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Implementation of food matrix effects into chemical food contaminant risk assessment

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Abstract

Food risk assessment plays an important role in protecting public health worldwide. Stakeholders involved in food risk assessment, such as national authorities, agencies, non-governmental organisations (NGOs), industry and consumers, need to properly understand the terminology of food risk assessment effectively. In this respect, the first part of the EU-FORA work programme (WP1) aimed to provide insights into the actual translation of two essential terms used in food risk assessment. 'Hazard' and 'risk' were first identified and compared between the English version of various food regulations and their equivalents in the national legislation of EU Member States. The comparison and critical evaluation revealed several inconsistencies. These inconsistencies could lead to misinterpretations, followed by errors in conducting risk assessments or communicating risks. We recommend that consistency is restored and maintained so that the message is properly communicated. The second part of the work programme (WP2) was focused on a specific area within chemical risk assessment (CRA). In this context, special attention was given to the impact of the food matrix on the bioaccessibility and bioavailability of heavy metals and metalloids. After collection and careful selection of data from scientific journals, a database with information on the bioaccessibility and bioavailability of cadmium (Cd), lead (Pb), mercury (Hg) and arsenic (As) in different food matrices was created for future statistical analyses related to dietary exposure.

Keywords: hazard, risk, food regulation, chemical contaminants, bioavailability, bioaccessibility, food matrix

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Declarations of interest: If you wish to access the declaration of interests of any expert contributing to an EFSA scientific assessment, please contact interestmanagement@efsa.europa.eu.

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1. Introduction

In a constantly changing environment, the safety of food for human consumption remains a priority. For this purpose, science about food risk assessment aims to protect public health as much as possible. The steps used in food risk assessment are hazard identification, hazard characterisation, exposure assessment and risk characterisation. All these steps revolve around the terms 'hazard' and 'risk' (EUFIC, 2019). The use of these terms as synonyms or their interchange is a problem that has not yet been overcome, despite awareness raised by European food authorities and organisations (EFSA Scientific Committee, 2012; EFSA, 2016, 2021; EUFIC, 2017, 2019). It is essential for all food safety stakeholders to differentiate between 'hazard' and 'risk'. On the one hand, risk assessors, risk managers and the food industry need to clearly understand these terms, as they play an important role in preventing and controlling hazards and minimising risks. On the other hand, consumers should be able to discriminate between these two terms in risk communication to get an accurate information of the food safety level. Precise definitions of these terms can be found in the Codex Alimentarius, the General Food Law and some other food regulations (xxxx, 2015; xxxx, n.d.-a, n.d.-b). Hazard refers to any physical, chemical or biological agent or condition with the potential to cause an adverse health effect. Risk is a function of the probability of occurrence of an adverse effect due to exposure to a hazard. Furthermore, recognising the difference between 'hazard' and 'risk' is a basic requirement for any food risk assessment, whether it is microbiological or chemical. Chemical contamination of food can arise from chemical substances in the environment during production, processing, packing, transport and storage. In most cases, residues of metals and metalloids originate from human-related activities (e.g. agriculture, industry, etc.). Compounds such as Cd, Pb, Hg and As can enter the human body after food consumption and cause disease or adverse effects over time (EFSA, 2009; EFSA CONTAM Panel, 2009, 2010, 2012). Given the increasing variety of foods available to consumers, it is important to provide information on how effectively contaminants from digested foods are absorbed into the systemic circulation. Once ingested, digestion of foods in the gastrointestinal tract can positively or negatively affect the bioaccessibility and bioavailability of substances, depending on the food matrix.

2. Programme description

2.1. Aims and objectives

2.1.1. WP1

The aim of WP1 was to identify inconsistencies in the translation of 'hazard' and 'risk' in the national food legislation of the EU Member States. Understanding and using these terms correctly supports more accurate assessments and ensures effective communication between stakeholders such as assessors, managers and the general public. Interaction with the EU-FORA community and representatives of some EFSA focal points was maintained during this task to seek the opinion of native speakers of the official EU languages, who are also experts with background knowledge in food safety, on the correct translations. At the same time, this action served to network and build professional relationships between food safety experts.

