November 2022

Food Safety Briefs

IAFNS Science Innovation Showcase - 2022

Virtual Event, December 13–15, 2022

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Risk Assessment

Food Safety Risk-Assessment Systems Utilized by China, Australia/New Zealand, Canada and the United States.

Sieh Ng, Shuyan Shao, Nan Ling. *J Food Sci.* 2022 Nov;87(11):4780-4795. doi: 10.1111/1750-3841.16334.
Article link

Significance: Risk assessment underpins the international food trade and is integral to building company and consumer confidence. Achieving this requires effective systems to support the safety of food across the supply chain. Bench marking different risk approaches against international food safety standards can assist in the development of country-specific systems.

Ensuring the chemical, physical, and microbial safety of food and ingredients underpins the international trade of food items and is integral to building consumer confidence. Achieving this requires effective systems to support the safety of food across the supply chain. Differing risk-assessment approaches are utilized globally for establishing food safety systems, and bench marking these approaches against international food safety standards can assist in the development of country-specific systems. This China-Australia collaborative review examined similarities and differences in the food safety risk-assessment systems of China, Australia/New Zealand, Canada, and the United States, with the view to identify areas that could support improvements to the Chinese system. Key differences include the level of cohesiveness among stakeholders and the level to which each country promotes the international harmonization of standards. The evidence highlights a need for greater capacity-building in risk assessment in China that may support greater stakeholders' cohesion, improve hazard identification, and allow

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regulators to more readily keep abreast of changes to international standards. This review may help the Chinese food industry to replicate the same level of food safety risk assessment currently applied by other key countries, and reflects the determination, government prioritization, and active strengthening of China's National Centre for Food Safety Risk Assessment currently underway.

Foodborne Pathogens

Integrative Assessment of Reduced *Listeria monocytogenes* Susceptibility to Benzalkonium Chloride in Produce Processing Environments

Yingshu He, Tongzhou Xu, Shaoting Li, David A Mann, Brianna Britton, Haley F Oliver, Hendrik C den Bakker, Xiangyu Deng. *Appl Environ Microbiol*. 2022 Nov 8;88(21):e0126922. doi: 10.1128/aem.01269-22. **Article link**

Significance: Collective leveraging of genomic surveys, laboratory assays, and processing facility sampling can improve food safety assessment and control.

For decades, quaternary ammonium compounds (QAC)-based sanitizers have been broadly used in food processing environments to control foodborne pathogens such as *Listeria monocytogenes*. Still, there is a lack of consensus on the likelihood and implication of reduced *Listeria* susceptibility to benzalkonium chloride (BC) that may emerge due to sublethal exposure to the sanitizers in food processing environments. With a focus on fresh produce processing, we attempted to fill multiple data and evidence gaps surrounding the debate. We determined a strong correlation between tolerance phenotypes and known genetic determinants of BC tolerance with an extensive set of fresh produce isolates. We assessed BC selection on *L. monocytogenes* through a large-scale and source-structured genomic survey of 25,083 publicly available *L. monocytogenes* genomes from diverse sources in the United States. With the consideration of processing environment constraints, we monitored the temporal onset and duration of adaptive BC tolerance in both tolerant and sensitive isolates. Finally, we examined residual BC concentrations throughout a fresh produce processing facility at different time points during daily operation. While genomic evidence supports elevated BC selection and the recommendation for sanitizer rotation in the general context of food processing environments, it also suggests a marked variation in the occurrence and potential impact of the selection among different commodities and sectors. For the processing of fresh fruits and vegetables, we conclude that properly sanitized and cleaned facilities are less affected by BC selection and unlikely to provide conditions that are conducive for the emergence of adaptive BC tolerance in *L. monocytogenes*. **Importance**: Our study demonstrates an integrative approach to improve food safety assessment and control strategies in food processing environments through the collective leveraging of genomic surveys, laboratory assays, and processing facility sampling. In the example of assessing reduced *Listeria* susceptibility to a widely used sanitizer, this approach yielded multifaceted evidence that incorporates population genetic signals, experimental findings, and real-world constraints to help address a lasting debate of policy and practical importance.

