December 2022

Food Safety Briefs

Risk Assessment

Unveiling Toxicity Profile for Food Risk Components: A Manually Curated Toxicological Databank of Food-Relevant Chemicals

Xing-Xing Shi, Fan Wang, Zhi-Zheng Wang, Guang-Yi Huang, Min Li, Jesus Simal-Gandara, Ge-Fei Hao, et. al. *Crit Rev Food Sci Nutr*. 2022 Dec 1;1-16. doi: 10.1080/10408398.2022.2152423. **Article link**

Significance: 221,439 experimental toxicity records for 5,657 food-relevant chemicals were identified and stored in a new database that facilitates toxicological studies, toxicity prediction, and risk assessments for the food sector.

Rigorous risk assessment of chemicals in food and feed is essential to address the growing worldwide concerns about food safety. High-quality toxicological data on food-relevant chemicals are fundamental for risk modeling and assessment in the food safety area. The organization and analysis of substantial toxicity information can positively support decision-making by providing insight into toxicity trends. However, it remains challenging to systematically obtain fragmented toxicity data, and related toxicological resources are required to meet the current demands. In this study, we collected 221,439 experimental toxicity records for 5,657 food-relevant chemicals identified from extensive databases and literature, along with their information on chemical identification, physicochemical properties, environmental fates, and biological targets. Based on the aggregated data, a freely available web-based databank, Food-Relevant Available Chemicals Toxicology Databank (FRAC-TD) is presented, which supports multiple browsing ways and search criterions. Applying FRAC-TD for data-driven analysis, we revealed the underlying toxicity profiles of food-relevant chemicals in humans, mammals, and other species in the food chain. Expectantly, FRAC-TD could positively facilitate toxicological studies, toxicity prediction, and risk assessments in the food industry.

Foodborne Pathogens

Accelerating the Detection of Bacteria in Food Using Artificial Intelligence and Optical Imaging

Luyao Ma, Jiyoon Yi, Nicharee Wisuthiphaet, Mason Earles, Nitin Nitin. *Appl Environ Microbiol*. 2022 Dec 19;e0182822. doi: 10.1128/aem.01828-22. **Article link**

Significance: Current detection methods for *E. Coli* take a few days and is a labor-intensive and technical process. Using Artificial Intelligence methods has led to new methods that do not require expensive instruments and significantly trained specialists.

In assessing food microbial safety, the presence of *Escherichia coli* is a critical indicator of fecal contamination. However, conventional detection methods require the isolation of bacterial macrocolonies for biochemical or genetic characterization, which takes a few days and is labor-intensive. In this study, we show that the real-time object detection and classification algorithm You Only Look Once version 4 (YOLOv4) can accurately identify the presence of *E. coli* at the microcolony stage after a 3-h cultivation. Integrating with phase-contrast microscopic imaging, YOLOv4 discriminated *E. coli* from seven other common foodborne bacterial species with an average precision of 94%. This approach also enabled the rapid quantification of *E. coli* concentrations over 3 orders of magnitude with an R2 of 0.995. For romaine lettuce spiked with *E. coli* (10 to 103 CFU/g), the trained YOLOv4 detector had a false-negative rate of less than 10%. This approach accelerates analysis and avoids manual result determination, which has the potential to be applied as a rapid and user-friendly bacterial sensing approach in food industries. Importance: A simple, cost-effective, and rapid method is desired to identify potential pathogen

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contamination in food products and thus prevent foodborne illnesses and outbreaks. This study combined artificial intelligence (AI) and optical imaging to detect bacteria at the microcolony stage within 3 h of inoculation. This approach eliminates the need for time-consuming culture-based colony isolation and resource-intensive molecular approaches for bacterial identification. The approach developed in this study is broadly applicable for the identification of diverse bacterial species. In addition, this approach can be implemented in resource-limited areas, as it does not require expensive instruments and significantly trained human resources. This AI-assisted detection not only achieves high accuracy in bacterial classification but also provides the potential for automated bacterial detection, reducing labor workloads in food industries, environmental monitoring, and clinical settings.

Foodborne Illness

Magnetic Nanoseparation Technology for Efficient Control of Microorganisms and Toxins in Foods: A Review

Yi Kang, Shuo Shi, Hao Sun, Jie Dan, Yanmin Liang, Qiuping Zhang, Zehui Su, Jianlong Wang, Wentao Zhang. J *Agric Food Chem*. 2022 Dec 28;70(51):16050-16068. doi: 10.1021/acs.jafc.2c07132. **Article link**

Significance: Current methods for detection and removal of pathogens are limited but magnetic nanoparticles show promise for increasing the efficiency of detection and identification of microorganisms and toxins in rapid assays.