2.1.2. WP2

The aim of WP2 was to find data on the bioaccessibility and bioavailability of Cd, Pb, Hg and As from different food matrices to build a database in a form that it will allow statistical analysis.

2.2. Activities and methods

2.2.1. WP1

First, a software tool was developed to identify inconsistencies in translation based on the comparison between national food regulations of EU Member States and their corresponding English version. With the help of this tool, we were able to speed up the process of comparing food regulations in English with their counterparts in each of the official EU languages: Bulgarian, Czech, Spanish, Danish, German, Estonian, Greek, French, Gaelic, Croatian, Italian, Latvian, Lithuanian, Hungarian, Maltese, Dutch, Polish, Portuguese, Romanian, Slovak, Slovenian, Finnish and Swedish.

Emphasis was placed on the Regulations where food risk assessment terminology occurs most frequently and on specific words such as 'hazard' and 'risk'. The old versions of the Regulations were reviewed in parallel with the new versions (Figure 1). All specific terms are defined in Regulation (EC) 178/2022 (Chapter I. Scope and Definitions) and Regulation (EC) 625/2017 (Title I. Article 3. Definitions) for each language. This served as a reference point to determine whether a translation is consistent or inconsistent with selected definitions of hazard or risk. Following the collection of inconsistencies in the selected regulations, a survey was prepared and different experts involved in food risk assessment who are also native speakers of the official EU languages were asked to participate. At least one native speaker of each language completed the survey. The results of the survey were expressed as marks from 1 (consistent) to 5 (inconsistent) (Figure 2). The marks were collected in pivot tables in Excel. The collected data was statistically analysed by different methods, e.g. clustering.

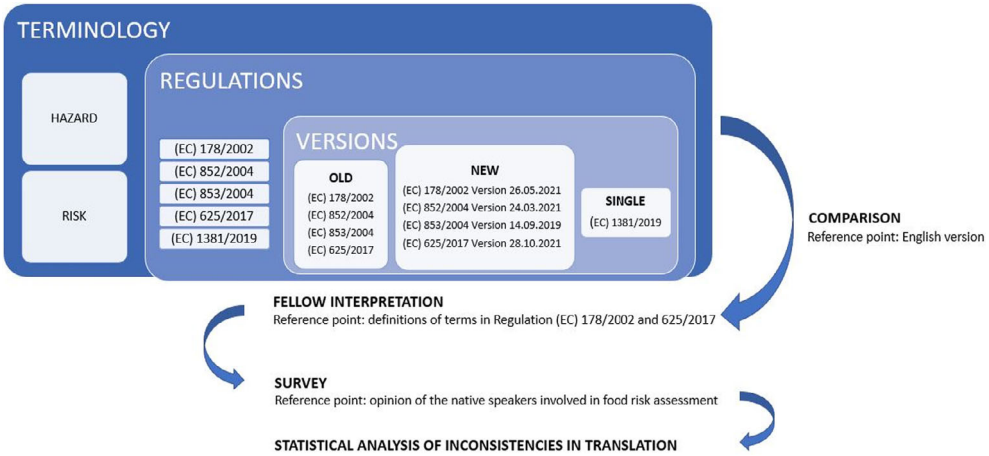

Figure 1: WP1 flow chart

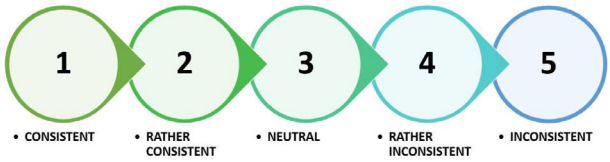

Figure 2: Marking system

2.2.2. WP2

The screening was conducted to collect data from scientific journals published between 2002 and 2022. The number of selected articles that were included into the database was 122 (see Figure 3 for the detailed process).

