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Chemical and microbial risk assessment of wild edible plants and flowers

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Abstract

The document focuses on the chemical and microbial risk assessment of wild edible plants (WEPs) and flowers, highlighting potential risks from heavy metals, pesticides and microorganisms. WEPs are valuable for human nutrition and gastronomy, offering essential compounds and health benefits. They are also seen as a sustainable food source. The study used various data sources and methodologies, including microbiological load and heavy metals' analysis, to assess the risks associated with WEPs. Consumption data were gathered to comprehensively assess exposure assessment. This document provides detailed recommendations for risk characterisation and management to mitigate potential health hazards associated with WEPs. The document was developed as part of the EU-FORA fellowship programme, which aims to enhance food risk assessment expertise through training to ensure preparedness for future risk analysis needs.

KEYWORDS

edible flowers, exposure assessment, food safety, heavy metals, microbiological testing, risk assessment, wild edible plants

CONTENTS

SUMMARY

The final report of the EU-FORA fellowship programme, entitled 'Chemical and microbial risk assessment of wild edible plants and flowers', defines the work programme and description of the activities undertaken by the fellow during its implementation. This programme was developed by the fellow María Carpena Rodríguez, MSc. hosted by the Warsaw University of Life Sciences–SGGW under the supervision of Dr. Monika Trząskowska and awarded by EFSA to the University of Vigo (UVIGO) in Spain as sending institution under the supervision of Dr. Miguel A. Prieto. This technical report includes the description of the applied methodologies and part of the assessment results. As part of the programme, a scientific article is ongoing and thus, some outcomes are not presented in this report.

Plants have been frequently reported in literature for their health-related properties, as food and more recently, as a source to obtain bioactive molecules and formulate novel foods. Wild edible plants, both herbs and flowers, (WEPs) may contain compounds of biological value, but they may also contain harmful compounds. The primary objective of the work programme was to develop a comprehensive assessment of health risks associated with WEPs based on the methodology recommended by EFSA. The research was divided into six main tasks: (1) creating a risk profile of WEPs, (2) hazard identification, (3) hazard characterisation, (4) exposure assessment, (5) risk characterisation and 6) data analysis. As part of the programme, four plants from the Lamiaceae family, which are commonly consumed in Europe, were selected for analysis: basil (*Ocimum basilicum*), oregano (*Origanum vulgare*), rosemary (*Salvia rosmarinus*) and thyme (*Thymus vulgaris*). Additionally, due to the increasing popularity of edible flowers, two species were included in the study: dandelion (*Taraxacum officinale*) and cornflower (*Centaurea cyanus*).

The document focuses on assessing the risks associated with consuming WEPs. These risks include chemical risks, arising from heavy metals, pesticides and other contaminants that can accumulate in plants. The study highlights the presence of substances like chlorpyrifos, ethylene oxide, pyrrolizidine alkaloids, aflatoxin B1 and ochratoxin A. It also includes microbial risks, including contamination by pathogens such as *Salmonella*, *Bacillus cereus*, *Escherichia coli*, *Listeria monocytogenes* and *Clostridium perfringens*. The document notes that basil is particularly prone to microbial contamination.

The study employed a comprehensive approach to assess the risks associated with WEPs, including (a) data collection utilising EFSA and EU databases to gather data on chemical and microbiological hazards, (b) microbiological quality testing through pour plate or surface seeding methods to test the occurrence of microbial contamination on representative samples of herbs and flowers, (c) heavy metals analysis using inductively coupled plasma optical emission spectrometry (ICP-OES) to quantify the concentrations of heavy metals in the plant samples, (d) exposure assessment to analyse the patterns of consumption based on literature and database searches and (e) risk characterisation to estimate the probability and severity of health effects from the identified hazards.

The report highlights the importance of the effective risk assessment, management and communication, to achieve a high level of protection for human health and safety. The fellow's contributions to the project support the goal of enhancing risk assessment models and increasing the pool of experts in Europe to ensure that food industry practices adhere to food safety standards.