Outbreaks of foodborne diseases mediated by food microorganisms and toxins remain one of the leading causes of disease and death worldwide. It not only poses a serious threat to human health and safety but also imposes a huge burden on health care and socioeconomics. Traditional methods for the removal and detection of pathogenic bacteria and toxins in various samples such as food and drinking water have certain limitations, requiring a rapid and sensitive strategy for the enrichment and separation of target analytes. Magnetic nanoparticles (MNPs) exhibit excellent performance in this field due to their fascinating properties. The strategy of combining biorecognition elements with MNPs can be used for fast and efficient enrichment and isolation of pathogens. In this review, we describe new trends and practical applications of magnetic nanoseparation technology in the detection of foodborne microorganisms and toxins. We mainly summarize the biochemical modification and functionalization methods of commonly used magnetic nanomaterial carriers and discuss the application of magnetic separation combined with other instrumental analysis techniques. Combined with various detection techniques, it will increase the efficiency of detection and identification of microorganisms and toxins in rapid assays.

Mycotoxins

Microbial Enzymes Involved in the Biotransformation of Major Mycotoxins

Tosin Victor Adegoke, Bolei Yang, Fuguo Xing, Xiaoyu Tian, Gang Wang, Bowen Tai, Peidong Si, et. al. *J Agric Food Chem*. 2022 Dec 27. doi: 10.1021/acs.jafc.2c06195. **Article link**

Significance: A new biotransformation method using whole microbial cells or isolated enzymes could be optimal for mitigating mycotoxins. Using specific enzymes may avoid the disadvantages of utilizing a full microbe, among other benefits.

Mycotoxins, the most researched biological toxins, can contaminate food and feed, resulting in severe health implications for humans and animals. Physical, chemical, and biological techniques are used to mitigate mycotoxin contamination. The biotransformation method using whole microbial cells or isolated enzymes is the best choice to mitigate mycotoxins. Using specific enzymes may avoid the disadvantages of utilizing a full microbe, such as accidental harm to the product's organoleptic characteristics and hazardous safety features. Moreover, the degradation rates of the isolated enzymes are higher than those of the whole-cell reactions, and they are substrate-specific. Their specificity is comprehensive and is shown at the positional and/or chiral center in many circumstances. Currently, only a few enzymes of microbial origin are commercially available. Therefore, there is a need to identify more novel enzymes of microbial origin that can mitigate mycotoxins. In this review, we conducted an in-depth summary of the microbial enzymes involved in the biotransformation of mycotoxins.

Chromatographic Methods for Rapid Aflatoxin B1 Analysis in Food: A Review

Yinyin Liu, Dan Liu, Can Li, Shuangshuang Cui, Ziguang Yun, Jian Zhang, Yong Wei, Fengxia Sun. *Crit Rev Food Sci Nutr*. 2022 Dec 15;1-18. doi: 10.1080/10408398.2022.2155107. **Article link**

Significance: Chromatographic test strips are a rapid detection technology combining labeling technology with chromatography. The strips have been widely used in the fields of environmental monitoring, medical diagnosis,

and show promise for further food safety analysis.

Aflatoxin B1 (AFB1) is a mycotoxin and is the most carcinogenic of all known chemicals. In view of the AFB1 characteristics of widespread distribution, serious pollution, great harm to humans, and animals and difficult to remove, it is urgent to develop a convenient and sensitive detection method. Moreover, chromatographic test strips (CTSs) are a rapid detection technology that combines labeling technology with chromatography technology. CTSs have been widely used in the fields of environmental monitoring, medical diagnosis, and food safety analysis in recent years. Different from other immune assays, they have the advantages of short measuring time, low cost, high efficiency and no need for professionals to operate. In addition, the introduction of nanomaterials has laid a good foundation for the detection of high sensitivity, high specificity and high efficiency via CTSs. Herein, we tend to comprehensively introduce the applications of chromatographic methods in AFB1 detection and pay attention to the signal detection modes based on nanomaterials in antibody-based immunochromatographic strips (ICSs), such as colorimetric, fluorescent, chemiluminescent, and Raman scattering sensing. Some typical examples are also listed in this review. In the end, we make a summary and put forward prospects for the development of CTSs.

