Many Ways

MICROBIOMES, CHEMICALS AND HEALTH: UNRAVELLING AN INTRICATE TRIAD

Summary

The communities of microorganisms in a defined environment are collectively referred to as microbiomes, and they include Bacteria, Archaea, Eukarya and viruses. Microbiome structures and dynamics across the food system can have both direct and indirect effects on human, animal and soil health, thus occupying a central position in the One Health framework. The gut microbiome is currently viewed as an additional mediator of both potentially beneficial and adverse effects of dietary or environmental exposure to chemicals. Regarding soil microbiome, recent research directly attributes improved plant health and soil fertility to an optimal balance within soil microorganisms. It also appears that this balance may be impaired by several anthropogenic factors, such as plant protection products.

Among the challenges to be addressed before integrating microbiome considerations into regulatory safety assessments are the following: (1) a lack of internationally agreed guidance to systematically account for possible effects on microbiomes or effects by microbiomes on host health; (2) the need for more knowledge on how the human microbiome modulates the pharmacokinetics and metabolism of chemicals; and (3) the hindering of translating a decrease in microbiome diversity into a functional consequence due to the absence of standards to define a healthy microbiome. This session aims to improve our understanding of the relevance of microbiome structural changes to chemical risk assessments.

The main quest in this scientific domain is to enhance the evidence base that demonstrates the causality between a structurally altered microbiome and subsequent change(s) in metabolic pathways leading to adverse effects in the host.

Vision

Microbiomes in the food and feed system can have beneficial and adverse effects on human, animal and environmental health. They can impact on food and feed quality, safety and sustainability, either directly or indirectly. Microbiomes are therefore an integral part of the “One Health” framework. More consideration should be placed however on the role of microbiomes to ensure further progress is made in chemical risk assessment. We must also explore how this can best be achieved in a regulatory context for food and feed safety and sustainability.

As the Joint Research Centre (JRC) and the Food and Agriculture Organisation (FAO) have several ongoing projects on microbiomes, in particular regarding soil/plant health and the food system, this session will be co-developed with them.

Organiser Co-organisers

efsa European Food Safety Authority
ecdc European Centre for Disease Prevention and Control
ECHA European Chemicals Agency
European Environment Agency
European Medicines Agency Science Medicines Health
European Commission Joint Research Centre

Background – Challenges and opportunities

Communities of microorganisms and their genomes that exist in a defined environment are collectively referred to as microbiomes. They are found in most environments such as soils, aquatic habitats, surfaces and specific lumen of plants, animals and humans.

Research has shown associations between microbiomes and a wide range of human diseases. The gut microbiome is currently viewed as an additional modulator of both potentially beneficial and adverse effects of environmental exposure (namely diet, chemicals, pathogens, etc.). There is compelling evidence of gut microbiome involvement in the metabolic transformation of chemicals in broad chemical classes, including metals, polycyclic aromatic hydrocarbons (PAHs), pesticides and persistent organochlorines, nitrosamines and aromatic amines, and other toxicant classes. The optimal balance within soil microorganisms is directly attributed to improved plant health and soil fertility. However, the actual balance may be impaired by several anthropogenic factors, such as antimicrobials, heavy metals and plant protection products (PPP).

There is currently no internationally agreed guidance nor methodology in place to systematically account for possible effects on microbiomes or effects by microbiomes on host health or environment. Knowledge of how the human microbiome modulates the pharmacokinetics and metabolism of chemicals is lacking. Translating a decrease in microbiome diversity into a functional consequence is challenging as there are as yet no standards to define a healthy microbiome. Therefore, more data are required for a better understanding of covariates driving the human and animal gut microbiome variation within ranges not leading to adverse effects. This knowledge is needed to further assess when a change either in structure and/or function of the microbiome profile goes beyond those variations and translates into an adverse biological effect on the host. Furthermore, there are no standardised approaches to characterise healthy soil from a microbiome perspective. We need to define specific microbial groups to serve as a proxy for the microbiome as a whole. This would provide us with an agreed starting point for a protocol to study the links with microbial biodiversity, metabolic functions and interaction with anthropogenic factors. Although multi-omics approaches hold enormous potential to unravel links between a compromised microbiome and disease status, more experimental work is needed to confirm causality.

