May 2023

Food Safety Briefs

Risk Assessment

Producing Ratio Measures of Effect with Quantitative Microbial Risk Assessment
Drew Capone, Aaron Bivins, Joe Brown. *Risk Anal.* 2023 May;43(5):917-927. doi: 10.1111/risa.13972. **Article link**

Significance: To better evaluate control measures, ratio estimates of effect such as odds and risk ratios are needed that are more broadly interpretable and consistent with concepts from the field of epidemiology.

Estimating the risk of infections or other outcomes incident to pathogen exposure is a primary goal of quantitative microbial risk assessment (QMRA). Such estimates are useful to predict population-level risks, to evaluate exposures based on normative or tolerable risk guidelines, and to interpret the likely public health relevance of microbial measurements in environmental media. To evaluate alternative control measures (interventions), ratio estimates of effect (e.g., odds and risk ratios) are needed that are more broadly interpretable in the health sciences and consistent with convention in epidemiology. In this paper, we propose a general method for estimating widely used ratio measures of effect derived from stochastic QMRA approaches, including the generation of appropriate confidence intervals. Such QMRA-derived ratios can be used as a basis for evaluating interventions via hypothesis testing and for inclusion in systematic reviews and meta-analyses in a form consistent with risk estimation approaches commonly used in epidemiology.

Foodborne Pathogens

Susceptibility of *Campylobacter jejuni* to Stressors in Agrifood Systems and Induction of a Viable-but-Nonculturable State

Jingbin Zhang, Xiaonan Lu. *Appl Environ Microbiol.* 2023 May 31;89(5):e0009623. doi: 10.1128/aem.00096-23. **Article link**

Significance: The culturability and viability of *C. jejuni* cells are investigated under various stress conditions to understand the transition to a viable but nonculturable (VBNC) state in agrifood systems.

Many bacteria can become viable but nonculturable (VBNC) in response to stressors commonly identified in agrifood systems. *Campylobacter* is able to enter the VBNC state to evade unfavorable environmental conditions, but how food processing can induce *Campylobacter jejuni* to enter this state and the potential role of foods in inducing the VBNC state in *C. jejuni* remains largely unknown. In this study, the culturability and viability of *C. jejuni* cells were investigated under chlorine treatment (25 ppm), aerobic stress (atmospheric condition), and low-temperature (4°C) conditions that mimicked food processing. In addition, the behaviors of *C. jejuni* cells in

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ultrahigh-temperature (UHT) and pasteurized milk were also monitored during refrigerated storage. The numbers of viable and culturable *C. jejuni* cells in both the pure bacterial culture and food matrices were separately determined by propidium monoazide (PMA)-quantitative PCR (qPCR) and plating assay. The *C. jejuni* cells lost their culturability but partially retained their viability (1% to 10%) once mixed with chlorine. In comparison, ~10% of *C. jejuni* cells were induced to enter the VBNC state after 24 h and 20 days under aerobic and low-temperature conditions, respectively. The viability of the *C. jejuni* cells remained stable during the induction process in UHT (>10%) and pasteurized (>10%) milk. The number of culturable *C. jejuni* cells decreased quickly in pasteurized milk, but culturable cells could still be detected in the end (day 21). In contrast, the number of culturable *C. jejuni* cells slowly decreased, and they became undetectable after >42 days in UHT milk. The *C. jejuni* cells responded differently to various stress conditions and survived in high numbers in the VBNC state in agrifood systems.

Foodborne Illness

Improving Foodborne Disease Surveillance and Outbreak Detection and Response Using Peer Networks-The Integrated Food Safety Centers of Excellence

Alice E White, Katie N Garman, Craig Hedberg, Paula Pennell-Huth, Kirk E Smith, Elizabeth Sillence, Janet Baseman, et. al. *J Public Health Manag Pract.* 2023 May-Jun;29(3):287-296. doi: 10.1097/PHH.0000000000001607. **Article link**

Significance: The implementation of Integrated Food Safety (IFS) Centers of Excellence (CoEs) allows for increased public health agency capacity and supports a greater outbreak response to emerging issues.

