Food Safety Briefs

Institute for the Advancement of Food and Nutrition Sciences

Foodborne Pathogens

Levels and Types of Microbial Contaminants in Different Plant-Based Ingredients used in Dairy Alternatives

Significance: 845 individual bacterial colonies were isolated belonging to 33 different genera. Determination of the microbial contaminants in plant-based ingredients will help to improve food safety during processing of plant-based foods.

In this study levels and types of microbial contaminants were investigated in 88 different plant-based ingredients including many that are used to manufacture dairy alternatives. Studied ingredients encompassed samples of pulses (pea, faba bean, chickpea, and mung bean), cereals/pseudocereals (oat, rice, amaranth and quinoa) and drupes (coconut, almond and cashew). The microbial analysis included: i) total viable count (TVC), ii) total aerobic mesophilic spore count (TMS), iii) heat resistant aerobic thermophilic spore count (HRTS), iv) anaerobic sulfite reducing *Clostridium* spore count (SRCS), and v) *Bacillus cereus* spore count (BCES). Microorganisms isolated from the counting plates with the highest sample dilutions were identified using 16S rRNA and MALDI-TOF MS analyses. Many of the investigated ingredients showed a high proportion of spores as part of their total aerobic mesophilic counts. In 63 % of the samples, the difference between TVC and TMS counts was 1 Log10 unit or less. This was particularly the case for the majority of pea isolates and concentrates, faba bean isolates, oat kernels and flakes, and for single samples of chickpea isolate, almond, amaranth, rice, quinoa, and coconut flours. Concentrations of TVC ranged between <1.0 and 5.3 Log10 CFU/g in different samples, and TMS varied between <1.0 and 4.1 Log10 CFU/g. Levels of HTRS, BCES and SRCS were generally low, typically around or below the LOD of 1.0 Log10 CFU/g. In total, 845 individual bacterial colonies were isolated belonging to 33 different genera. *Bacillus licheniformis* and B. cereus group strains were most frequently detected among Bacillus isolates, and these species originated primarily from pea and oat samples. *Geobacillus stearothermophilus* was the main species encountered as part of the HRTS. Among the *Clostridium* isolates, *Clostridum sporogenes/tepidum* were predominant species, which were mostly found in pea and almond samples. Strains with potential to cause foodborne infection or intoxication were typed using the PCR-based method for toxin genes detection. In the *B. cereus* group, 9 % of isolates contained the *ces* gene, 28 % contained *hbl*, 42 % *cytK*, and 69 % were positive for the *nhe* gene. Absence of the *boNT-A* and *-B* genes was confirmed for all isolated *C. sporogenes/tepidum* strains. Nearly all (98 %) *B. licheniformis* isolates were positive for the *lchAA* gene. Insight into the occurrence of microbial contaminants in plant-based

ingredients, combined with knowledge of their key inactivation and growth characteristics, can be used for the microbial risk assessment and effective design of plant-based food processing conditions and formulations to ensure food safety and prevent spoilage.

Foodborne Illness

Predicting Foodborne Disease Outbreaks with Food Safety Certifications: Econometric and Machine Learning Analyses

Yuqing Zheng, Azucena Gracia, Lijiao Hu. *J Food Prot*. 2023 Sep;86(9):100136. doi: 10.1016/j.jfp.2023.100136. Article link

Significance: Applying several algorithms to the U.S. data, models with food safety certification adoption can predict the number of U.S. foodborne illnesses or deaths with a relatively high degree of precision – with testing accuracy at around 70% or better.

Since the late 1990s, food safety certification has emerged as a prominent and influential regulatory mechanism in both the private and public spheres of the contemporary agri-food system. Food safety standards protect consumers from foodborne illnesses and help producers avoid the massive economic losses associated with food safety breaches. We empirically examine the relationship between foodborne disease outbreaks and certification adoption by utilizing the data on food safety certification adoption in the United States and Europe from 2015 through 2020. In our regression models, food safety certification along with select economic variables such as gross domestic product are used to explain the number of illnesses caused by foodborne disease outbreaks. For the United States at the state level, we found that certifications to SQF, PrimusGFS, BRC, or FSSC 22000 are negatively associated with the number of foodborne illnesses. For the case of Europe at the country level, certifications to ISO 22000 or FSSC 22000 are negatively associated with the number of foodborne illnesses. We then proceed to use machine learning techniques to examine how well we can use food safety certification data to predict foodborne disease outbreaks. Applying several algorithms (ordinary least squares, multinomial, decision tree, and random forest) to the U.S. data, we found that our models with food safety certification adoption can predict the number of U.S. foodborne illnesses or deaths with a relatively high degree of precision (testing accuracy at around 70% or better). Feature importance analysis allows us to inspect the relative importance of each explanatory variable (or feature) for making accurate predictions of the illness or death numbers. Through ranking the importance of explanatory variables, our study reveals that certification information could be the second most important variable (after gross domestic product) contributing to explain foodborne disease outbreaks.