1 | INTRODUCTION

Since ancient times, humans have consumed wild edible plants (WEPs) located in their surroundings. This term refers to all non-domesticated plants that grow and reproduce naturally in self-sustaining populations, independent of direct human intervention and are collected from forests and bushlands for human nutrition (Shaheen et al., 2017). WEPs encompass a diverse array of plant life and botanical features such as herbs, forbs, vines, sedges, rushes, grasses, shrubs, trees and ferns (Carvalho & Barata, 2016). Most traditionally, the term 'herbs' refers to plant leaves while flowers, seeds, rhizomes, roots, barks, arils and pods are encompassed under the term 'spices' (El-Sayed & Youssef, 2019). WEPs can be consumed in different ways: as snacks, in salads, herbal teas, alcoholic beverages and cooked in traditional recipes, among others (Pinela et al., 2017). Nowadays, WEPs are being re-evaluated and hold economic, nutritional and environmental importance. Numerous studies have demonstrated that WEPs are a good source of essential compounds for the human diet, such as carbohydrates, proteins and lipids (Datta et al., 2019). They have recently been proposed as a new source of food to address the gap between food production and demand. Consequently, re-recovering knowledge about these plants, as well as investigating new applications are important goals. WEPs not only present a high nutritional value, but they also have great culinary value, due to their organoleptic characteristics. They are considered as appealing gastronomic resources for modern culinary experiences (Carvalho & Barata, 2016). WEPs may contain compounds of biological value, such as phenolic compounds, carotenoids, vitamins, fibre or minerals. These non-nutritional bioactive compounds exert beneficial bioactivities like antioxidant, anti-binding, anti-inflammatory or antitumour activity (Shaheen et al., 2017). They also represent an opportunity to develop natural and sustainable food additives (Sánchez-Mata et al., 2012; Sibiya et al., 2021). Besides, WEPs' ethnobotany has been considered to be one of the most suitable approaches and foundations for the screening of candidates for the development of novel foods (Gras et al., 2021).

However, there are some risks associated with these raw materials, either from the compounds present in the plants themselves (such as some alkaloids and monoterpenes) or from bioaccumulated compounds derived from human activity (such as heavy metals or pesticides) (Ali et al., 2021; Haile et al., 2018). For example, pesticides are widely used in conventional crops and nowadays, most of WEPs are cultivated so the probability of finding pesticides residues is relevant (Besil et al., 2017). In addition, special attention should be given to the absorption of micro- and nano-plastics to/by plants, and their subsequent potential effects of exposure on human health (Karalija et al., 2022; Rodríguez-Pérez et al., 2023).

The renewed interest in WEPs has led to an increase in the cases of poisoning, in many cases due to the plant misidentification (Cornara et al., 2018). In this regard, the legislation is not so strict, mainly because WEPs are less common, and in most cases, toxic plants are bitter, so they are not as attractive to the consumer (Sánchez-Mata & Tardío, 2016). In addition, not all plants have the same degree of toxicity. Some plants can cause the death at low concentrations while others will only have effect in sensitive people (e.g. allergies). Currently, there are two Compendiums of Botanicals by European Food Safety Authority (EFSA) regarding botanical aspects and comprising wild flora. The first one compiles plants reported containing naturally occurring substances of possible concern for human health when used in food and food supplements (EFSA, 2012), while the second one collects botanicals reported to contain toxic, addictive, psychotropic or other substances of concern (EFSA, 2017).

This area offers a remarkable goal in terms of risk assessment that will lead to knowledge generation about toxicity, bioactive compounds and related benefits. With this purpose, update the legislation periodically and put the eye on the consumer safety must be a priority. These raw materials must be subjected to continuous evaluations to check their potential risk. Therefore, it becomes imperative to document and preserve knowledge on wild foods, preserve its habitat and to evaluate its risk, especially in remote areas (Geng et al., 2016; Sánchez-Mata et al., 2012).

1.1 | Description of work programme

As part of the EU-FORA fellowship, the objective of this study was focused on acquiring knowledge on how to conduct the assessment of the risks that may be associated with edible herbs and flowers based on the methodology recommended by EFSA.