Research on the microbiome is proceeding at a very fast pace and it is critical that we evaluate how our greater understanding of the role of microbiomes in host and environmental health may need to be integrated into regulatory scientific

assessment processes. Clarity is needed on which data are required to include microbiome considerations into risk assessment. Currently, several Horizon 2020 EU initiatives are investigating systems-level microbiome effects on the whole food chain from a wider perspective. The European Food Safety Authority (EFSA) awarded two grants in early 2021 to build capacity for the evaluation of the impact of various modulators under EFSA assessment on microbiomes and of microbiomes on host health. In parallel, the JRC LUCAS Soil Programme is currently undertaking the largest systematic assessment of the soil microbiome so far, with a view to develop policy indicators that capture the impact of land management and emissions on soil health. While there is a lot of research on the links between the soil microbiome, soil fertility and plant health, many open questions remain to be explored, both from a purely research point of view and regulatory science point of view. The ongoing FAO literature review on the soil microbiome will provide a list of key research gaps.

As microbiome assessment lies at the very heart of the intersection between chemical and biological risk assessment, there will be ample opportunities in the future for these two disciplines to collaborate and foster mutual understanding on their respective risk assessments.

Scope and objectives

The thematic session aims to clarify our current understanding of the relevance of microbiome structural changes to the risk assessment of chemicals and to identify goals for developing risk assessment. An important avenue is to enhance the evidence base that demonstrates the causality between a structurally altered microbiome and subsequent change(s) in metabolic pathways leading to adverse effects in the host

The focus will be on chemicals to which humans and animals are exposed via dietary intake (preferably within EFSA's remit for risk assessment) and via the environment, but new evidence on other chemicals is also relevant. The thematic session will present proof of concepts from a wider human, animal and environmental perspective. This could be complemented by an overview of current models and what is needed to validate them to meet accepted standards for use in risk assessment.

This session is connected to goal 2 and 3 of the EFSA 2022 conference by advancing food/feed regulatory science and showcasing & sharing relevant developments on how microbiome considerations can be integrated into chemical risk assessment. A collaborative approach is followed by co-creating the event with JRC and FAO.

The main objectives of the thematic sessions are to:

- Improve understanding of the relevancy of microbiome for regulatory chemical risk assessment;
- Identify development goals for chemical and environmental risk assessment;
- Enhance the evidence base that demonstrates the causality.

People behind the session

Session Coordinator: Caroline Merten (EFSA)
Chairpersons: Yolanda Sanz, Institute of Agrochemistry and Food Technology Spanish National Research Council (IATA-CSIC)
Moderators: Daphne Miller, University of California San Francisco
Rapporteurs: Catherine Bessy, Food and Agriculture Organization of the United Nations (FAO); Javier Moreno, Consejo Superior de Investigaciones Científicas (CSIC); Caroline Merten, European Food Safety Authority (EFSA); Elisa Pettenati, European Food Safety Authority (EFSA)

Many Ways – Session affiliate profiles

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Elisa Pettenati, European Food Safety Authority (EFSA)
Rapporteur

Elisa Pettenati graduated in 2015 as industrial biotechnologist at the University of Parma (Italy). After her studies she worked for a year in the laboratory of molecular genetics at the University of Parma and gained experience with techniques used in molecular biology, biotechnology and biochemistry. Then she gained professional experience in microorganisms working in microbiological laboratories of private companies in the pharmaceutical and food sectors. She joined the European Food Safety Authority (EFSA) in 2018 and currently holds the position of scientific officer in the FEED team of the Feed and Contaminants unit (FEEDCO Unit). She provides scientific and administrative support to the activities of the Panel on Additives and Products or Substances used in Animal Feed (FEEDAP Panel), as well as its Working Groups. In particular, she supports the FEEDAP Panel in the delivery of scientific opinions on the assessment of the safety and efficacy of feed additives.

