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Food Safety

Risk Assessment

Migration of Endocrine-Disrupting Chemicals into Food from Plastic Packaging Materials: An Overview of Chemical Risk Assessment, Techniques to Monitor Migration, and International Regulations

Hooi-Theng Ong, Hayati Samsudin, Herlinda Soto-Valdez. *Crit Rev Food Sci Nutr*. 2022;62(4):957-979. doi: 10.1080/10408398.2020.1830747. **Article link**

Significance: This article gives an overview of the migration of endocrine-disrupting chemicals from plastic packaging materials and control measures to reduce the risk of adverse impacts on human health.

Plastic packaging materials (PPMs) protect food from contamination, maintain quality, and ease transportation and distribution. Additives included during the manufacturing and processing of PPMs improve flexibility, durability, barrier properties, and sometimes aid the processing itself. During processing, these additives, even the monomers used to produce the plastics, can produce side products or breakdown products as a result of degradation and various chemical reactions. These starting substances and reaction products include 2,2-bis(4-hydroxyphenyl)propane (bisphenol A), phthalates/phthalic acid esters, alkylphenols, and bis(2-ethylhexyl) adipate, which are considered endocrine-disrupting chemicals (EDCs) that may interfere with the human endocrine system and produce adverse reproductive, neurological, developmental, and immune effects. When in contact with food, EDCs can migrate into food if conditions are appropriate, thereby possibly jeopardizing food safety. Chemical risk assessment and regulatory control were developed to reduce human exposure to harmful migrated EDCs. This article gives an overview of the migration of EDCs from PPMs and control measures to reduce the risk of adverse impacts on human health.

Foodborne Pathogens

Induction of the Viable-but-Nonculturable State in Salmonella Contaminating Dried Fruit

Victor Jayeola, J M Farber, S Kathariou. *Appl Environ Microbiol*. 2022 Jan 25;88(2):e0173321. doi: 10.1128/AEM.01733-21. Article link. **Article link**

Significance: Data suggest that the unique combination of stressors in dried fruit can induce large numbers of viable but nonculturable cells of Salmonella.

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Salmonella can become viable but nonculturable (VBNC) in response to environmental stressors, but the induction of the VBNC state in *Salmonella* contaminating ready-to-eat dried fruit is poorly characterized. Dried apples, strawberries, and raisins were mixed with a five-strain cocktail of *Salmonella* at 4% volume per weight of dried fruit at 109 CFU/g. The inoculated dried fruit were then dried in desiccators at 25°C until the water activity (aw) approximated that of the uni-noculated dried fruit. However, *Salmonella* could not be recovered after drying, not even after enrichment, suggesting a population reduction of approximately 8 log CFU/g. To assess the potential impact of storage temperature on survival, dried apples were spot-inoculated with the *Salmonella* cocktail, dried under ambient atmosphere at 25°C, and stored at 4 and 25°C. Spot inoculation permitted recovery of *Salmonella* on dried apple after drying, with the population of Salmonella decreasing progressively on dried apples stored at 25°C until it was undetectable after about 46 days, even following enrichment.

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The population decline was noticeably slower at 4°C, with *Salmonella* being detected until 82 days. However, fluorescence microscopy and laser scanning confocal microscopy with the LIVE/DEAD BacLight bacterial viability system at time points at which no *Salmonella* could be recovered on growth media even following enrichment showed that a large proportion (56 to 85%) of the *Salmonella* cells on the dried fruit were viable. The data suggest that the unique combination of stressors in dried fruit can induce large numbers of VBNC cells of *Salmonella*. **IMPORTANCE:** *Salmonella* is a leading foodborne pathogen globally causing numerous outbreaks of foodborne illnesses and remains the leading contributor to deaths attributed to foodborne disease in the United States and other industrialized nations. Therefore, efficient detection methods for *Salmonella* contaminating food are critical for public health and food safety. Culture-based microbiological methods are considered the gold standard for the detection and enumeration of *Salmonella* in food. Findings from this study suggest that unique stressors on dried fruit can induce the VBNC state in *Salmonella*, thus rendering it undetectable with culture-based methods even though the bacteria remain viable. Therefore, strong consideration should be given to using, in addition to culture-based methods, microscopic and molecular methods for the accurate detection of all viable and/or culturable cells of *Salmonella* contaminating dried fruit, as all of these cells have the potential to cause human illness.