Mycotoxins

The Occurrence of Non-Regulated Mycotoxins in Foods: A Systematic Review

Octavian Augustin Mihalache, Marthe De Boevre, Luca Dellafiora, Sarah De Saeger, Antonio Moretti, Laetitia Pinson-Gadais, Nadia Ponts, et. al. *Toxins*. 2023 Sep 20;15(9):583. doi: 10.3390/toxins15090583. Article link

Significance: Fifteen non-regulated mycotoxins were found in 19 food categories worldwide indicating the need for continuous monitoring and higher-quality data.

The aim of this systematic review is to provide an update on the occurrence and co-occurrence of selected non-regulated mycotoxins and provide an overview of current regulations. Fifteen non-regulated mycotoxins were found in 19 food categories worldwide. On top of that, 38 different combinations of non-regulated mycotoxins were found, with mixtures varying from binary combinations up to 12 mycotoxins. Taking into consideration the amount of evidence regarding the prevalence and co-occurrence of non-regulated mycotoxins, future steps should be taken considering continuous monitoring, scientific exchange, and generation of high-quality data. To enhance data quality, guidelines outlining the minimum quality criteria for both occurrence data and metadata are needed. By doing so, we can effectively address concerns related to the toxicity of non-regulated mycotoxins. Furthermore, obtaining more data concerning the co-occurrence of both regulated and non-regulated mycotoxins could aid in supporting multiple chemical risk assessment methodologies. Implementing these steps could bolster food safety measures, promote evidence-based regulations, and ultimately safeguard public health from the potential adverse effects of non-regulated mycotoxins.

Heavy Metals

Interactions of Arsenic Exposure, Arsenic Metabolism with Red Blood Cell Folate on the Risk of Hypertension: NHANES 2007-2016

Significance: There was significant interactions between high urinary total arsenic and excessive red blood cell folate on hypertension risk in this NHANES survey from 2007-2016.

Purpose: Arsenic exposure was associated with hypertension, and arsenic metabolism might be influenced by folate concentrations. Thus, this study aimed to explore the interaction between arsenic exposure and metabolism with folate concentrations on hypertension. **Methods:** We studied 6643 adults aged 20 years and older who participated in the National Health and Nutrition Examination Survey from 2007 through 2016. Urinary total arsenic (UTAs), the percentage of urinary dimethylarsinic acid (DMA%), serum and red blood cell (RBC) folate were collected. Logistic regression and restricted cubic spline (RCS) analyses were performed to determine the association and dose-response relationship. Interaction analyses were conducted on both additive and multiplicative scales. **Results:** UTAs (median: 7.05 µg/L) was positively associated with hypertension risk, and the adjusted OR was 1.44 (95% CI: 1.06-1.95) when comparing the third with the lowest quartile. And participants with the highest quintile of RBC folate had increased hypertension risk than those with the lowest quintile (adjusted OR = 1.43, 95% CI: 1.06-1.94). Significant additive interaction was observed between excessive RBC folate with high UTAs (AP = 0.323, 95% CI: 0.083-0.564) and low DMA% (AP = 0.381, 95% CI: 0.119-0.643) on hypertension risk. **Conclusion:** Our results suggested significant interactions between high UTAs and low DMA% with excessive RBC folate on hypertension risk.

Food Packaging

The Potential of Postbiotics as a Novel Approach in Food Packaging and Biopreservation: A Systematic Review of the Latest Developments

Significance: Postbiotics can be an alternative strategy to control the growth of pathogens and spoilage microorganisms, thereby extending the shelf life of food products.