Benoit Chassaing, French National Institute of Health and Medical Research (Inserm)
Speaker

Dr. Benoit Chassaing obtained his PhD in microbiology at the University of Clermont-Ferrand (France), identifying factors involved in the virulence of adherent and invasive Escherichia coli strains (pathovar involved in the etiology of Crohn's disease). Following his PhD, he joined Georgia State University to work with Dr. Andrew T. Gewirtz on various subjects related to mucosal immunology, trying to decipher how genetic and environmental factors can perturb the intestinal microbiota composition in a detrimental way, leading to chronic intestinal inflammation and metabolic deregulations Appointed assistant professor in 2015, his laboratory was relocated to Paris, France and focus on the understanding of mechanisms by which environmental factors - such as select food components - are involved in shaping detrimental microbiota, with a particular focus on intestinal inflammation and altered metabolism. His current research is using pre-clinical and clinical approaches, as well as in vitro modelling of the intestinal microbiota, to better define microbiota regulation and subsequent impact on intestinal health and metabolism.

Title of talk: Food additives: modern stressors of the intestinal microbiota

Abstract of talk
The gastro-intestinal tract is heavily colonised by a complex community of microorganisms called the intestinal microbiota, which play numerous roles in both health and diseases. In his presentation, Benoit Chassaing will present his work related to the detrimental impact of various emulsifiers on the intestinal microbiota. Research carried out by his team has indeed demonstrated that various emulsifiers can directly alter the intestinal microbiota, both compositionally and functionally, in a way that can promote numerous chronic inflammatory diseases, metabolic deregulation and susceptibility to colon cancer. Mechanistically, dietary emulsifiers directly target the intestinal microbiota, with the observation that germfree models are protected against emulsifier-detrimental impacts, while faecal microbiota transplantation is sufficient to transfer chronic intestinal inflammation and metabolic deregulation. Moreover, dietary emulsifiers directly target select members of the intestinal microbiota to promote their pathogenic potential. A recent clinical trial highlighted the potential detrimental impact of emulsifiers on intestinal and human health, with the observation that short-term exposure of healthy individuals to Carboxymethylcellulose – E466 – is sufficient to induce microbiota alterations, faecal metabolome depletion and microbiota encroachment within the normally sterile mucus layer. We will also discuss the impact of various other food additives, with the important observation that not all the commonly used dietary emulsifiers detrimentally impact the intestinal microbiota. Moreover, we will discuss the importance of inter-individual variations in microbiota composition in driving the response/susceptibility to dietary emulsifiers, with the observation that while some microbiota are fully protected against the detrimental impact of emulsifiers, some other microbiota, hosting select microbiota members, are highly susceptible to emulsifier-induced disturbance and following chronic intestinal inflammation, metabolic deregulation.

Javier Moreno, Consejo Superior de Investigaciones Científicas (CSIC)
Rapporteur

F. Javier Moreno is working at the Instituto de Investigación en Ciencias de la Alimentación (CIAL) belonging to the Spanish National Research Council (CSIC). He is the co-author of more than 135 peer-reviewed papers (Food Science & Technology, Nutrition, Analytical Chemistry or Biotechnology fields) and more than 40 scientific documents published by the EFSA GMO Panel (guidance, statement and scientific opinions), 2 edited books, 17 book chapters and more than 120 communications to international conferences (including invited conferences). He has supervised 9 Doctoral Thesis and has been the principal investigator of 21

research projects/contracts. His main areas of research include food biochemistry and food technology. He has experience in risk assessment as a former member of the Spanish National Biosecurity Commission. He is the current Chair of the Working Groups GMO Applications in Food-Feed and a member of the EFSA GMO Panel since July 2018. For full list of publications please see: www.orcid.org/0000-0002-7637-9542.