Foodborne Illness

Detection of Norovirus Using Paper-Based Cell-Free Systems

Kaiyue Wu, Alexander A Green. *Methods Mol Biol*. 2022;2433:375-390. doi: 10.1007/978-1-0716-1998-8_23. **Article link**

Significance: New diagnostic tests are promising assays for confronting norovirus outbreaks and can be adapted to a variety of other human pathogens.

Norovirus infections are the leading cause of foodborne illness and human gastroenteritis, afflicting hundreds of millions of people each year. Molecular assays with the capacity to detect norovirus without expensive equipment and with high sensitivity and specificity represent useful tools to track and contain future outbreaks. Here we describe how norovirus can be detected in low-cost paper-based cell-free reactions. These assays combine freeze-dried, thermostable cell-free transcription-translation reactions with toehold switch riboregulators designed to target the norovirus genome, enabling convenient colorimetric assay readouts. Coupling cell-free reactions with synbody-based viral enrichment and isothermal amplification enables detection of norovirus from clinical samples down to concentrations as low as 270 zM. These diagnostic tests are promising assays for confronting norovirus outbreaks and can be adapted to a variety of other human pathogens.

Mycotoxins

The Control of Fungi and Mycotoxins by Food Active Packaging: A Review

Shima Jafarzadeh, Milad Hadidi, Mehrdad Forough, Abdorreza Mohammadi Nafchi, Amin Mousavi Khaneghah. *Crit Rev Food Sci Nutr*. 2022 Jan 28;1-19. doi: 10.1080/10408398.2022.2031099. **Article link**

Significance: Incorporating biopolymer films and coatings with antimicrobial agents provides great potential for controlling common fungi and mycotoxins.

Conventionally used petrochemical-based plastics are poorly degradable and cause severe environmental pollution. Alternatively, biopolymers (e.g., polysaccharides, proteins, lipids, and their blends) are biodegradable and environment-friendly, and thus their use in packaging technologies has been on the rise. Spoilage of food by mycotoxigenic fungi poses a severe threat to human and animal health. Hence, because of the adverse effects of synthetic preservatives, active packaging as an effective technique for controlling and decontaminating fungi and related mycotoxins has attracted considerable interest. The current review aims to provide an overview of the prevention of fungi and mycotoxins through active packaging. The impact of different additives on the antifungal and anti-mycotoxigenic functionality of packaging incorporating active films/coatings is also investigated. In addition, active packaging applications to control and decontaminate common fungi and mycotoxins in bakery products, cereal grains, fruits, nuts, and dairy products are also introduced. The results of recent studies have confirmed that biopolymer films and coatings incorporating antimicrobial agents provide great potential for controlling common fungi and mycotoxins and enhancing food quality and safety.

Food Packaging

Nanocellulose: A Promising Green Treasure from Food Wastes to Available Food Materials

Tao Ma, Xinna Hu, Shuyu Lu, Xiaojun Liao, Yi Song, Xiaosong Hu. *Crit Rev Food Sci Nutr*. 2022;62(4):989-1002. DOI: 10.1080/10408398.2020.1832440. **Article link**

Significance: This review presents the structural characteristics and advances in the extraction approaches of nanocellulose, with an emphasis on recent progress in the various applications of nanocellulose in the field of food industry. Validated standards will be necessary for commercialization.

The synthesis of novel functional materials from abundant food waste resources has great application potentials and ecological benefits. Nanocellulose is a renewable and sustainable polymer that possesses a modifiable surface, excellent mechanical strength, and high aspect ratio, and it is nontoxic. These unique properties garner nanocellulose a promising prospect for multi-various applications including the food industry. This review presents the structural characteristics and advances in the extraction approaches of nanocellulose, with an emphasis in recent progress on the various applications of nanocellulose in the field of food industry. Finally, the environmental and human health issues related to the production of nanocellulose are evaluated. The scheme to extract and produce nanocellulose from food wastes provides a platform for the sustainable utilization of waste biomass. These nanocelluloses exhibit excellent performances in green food packaging materials, emulsion stabilizers, dietary fiber, nutrition delivery and food three-dimensional (3 D) printing hydrogels. To ensure the security and regulatory issues, validated standards to characterize the structure and evaluate its toxicity are still indispensable to achieve the commercialization of nanocellulose in the food industry.