Metabolic by-products are part of the so-called postbiotics of probiotics and other beneficial microorganisms, particularly lactic acid bacteria, which have gained popularity as a feasible alternative to improving food quality and safety. Postbiotics in dry and liquid forms can be easily integrated into food formulations and packaging materials, exhibiting antimicrobial and antioxidant effects owing to the presence of multiple antimicrobials, such as organic acids, bacteriocins, exopolysaccharides and bioactive peptides. Postbiotics can thus control the growth of pathogens and spoilage microorganisms, thereby extending the shelf life of food products. Because of their ability to be easily manufactured without requiring extensive processing, postbiotics are regarded as a safer and more sustainable alternative to synthetic preservatives, which can have negative environmental consequences. Additionally, food manufacturers can readily adopt postbiotics in food formulations without significant modifications. This systematic review provides an in-depth analysis of studies on the use of postbiotics in the biopreservation and packaging of a wide range of food products. The review evaluates and discusses the types of microorganisms, postbiotics preparation and modification techniques, methods of usage in dairy products, meat, poultry, seafood, fruits, vegetables, bread, and egg, and their effects on food quality and safety.

Chemical Contaminants

Dietary Intake of Acrylamide in the Norwegian EuroMix Biomonitoring Study: Comparing Probabilistic Dietary Estimates with Haemoglobin Adduct Measurements

Significance: The Margin of Exposure from this study indicates a possible health risk concern from dietary acrylamide in the adult Norwegian population after comparing acrylamide intake measurements from haemoglobin adduct levels and self-registered dietary consumption data.

Acrylamide is a probable human carcinogen with widespread exposure via food. The present study compared acrylamide intake measurements obtained from haemoglobin adduct levels and self-registered dietary consumption data in a group of 144 Norwegian healthy adults. Acrylamide adducts to N-terminal valine in haemoglobin were measured and used to estimate the intake via the internal dose approach which showed a median (interquartile range) of 0.24 (0.19-0.30) µg/kg bw/day. Data from weighed food records and food frequency questionnaires from the same individuals were used for probabilistic modelling of the intake of acrylamide. The median acrylamide intake was calculated to be 0.26 (0.16-0.39) and 0.30 (0.23-0.39) µg/kg bw/day, respectively from the two sources of self-registered dietary consumption data. Overall, a relatively good agreement was observed between the methods in pairwise comparison in Bland-Altman plots, with the methods disagreeing with 7% or less of the values. The intake estimates obtained with the two dietary consumption methods and one biomarker method are in line with earlier dietary estimates in the Norwegian population. The Margin of Exposure indicate a possible health risk concern from dietary acrylamide. This is the first study with a comparison in the same individuals of acrylamide intake estimates obtained with these methods.

Risk Assessment

Development of a Framework for Risk Assessment of Carcinogens

Christopher A Bates, Lynne T Haber, Martha M Moore, Rita Schoeny, Andrew Maier. *Food Chem Toxicol*. 2023 Sep 15:180:114022. doi: 10.1016/j.fct.2023.114022. Article link

Significance: A new carcinogen framework enhances approaches for weight of evidence evaluation of genetic toxicology data and other refinements.

This work was supported by IAFNS' Food & Chemical Safety Committee.

Although there are a number of guidance documents and frameworks for evaluation of carcinogenicity, none of the current methods fully reflects the state of the science. Common limitations include the absence of dose-response assessment and not considering the impact of differing exposure patterns (e.g., intermittent, high peaks vs. lower, continuous exposures). To address these issues, we have developed a framework for risk assessment of dietary carcinogens. This framework includes an enhanced approach for weight of evidence (WOE) evaluation for genetic toxicology data, with a focus on evaluating studies based on the most recent testing guidance to determine whether a chemical is a mutagen. Included alongside our framework is a discussion of resources for evaluating tissue dose and the temporal pattern of internal dose, taking into account the chemical's toxicokinetics. The framework then integrates the mode of action (MOA) and associated dose metric category with the exposure data to identify the appropriate approach(es) to low-dose extrapolation and level of concern associated with the exposure scenario. This framework provides risk managers with additional flexibility in risk management and risk communication options, beyond the binary choice of linear low-dose extrapolation vs. application of uncertainty factors.