Martin Iain Bahl, Technical University of Denmark (DTU)
Speaker

Martin Iain Bahl obtained his PhD degree in Microbiology from the University of Copenhagen in 2007. After four years at Statens Serum Institute (DK) working on biosecurity and bio-preparedness, he transitioned to the Technical University of Denmark, where he is now Senior Researcher in the Gut Microbes and Health research group at the National Food Institute. He has a strong background in molecular microbial ecology with emphasis on ecology and dynamics of bacterial communities and broadly studies bacterial/host interactions in the intestinal environment. He has led several research projects investigating effects of xenobiotic compounds on the microbial communities in the intestine, including exposure studies towards pesticides and antibiotic compounds. Currently, a focus area is to explore different approaches to facilitate recovery from states of microbial dysbiosis in the gut environment. These include the use of prebiotics, probiotics, fecal microbiota transplantation as well as methods to adjust the environmental conditions in the intestinal environment.

Title of talk: The need to consider human microbiome in chemical risk assessment

Abstract of talk

The complex interplay between the natural bacterial communities colonising the gut environment and the human host have evolved through millions of years of co-evolution. A multitude of scientific studies have revealed the important role of the gut microbiota in states of both health and disease and highlighted that changes in the resident microbial ecosystem may represent a risk factor. For this reason, it is important to consider the human microbiome in a chemical risk assessment, with an emphasis on elucidating any microbiota-disrupting effects that may be associated with exposure. Clearly, some compounds (such as antibiotics) have a large capacity to disturb the natural ecosystem within the gut environment, which has been linked to long-term health effects. Other compounds may have putative effects, due to a specific mode-of-action known to be associated with microbial pathways, while still other compounds overall can be considered inert in terms of effects on the natural microbiota. In this talk, examples from animal trials conducted in our research group and representing the three above scenarios will we presented and discussed.

Specifically, I will discuss exposure to beta-lactam antibiotics, the widely used herbicide glyphosate, and the anthropogenic fluorosurfactant perfluorooctanesulfonic acid (PFOS). It is important to appreciate that many natural food ingredients and dietary choices will affect the intestinal bacterial composition. This means that risk assessments of chemical compounds towards the microbiota cannot solely be based on observed changes of the gut microbiota structure or function, as not all changes are bad. I will present considerations for future guidance on this issue, including tools, markers and end-points to assess actual microbiota disruption, defined as induced changes in microbiota composition and/or activity that can cause a detrimental effect on health. While chemical compounds may disrupt the microbiota, the microbiota may also affect the degradation and absorption of chemical compounds entering the gut environment. Data will be presented on how antibiotic-induced microbiota disturbances may affect overall systemic exposure to chemical compounds exemplified by PFOS exposure.

Yolanda Sanz, Institute of Agrochemistry and Food Technology Spanish National Research Council (IATA-CSIC)

Chair/Co-chair

Yolanda Sanz holds a PhD in Pharmacy and is Full Professor at the Spanish National Research Council (IATA-CSIC) and head of the research group. Her research focuses on the role the gut microbiota plays in health and disease through its interaction with the diet and the immune and neuroendocrine systems of the human organism. She has coordinated one of the largest European projects on the human microbiome and its impact on obesity and behaviour (). Currently, she is principal investigator of other EU projects focused on stress and psycho-cardio-metabolic co-morbidities (EarlyCause) and food system microbiomes (CIRCLES and Microbiome Support). She also coordinates a new European project (CLIMB-OUT) and Marie Curie actions (MiVaO, MicroILCs) related to obesity. She has published over 195 (WoS) scientific papers, some in high-rated journals (Nat Commun, Am J Clin Nut., Gut, etc.), (WoSH-index 61 on WoS), and is author of 13 patent applications. She was Member of the Panel on Dietetic Products, Nutrition and Allergies (NDA) of the European Food Safety Authority (EFSA) (2009-2018). Currently, she is member of the EFSA FEEDAP/ FEEDCO Panel (2018-2023).