To achieve the overall objective, the following tasks will be implemented:

- Task 1 – Create a risk profile of WEPs: (a) In-depth literature search on any risks associated with WEPs; (b) Evaluation of the collected data and gaps identification.
- Task 2 – Hazard identification: i.e. identify sources of hazard (both microbiological and chemical), epidemiological investigations and surveillance studies based on literature.
- Task 3 – Hazard characterisation: (a) Selection of raw materials (wild edible plants in Spain/Poland); (b) Extraction, identification and quantification of target compounds of concern in representative products; (c) Microbiological analysis; and (d) Data analysis.
- Task 4 – Exposure assessment: patterns of consumption and occurrence of contaminants based on literature.
- Task 5 – Risk characterisation: estimation of the probability of occurrence and severity of known or potential health effects.
- Task 6 – Data analysis, writing and communication of results.

1.2 | Aims

WEPs have been frequently reported in literature for their health-related properties, as food and more recently, as a source to obtain bioactive molecules and to formulate novel foods. The possibility of microbiological contamination and the presence of chemical residues makes it necessary to pay special attention to the processing of WEPs. Concerning microbiological quality, very little data is available. The overall objective of the work programme is learning-by-doing training, which will consist of a comprehensive assessment of health risks associated with WEPs based on the methodology recommended by EFSA.

1.3 | Additional activities for training and networking

All these activities were conducted as part of the European Food Risk Assessment (EU-FORA) Fellowship Programme for the 2023–2024 cycle. This initiative aims to expand the pool of food safety experts and enhance the food risk assessment network across the European Union. During the 12-month EU-FORA fellowship, the fellow engaged in a risk assessment training programme that consists of 7 weeks of training, consisting of 3 weeks of introductory training and four specific 1-week modules. Moreover, the fellow completed a 3-month stay at the Department of Food Gastronomy and Food Hygiene, Institute of Human Nutrition Sciences, Warsaw University of Life Sciences–SGGW in Poland under the supervision of Dr. Monika Trząskowska.

The EU-FORA programme also allowed the fellow to participate in various activities to widen her knowledge on the risk assessment field and the scope of the specific project. To meet these goals, the fellow participated in multidisciplinary activities including five conferences and visited a processing plant of herbs and flowers in Grodzisk (Poland), described in **Appendix A**.

2 | DATA AND METHODOLOGIES

2.1 | Data

This study used the Rapid Alert System for Food and Feed (RASFF) to assess the incidence of microbiological and chemical hazards in 'herbs and spices' (as per product category) in the European Union, during the last 10 years (2013–2023). The Chemical contaminants occurrence database held by EFSA was used to assess the number of results on chemical contaminants in 'herbs, spices and condiments' (as per FoodEx category).

To create the risk profile and to develop the in-depth literature search on risks associated with WEPs, an extensive search of peer-reviewed journals and official reports was conducted using databases such as PubMed, Scopus, ScienceDirect, Google Scholar and Web of Science, focusing on contaminants such as mycotoxins, unauthorised colourants, pesticide residues, heavy metals and environmental pollutants. Articles were selected to ensure the inclusion of reliable and cutting-edge research and assessed for prevalence, findings and concordance.

2.2 | Methodologies

2.2.1 | Plant material

As a part of the programme (namely, selecting raw materials), the risk assessment was studied in four plants from the Lamiaceae family commonly consumed in Europe (including Spain and Poland): Basil (*Ocimum basilicum*), Oregano (*Origanum vulgare*), Rosemary (*Salvia rosmarinus*) and Thyme (*Thymus vulgaris*). Moreover, due to the growing trend of consuming edible flowers, two species have been included: Dandelion (*Taraxacum officinale*) and Cornflower (*Centaurea cyanus*) (Figure 1). A total of 142 random samples were purchased from retail outlets in Poland (82) and Spain (60).

