Foodborne Pathogens

Seafood Spoilage Microbiota and Associated Volatile Organic Compounds at Different Storage Temperatures and Packaging Conditions

Significance: Current knowledge surrounding seafood spoilage microbiota and the effects of storage temperature and packaging on seafood quality are discussed.

Seafood comprising of both vertebrate and invertebrate aquatic organisms are nutritious, rich in omega-3 fatty acids, essential vitamins, proteins, minerals and form part of healthy diet. However, despite the health and nutritional benefits, seafood is highly perishable. Spoilage of seafood could be as a result of microbial activity, autolysis or chemical oxidation. Microbial activity constitutes more spoilage than others. Spoilage bacteria are commonly Gram negative and produce off odours and flavours in seafood as a result of their metabolic activities. Storage temperature, handling and packaging conditions affect microbial growth and thus the shelf-life of seafood. Due to the complexity of the microbial communities in seafood, culture dependent methods of detection may not be useful, hence the need for culture independent methods are necessary to understand the diversity of microbiota and spoilage process. Similarly, the volatile organic compounds released by spoilage bacteria are not fully understood in some seafood. This review therefore highlights current knowledge and understanding of seafood spoilage microbiota, volatile organic compounds, effects of storage temperature and packaging conditions on quality of seafood.

Food Processing Safety

Novel Approaches for Chemical and Microbiological Shelf Life Extension of Cereal Crops

Significance: The suitability, benefits and drawbacks of novel approaches for chemical decontamination of cereal crops are discussed.

Economic losses due to post-harvest fungal spoilage and mycotoxin contamination of cereal crops is a frequently encountered issue. Typically, chemical preservatives are used to reduce the initial microbial load and the environmental conditions during storage are controlled to prevent microbial growth. However, in recent years the consumers’ desire for more naturally produced foods containing less chemical preservatives has grown increasingly stronger. This article reviews the latest advances in terms of novel approaches for chemical decontamination, namely application cold atmospheric pressure plasma and electrolyzed water, and their suitability for preservation of stored cereal crops. In addition, the alternative use of bio-preservatives, such as starter cultures or purified antimicrobial compounds, to prevent the growth of spoilage organisms or remove in-field accumulated mycotoxins is evaluated. All treatments assessed here show potential for inhibition of microbial spoilage. However, each method encounters draw-backs, making industrial application difficult. Even under optimized processing conditions, it is unlikely that one single treatment can reduce the natural microbial load sufficiently. It is evident that future research needs to examine the combined application of several treatments to exploit their synergistic properties. This would enable sufficient reduction in the microbial load and ensure microbiological safety of cereal crops during long-term storage.

Risk Assessment

New in Silico Trends in Food Toxicology

Significance: This article discusses new in silico chemical methods for hazard characterization in food and drinking water.
Ever growing numbers of chemicals in food and drinking water make it impossible to address safety by classical approaches in toxicology. *In silico* chemical methods could be a first-line for hazard characterization, requiring food toxicology to expand the use of approaches currently well applied in medicinal chemistry.

**Presence of Mycotoxins in Ready-to-Eat Food and Subsequent Risk Assessment**


**Significance:** In this study of 328 ready-to-eat meals, presence of mycotoxins were considered to be of no toxicological concern.

A study on a set of ready-to-eat meals (n = 328) based on cereals, legumes, vegetables, fish and meat was carried out to determine the natural presence of twenty-seven mycotoxins by both liquid chromatography and gas chromatography coupled mass spectrometry in tandem (MS/MS) after QuEChERS extraction. The occurrence of mycotoxins was headed by cereal samples with 35% of samples contaminated by at least one mycotoxin followed by vegetables (32%), legumes (15%) and lastly, 9% of fish and meat samples were contaminated. DON was the most detected mycotoxin in vegetables, meat, fish and cereals with an incidence of 13% 18% 19% and 60%, respectively, and the highest mean levels were found in fish (1.19 μg/kg) and vegetable (1.53 μg/kg), respectively. The highest levels means were for HT-2 toxin ranging from 4.03 to 7.79 μg/kg, in cereal and legume samples respectively. In this last, HT-2 toxin was also the most prevalent (54%). In meat samples, OTA resulted with highest value with 8.09 μg/kg. Likewise, PCA analysis revealed a high correlation between the mycotoxins and the food groups analyzed. The findings indicate that there is no toxicological concern associated with exposure to mycotoxins for consumers as all levels were in accordance with the legislation.