Maeva Labouyrie, Joint Research Centre (JRC)

Speaker

Maeva Labouyrie is a PhD student (2020-2024) in a collaborative doctoral partnership between University of Zurich and European Commission's Joint Research Center. She graduated in 2020 as agronomist specialized in data sciences at l'Institut Agro (France) and owns an engineer diploma and a master's degree in

statistics and applied mathematics (University Rennes). Maeva's interests are data analysis and modelling to address biological and ecological questions and propose concrete actions to tackle (soil) biodiversity issues faced. Currently, she is investigating the impacts of environmental drivers and soil pressures on bacterial and fungal communities and their functions at the European scale. She is interested in linking her scientific findings to policy-related actions in order to further open dialogues with all the stakeholders involved (or impacted by) current and future decisions at the European Union level, and participate to the implementation and development of a legal framework protecting (soil) biodiversity.

Title of talk: Are soil microbiome communities and functions influenced by anthropogenic factors?

Abstract of talk
The global area of cultivated land has increased considerably over the past five decades, accompanied by an increase in use of agrochemicals. Despite the many ecosystem services provided by soils, there is very little understanding on how land-use intensification (including use of pesticides) influences soil microbiome and the related services that humans rely upon. The presence of pesticide residues in soils is well-known, but an understanding of its impact on soil microorganisms is still lacking at a large scale. Here we used an extensive soil DNA dataset derived from the last European Union (EU) LUCAS survey (2018). A total of 715 sampling locations distributed across Europe were included and classified according to a gradient of increasing land-use intensification: from woodlands (less anthropic), to grasslands and croplands (more anthropic). We assessed how this intensification gradient influenced the diversity, structure and predicted functions of bacterial and fungal communities (e.g., plant symbiosis and human and plant pathogenicity).
We found that more anthropic habitats (croplands and grasslands) had higher microbial richness than natural ones (woodlands). However, high diversity was not necessarily correlated with beneficial functions carried out by microorganisms, as croplands were characterised by a higher presence of fungal plant pathogens that could have been selected by pesticide input. Anthropogenic activities (chemical application) may have been selected for some bacterial functional groups in more intensified land types, as nitrogen-fixing bacteria were more abundant there, and could have been favoured through fertiliser applications. We also observed that differences in community structure were the most important between croplands and woodlands, indicating that anthropogenic activities can effectively shape soil bacterial and fungal communities. In addition, in over 400 sites, we combined LUCAS soil biodiversity data with pesticide residue concentrations (over 110 active ingredients) in order to explore how pesticide inputs may affect soil microbial biodiversity. Impacts of pesticides on the diversity, structure and predicted functions of bacterial and fungal communities in croplands will be presented. Our findings

represent a step forward to a more comprehensive assessment on the anthropogenic factors shaping soil microbial communities. They can contribute to the development of policy recommendations for better preserving soil microbiomes in Europe.

Sangeeta Khare, U.S. Food and Drug Administration (US FDA)
Speaker

Dr. Sangeeta Khare is a Research Microbiologist at the US-FDA and leads an active team with an emphasis on host-pathogen/host-microbiome interaction. Dr. Khare received her Ph.D in the area of infectious diseases from the All India Institute of Medical Sciences, New Delhi, India. She studied gastrointestinal pathogen-host interaction at the University of Saskatchewan, Canada and Texas A&M University, College Station TX. Dr. Khare's ongoing research at the US-FDA is on: 1) risk-assessment of exposure to xenobiotics on the gastrointestinal tract using animal (gestational and developmental period), in-vitro and ex-vivo models to assess effects on the commensal microbiota and intestinal barrier, and 2) use of advanced technologies, such as NGS, omics and systems biology approaches for drug-discovery and in establishing decision-tree for the intestinal toxicity. The long-term goal of Dr. Khare's research program is to support FDA mission by Evaluating Innovative Emerging Technologies and Modernize Toxicology to Enhance Product Safety.