Heavy Metals

Associations of Childhood and Perinatal Blood Metals with Children's Gut Microbiomes in a Canadian Gestation Cohort.

Yike Shen, Hannah E Laue, Martha J Shrubsole, Haotian Wu, Tessa R Bloomquist, Annie Larouche, Kankan Zhao et. al. *Environ Health Perspect*. 2022 Jan;130(1):17007. doi: 10.1289/EHP9674. **Article link**

Significance: This results from this study show both long- and short-term associations between metal exposure and the childhood gut microbiome, with stronger associations observed with more recent exposure.

Background: The gut microbiome is important in modulating health in childhood. Metal exposures affect multiple health outcomes, but their ability to modify bacterial communities in children is poorly understood. Objectives: We assessed the associations of childhood and perinatal blood metal levels with childhood gut microbiome diversity, structure, species, gene family-inferred species, and potential pathway alterations. **Methods**: We assessed the gut microbiome using 16S rRNA gene amplicon sequencing and shotgun metagenomic sequencing in stools collected from 6- to 7-year-old children participating in the GESTation and Environment (GESTE) cohort study. We assessed blood metal concentrations [cad-mium (Cd), manganese (Mn), mercury (Hg), lead (Pb), selenium (Se)] at two time points, namely, perinatal exposures at delivery (N=70) and childhood exposures at the 6- to 7-y follow-up (N=68). We used multiple covariate-adjusted statistical models to determine microbiome associations with continuous blood metal levels, including linear regression (Shannon and Pielou alpha diversity indexes), permutational multivariate analysis of variance (adonis; beta diversity distance matri-ces), and multivariable association model (MaAsLin2; phylum, family, species, gene family-inferred species, and path-ways). **Results**: Children's blood Mn and Se significantly associated with microbiome phylum [e.g., Verrucomicrobiota (coef=−0.305, q=0.031; coef=0.262, q=0.084, respectively)] and children's blood Mn significantly associated with family [e.g., *Eggerthellaceae* (coef=−0.228, q=0.052)]-level differences. Higher relative abundance of potential pathogens (e.g., *Flavonifractor plautii*), beneficial species (e.g., *Bifidobacterium longum*, *Faecalibacterium prausnitzii*), and both poten-tially pathogenic and beneficial species (e.g., B*acteriodes vulgatus*, *Eubacterium rectale*) inferred from gene families were associated with higher childhood or perinatal blood Cd, Hg, and Pb (q<0.1). We found significant negative associations between childhood blood Pb and acetylene degradation pathway abundance (q<0.1). Finally, neither perinatal nor childhood metal concentrations were associated with children's gut microbial inter- and intrasubject diversity. **Discussion**: Our findings suggest both long- and short-term associations between metal exposure and the childhood gut microbiome, with stronger associations observed with more recent exposure. Future epidemiologic analyses may elucidate whether the observed changes in the microbiome relate to children's health.

Recent Progress on Single-Molecule Detection Technologies for Food Safety.

Zhuoqun Su, Tong Li, Di Wu, Yongning Wu, Guoliang Li. *J Agric Food Chem*. 2022 Jan 19;70(2):458-469. doi: 10.1021/acs.jafc.1c06808. **Article link**

Significance: This review highlights typical single-molecule detection methods used in food safety including electrochemistry, optical spectrum, and atom force microscopy, as well as their applications in detecting food contaminants such as biotoxins, pesticides and heavy metals.