**Probabilistic Cumulative Dietary Risk Assessment of Pesticide Residues in Foods for the German Population Based on Food Monitoring Data from 2009 to 2014**


**Significance:** Cumulative dietary risks from pesticide residues in foods were assessed and the most potent risk drivers identified.

Cumulative dietary risks for the German population owing to pesticide residues in foods were assessed using food monitoring and consumption data. Based on grouping principles for cumulative assessment groups (CAG) as defined by the European Food Safety Authority, probabilistic modelling gave cumulative long- and short-term dietary exposures relevant to the nervous and thyroid system. Compound specific toxicological reference values were considered to assess the total margins of exposure (MoEs) for each CAG, allowing an assessment of the cumulative dietary consumer risk. For the German population, no public health concerns were identified for 6 of 11 CAGs. For three CAGs high uncertainties remained, since MoEs were less than the usually required threshold of 100 for the upper confidence interval of the modelling uncertainty. For two CAGs relevant to the nervous and thyroid system, possible health risks cannot be excluded with the selected approach. Most potent risk drivers were chlorpyrifos and the group of dithiocarbamates (expressed as propineb). For regulatory decisions on possible cumulative dietary health risks the limitations of the published approaches and the absence of harmonized data sources for robust refinements have to be considered. Future research to reduce this high uncertainty is considered necessary in this area.

**Combining Quantitative Risk Assessment of Human Health, Food Waste, and Energy Consumption: The Next Step in the Development of the Food Cold Chain?**


**Significance:** The human health risks associated with *Listeria monocytogenes*, spoilage bacteria growth and electrical consumption along the cold chain are predicted.

The preservation of perishable food via refrigeration in the supply chain is essential to extend shelf life and provide consumers with safe food. However, electricity consumed in refrigeration processes has an economical and an environmental impact. This study focuses on the cold chain of cooked ham, including transport, cold room in supermarket, display cabinet, transport by consumer, and domestic refrigerator, and aims to predict the risk for human health associated with *Listeria monocytogenes*, the amount of food wasted due to the growth of spoilage bacteria, and the electrical consumption to maintain product temperature through the cold chain. A set of eight intervention actions
were tested to evaluate their impact on the three criteria. Results show that the modification of the thermostat of the domestic refrigerator has a high impact on food safety and food waste and a limited impact on the electrical consumption. Inversely, the modification of the airflow rate in the display cabinet has a high impact on electrical consumption and a limited impact on food safety and food waste. A cost-benefit analysis approach and two multicriteria decision analysis methods were used to rank the intervention actions. These three methodologies show that setting the thermostat of the domestic refrigerator to 4 °C presents the best compromise between the three criteria. The impact of decisionmaker preferences (criteria weight) and limitations of these three approaches are discussed. The approaches proposed by this study may be useful in decision making to evaluate global impact of intervention actions in issues involving conflicting outputs.

Heavy Metals

Analysis of Arsenic Species in Processed Rice Bran Products Using HPLC-ICP-MS

Significance: The risk of human exposure to inorganic arsenic was determined in rice bran products.

