.

Cao P, Zhong HN, Qiu K, Li D, Wu G, Sui HX and Song Y, 2021. Exposure to bisphenol A and its substitutes, bisphenol F and bisphenol S from canned foods and beverages on Chinese market. Food Control, 120, 107502.

Chen D, Kannan K, Tan H, Zheng Z, Feng YL, Wu Y and Widelka M, 2016. Bisphenol analogues other than BPA: environmental occurrence, human exposure, and toxicity – a review. Environmental Science & Technology, 50 (11), 5438–5453.

EFSA CEF Panel (EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids), 2015. Scientific opinion on the risks to public health related to the presence of bisphenol A (BPA) in foodstuffs. EFSA Journal 2015;13(1):3978, 1040 pp. https://doi.org/10.2903/j.efsa.2015.3978

EFSA CEP Panel (EFSA Panel on Food Contact Materials, Enzymes and Processing Aids), 2023. Scientific opinion on the re-evaluation of the risks to public health related to the presence of bisphenol A (BPA) in foodstuffs. EFSA Journal 2023;21(4):6857, 392 pp. https://doi.org/10.2903/j.efsa.2023.6857

EFSA Panel on Contaminants in the Food Chain (CONTAM), 2009. Scientific opinion on cadmium in food. EFSA Journal 2009;7(3):980, 1–13. https://doi.org/10.2903/j.efsa.2009.980

European Commission, 2002. Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.

European Commission, 2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs (Text with EEA relevance).

European Commission, 2007. Commission Regulation (EC) No 333/2007 of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs (Text with EEA relevance).

European Commission, 2018. Commission Regulation (EU) 2018/213 of 12 February 2018 on the use of bisphenol A in varnishes and coatings intended to come into contact with food and amending Regulation (EU) No 10/2011 as regards the use of that substance in plastic food contact materials (Text with EEA relevance).

European Commission, 2021. Commission Regulation (EU) 2021/1323 of 10 August 2021 amending Regulation (EC) No 1881/2006 as regards maximum levels of cadmium in certain foodstuffs (Text with EEA relevance).

European Committee for Standardization, 2009. Determination of arsenic, cadmium, mercury and lead in foodstuffs by inductively coupled plasma mass spectrometry (ICP-MS) after pressure digestion.

European Committee for Standardization, 2014. Foodstuffs - Determination of trace elements - Pressure digestion.

European Parliament and European Union Council, 2000. Directive 2000/36/EC of the European Parliament and of the Council of 23 June 2000 relating to cocoa and chocolate products intended for human consumption.

Kruszewski B, Obiedziński MW and Kowalska J, 2018. Nickel, cadmium and lead levels in raw cocoa and processed chocolate mass materials from three different manufacturers. Journal of Food Composition and Analysis, 66, 127–135.

Russo G, Barbato F, Mita DG and Grumetto L, 2019. Occurrence of Bisphenol A and its analogues in some foodstuff marketed in Europe. Food and Chemical Toxicology, 131, 110575.

Sekula W, Nelson M, Figurska K, Oltarzewski M, Weisell R and Szponar L, 2004. Comparison between household budget survey and 24-hour recall data in a nationally representative sample of polish households. Public Health Nutrition, 8(4), 430–439.

Szponar L, Sekula W, Nelson M and Weisell RC, 2001. The household food consumption and anthropometric survey in Poland. Public Health Nutrition, 4(5b), 1183–1186.

Vanderschueren R, Argüello D, Blommaert H, Montalvo D, Barraza F, Maurice L, Schrek E, Schulin R, Lewis C, Vazquez JL, Umaharan P, Chavez E, Sarret G and Smolders E, 2021. Mitigating the level of cadmium in cacao products: reviewing the transfer of cadmium from soil to chocolate bar. Science of the Total Environment, 781, 146779.

Vilarinho F, Sendón R, Van der Kellen A, Vaz MF and Silva AS, 2019. Bisphenol A in food as a result of its migration from food packaging. Trends in Food Science & Technology, 91, 33–65.

Wade J, Ac-Pangan M, Favoretto VR, Taylor AJ, Engeseth N and Margenot AJ, 2022. Drivers of cadmium accumulation in *Theobroma cacao* L. beans: a quantitative synthesis of soil-plant relationships across the Cacao Belt. PLoS One, 17(2), e0261989.

Wang H, Song S, Shao M, Gao Y, Yang C, Li Y, Wang W, He Y and Li P, 2019. Determination of bisphenol analogues in food-contact plastics using diode array detector, charged aerosol detector and evaporative light-scattering detector. Ecotoxicology and Environmental Safety, 186, 109778.

Abbreviations

BP	bisphenol
BPA	bisphenol A
BPF	bisphenol F
BPS	bisphenol S
bw	body weight
dBPA	deuterated BPA
EU-FORA	European food risk assessment
FAO	Food and Agriculture Organization of the United Nations
IAFB	Institute of Agriculture and Food Biotechnology – State Research Institute of Warsaw
ICP-MS	inductively coupled plasma-mass spectrometry
IŻŻ	Instytut Żywności i Żywienia (National Food and Nutrition Institute)
KED	kinetic energy discrimination
LC	liquid chromatography
LOQ	limit of quantification
MTX	FoodEx2 Matrix hierarchy
MW	microwave
PC	polycarbonate plastics
SPE	solid phase extraction
t-TDI	temporary tolerable daily intake
TDI	tolerable daily intake
TWI	tolerable weekly intake
UB	upper bound
UPLC-HRMS	ultra-performance liquid chromatography high-resolution mass spectrometry