Mycotoxins

Recent Advances in Simultaneous Detection Strategies for Multi-Mycotoxins in Foods

Ying Yang, Meng-Yu Ren, Xiao-Guang Xu, Yue Han, Xin Zhao, Chun-Hua Li, Zhi-Lei Zhao. *Crit Rev Food Sci Nutr*. 2022 Nov 4;1-29. doi: 10.1080/10408398.2022.2137775. **Article link**

Significance: Mycotoxins are small-molecule toxic metabolites produced by several species belonging to the genera *Aspergillus*, *Fusarium*, and *Penicillium* growing in food. This review provides a comprehensive overview of advances in multiple detection methods for mycotoxins during the last 5 years.

Mycotoxin contamination has become a challenge in the field of food safety testing, given the increasing emphasis on food safety in recent years. Mycotoxins are widely distributed, in heavily polluted areas. Food contamination with these toxins is difficult to prevent and control. Mycotoxins, as are small-molecule toxic metabolites produced by several species belonging to the genera *Aspergillus*, *Fusarium*, and *Penicillium* growing in food. They are considered teratogenic, carcinogenic, and mutagenic to humans and animals. Food systems are often simultaneously contaminated with multiple mycotoxins. Due to the additive or synergistic toxicological effects caused by the co-existence of multiple mycotoxins, their individual detection requires reliable, accurate, and high-throughput techniques. Currently available, methods for the detection of multiple mycotoxins are mainly based on chromatography, spectroscopy (colorimetry, fluorescence, and surface-enhanced Raman scattering), and electrochemistry. This review provides a comprehensive overview of advances in the multiple

detection methods of mycotoxins during the recent 5 years. The principles and features of these techniques are described. The practical applications and challenges associated with assays for multiple detection methods of mycotoxins are summarized. The potential for future development and application is discussed in an effort, to provide standards of references for further research.

Heavy Metals

Exposure to Metal Mixtures and Overweight or Obesity Among Chinese Adults

Gaojie Fan, Qing Liu, Mingyang Wu, Jianing Bi, Xiya Qin, Qing Fang, Zhengce Wan et. al. *Biol Trace Elem Res*. 2022 Nov 16. doi: 10.1007/s12011-022-03484-0. **Article link**

Significance: This study suggests that metal mixture exposure might be negatively associated with overweight. Zinc, Arsenic and Cadmium contributed most to the effect of the mixture.

Previous research has investigated the association between individual metal exposure and overweight/obesity (OW/OB). However, there is limited data about metal mixture exposure and OW/OB. This study aimed to explore the individual and joint effects of 21 metals on OW/OB and its metabolic phenotypes. A total of 4042 participants were enrolled in our study, and 51.0% of them were overweight/obese. We quantified 21 metal levels in the urine sample. OW/OB was defined as BMI ≥ 24 kg/m2, while the metabolic phenotypes, including metabolic unhealthy overweight/obesity (MUOW/OB) and metabolic health overweight/obesity (MHOW/OB), were determined by BMI and metabolic state. We used logistic regression to analyze the effect of individual metal exposure on OW/OB and its metabolic phenotypes. Quantile g-computation was applied to evaluate the joint effect of metal exposure on OW/OB and its metabolic phenotypes. In logistic regression, zinc (Zn) was positively associated with OW/OB, with the odds ratio (OR) in the highest quartiles of 2.19 (95% confidence interval (CI), 1.74, 2.77; P trend < 0.001), while arsenic (As) and cadmium (Cd) were negatively associated with OW/OB (OR = 0.70 (0.56, 0.87) and 0.61 (0.48, 0.78), respectively). After adjustment for age, gender, education, cigarette smoking, alcohol drinking, physical activity, meat intake, and vegetable intake, Zn was positively associated with MUOW/OB, while As, Cd, nickel (Ni), and strontium (Sr) were negatively associated with MUOW/OB (all P trend < 0.05). Quantile g-computation showed a significantly negative association between metal mixture exposure and MUOW/OB. Our study suggested that metal mixture exposure might be negatively associated with OW/OB, particularly with MUOW/OB. Zn, As and Cd contributed most to the effect of the mixture. More prospective studies are warranted to confirm these findings and reveal the underlying mechanisms.