Rapid and sensitive detection technologies for food contaminants play vital roles in food safety. Due to the complexity of the food matrix and the trace amount distribution, traditional methods often suffer from unsatisfying accuracy, sensitivity, or specificity. In past decades, single-molecule detection (SMD) has emerged as a way to realize the rapid and ultrasensitive measurement with low sample consumption, showing a great potential in food contaminants detection. For instance, based on the nanopore technique, simple and effective methods for single-molecule analysis of food contaminants have been developed. To our knowledge, there has been a rare review that focuses on SMD techniques for food safety. The present review attempts to cover some typical SMD methods in food safety, including electrochemistry, optical spectrum, and atom force microscopy. Then, recent applications of these techniques for detecting food contaminants such as biotoxins, pesticides, heavy metals, and illegal additives are reviewed. Finally, existing research challenges and future trends of SMD in food safety are also tentatively proposed.

Chemical Contaminants

Hemoglobin Adducts of Acrylamide in Human Blood - What Has Been Done and What is Next?

Marie Pedersen, Efstathios Vryonidis, Andrea Joensen, Margareta Törnqvist. *Food Chem Toxicol*. 2022 Jan 4;112799. doi: 10.1016/j.fct.2021.112799. **Article link**

Significance: The determination of hemoglobin (Hb) adducts from acrylamide is increasingly being used to improve the exposure assessment of acrylamide. We aim to outline the literature on Hb adduct levels from acrylamide in humans and discuss methodological issues and research gaps.

Acrylamide forms in many commonly consumed foods. In animals, acrylamide causes tumors, neurotoxicity, developmental and reproductive effects. Acrylamide crosses the placenta and has been associated with restriction of intrauterine growth and certain cancers. The impact on human health is poorly understood and it is impossible to say what level of dietary exposure to acrylamide can be deemed safe as the assessment of exposure is uncertain. The determination of hemoglobin (Hb) adducts from acrylamide is increasingly being used to improve the exposure assessment of acrylamide. We aim to outline the literature on Hb adduct levels from acrylamide in humans and discuss methodological issues and research gaps. A total of 86 studies of 27,966 individuals from 19 countries were reviewed. Adduct levels were highest in occupationally exposed individuals and smokers. Levels ranged widely from 3 to 210 pmol/g Hb in non-smokers and this wide range suggests that dietary exposure to acrylamide varies largely. Non-smokers from the US and Canada had slightly higher levels as compared with non-smokers from elsewhere, but differences within studies were larger than between studies. Large studies with exposure assessment of acrylamide and related adduct forming compounds from diet during early-life are encouraged for the evaluation of health effects.

Caffeine

Determination of Caffeine in Dietary Supplements by Miniaturized Portable Liquid Chromatography

C Soto, H D Ponce-Rodríguez, J Verdú-Andrés, R Herráez-Hernández, P Campíns-Falco. *J Chromatogr A*. 2022;1664:462770. doi: 10.1016/j.chroma.2021.462770. **Article link**

Significance: A new method for the rapid measurement of caffeine in dietary supplements is presented. This portable liquid chromatography-based method can be used as a simple and rapid alternative to bench-based methods for quantitation of caffeine content.

In this study three miniaturized liquid chromatography (LC) instruments have been evaluated and compared for the analysis of caffeine in dietary supplements, namely a benchtop capillary LC (capLC) system, a benchtop nano LC (nanoLC)system and a portable LC system. Commercial products derived from different sources of caffeine have been analyzed. Under optimized conditions, the methods based on benchtop systems were superior in terms of sensitivity. The limits of detection (LODs) found with the capLC and nanoLC systems were 0.01 and 0.003 μg mL-1, respectively, whereas the LOD obtained with the portable LC instrument was of 1 μg mL-1. The portable LC-based method was superior in terms of simplicity and throughput (total analysis time < 15 min). On the basis of the results obtained, a new method for the rapid measurement of caffeine in dietary supplements by portable miniaturized LC is presented. This method provided good linearity within the 1-20 μg mL-1 interval, and it allowed the quantification of caffeine even in products derived from decaffeinated green coffee extracts. The contents of caffeine found with the proposed portable LC method in the real samples analyzed ranged from 1.38 to 7 mg per gram of product, which were values statistically equivalent to those found with the benchtop capLC and nanoLC methods, being the precision, expressed as relative standard deviation (RDS), of 2 -14% (n = 3). The proposed portable LC based method can be used as a simple and rapid alternative to estimate the quality, effectiveness and safety of dietary supplements, regarding their caffeine content.