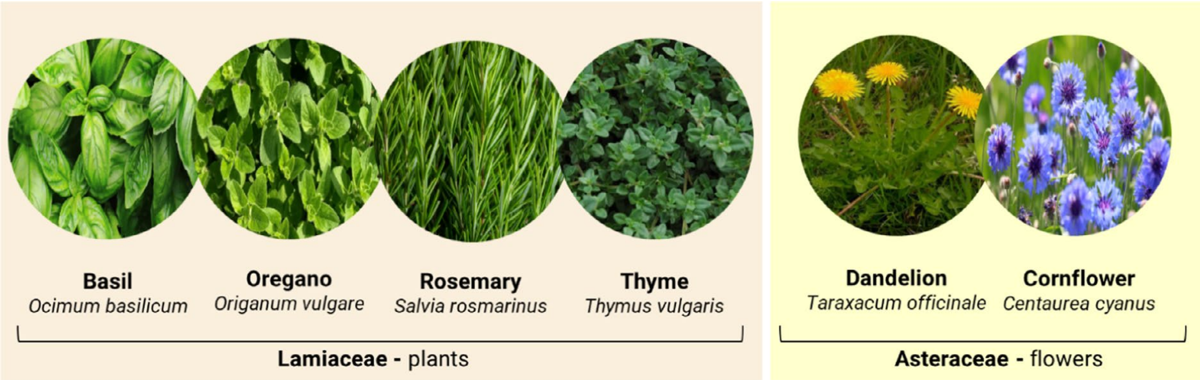

FIGURE 1 Appearance, common and scientific names of the six studied species.

2.2.2 | Microbiological quality testing

Representative 25 g portions of herbs were aseptically weighed and homogenised with 225 mL sterile buffered peptone water. Pour plate or surface seeding methods were used according to Table 1. All laboratory analyses were performed in triplicate.

TABLE 1 Microorganisms evaluated in the experiment.

Microorganism	Media	Incubation	Notes
TVC	Plate Count Agar	37°C; 48 h	
Enterobacteriaceae	Violet Red Bile Glucose Agar without Lactose	37°C; 24 h	
Yeasts and moulds	Yeast Extract Glucose Chloramphenicol Agar	25°C; 5 days	
Salmonella	Brilliant Green Agar/Xylose Lysine Deoxycholate agar/RAPID' *Salmonella* Medium	37°C; 24 h	Pre-enrichment
Escherichia coli	Tryptone Bile X-Glucuronide Agar	37°C; 24 h	Pre-enrichment
Bacillus cereus	*Bacillus cereus Agar* (PEMBA) RAPID' *B. cereus* Medium	30°C; 48 h	Pre-enrichment

2.2.3 | Heavy metals occurrence

The concentrations of heavy metals arsenic (As), cadmium (Cd), chromium (Cr), cooper (Cu), plum (Pb), thallium (Tl) and zinc (Zn) were quantified using inductively coupled plasma optical emission spectrometry (ICP-OES). The analysis was performed with a PerkinElmer optima 4300 DV spectrometer (Shelton, CT, USA), equipped with an AS-90 autosampler axial system, a high dynamic range detector and a crossflow nebuliser for pneumatic nebulisation.

The ICP-OES method adhered to procedures described in prior studies (Millos et al., 2009). Briefly, 0.25 g of each sample was digested using nitric acid (HNO_3) and hydrogen peroxide in a Multiwave 3000 oven (Anton Paar, Graz, Austria), equipped with eight digestion vessels. Post-digestion, element concentrations were assessed by ICP-OES in an axial configuration. The equipment's operational conditions followed those documented (Millos et al., 2009). Calibration curves were established using a stock solution with ^{115}In as the internal standard. All results were expressed as mg/kg.

2.2.4 | Collection of wild edible plants (WEPs) consumption data

The EFSA Comprehensive European Food Consumption Database was used to search data for the six species in the European Union, for all age categories. For the four herbs from the Lamiaceae family, the products were classified as exposure hierarchy as follows: Vegetables and vegetable products (L1) > Herbs and edible flowers (L2) > Herbs and edible flowers (L3). Then, it was classified as follows for each product:

- Basil (*Ocimum basilicum*): Basils and mints (L4) > Basil (L5).
- Oregano (*Origanum vulgare*): Thyme and similar (L4) > Oregano (L5).
- Rosemary (*Salvia rosmarinus*): Rosemary and similar (L4) > Rosemary (L5).
- Thyme (*Thymus vulgaris*): Thyme and similar (L4) > Thyme (L5).