Caffeine

Coffee Consumption and Abdominal Aortic Calcification among Adults with and without Hypertension, Diabetes and Cardiovascular Diseases

Heze Fan, Ying Xiong, Yuzhi Huang, Wenyuan Li, Chenbo Xu, Xueying Feng, Rui Hua, et. al. *Nutr Metab Cardiovasc Dis*. 2023 Oct;33(10):1960-1968. doi: 10.1016/j.numecd.2023.06.013. Article link

Significance: Compared with non-drinkers, high coffee consumption was associated with higher abdominal aortic calcification scores among participants with hypertension, diabetes and cardiovascular disease but was not associated with those without those conditions.

Backround and aims: This study was performed to investigate the effect of coffee consumption on abdominal aortic calcification (AAC) among adults with and without hypertension, diabetes, and cardiovascular diseases (CVD). **Methods and results**: A total of 2548 participants from the National Health and Nutrition Examination Survey (NHANES) 2013-2014 were included. Coffee consumption was obtained from 24-h dietary recalls. Dual-energy X-ray absorptiometry (DXA) was used to measure the severity of AAC. In the fully adjusted model, compared with non-drinkers, high coffee consumption (≥390 g/d) was associated with higher AAC scores among participants with hypertension (β = 0.72, 95% CI: 0.21-1.22), diabetes (β = 1.20, 95% CI: 0.35-2.05), and CVD (β = 2.03, 95% CI: 0.71-3.36). We did not observe such an association among participants without hypertension, diabetes, and CVD. Furthermore, decaffeinated coffee was not associated with AAC. **Conclusion:** In conclusion, patients with hypertension, diabetes, and CVD should focus on coffee consumption, especially caffeinated coffee, to reduce the burden of AAC.

Food Allergens

New Perspectives on Food Matrix Modulation of Food Allergies: Immunomodulation and Component Interactions

Significance: This review focuses on the interaction of the food matrix and food allergies, specifically focusing on the immune role of the food matrix components.

Food allergy is a multifactorial interplay process influenced not only by the structure and function of the allergen itself but also by other components of the food matrix. For food, before it is thoroughly digested and absorbed, numerous factors make the food matrix constantly change. This will also lead to changes in the chemistry, biochemical composition, and structure of the various components in the matrix, resulting in multifaceted effects on food allergies. In this review, we reveal the relationship between the food matrix and food allergies and outline the immune role of the components in the food matrix, while highlighting the ways and pathways in which the components in the food matrix interact and their impact on food allergies. The in-depth study of the food matrix will essentially explore the mechanism of food allergies and bring about new ideas and breakthroughs for the prevention and treatment of food allergies.

Emerging Science Areas

Emerging Area: Agriculture and Metals

Root Microbiota Confers Rice Resistance to Aluminum Toxicity and Phosphorus Deficiency in Acidic Soils

Chaoyang Liu, Meitong Jiang, Yuting Liang. *Nature Food.* 2 Oct 2023. doi.org/10.1038/s43016-023-00848-0. Article link

Significance: A new microbial tool promises to reduce heavy metals in acidic soils.

Aluminum (Al) toxicity impedes crop growth in acidic soils and is considered the second largest abiotic stress after drought for crops worldwide. Despite remarkable progress in understanding Al resistance in plants, it is still unknown whether and how the soil microbiota confers Al resistance to crops. Here we found that a synthetic community composed of highly Al-resistant bacterial strains isolated from the rice rhizosphere increased rice yield by 26.36% in acidic fields. The synthetic community harvested rhizodeposited carbon for successful proliferation and mitigated soil acidification and Al toxicity through extracellular protonation. The functional coordination between plants and microbes offers a promising way to increase the usage of legacy phosphorus in topsoil. These findings highlight the potential of microbial tools for advancing sustainable agriculture in acidic soils.

Engage with IAFNS

The Promise and Hype of AI: Where Are We – And Where Are We Going?
October 17, 2023, Virtual
Despite questions around their responsible use, ChatGPT and other AI tools are currently being implemented from education to business to research, with even more transformational advances on the horizon.
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Technical Workshop on Probabilistic Exposure Assessment
November 9, 2023. Washington, DC, United States
Despite significant advances in risk assessments of foods and ingredients, exposure assessments tend to rely on deterministic approaches utilizing very conservative inputs. This workshop will focus on probabilistic exposure assessments which move away from single-point, deterministic exposure inputs.
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November 28, 2023, Virtual, Event
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December 12 – 14, 2023, Virtual, Event
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