Context: Foodborne disease surveillance and outbreak investigations are foundational to the prevention and control of foodborne disease in the United States, where contaminated foods cause an estimated 48 million illnesses, 128 000 hospitalizations, and 3000 deaths each year. Surveillance activities and rapid detection and investigation of foodborne disease outbreaks require a trained and coordinated workforce across epidemiology, environmental health, and laboratory programs. Program: Under the 2011 Food Safety Modernization Act, the Centers for Disease Control and Prevention (CDC) was called on to establish Integrated Food Safety (IFS) Centers of Excellence (CoEs) at state health departments, which would collaborate with academic partners, to identify, implement, and evaluate model practices in foodborne disease surveillance and outbreak response and to serve as a resource for public health professionals. Implementation: CDC designated 5 IFS CoEs in August 2012 in Colorado, Florida, Minnesota, Oregon, and Tennessee; a sixth IFS CoE in New York was added in August 2014. For the August 2019-July 2024 funding period, 5 IFS CoEs were designated in Colorado, Minnesota, New York, Tennessee, and Washington. Each IFS CoE is based at the state health department that partners with at least one academic institution. Evaluation: IFS CoEs have built capacity across public health agencies by increasing the number of workforce development opportunities (developing >70 trainings, tools, and resources), supporting outbreak response activities (responding to >50 requests for outbreak technical assistance annually), mentoring students, and responding to emerging issues, such as changing laboratory methods and the COVID-19 pandemic.

Mycotoxins

MycotoxinDB: A Data-Driven Platform for Investigating Masked Forms of Mycotoxins

Jian Ji, Dachuan Zhang, Jin Ye, Yi Zheng, Jing Cui, Xiulan Sun. *J Agric Food Chem.* 2023 May 5. Doi: 10.1021/acs.jafc.3c01403. **Article link**

Significance: The structure elucidation of masked mycotoxins is challenging due to the limitations of traditional analysis methods. MycotoxinDB, an online prediction tool, was developed to assist in the rapid detection of masked mycotoxins.

Mycotoxins are likely to be converted into masked forms when subjected to plant metabolism or food processing. These masked forms of mycotoxins together with their prototypes may cause mixture toxicity effects, causing adverse effects on animal welfare and productivity. The structure elucidation of masked mycotoxins is the most challenging task in mycotoxin research due to the limitations of traditional analysis methods. To assist in the rapid identification of masked mycotoxins, we developed a data-driven online prediction tool, MycotoxinDB, based on reaction rules. Using MycotoxinDB, we identified seven masked DONs from wheat samples. Given its widespread applications, we expect that MycotoxinDB will become an indispensable tool in future mycotoxin research. MycotoxinDB is freely available at: http://www.mycotoxin-db.com/.

Heavy Metals

Cognitive Outcomes Caused by Low-Level Lead, Cadmium and Mercury Mixture Exposure at Distinct Phases of Brain Development

Lu Ouyang, Qi Li, Shaoqi Rao, Rui Su, Yanhui Zhu, Guihua Du, Jie Xie, et. al. *Food Chem Toxicol*. 2023 May;175:113707. doi: 10.1016/j.fct.2023.113707. **Article link**

Significance: Exposure to lead, cadmium and mercury mixtures in test animals decreased the density of memory- and learning-related dendritic spines in the hippocampus during the critical period of brain development, resulting in spatial memory deficits.

Contaminated water and food are the main sources of lead, cadmium, and mercury in the human body. Long-term and low-level ingestion of these toxic heavy metals may affect brain development and cognition. However, the neurotoxic effects of exposure to lead, cadmium, and mercury mixture (Pb + Cd + Hg) at different stages of brain development are rarely elucidated. In this study, different doses of low-level Pb + Cd + Hg were administered to Sprague-Dawley rats via drinking water during the critical stage of brain development, late stage, and after maturation, respectively. Our findings showed that Pb + Cd + Hg exposure decreased the density of memory- and learning-related dendritic spines in the hippocampus during the critical period of brain development, resulting in hippocampus-dependent spatial memory deficits. Only the density of learning-related dendritic spines was reduced during the late phase of brain development and a higher-dose of Pb + Cd + Hg exposure was required, which led to hippocampus-independent spatial memory abnormalities. Exposure to Pb + Cd + Hg after brain maturation revealed no significant change in dendritic spines or cognitive function. Further molecular analysis indicated that morphological and functional changes caused by Pb + Cd + Hg exposure during the critical phase were associated with PSD95 and GluA1 dysregulation. Collectively, the effects of Pb + Cd + Hg on cognition varied depending on the brain development stages.