Title of talk: Unlocking the potential of host-microbiome interaction in the risk assessment

Abstract of talk
The intestinal microbiome is a key contributor in the metabolism of xenobiotics. Xenobiotics used on a day-to-day basis include drugs, food additives, pesticides, herbicides, and several other environmental and food contaminants. The commensal microbiome, as well as intestinal mucosa itself could be impacted by these xenobiotics. An in-depth understanding of the experimental model, dose, route, frequency of exposure is required when evaluating the safety of xenobiotics that humans are exposed to on a daily basis. Interactions of these products with the gastrointestinal tract might have an adverse effect on the commensal microbiota, impact antimicrobial resistance and alter the host xenobiotics metabolism, immune responses and intestinal permeability. The aim of my research group is to determine risk assessment criteria for gastrointestinal toxicity. My presentation will discuss current approaches, challenges, and opportunities to establish science-based minimum standards for conducting hazard analyses of such products using animal models, as well as in vitro and ex vivo models. Furthermore, developmental effects (from gestational stages to adult stage) during exposure to xenobiotics will also be

discussed. This presentation will provide an example of interaction one such xenobiotic with a host using innovative methods of risk assessment that could lead to discovery of biomarkers, improved food safety and personalised treatment. Moreover, this comprehensive research provides understanding into the mechanistic interaction of xenobiotics-host-microbiome to determine end points to be included in the decision tree for the risk assessment of such products. The outcome of this research will lead to a knowledge-based evaluation of potential toxic or beneficial effects to help regulatory agencies form recommendations and regulatory policy.

Jack Gilbert, University of California San Diego
Speaker

Professor Jack A Gilbert Gilbert earned his Ph.D. from Unilever and Nottingham University, UK in 2002, and received his postdoctoral training at Queens University, Canada. From 2005-2010 he was a senior scientist at Plymouth Marine Laboratory, UK. From 2010-2018 he was Group Leader for Microbial Ecology at Argonne National Laboratory, Professor of Surgery, and Director of The Microbiome Center at University of Chicago. In 2019 he moved to University of California San Diego, where he is a Professor in Pediatrics and Scripps Institution of Oceanography, as well as the Director of the Microbiome Core. He uses molecular analysis to test fundamental hypotheses in microbial ecology. Dr. Gilbert cofounded the Earth Microbiome Project, the Microbiota Vault, helps coordinate the American Gut Project, and cofounded BiomeSense Inc to develop microbiome collection tools. He has authored more than 350 peer reviewed publications and book chapters on microbial ecology and is the founding Editor in Chief of mSystems journal.

Title of talk: Food additives and contaminants, human health, and the microbiome

Abstract of talk

The microbiome is global. Over the 4-billion-year history of microbial life on Earth, bacteria, archaea, microbial eukaryotes and viruses have colonised every facet and niche on this planet. Through large-scale initiatives such as the Earth Microbiome Project, we have developed the tools and the data to help to understand how human activity is influencing the microbiology of our water, air and soils. Importantly, this also extends to our food crops. Plant crops acquire their microbiome from the soils, and if those soils are disturbed the resulting shift in the microbiome may influence crop productivity, resilience to stress and even nutrient content. The same principal is true for animal crops, whereby management practices and feed stock contaminants can influence animal health and meat quality through changes to the animal's microbiome. Understanding how disturbances in the microbial dynamics of environments and cropping systems influences human health is a key gap in current research knowledge, primarily due to the inherent complexity of scales and

interactions that underpin any association. However, efforts to understand how food nutritional quality and contaminants can influence human health via changes to the gut microbiome are underway. Disturbing the human microbiome can have profound influences on human health. The immune system controls our interaction with the microbial world, and yet the microbial communities in our bodies are central to modulating the immune response. Changes in the human microbiome have substantial influence on atopy, neurological disorders, metabolic disorders, and a range of complex conditions and disease states. We will discuss evidence of these mechanisms of interaction and how we have started to disturb the delicate balance of the immune-microbe equilibrium, impacting the development and function of our immune systems. The application of new strategies to identify how the microbial health of our environments, foods and bodies correlates with diseases and treatment efficacy, through Microbiome-Wide Association Studies (MWAS), is providing an alternative approach to assessing the impact of manifold exposures on human health. New studies, such as the NIH Nutrition for Precision Health initiative, that simultaneously quantify food and environmental contaminants, additives, nutrients, pesticides, etc., while also examining how these potential insults influence host-microbiome communication, are helping us to elucidate the mechanisms that provide evidence to shift policy to improve human health protection.