Food Packaging

Recent Advances in Metal Sulfide Nanoparticle-Added Bionanocomposite Films for Food Packaging Applications

Swarup Roy, Parya Ezati, Ruchir Priyadarshi, Deblina Biswas, Jong-Whan Rhim. *Crit Rev Food Sci Nutr*. 2022 Nov 11;1-14. doi: 10.1080/10408398.2022.2144794. **Article link**

Significance: Metal sulfide nanoparticles added as nanofillers are attracting attention in packaging applications due to improved mechanical, barrier properties, and antibacterial activity. This review covers the fabrication process and important applications.

Metal sulfide nanoparticles have recently attracted much attention due to their unique physical and functional properties. Metal sulfide nanoparticles used as optoelectronic and biomedical materials in the past decades are promising for making functional nanocomposite films due to their low toxicity and strong antibacterial activity. Recently, copper sulfide and zinc sulfide nanomaterials have been used to produce food packaging films for active packaging. Metal sulfide nanoparticles added as nanofillers are attracting attention in packaging applications due to their excellent potential to improve mechanical, barrier properties, and antibacterial activity. This review covers the fabrication process and important applications of metal sulfide nanoparticles. The development of metal sulfides reinforcing mainly copper sulfide and zinc sulfide nanomaterials as multifunctional nanofillers in bio-based films for active packaging applications has been comprehensively reviewed. As the recognition of metal sulfide nanoparticles as a functional filler increases the development and application potential of active packaging films using them is expected to increase.

Chemical Contaminants

Advancing the Science of a Read-Across Framework for Evaluation of Data-Poor Chemicals Incorporating Systematic and New Approach Methods

Lucina E Lizarraga, Glenn W Suter, Jason C Lambert, Grace Patlewicz, Jay Q Zhao, Jeffry L Dean, Phillip Kaiser. *Regul Toxicol Pharmacol*. 2022 Nov 19;137:105293. doi: 10.1016/j.yrtph.2022.105293. **Article link**

Significance: New methods to leverage existing chemical data and predict toxicities for data-poor chemicals are advancing. New 'read-across' techniques and frameworks emphasize the integration of systematic methods and alternative toxicity testing.

The assessment of human health hazards posed by chemicals traditionally relies on toxicity studies in experimental animals. However, most chemicals currently in commerce do not meet the minimum data requirements for hazard identification and dose-response analysis in human health risk assessment. Previously, we introduced a read-across framework designed to address data gaps for screening-level assessment of chemicals with insufficient in vivo toxicity information (Wang et al., 2012). It relies on inference by analogy from suitably tested source analogues to a target chemical, based on structural, toxicokinetic, and toxicodynamic similarity. This approach has been used for dose-response assessment of data-poor chemicals relevant to the U.S. EPA's Superfund program. We present herein, case studies of the application of this framework, highlighting specific examples of the use of biological similarity for chemical grouping and quantitative read-across. Based on practical knowledge and technological advances in the fields of read-across and predictive toxicology, we propose a revised framework. It includes important considerations for problem formulation, systematic review, target chemical analysis, analogue identification, analogue evaluation, and incorporation of new approach methods. This work emphasizes the integration of systematic methods and alternative toxicity testing data and tools in chemical risk assessment to inform regulatory decision-making.

Caffeine

Habitual Coffee Consumption and Subsequent Risk of Type 2 Diabetes in Individuals with a History of Gestational Diabetes - A Prospective Study

Jiaxi Yang, Deirdre K Tobias, Shanshan Li, Shilpa N Bhupathiraju, Sylvia H Ley, Stefanie N Hinkle, Frank Qian, et. al. *Am J Clin Nutr*. 2022 Nov 14;nqac241. doi: 10.1093/ajcn/nqac241. **Article link**

Significance: In this study of Caucasian females, caffeine consumption is associated with a lower risk of Type 2 diabetes and more favorable metabolic profiles.