Food Packaging

The Preparation, Resources, Applications and Future Trends of Nanofibers in Active Food Packaging: A Review

Chaoyi Shen, Zhichao Yang, Di Wu, Kunsong Chen. *Crit Rev Food Sci Nutr*. 2023 May 22;1-16. doi: 10.1080/10408398.2023.2214819. **Article link**

Significance: Three common methods for the preparation of nanofibers in active food packaging and their influencing parameters are presented, as well as a comparison of their advantages and disadvantages for use in commercial food packaging.

Active packaging is a novel strategy for maintaining the shelf life of products and ensuring their safety, freshness, and integrity that has emerged with the consumer demand for safer, healthier, and higher quality food. Nanofibers have received a lot of attention for the application in active food packaging due to their high specific surface area, high porosity, and high loading capacity of active substances. Three common methods (electrospinning, solution blow spinning, and centrifugal spinning) for the preparation of nanofibers in active food packaging and their influencing parameters are presented, and advantages and disadvantages between these methods are compared. The main natural and synthetic polymeric substrate materials for the nanofiber preparation are discussed; and the application of nanofibers in active packaging is elaborated. The current limitations and future trends are also discussed. There have been many studies on the preparation of nanofibers using substrate materials from different sources for active food packaging. However, most of these studies are still in the laboratory research stage. Solving the issues of preparation efficiency and cost of nanofibers is the key to their application in commercial food packaging.

Chemical Contaminants

Acrylamide in Food: Occurrence, Metabolism, Molecular Toxicity Mechanism and Detoxification by Phytochemicals

Fangfang Yan, Li Wang, Li Zhao, Chengming Wang, Qun Lu, Rui Liu. *Food Chem Toxicol*. 2023 May;175:113696. doi: 10.1016/j.fct.2023.113696. **Article link**

Significance: Acrylamide level in foods and its metabolic pathways and toxicological mechanisms are important to understand in addition to its detoxification by phytochemicals.

Acrylamide (ACR) is a common pollutant formed during food thermal processing such as frying, baking and roasting.

ACR and its metabolites can cause various negative effects on organisms. To date, there have been some reviews summarizing the formation, absorption, detection and prevention of ACR, but there is no systematic summary on the mechanism of ACR-induced toxicity. In the past five years, the molecular mechanism for ACR-induced toxicity has been further explored and the detoxification of ACR by phytochemicals has been partly achieved. This review summarizes the ACR level in foods and its metabolic pathways, as well as highlights the mechanisms underlying ACR-induced toxicity and ACR detoxification by phytochemicals. It appears that oxidative stress, inflammation, apoptosis, autophagy, biochemical metabolism and gut microbiota disturbance are involved in various ACR-induced toxicities. In addition, the effects and possible action mechanisms of phytochemicals, including polyphenols, quinones, alkaloids, terpenoids, as well as vitamins and their analogs on ACR-induced toxicities are also discussed. This review provides potential therapeutic targets and strategies for addressing various ACR-induced toxicities in the future.

Caffeine

Acute Effects of Coffee Consumption on Health among Ambulatory Adults

Gregory M Marcus, David G Rosenthal, Gregory Nah, Eric Vittinghoff, Christina Fang, Kelsey Ogomori, Sean Joyce, et. al. *N Engl J Med*. 2023 Mar 23;388(12):1092-1100. doi: 10.1056/NEJMoa2204737. **Article link**

Significance: A randomized trial found that the consumption of caffeinated coffee did not result in significantly more daily premature atrial contractions than its avoidance.

Background: Coffee is one of the most commonly consumed beverages in the world, but the acute health effects of coffee consumption remain uncertain. Methods: We conducted a prospective, randomized, case-crossover trial to examine the effects of caffeinated coffee on cardiac ectopy and arrhythmias, daily step counts, sleep minutes, and serum glucose levels. A total of 100 adults were fitted with a continuously recording electrocardiogram device, a wrist-worn accelerometer, and a continuous glucose monitor. Participants downloaded a smartphone application to collect geolocation data. We used daily text messages, sent over a period of 14 days, to randomly instruct participants to consume caffeinated coffee or avoid caffeine. The primary outcome was the mean number of daily premature atrial contractions. Adherence to the randomization assignment was assessed with the use of real-time indicators recorded by the participants, daily surveys, reimbursements for date-stamped receipts for coffee purchases, and virtual monitoring (geofencing) of coffee-shop visits. Results: The mean (±SD) age of the participants was 39±13 years; 51% were women, and 51% were non-Hispanic White. Adherence to the random assignments was assessed to be high. The consumption of caffeinated coffee was associated with 58 daily premature atrial contractions as compared with 53 daily events on days when caffeine was avoided (rate ratio, 1.09; 95% confidence interval [CI], 0.98 to 1.20; P = 0.10). The consumption of caffeinated coffee as compared with no caffeine consumption was associated with 154 and 102 daily premature ventricular contractions, respectively (rate ratio, 1.51; 95% CI, 1.18 to 1.94); 10,646 and 9665 daily steps (mean difference, 1058; 95% CI, 441 to 1675); 397 and 432 minutes of nightly sleep (mean difference, 36; 95% CI, 25 to 47); and serum glucose levels of 95 mg per deciliter and 96 mg per deciliter (mean difference, -0.41; 95% CI, -5.42 to 4.60). Conclusions: In this randomized trial, the consumption of caffeinated coffee did not result in significantly more daily premature atrial contractions than the avoidance of caffeine.