The purpose of this study was to compare the content of arsenic species (As(V), monomethylarsonic acid [MMA], As(III), and dimethylarsinic acid [DMA]) in products, such as bran powder and tablets, using high-performance liquid chromatography-inductively coupled plasma mass spectrometry, and to determine the risk of human exposure to inorganic arsenic (iAs). The products presented As(III) > As(V) > DMA > MMA, at 241.03 to 579.35, 43.41 to 271.91, 15.16 to 30.43, and limit of quantification to 14.31 μg/kg, respectively. The contents of arsenic species tended to differ among the products (P < 0.05). When the maximum level (0.2 mg/kg) of iAs in white rice was applied to products, it exceeded 1.4 to 3.3 times as 284.43 to 767.10 μg/kg. Also, if more than 109.42 g/day of rice bran powder product containing 767.10 μg/kg as iAs was ingested, the provisional tolerable weekly intake (9.0 μg/kg body weight/wk) was exceeded. Practical Application: This study could provide analysis necessary of As for defining an accurate risk assessment of products and tablets containing rice bran powder. In addition with this study, the regulations for As contents in rice bran power products would be set.

Probabilistic Integrated Human Mixture Risk Assessment of Multiple Metals Through Seafood Consumption

Significance: By linking probabilistic risk assessment to the HIINT approach, the human mixture risk posed by the dietary intake and toxic interactions of heavy metals from seafood was assessed.

Inorganic arsenic (iAs), cadmium (Cd), lead (Pb), and methylmercury (MeHg) are toxic metals that cause substantial health concern and are present in various seafood items. This study linked probabilistic risk assessment to the interactive hazard index (HIINT ) approach to assess the human mixture risk posed by the dietary intake of iAs, Cd, Pb, and MeHg from seafood for different age populations, and joint toxic actions and toxic interactions among metals were also considered in the assessment. We found that, in combination, an iAs-Cd-Pb-MeHg mixture synergistically causes neurological toxicity. Furthermore, an iAs-Cd-Pb mixture antagonistically causes renal and hematological effects and additively causes cardiovascular effect. Our results demonstrated that if toxic interactions are not considered, the health risk may be overestimated or underestimated. The 50th percentile HIINT estimates in all age populations for neurological, renal, cardiovascular, and hematological effects were lower than 1; however, the 97.5th percentile HIINT estimates might exceed 1. In particular, toddlers and preschoolers had the highest neurological risk, with 0.16 and 0.19 probabilities, respectively, of neurological HIINT exceeding 1. Saltwater fish consumption was the principal contributor to the health risk. We suggest that regular monitoring of metal levels in seafood, more precise dietary surveys, further toxicological data, and risk-benefit analysis of seafood consumption are warranted to improve the accuracy of human mixture risk assessment and determine optimal consumption.

Source Contribution Analysis and Collaborative Assessment of Heavy Metals in Vegetable-Growing Soils

Significance: Sources of heavy metals in vegetable growing soils were identified and quantified using a new method of collaborative assessment.
Source quantification of heavy metals in farmland is essential for developing and implementing restoration strategies. We used various data analyses to identify and quantify sources of arsenic, cadmium, chromium, copper, mercury, nickel, lead, and zinc in vegetable-growing soils. A new method of collaborative assessment, combining soil environmental quality and agricultural product safety showed approximately 5.20% of cultivation systems were multi-contaminated by heavy metals. The nonlinear relationship between pollution sources and the comprehensive contamination situation was established, deriving from a fitted bivariate model. The model revealed that anthropogenic sources and natural origins accounted for 65.8-86.0% and 34.2-14.0% of the comprehensive pollution. These results suggested both human activities and natural factors contributed to the decline of local soil quality, and influence of the former was more substantial than the latter.

**Food Allergy**

**Protein or No Protein? Opportunities for DNA-Based Detection of Allergenic Foods**


**Significance:** This perspective highlights molecular aspects and opportunities for the application of DNA-based methods for detection of allergenic foods.

In food allergy, a common immunological disease with a potentially severe outcome, a causative cure is not available. Correct ingredient labeling and risk assessment of unlabeled allergen cross-contact is a prerequisite for effective allergen avoidance. Specific and sensitive analytical methods, which allow for unequivocal identification and accurate quantification of allergenic components, are important tools in allergen risk management. Both protein- and DNA-based methods are in place and reveal pros and cons depending upon the application and individual analytical question. This perspective highlights relevant molecular aspects and discusses, especially, opportunities for the application of DNA-based methods for the detection of allergenic foods.