Background: Females with a history of gestational diabetes mellitus (GDM) are at higher risk of developing type 2 diabetes mellitus (T2D) later in life. **Objective**: This study prospectively examined whether greater habitual coffee consumption was related to a lower risk of T2D among females with a history of GDM. **Methods**: We followed 4522 participants with a history of GDM in the NHS II for incident T2D between 1991 and 2017. Demographic, lifestyle factors including diet, and disease outcomes were updated every 2-4 y. Participants reported consumption of caffeinated and decaffeinated coffee on validated FFQs. Fasting blood samples were collected in 2012-2014 from a subset of participants free of diabetes to measure glucose metabolism biomarkers (HbA1c, insulin, C-peptide; n = 518). We used multivariable Cox regression models to calculate adjusted HRs and 95% CIs for the risk of T2D. We estimated the least squares mean of glucose metabolic biomarkers according to coffee consumption. **Results**: A total of 979 participants developed T2D. Caffeinated coffee consumption was inversely associated with the risk of T2D. Adjusted HR (95% CI) for ≤1 (nonzero), 2-3, and 4+ cups/d compared with 0 cup/d (reference) was 0.91 (0.78, 1.06), 0.83 (0.69, 1.01), and 0.46 (0.28, 0.76), respectively (P-trend = 0.004). Replacement of 1 serving/d of sugar-sweetened beverage and artificially sweetened beverage with 1 cup/d of caffeinated coffee was associated with a 17% (risk ratio [RR] = 0.83, 95% CI: 0.75, 0.93) and 9% (RR = 0.91, 95% CI: 0.84, 0.99) lower risk of T2D, respectively. Greater caffeinated coffee consumption was associated with lower fasting insulin and C-peptide concentrations (all P-trend <0.05). Decaffeinated coffee intake was not significantly related to T2D but was inversely associated with C-peptide concentrations (P-trend = 0.003). **Conclusions**: Among predominantly Caucasian females with a history of GDM, greater consumption of caffeinated coffee was associated with a lower risk of T2D and a more favorable metabolic profile.

Food Allergens

Effect of Processing Treatments on the Allergenicity of Nuts and Legumes: A Meta-Analysis

Rizki Maryam Astuti, Nurheni Sri Palupi, Maggy Thenawidjaja Suhartono, Eni Kusumaningtyas, Hanifah Nuryani Lioe. *J Food Sci*. 2022 Nov 29. doi: 10.1111/1750-3841.16381. **Article link**

Significance: Nuts and legumes are key protein sources globally, but they usually contain allergens. This study investigates the food processing methods that effectively reduce their allergenicity by meta-analysis.

The effective food processing to reduce nuts and legumes allergenicity could not be easily and directly concluded from reading a few published reports. Therefore, we conducted a meta-analysis to investigate this issue. A literature search was conducted in eight electronic databases from January 2000 to June 11, 2021. The primary outcome of interest was the allergenicity of processed nuts or legumes determined by enzyme-linked immunosorbent assay from in vitro studies. Data with the standardized mean difference (SMD) of 95% confidence interval (CI) were pooled using a random-effect model by RevMan 5.4 software. Heterogeneity was assessed using Cochran's Q (PQ) and I2 tests. The search strategy identified 18,793 articles. However, only 61 studies met the inclusion criteria and were included in this meta-analysis. There were 21 and 15 types of respective single and combined food processing treatments analyzed for their effects on reducing allergenicity. In single processing treatment, the extrusion and fermentation had the largest reduction in allergenicity, considering their SMD value, that is, -20.19 (95% CI: -22.22 to -18.17; the certainty of evidence: moderate) and -20.8 (95% CI: -24.10 to -17.50; the certainty of evidence: moderate), respectively. Whereas in the combination, the treatment of fermentation followed by proteolytic hydrolysis showed the most significant reduction (SMD: -53.34; 95% CI: -70.18 to -36.5) and the evidence quality of this treatment was considered moderate. In conclusion, these three food processing methods showed a desirable impact in reducing nuts or legumes allergenicity. PRACTICAL APPLICATION: Nuts and legumes play an essential role as protein sources in food consumption worldwide, but they usually contain allergens. Our study has investigated the food processing methods that effectively reduce their allergenicity by meta-analysis. The result gives valuable information for further laboratory investigation on allergens and can be used by food industries in providing foods from nuts and legumes with lower allergenicity.