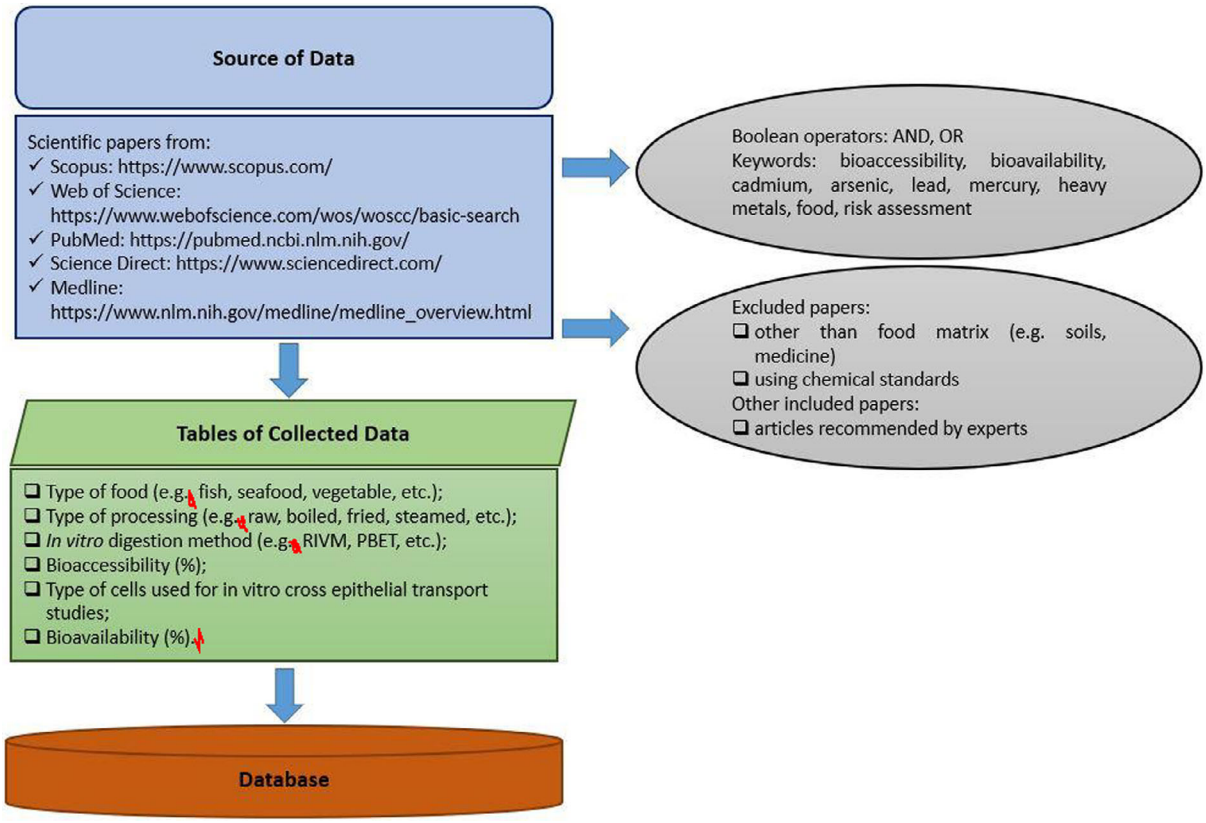

Figure 3: WP2 flow chart

3. Conclusions

3.1. WP1

The results showed inconsistencies in translation in all the regulations studied and for all official EU languages except Gaelic. Inconsistencies in translation include using the 'hazard' instead of 'risk' and vice versa, but also issues that are specific to some languages only. Specific problems include interchanging risk assessment with risk determination (Spanish), translating hazard to source of danger or risk (Greek) and translating hazard as risk factor (Greek, Slovenian and Lithuanian). In most cases, the native speakers confirmed our results, as seen in Figure 4. In very few cases where opinions diverged, we argued with the definitions of terms from Regulation (EC) 178/2022 and Regulation (EC) 625/2017, while the native speakers argued for linguistic freedom. In this case, linguistic freedom stems from the fine distinction between the meaning of 'hazard' and 'risk' in some languages and the degree of rigour in using technical terminology used by different experts in specific contexts. In the old versions of the regulations, the highest number of inconsistencies was found in Lithuanian (48). For the new versions of the regulations, the results showed that the Greek regulations have the highest number of inconsistencies, namely 36. Overall, the newer versions of the regulations (EC) 178/2002, 852/2004, 853/2004 and (EC) 625/2017 have a lower number of inconsistent translations than the old versions. However, revisions are still necessary. Regulation (EC) 1381/2019 has the lowest absolute number of problematic translations. In conclusion, we recommend correcting all regulations containing inconsistent translations of terms related to food risk assessment. Accurate translations should strictly follow the technical terms defined in Regulation (EC) 178/2022 and Regulation (EC) 625/2017. Any deviation from the definitions could lead to misinterpretations that complicate the understanding of 'hazard' and 'risk' for food safety stakeholders (Scheer et al., 2014).