For the two edible flowers from the Asteraceae family, cornflower (*Centaurea cyanus*) was not found as a product in the database. Dandelion (*Taraxacum officinale*) was classified as exposure hierarchy as follows: Vegetables and vegetable products (L1) > Leafy vegetables (L2) > Witloofs and similar (L3) > Dandelion leaves (forced) (L4). Depending on the product, results were available for specific countries and population groups. It must be noted that in many cases, comments on the database arose related to the lower number of observations so the 95th percentile may not be statistically robust.

3 | ASSESSMENT

3.1 | Data risk profile and hazard identification

Based on the work programme, our goal was to identify trends of food safety hazards in the European WEPs chain. According to the revision of the RASFF, 1133 notifications were posted for spices and herbs.

Notifications indicated that 58.7% (665 alerts) corresponded to chemical hazards. Regarding the chemical hazard type, chlorpyrifos (135) was most frequently detected in herbs and spices, followed by ethylene oxide (104), pyrrolizidine alkaloids (94), aflatoxin B1 (90) and ochratoxin A (39) (Figure 2A). Other contaminants included artificial unauthorised dyes, 2-chloroethanol, carbendazim or polycyclic aromatic hydrocarbons in decrescent order of prevalence. Regarding the plant type, 89 species corresponded to spices and 120 to herbs and were distributed as follows by family: Lamiaceae (82), Apiaceae (60), Piperaceae (50) and Solanaceae (17) (Figure 2B). Pepper (50) and oregano (39) were the products most contaminated.

FIGURE 2 Appearance, common and scientific names of the six studied species.

Based on RASFF notifications, 32.1% (375 alerts) corresponded to microbiological hazards using 'pathogenic microorganisms' and 'non-pathogenic microorganisms' as operators (Figure 2E). The most frequent origin of the products was Brazil (231) followed by India, China, Egypt and Turkey (Figure 2C). Salmonella was most frequently detected in culinary herbs, followed by *Bacillus cereus, E. coli, L. monocytogenes* and *C. perfringens*; 94.4% (357), 2.6% (10), 2.4% (9), 0.3% (1) and 0.3% (1), respectively (Figure 2D). Black pepper contaminated with *Salmonella* were the most frequent notifications followed by paprika. Focusing on herbs, basil was the herb most contaminated with microorganisms (11) and others include thyme (6), mint (5), parsley (5) or bay leaves (5) (Figure 2F). According to the chemical contaminants occurrence database held by EFSA, the number of results reported by substance was higher on mycotoxins > lead > cadmium > dioxins and

PCBs > arsenic > chlorine > with more than 500 analytical results. The number of results by FoodEx food category also highlighted spices (41.77%) to have higher occurrence than herbs (20.45%).

3.2 | Microbiological analysis

Both the literature data and the analysis of RASFF notifications indicate that among the selected culinary herbs (basil, oregano, rosemary and thyme), basil is the herb most contaminated with microorganisms. Available data still include a scant number of reports on microorganisms in herbs. The few studies on the presence of these threats concern fresh herbs (Table 2).

TABLE 2 Microbiological contamination in selected WEPs.[a,b]

Microorganism	Basil	Oregano	Rosemary	Thyme
Yeast and Moulds	4.92–5.35	–	–	–
Aerobic Mesophilic Bacteria	5.00–6.95	–	$<10–2.3\times10^6$	–
Mesophilic bacteria	$<10–1.2\times10^7$	$4.5\times10–1.4\times10^6$	–	$2.8\times10^2–3.1\times10^6$
Escherichia coli	–	1.4–6.5	–	–
Enterobacteriaceae	–	6.47	–	–
Aerobic plate counts	–	2.47–4.53	5.57	–
Bacillus cereus	–	–	$5–1\times10^6$	–
Listeria monocytogenes	–	–	1.5×10^3	7.9×10^3
Clostridium perfringens	–	–	0.8×10^3	2.5×10^3

Abbreviation: –, no information available.