Caroline Merten, European Food Safety Authority (EFSA)
Rapporteur

Dr Caroline Merten, a veterinarian specialised in food sciences, currently holds a position as Team Leader of the Data Gateway & Outreach team in the Integrated Data unit at the European Food Safety Authority (EFSA) in Parma, Italy. Her team is coordinating the European wide cross sectorial data collections that serve EFSA's risk assessment needs. She is overseeing an ongoing research project on Evaluating the impact on human and animal gut microbiomes by potential modulators under EFSA's remit. In her previous position with EFSA as a scientific officer in the Scientific Committee and Emerging risk unit she was coordinating all uncertainty assessment related methodological work, EFSA's European Emerging Risk Exchange Network and oversaw multiple methodological research projects to identify emerging risks in the remit of EFSA. Before joining EFSA she has worked in the Emergency Prevention System for food safety group at the Food and Agriculture Organisation of the United Nations (FAO) in Rome. Her responsibilities included planning and managing programs to strengthening prevention and response to food safety emergencies in developing countries, mainly in Africa and Asia and served as the FAO secretariat for the FAO/WHO International Food Safety Authorities Network (INFOSAN). In her past positions she worked as an exposure assessor in the Data Collection and Monitoring unit at EFSA and coordinated development programs to improve the food safety in West African countries.

Catherine Bessy, Food and Agriculture Organization of the United Nations (FAO)
Rapporteur

Catherine Bessy is a Senior Food Safety Officer working for FAO, Food Systems and Food Safety Division. She leads the programme on policy advice and capacity development in food control, and has guided the work on the development of the FAO strategic priorities for food safety. Engineer by training, specialized in food science and technology, she has 25 years of experience in FAO in positions of increasing responsibility in the area of food safety, including situation analysis, needs identification, conception of projects and provision of technical assistance to members to improve their regulatory capacities and their food control systems. In particular, she conceived, guided and coordinated the work leading to the publication on the FAO/WHO food control system assessment tool. Besides leading capacity development projects, she also coordinates the development of policy and technical guidance for Countries, helping them to better implement Codex Alimentarius standards, recommendations and guidelines. She also represents FAO at several Codex Alimentarius Committees. Prior to joining FAO in 1997, she has worked for the food industry as a food safety specialist, and for the International Committee of the Red Cross as a food security specialist advising on food safety and nutrition dimensions to be brought into the agricultural rehabilitation programmes.

Daphne Miller, University of California San Francisco
Moderator

Daphne Miller, MD is Founder and Director of The Growing Health Collaborative, a program based at the University of California Berkeley Center for Occupational and Environmental Health, which engages health professionals in transforming the food system from the soil up. She is a practicing family physician, Clinical Professor of Family and Community Medicine at the University of California San Francisco, and Curriculum Director for Integrative and Community Medicine at the Lifelong Family Medicine Residency Program in Richmond, California. Miller is also a Health and Science Contributor to the Washington Post and the author of two books on food and farming: The Jungle Effect, The Science and Wisdom of Traditional Diets and Farmacology, Total Health from the Ground Up. Miller is a past Fellow at the Berkeley Food Institute and the University of Arizona Center for Integrative Medicine. She has served as a health advisor or consultant to national and international organizations dedicated to sustainable and equitable food production, including the Rodale Institute, #NoRegretsInitiative, The Edible Schoolyard, Indigenous Terra Madre, Vice President Al Gore's Climate Underground, and the Food and Agriculture Organization of the UN. Dr. Miller lives and gardens in Berkeley, California.