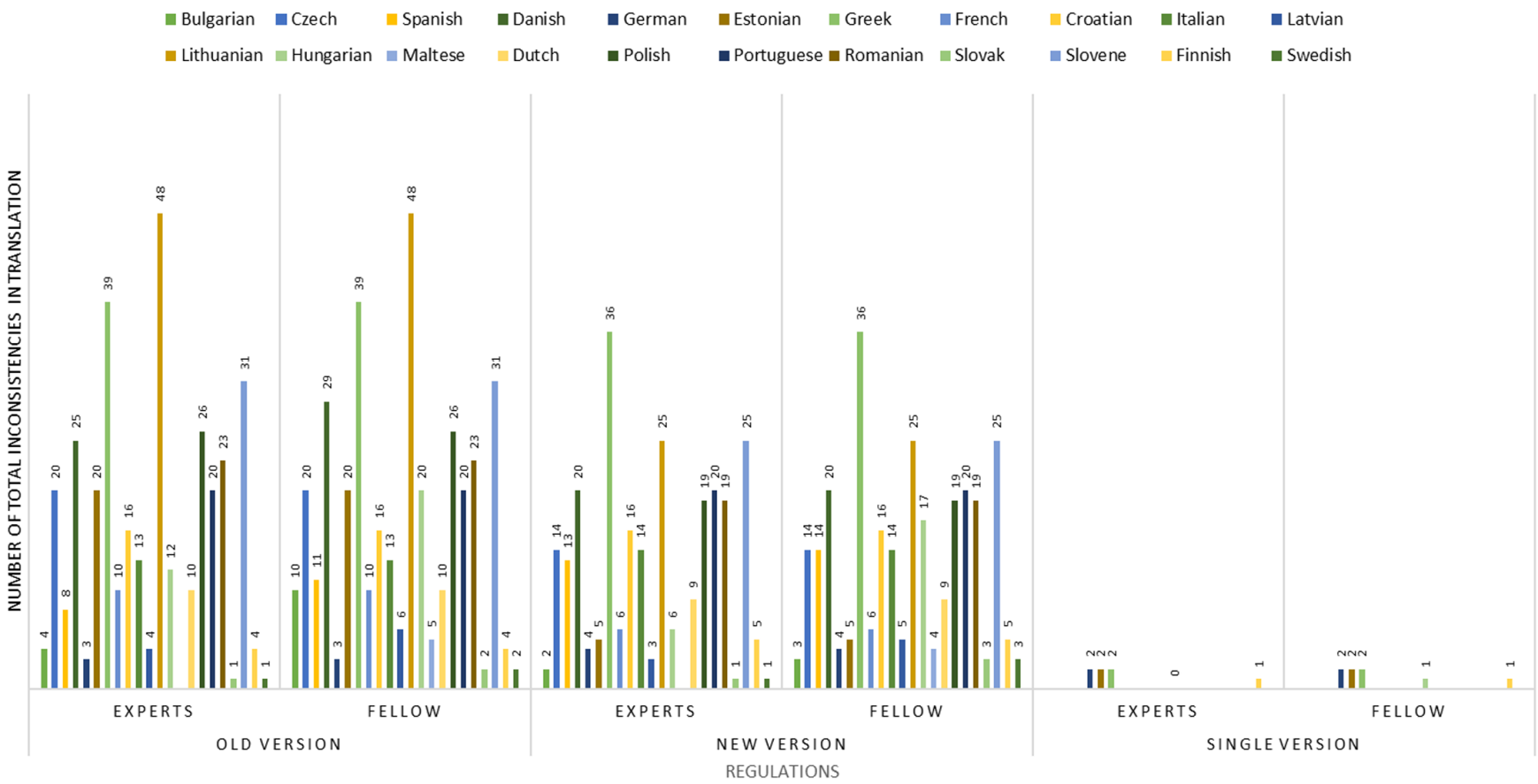

Figure 4: Comparison of total inconsistencies in translation. Old version – Regulations (EC) 178/2002, 852/2004, 853/2004 and 625/2017; New version – Regulations (EC) 178/2002, 852/2004, 853/2004 and 625/2017; Single version – Regulation (EC) 1381/2019.

3.2. WP2

The selected data included into our database contained information on bioaccessibility and bioavailability of heavy metals or metalloids in matrices such as fish, seafood, rice, vegetables, seaweed, mushrooms, etc. Studies on bioaccessibility were more commonly found than studies on bioavailability. Statistical processing of preliminary extracted data showed differences in the bioaccessibility of the individual chemical contaminants depending on the food matrix. The results presented in Figure 5 describe bioaccessibility in different foods, which was determined using average values from several *in vitro* studies. Although the data can be grouped in a more refined manner (e.g. groups for the exact type of fish, vegetables, mushrooms, etc.), the plots are sufficient to highlight the importance of the effects of the food matrix. In addition, the database provides access to some relevant information that could be considered in future research. It confirms the contribution of some factors to the bioaccessibility and bioavailability of heavy metals and metalloids. These are food processing factors (e.g. cooking, frying, grilling, steaming, etc.), factors related to *in vitro* analysis (e.g. *in vitro* method) or characteristics associated with the chemical element (e.g. speciation in the case of elements such as As, Hg). The existence of databases that collect knowledge in this area can improve chemical food risk assessment by incorporating the effects of the food matrix into the exposure assessment. This approach allows a more realistic understanding of the risks to human health.