Food Allergens

Efficacy and Safety of Oral Immunotherapy in Children Aged 1–3 Years with Peanut Allergy (the Immune Tolerance Network IMPACT Trial): A Randomised Placebo-Controlled Study)

Stacie M Jones, Edwin H Kim, Kari C Nadeau, Anna Nowak-Wegrzyn, Robert A Wood, Hugh A Sampson, et al. *The Lancet*. Vol. 399, Issue 10322, p359-371, Jan 22, 2022. **Article link**

Significance: In children with a peanut allergy, initiation of peanut oral immunotherapy before age 4 years was associated with an increase in both desensitisation and remission. The outcomes suggest a window of opportunity for intervention to induce remission of peanut allergy.

Background: For young children with peanut allergy, dietary avoidance is the current standard of care. We aimed to assess whether peanut oral immunotherapy can induce desensitisation (an increased allergic reaction threshold while on therapy) or remission (a state of non-responsiveness after discontinuation of immunotherapy) in this population. **Methods**: We did a randomised, double-blind, placebo-controlled study in five US academic medical centres. Eligible participants were children aged 12 to younger than 48 months who were reactive to 500 mg or less of peanut protein during a double-blind, placebo-controlled food challenge (DBPCFC). Participants were randomly assigned by use of a computer, in a 2:1 allocation ratio, to receive peanut oral immunotherapy or placebo for 134 weeks (2000 mg peanut protein per day) followed by 26 weeks of avoidance, with participants and study staff and investigators masked to group treatment assignment. The primary outcome was desensitisation at the end of treatment (week 134), and remission after avoidance (week 160), as the key secondary outcome, were assessed by DBPCFC to 5000 mg in the intention-to-treat population. Safety and immunological parameters were assessed in the same population. **Findings:** Between Aug 13, 2013, and Oct 1, 2015, 146 children, with a median age of 39·3 months (IQR 30·8–44·7), were randomly assigned to receive peanut oral immunotherapy (96 participants) or placebo (50 participants). At week 134, 68 (71%, 95% CI 61–80) of 96 participants who received peanut oral immunotherapy compared with one (2%, 0·05–11) of 50 who received placebo met the primary outcome of desensitisation (risk difference [RD] 69%, 95% CI 59–79; p<0·0001). The median cumulative tolerated dose during the week 134 DBPCFC was 5005 mg (IQR 3755–5005) for peanut oral immunotherapy versus 5 mg (0–105) for placebo (p<0·0001). After avoidance, 20 (21%, 95% CI 13–30) of 96 participants receiving peanut oral immunotherapy compared with one (2%, 0·05–11) of 50 receiving placebo met remission criteria (RD 19%, 95% CI 10–28; p=0·0021). The median cumulative tolerated dose during the week 160 DBPCFC was 755 mg (IQR 0–2755) for peanut oral immunotherapy and 0 mg (0–55) for placebo (p<0·0001). A significant proportion of participants receiving peanut oral immunotherapy who passed the 5000 mg DBPCFC at week 134 could no longer tolerate 5000 mg at week 160 (p<0·001). The participant receiving placebo who was desensitised at week 134 also achieved remission at week 160. Compared with placebo, peanut oral immunotherapy decreased peanut-specific and Ara h2-specific IgE, skin prick test, and basophil activation, and increased peanut-specific and Ara h2-specific IgG4 at weeks 134 and 160. By use of multivariable regression analysis of participants receiving peanut oral immunotherapy, younger age and lower baseline peanut-specific IgE was predictive of remission. Most participants (98% with peanut oral immunotherapy vs 80% with placebo) had at least one oral immunotherapy dosing reaction, predominantly mild to moderate and occurring more frequently in participants receiving peanut oral immunotherapy. 35 oral immunotherapy dosing events with moderate symptoms were treated with epinephrine in 21 participants receiving peanut oral immunotherapy. **Interpretation**: In children with a peanut allergy, initiation of peanut oral immunotherapy before age 4 years was associated with an increase in both desensitisation and remission. Development of remission correlated with immunological biomarkers. The outcomes suggest a window of opportunity at a young age for intervention to induce remission of peanut allergy.