[a]All data is expressed in log CFU/g.

[b]Data was collected from bibliographic sources: (Altay et al., 2019; Bafana, 2013; Ceuppens et al., 2015; García-Galdeano et al., 2020; Mathot et al., 2021; Melo et al., 2020; Sospedra et al., 2010; Velazquez-Medellin et al., 2023).

3.3 | Heavy metals analysis

Article 2.2 from the Regulation (EU) 2018/848 establishes WEPs as organic production under the concept of plant production, as long as the areas where they are collected have not been treated with non-authorised products or substances for at least 3 years; and '*the collection of these plants does not affect the stability of the natural habitat or the maintenance of the species in the collection area*'. Also, Commission Regulation (EC) No 2023/915., Annex-I provides the maximum levels of foodstuff contaminants, including mycotoxins, tropane alkaloids, pyrrolizidine alkaloids, pesticides and metals, among others.

The literature revision showed that WEPs herbs (basil, oregano, rosemary and thyme) and flowers (cornflower and dandelion) are generally not contaminated with heavy metals exceeding legal limits (Table 3). However, some experiments were conducted collecting samples from wild environments, including areas nearby contaminated waters, and both in fresh and dried samples.

According to European legislation, the maximum levels for heavy metals in food, particularly in herbs and spices, are set to ensure consumer safety. The maximum levels are specified in Commission Regulation (EC) No 1881/2006 and its amendments. For example, for lead (Pb), the maximum permissible level in herbs and spices is 2.0 mg/kg and for cadmium (Cd) is regulated at 0.2 mg/kg. For copper (Cu), although there is no specific limit set for herbs and spices, the general limit for foodstuff is 50 mg/kg. These limits are designed to minimise exposure to these toxic elements and ensure food safety across the European Union. Our assessment of WEPs from Poland and Spain showed that all samples were below the maximum permitted levels (data not shown).

TABLE 3 Heavy metals' occurrence in selected WEPs.[a,b]

	Cornflower	Dandelion	Basil	Oregano	Rosemary	Thyme
Pb	0.2	3.42–23.3	0.01–9.632	0.01–9.39	0.10–12.56	0.49–9.07
Cd	–	0.074–0.21	0.01–0.17	0.01–0.10	0.02–0.22	0.03–0.45
Zn	0.64–1.95	28.84–92	0.03–15.22	11.30–87.60	2.91–18.94	4.01–49.2
Cu	0.66	7.66–35.50	0.01–1.44	3.99–11.9	0.38–27.60	2.70–35.3
As	–	–	0.01–0.66	0.01–0.58	0.48–3.56	0.06–1.03
Cr	0.25–1.46	4.40–76.10	0.01–0.96	0.06–0.35	0.37–2.40	0.1–2.59
Hg	–	–	0.005–0.009	0.02–0.30	0.024	0.02–0.13

[a]All data is expressed in mg/kg.

[b]Data was collected from bibliographic sources: (Akoury et al., 2022; Giacomino et al., 2016; Kowalska, 2021; Martín-Domingo et al., 2017; Ozyigit et al., 2018; Potortì et al., 2020, 2021; Reinholds et al., 2017; Shim et al., 2019; Storelli, 2014; Thabit et al., 2021).