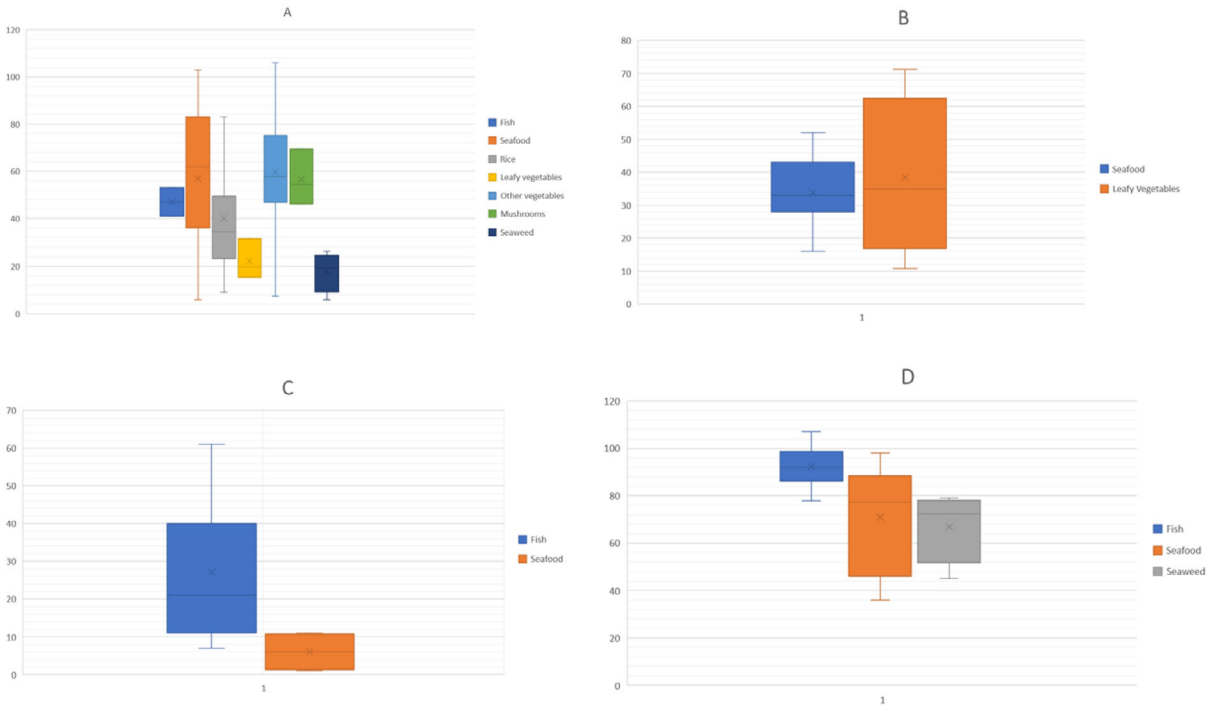

Figure 5: Cd (A), Pb (B), Hg (C) and As (D) bioaccessibility (%) in food

3.3. EU-FORA experience

It was a significant opportunity for the fellow to deepen her knowledge of food risk assessment terminology. The work programme enabled her to analyse and draw conclusions about the use of 'hazard' and 'risk' in oral and written communication. Understanding how these terms differ from each other was an important first step. After this clarification, the fellow was ready to expand her knowledge of food chemical risk assessment (CRA) and to address complex issues such as food matrix effects in bioaccessibility and bioavailability of heavy metals.

In addition to the individual research work, the fellow engaged EU-FORA fellows, Alumni and other relevant potential collaborators to complete her WP1 task. The achievement of interesting final results resulted from a combination of independent work and collaboration. This reinforced the idea that the EU-FORA programme provides a valuable context for building a professional network from the beginning of the fellowship.

In addition, the fellow participated in complementary activities to deepen the experience (described in Appendix A).

3.4. Disclaimer

More detailed results are excluded from this report to avoid specific copyright claims as they are intended for publication in scientific journals.

References

EFSA (European Food Safety Authority), 2009. Scientific opinion of the panel on contaminants in the food chain on a request from the European Commission on cadmium in food. EFSA Journal 2009:980, 139 pp. https://doi.org/10.2903/j.efsa.2009.980

EFSA (European Food Safety Authority), Infographic, 2016. Hazard vs risk. Available online: https://www.efsa.europa.eu/sites/default/files/images/infographics/hazard-vs-risk-2016.pdf [Accessed: 20 April 2022].