Heavy Metals

Maternal Metals Exposure and Infant Weight Trajectory: The Japan Environment and Children's Study (JECS)

Yu Taniguchi, Shin Yamazaki, Shoji F Nakayama, Makiko Sekiyama, Takehiro Michikawa, Tomohiko Isobe, Miyuki Iwai-Shimada, et. al. *Environ Health Perspect*. 2022 Dec;130(12):127005. doi: 10.1289/EHP10321. **Article link**

Significance: Maternal lead, mercury, selenium and manganese blood levels appear to affect infant growth trajectory pattern in the first 3 years of life according to a study conducted in Japan.

Background: To our knowledge, the association of maternal exposure to metallic elements with weight trajectory pattern from the neonatal period has not been investigated. **Objectives:** The goals of this study were to identify infant growth trajectories in weight in the first 3 y of life and to determine the associations of maternal blood levels of lead, cadmium, mercury, selenium, and manganese with growth trajectory. **Methods**: This longitudinal study, part of the Japan Environment and Children Study, enrolled 103,099 pregnant women at 15 Regional Centres across Japan between 2011 and 2014. Lead, cadmium, mercury, selenium, and manganese levels were measured in blood samples collected in the second (14-27 wk gestational age) or third trimester (≥28 wk). Growth trajectory of 99,014 children was followed until age 3 y. Raw weight values were transformed to age- and sex-specific weight standard deviation (SD) scores, and latent-class group-based trajectory models were estimated to determine weight trajectories. Associations between maternal metallic element levels and weight trajectory were examined using multinomial logistic regression models after confounder adjustment. **Results**: We identified 5 trajectory patterns based on weight SD score: 4.74% of infants were classified in Group I, very small to small; 31.26% in Group II, moderately small; 21.91% in Group III, moderately small to moderately large; 28.06% in Group IV, moderately large to normal; and 14.03% in Group V, moderately large to large. On multinomial logistic regression, higher maternal lead and selenium levels tended to be associated with increased odds ratios (ORs) of poor weight SD score trajectories (Groups I and II), in comparison with Group III. Higher levels of mercury were associated with decreased ORs, whereas higher levels of manganese were associated with increased ORs of "moderately large" trajectories (Groups IV and V). **Discussion**: Maternal lead, mercury, selenium, and manganese blood levels affect infant growth trajectory pattern in the first 3 y of life.

Food Packaging

Application of Biosensors, Sensors, and Tags in Intelligent Packaging Used for Food Products-A Review

Emilia Osmólska, Monika Stoma, Agnieszka Starek-Wójcicka. *Sensors*. 2022 Dec 17;22(24):9956. doi: 10.3390/s22249956. **Article link**

Significance: New applications of biosensors, sensors and tags in intelligent packaging used for food products show promise. A short history and the genesis of intelligent packaging are presented, and the individual possibilities of application of sensors, biosensors, gas sensors, and RFID tags, as well as nanotechnology are outlined.

The current development of science and the contemporary market, combined with high demands from consumers, force

manufacturers and scientists to implement new solutions in various industries, including the packaging industry. The emergence of new solutions in the field of intelligent packaging has provided an opportunity to extend the quality of food products and ensures that food will not cause any harm to the consumer's health. Due to physical, chemical, or biological factors, the state of food may be subject to degradation. The degradation may occur because the packaging, i.e., the protective element of food products, may be damaged during storage, transport, or other logistic and sales activities. This is especially important since most food products are highly perishable, and the maintenance of the quality of a food product is the most critical issue in the entire supply chain. Given the importance of the topic, the main purpose of this article was to provide a general overview of the application of biosensors, sensors, and tags in intelligent packaging used for food products. A short history and the genesis of intelligent packaging are presented, and the individual possibilities of application of sensors, biosensors, gas sensors, and RFID tags, as well as nanotechnology, in the area of the packaging of food products are characterized.

Chemical Contaminants

Probiotic Cultures as a Potential Protective Strategy Against the Toxicity of Environmentally Relevant Chemicals: State-of-the-Art Knowledge

Katarina Baralić, Katarina Živančević, Dragica Bozic, Danijela Đukić-Ćosić. *Food Chem Toxicol*. 2022 Dec 26;172:113582. doi: 10.1016/j.fct.2022.113582. **Article link**

Significance: Cell walls of probiotic bacteria/fungi are considered the main place of toxic substances adsorption. Moreover, probiotics are able to induce metabolism and degradation of various toxic substances, making them less toxic and more suitable for elimination.