4 | CONCLUSION

The primary objective of the work programme was to develop a comprehensive assessment of health risks associated with WEPs based on the methodology recommended by EFSA. The programme provided the fellow with knowledge and skills in performing risk assessments for both chemical and microbiological hazards. The comprehensive review of the literature, combined with the analysis of databases and experimental results, revealed that spices have a higher occurrence of chemical contaminants compared to herbs. The most frequently identified chemical hazards in spices were mycotoxins, followed by heavy metals, including lead, cadmium and arsenic, as well as other chemical residues. Regarding microbiological hazards, *Salmonella* was the most reported pathogen, followed by *B.cereus* and *E.coli*. Spices also exhibited a higher microbial load than herbs, with basil being the most contaminated among the herbs studied. Exposure assessments were conducted using data from the EFSA Comprehensive European Food Consumption Database; however, significant uncertainties were noted due to the limited number of observations, which affected the statistical robustness of the findings. These results, combined with the knowledge gained through the programme on effective risk assessment, management and communication, are crucial for conducting a thorough risk analysis and achieving a high level of protection for human health and safety.

5 | RECOMMENDATIONS

The EU-FORA fellowship programme significantly contributed to developing expertise in the different stages of risk assessment. The collaborative working groups formed across various organisations are an asset of the programme and will support future collaboration in risk assessment research.

ABBREVIATIONS

EU-FORA	European Food Risk Assessment Fellowship Programme
RASFF	Rapid Alert System for Food and Feed
WEPs	wild edible plants
ICP-OES	inductively coupled plasma optical emission spectrometry
CFU	colony forming unit

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APPENDIX A

Multidisciplinary activities

Additional relevant activities and opportunities completed by fellow:

Communication in international conferences

Carpena, M., Barciela, P., Perez-Vazquez, A., Noras, K., Trafiałek, J., Prieto, M., & Trząskowska, M. Assessment of Chemical Hazards in Herbs consumed in Europe: Toxins, Heavy Metals, and Pesticide Residues, in Proceedings of the 1st International Electronic Conference on Toxics, 20–22 March 2024, MDPI: Basel, Switzerland. Poster presentation.

Carpena, M., Perez-Vazquez, A., Barciela, P., Noras, K., Trafiałek, J., Trząskowska, M., & Prieto, M. Insights into the Toxicity and Molecular Mechanisms of Aflatoxin B1 and Ochratoxin A in Herbal Products, in Proceedings of the 3rd International Electronic Conference on Biomolecules, 23–25 April 2024, MDPI: Basel, Switzerland. Poster presentation.

Trząskowska, M., Carpena, M., Barciela, P., Perez-Vazquez, A., Noras, K., Trafiałek, J., & Prieto, M. Microbiological Hazard Identification in Culinary Herbs. Presented in the IAFP's European Symposium, 30 April-2 May, Geneva, Switzerland. Poster presentation.

Trząskowska, M., Carpena, M., Suryia, S. N., Aparna, P. M., Muhammad, M., Trafiałek, J., Prieto, M., Noras, K. Microbiological quality and risk factors in Culinary Herbs. Presented in 28th International ICFMH Conference FOOD MICRO 2024, 8–11 July 2024, Burgos, Spain. Poster presentation.

Carpena, M., Barciela, P., Perez-Vazquez, A., Noras, K., Trafiałek, J., Trząskowska, M., & Prieto, M. Safeguarding Herb and Spices Consumers in Europe: A Comprehensive Assessment of Chemical Hazard Identification. Presented in the IAFP 2024 Annual Meeting, 14–17 July 2024, Long Beach, California, USA. Oral presentation.

Proceedings paper publications

Carpena, M., Perez-Vazquez, A., Barciela, P., Noras, K., Trafiałek, J., Trząskowska, M., & Prieto, M. A. (2024). Insights into toxicity: Molecular Mechanisms of Aflatoxin B1 and Ochratoxin A in Spices. Biology and Life Sciences Forum, *35*(1), 3. https://doi.org/10.3390/blsf2024035003.

Carpena, M., Barciela, P., Perez-Vazquez, A., Noras, K., Trafiałek, J., Prieto, M., & Trząskowska, M. Assessment of Chemical Hazards in Herbs consumed in Europe: Toxins, Heavy Metals, and Pesticide Residues. Proceedings. 2024.

Study visits

The Dary Natury company in Grodzisk works on collecting herbs and creating its own mixtures, but also preserving the knowledge about the traditional use of herbs. Visit the website: https://darynatury.pl/.