Food Allergens

Gut Microbiota Maturity Mediates the Protective Effect of Siblings on Food Allergy

Yuan Gao, Jakob Stokholm, Martin O'Hely, Anne-Louise Ponsonby, Mimi Lk Tang, Sarath Ranganathan, Richard Saffery, et. al. *J Allergy Clin Immunol*. 2023 May 5;S0091-6749(23)00562-6. doi: 10.1016/j.jaci.2023.02.034. **Article link**

Significance: There is a protective effect of having older siblings on the risk of developing IgE-mediated food allergy during infancy which is mediated by advanced maturation of the gut microbiota at 1 year of age.

B Background: The mechanisms underlying the protective effect of older siblings on allergic disease remain unclear but may relate to the infant gut microbiota. Objective: We investigated whether having older siblings decreases the risk of Immunoglobulin E (IgE)-mediated food allergy by accelerating the maturation of the infant gut microbiota. Methods: In a birth cohort assembled using an unselected antenatal sampling frame (n=1074), fecal samples were collected at 1 month, 6 months and 1 year, and food allergy status at 1 year was determined by skin prick test and in-hospital food challenge. We used 16S rRNA gene amplicon sequencing to derive amplicon sequence variants (ASVs). Among a random subcohort (n=323), microbiota-by-age z-scores (MAZ) at each time point were calculated using fecal ASVs to represent the gut microbiota maturation over the first year of life. Results: A greater number of siblings was associated with a higher MAZ at 1 year of age (β =0.15 per an additional sibling; 95%CI (0.05, 0.24); p=0.003), which was in turn associated with decreased odds of food allergy (OR=0.45; 95%CI (0.33, 0.61); p<0.001). MAZ mediated 63% of the protective effect of siblings. Analogous associations were not observed at younger ages. Conclusion: The protective

effect of older siblings on the risk of developing IgE-mediated food allergy during infancy is substantially mediated by advanced maturation of the gut microbiota at 1 year of age.

Emerging Science Areas

Emerging Area: Food Processing

Behavior of Enzymes Under High Pressure in Food Processing: Mechanisms, Applications and Developments

Nan Zheng, Mengfei Long, Zehua Zhang, Shuang Du, Xinlei Huang, Tolbert Osire, Xiaole Xia. *Crit Rev Food Sci Nutr*. 2023 May 26;1-15. doi: 10.1080/10408398.2023.2217268. **Article link**

Significance: A review of the mechanism by which high pressure processing affects the stability and activity of enzymes, improving food quality.

High pressure processing (HPP) offers the benefits of safety, uniformity, energy-efficiency, and low waste, which is widely applied for microbial inactivation and shelf-life extension for foods. Over the past forty years, HPP has been extensively researched in the food industry, enabling the inactivation or activation of different enzymes in future food by altering their molecular structure and active site conformation. Such activation or inactivation of enzymes effectively hinders the spoilage of food and the production of beneficial substances, which is crucial for improving food quality. This paper reviews the mechanism in which high pressure affects the stability and activity of enzymes, concludes the roles of key enzymes in the future food processed using high pressure technologies. Moreover, we discuss the application of modified enzymes based on high pressure, providing insights into the future direction of enzyme evolution under complex food processing conditions (e.g. high temperature, high pressure, high shear, and multiple elements). Finally, we conclude with prospects of high-pressure technology and research directions in the future. Although HPP has shown positive effects in improving the future food quality, there is still a pressing need to develop new and effective combined processing methods, upgrade processing modes, and promote sustainable lifestyles.

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August 30, 2023, Virtual.

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