Emerging Science Areas

Chemical Mixture Exposure

Chemical Mixture Exposure Patterns and Obesity Among U.S. Adults in NHANES 2005–2012

Yuqing Zhang, Xu Wang, Xu Yang, Qi Hu, Kuldeep Chawla, Bo Hang, Jian-Hua Mao, et. al. *Ecotoxicology and Environmental Safety* 248 (2022) 114309. Vol. 248, 15 December 2022. https://doi.org/10.1016/j.ecoenv.2022.114309. **Article link**

Significance: Eight core chemical mixture exposure patterns were identified using a new model. This study identified five core exposure patterns of chemical mixtures that were significantly associated with obesity using the newly developed model.

Background: The effect of chemical exposure on obesity has raised great concerns. Real-world chemical exposure always imposes mixture impacts, however their exposure patterns and the corresponding associations with obesity have not been fully evaluated. **Objectives**: To discover obesity-related mixed chemical exposure patterns in the general U.S. population. **Methods**: Sparse Decompositional Regression (SDR), a model adapted from sparse representation learning technique, was developed to identify exposure patterns of chemical mixtures with exclusion (non-targeted model) and inclusion (targeted model) of health outcomes. We assessed the relationships between the identified chemical mixture patterns and obesity-related indexes. We also conducted a comprehensive evaluation of this SDR model by comparing to the existing models, including generalized linear regression model (GLM), principal component analysis (PCA), and Bayesian kernel machine regression (BKMR). **Results**: Eight core exposure patterns were identified using the non-targeted SDR model. Patterns of high levels of MEP, high levels of naphthalene metabolites (ΣOH-Nap), and a pattern of high exposure levels of MCOP, MCNP, and MCPP were positively associated with obesity. Patterns of high levels of BP3, and a pattern of higher mixed levels of MPB, PPB, and MEP were found to have negative associations. Associations were strengthened using the targeted SDR model. In the single chemical analysis by GLM, BP3, MBP, PPB, MCOP, and MCNP showed significant associations with obesity or body indexes. The SDR model exceeded the performance of PCA in pattern identification. Both SDR and BKMR identified a positive contribution of ΣOH-Nap and MCOP, as well as a negative contribution of BP3 and PPB to obesity. **Conclusion**: Our study identified five core exposure patterns of chemical mixtures significantly associated with obesity using the newly developed SDR model. The SDR model could open a new avenue for assessing health effects of environmental mixture contaminants.

Engage with IAFNS

Can Diet Impact the Gut Microbiome to Support a "Healthy" Immune Response? What We Know Today
January 11, 2023
Virtual Event

- Join IAFNS as Dr Philip Calder, Head of the School of Human Development and Health, and Professor of Nutritional Immunology at the University of Southampton, provides an overview of the knowns and unknowns related to how diet can support a "healthy" immune response, considering nutritional modulation of the gut microbiome.

  Register **here.**

Logical Fallacies in the Food and Nutrition Conversation: How to Spot Them & Diffuse Them
January 18, 2023
Virtual Event

- Join us! This Food for Thought webinar will explore logical fallacies and how when those fallacies are applied to food and beverage decisions, misinformation may result. Join us for a dialogue on Logical Fallacies in the Food and Nutrition Conversation: How to Spot Them & Diffuse Them.

  Register **here.**