Environmentally relevant toxic substances may affect human health, provoking numerous harmful effects on central nervous, respiratory, cardiovascular, endocrine and reproductive system, and even cause various types of carcinoma. These substances, to which general population is constantly and simultaneously exposed, enter human body via food and water, but also by inhalation and dermal contact, while accumulating evidence suggests that probiotic cultures are able to efficiently adsorb and/or degrade them. Cell wall of probiotic bacteria/fungi, which contains structures such as exopolysaccharide, teichoic acid, protein and peptidoglycan components, is considered the main place of toxic substances adsorption. Moreover, probiotics are able to induce metabolism and degradation of various toxic substances, making them less toxic and more suitable for elimination. Other probable *in vivo* protective effects have also been suggested, including decreased intestinal absorption and increased excretion of toxic substances, prevented gut microbial dysbiosis, increase in the intestinal mucus secretion, decreased production of reactive oxygen species, reduction of inflammation, etc. Having all of this in mind, this review aims to summarize the state-of-the-art knowledge regarding the potential protective effects of different probiotic strains against environmentally relevant toxic substances (mycotoxins, polycyclic aromatic hydrocarbons, pesticides, perfluoroalkyl and polyfluoroalkyl substances, phthalates, bisphenol A and toxic metals).

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 Dec 19;116(6):1693-1703. doi: 10.1093/ajcn/nqac241. **Article link**

Significance: This study prospectively examines whether greater habitual coffee consumption was related to a lower risk of Type 2 Diabetes among women with a history of gestational diabetes. Greater consumption of caffeinated coffee was associated with a lower risk of Type 2 Diabetes.

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

Gut Microbiome Modulation by Probiotics, Prebiotics, Synbiotics and Postbiotics: A Novel Strategy in Food Allergy Prevention and Treatment

Jialu Shi, Youfa Wang, Lei Cheng, Jin Wang, Vijaya Raghavan. *Crit Rev Food Sci Nutr*. 2022 Dec 28;1-17. doi: 10.1080/10408398.2022.2160962. **Article link**

Significance: Changes in gut microbial compositions are strongly associated with increases in food allergy. Altering microbial composition is crucial in modulating food antigens' immunogenicity. The potential roles of probiotics, prebiotics, synbiotics, and postbiotics in affecting gut bacteria communities and the immune system should be further explored as interventions.

Food allergy has caused lots of global public health issues, particularly in developed countries. Presently, gut microbiota has been widely studied on allergy, while the role of dysbiosis in food allergy remains unknown. Scientists found that changes in gut microbial compositions and functions are strongly associated with a dramatic increase in the prevalence of food allergy. Altering microbial composition is crucial in modulating food antigens' immunogenicity. Thus, the potential roles of probiotics, prebiotics, synbiotics, and postbiotics in affecting gut bacteria communities and the immune system, as innovative strategies against food allergy, begins to attract high attention of scientists. This review briefly summarized the mechanisms of food allergy and discussed the role of the gut microbiota and the use of probiotics, prebiotics, synbiotics, and postbiotics as novel therapies for the prevention and treatment of food allergy. The perspective studies on the development of novel immunotherapy in food allergy were also described. A better understanding of these mechanisms will facilitate the development of preventive and therapeutic strategies for food allergy.

Emerging Science Areas

Food Safety: Sampling

Simulation of Sampling Strategies for Food Safety: A New Tool for Improved Sampling Performance

Ruben A. Chavez, Matthew Stasiewicz. *Food Safety Magazine*. Dec, 2022. Testing and Analysis. **Article link**

Significance: Although many food products are tested for hazards, they test negative, and yet high-profile recalls or outbreaks still occur in those commodities. New sampling strategies could address that.

Food safety sampling is often in the spotlight when contaminated products cause illness or injury. Consumers question if the product was tested and, if so, why the testing did not detect the pathogen, toxin, or other hazard responsible. The unfortunate reality is that, although many food products are tested for hazards, they test negative, and yet high-profile recalls or outbreaks still occur in those commodities. Why does this happen? In many bulk products, hazard contamination is not uniformly distributed, and it occurs at low levels when it does occur. Even those clusters of low-level contamination may present a risk of a recall or an outbreak. Yet, such clusters of low-level contamination make it difficult to take what are typically relatively small product grab samples used for testing in a way that would capture the hazard if it were present. This is not a "needle in a haystack" problem—those are easy to solve with a metal detector. Instead, it is a microscopic bacterium on a few produce leaves or a few nanograms of toxin on some corn kernels in a large bin.

Engage with IAFNS

January 18, 2023
3:00 - 4:00 pm ET

- **Logical Fallacies in the Food and Nutrition Conversation: How to Spot Them and Diffuse Them,"** featuring Leah McGrath, RD, LDN (Buildup Dietitians) and Melanie Trecek-King (Massasoit Community College and Thinking is Power). Learn about how recognizing logical fallacies related to food dialogue helps with identifying misinformation.

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