EFSA (European Food Safety Authority), Laura Maxim, Mario Mazzocchi, Stephan Van den Broucke, Fabiana Zollo, Tobin Robinson, Claire Rogers, Domagoj Vrbos, Giorgia Zamariola, Anthony Smith, 2021. Technical assistance in the field of risk communication. EFSA Journal 2021;19(4):6574, 113 pp. https://doi.org/10.2903/j.efsa.2021.6574

EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain), 2009. Scientific opinion on arsenic in food. EFSA Journal 2009;7(10):1351, 199 pp. https://doi.org/10.2903/j.efsa.2009.1351

EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain), 2010. Scientific opinion on lead in food. EFSA Journal 2010;8(4):1570, 151 pp. https://doi.org/10.2903/j.efsa.2010.1570

EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain), 2012. Scientific opinion on the risk for public health related to the presence of mercury and methylmercury in food. EFSA Journal 2012;10(12):2985, 241 pp. https://doi.org/10.2903/j.efsa.2012.2985

EFSA Scientific Committee, 2012. Scientific opinion on risk assessment terminology. EFSA Journal 2012;10(5):2664, 43 pp. https://doi.org/10.2903/j.efsa.2012.2664

EUFIC (European Food Information Council), Infographic, 2017. Difference between hazard and risk. Available online: https://www.eufic.org/images/uploads/understanding-science/Hazard_Vs_Risk_-_Print_-_en.pdf [Accessed: 20 April 2022].

EUFIC (European Food Information Council), 2019. What are food safety risk assessments and why are they used? Available online: https://www.eufic.org/en/food-safety/article/what-are-food-safety-risk-assessments-and-why-are-they-used [Accessed: 22 July 2022].

European Commission, 2002. Commission Regulation 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, 178/2002/EC. Official Journal, 2002, L31.

European Commission, 2017. Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products, amending Regulations (EC) No 999/2001, (EC) No 396/2005, (EC) No 1069/2009, (EC) No 1107/2009, (EU) No 1151/2012, (EU) No 652/2014, (EU) 2016/429 and (EU) 2016/2031 of the European Parliament and of the Council, Council Regulations (EC) No 1/2005 and (EC) No 1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC (Official Controls Regulation)Text with EEA relevance. Official Journal, 2017, L 95/1.

FAO and WHO, 2015. CODEX ALIMENTARIUS COMMISSION. PROCEDURAL MANUAL, 23rd edition. Available online: https://www.fao.org/3/i4354e/i4354e.pdf [Accessed: 4 April 2022].

Scheer D, Benighaus C, Benighaus L, Renn O, Gold S, Röder B and Böl GF, 2014. The distinction between risk and hazard: understanding and use in stakeholder communication. Risk Analysis, 34, 1270–1285.

Abbreviations

CRA	chemical risk assessment
NGOs	non-governmental organisations
PBET	physiologically based extraction technique
RIVM	Dutch National Institute for Public Health and the Environment
WP1	1st part of the work programme
WP2	2nd part of the work programme

Appendix A – Secondary activities

Additional relevant activities and learning opportunities completed by the fellow:

- Induction training of the European Food Risk Assessment Fellowship Programme' (EFSA) (30 August–17 September 2021 – virtual).
- Visit to 'Jožef Stefan Institute' in Ljubljana (23 September 2021) (www.ijs.si).
- SPSS Statistics lecture by coordinator Assist. Prof. Livija Tušar (14 October 2021, 8 November 2021 and 22 November 2021).
- 'Module 1 training of the European Food Risk Assessment Fellowship Programme' (EFSA) (22–26 November 2021 – virtual).
- Visit to the renovated unit of the National Veterinary Institute (NVI) from Maribor (29 November 2021) (https://www.vf.uni-lj.si/en/area/nvi-maribor).
- 'Module 2 training of the European Food Risk Assessment Fellowship Programme' (EFSA) (22–26 March 2022 – virtual).
- European Climate Pact Ambassador, DG CLIMA – European Commission (https://europa.eu/climate-pact/ambassadors/meet-our-ambassadors/ana-andreea-cioca_en#responsibilities) – volunteer (1 April 2022).
- SPSS Statistics lecture by coordinator Assist. Prof. Livija Tušar (30 May 2022).
- Field trip organised by the Department of Microbiology, Biochemistry, Molecular Biology and Biotechnology, University of Maribor for students of Food Safety Master Degree (23 May 2022):
  - Visit to 'Vinakoper', Koper, Slovenia – wine producing unit (https://www.vinakoper.si/sl/);
  - Visit to 'Laboratory of the Institute for Oliveculture', Koper, Slovenia – olive oil analysis unit (https://www.zrs-kp.si/index.php/en/institutes-units/lab-ifo/#1523593162108-9fa67f4a-f3ba).
- 'Module 3 training of the European Food Risk Assessment Fellowship Programme' (EFSA) (6–10 June 2022, Athens, Greece – onsite).
- Team building Faculty of Agriculture and Life Science, University of Maribor (13–14 June 2022):
  - Visit to 'Konda' organic farm, Bela Krajina, Slovenia (sheep breeding and rearing, milk processing, Konda dairy products, http://www.kmetija-konda.si/sirarna/),
  - Visit to Vina Prus, Metlika, Slovenia – wine producing unit (https://www.vinaprus.si/).
- Conference Pesticides 2022, Ioannina, Greece, 23–26 June 2022 (online attendance). One abstract entitled 'Food Matrix Effects on Bioaccessibility and Bioavailability of Heavy Metals' was accepted. A poster was presented in POSTER SESSION III of the day 25 June 2022, between 15:10 and 16:00.
- Onsite attendance to lecture 'Post-Harvest Technologies in Agriculture' by Visiting Professor Elazar Fallik from the Volcani Institute, Rishon LeZiyyon Israel (16 June 2022).
- Regular meetings with supervisors (onsite and online).
- Online attendance at numerous scientific webinars and conferences:
  - RAFA 2021. 'Virtual event highlighting current Trends & Views', Recent advances in food analysis 2021 (3–4 November 2021);
  - EDQC 2021. European Dairy Quality Conference 2021 (16–18 November 2021);
  - eSymposium 'MILK THISTLE – PHYTOCHEMICAL, PHARMACOLOGICAL AND CLINICAL EVIDENCE', Herbal Medicinal Products Platform Austria (HMPPA) and the Society for Medicinal Plant and Natural Product Research (GA) (18 November 2021);
  - Taylor and Francis Group: The Impact of Publishing (22 November 2021);
  - Webinar on good practices in poultry production (23 November 2021);
  - Taller Internacional One Health y Cambio Climático 2021 (29 November–1 December 2021);
  - Future of Food Conference 2021 (30 November–1 December 2021);
  - OASPA Webinar: The Fully Open Access Agreement – an Essential Component of a Diverse, Open Access World (6 December 2021);
  - Evidence-based Toxicology Collaboration (EBTC) December Symposium (14 December 2021);
  - Food Safety 4 EU 'Sustainable food: how to keep it safe?' (15 December 2021);
  - Future of Food – Alternative Protein Industry and Our Diet (17–21 January 2022);

- Why you should consider Göttingen Minipigs as your large animal model (25 January 2022);
- CiFOOD Conference 2022 – MAJOR CHALLENGES OF FUTURE FOOD SYSTEMS (31 January–1 February 2022);
- A good start for calves (3 February 2022);
- Breakfast Bite: Food Safety Training – What you Need to Know (10 February 2022);
- Nutrition basics: Protein in pig feed (3 March 2022);
- SUSTAINABLE FOOD PACKAGING, ECO DESIGNS AND COMMUNICATION TO CONSUMERS, RESULTS FROM MARKET ANALYSES BY THE CIRCUL-A-BILITY NETWORK (21 April 2022).
- Solving critical gut challenges innovations contributing to farm profitability (11 May 2022);
- ONE Conference (21–22 June 2022).

The fellow will also attend the following events before the end of the EU-FORA programme:

- 'Module 4 training of the European Food Risk Assessment Fellowship Programme' (EFSA) (22–25 August 2022);
- Conference FoodMicro2022, Athens, Greece, 28–31 August 2022 (online attendance with a poster accepted). Poster title: "Risk Analysis: Towards a Better Understanding of 'Hazard' and 'Risk'".