



**Munich**  
GERMANY 4-6 May  
IAFP'S EUROPEAN SYMPOSIUM  
— ON FOOD SAFETY — **2022**

# IAFP's European Symposium on Food Safety

## PROGRAMME

HOLIDAY INN MUNICH - CITY

CENTRE



ORGANIZED BY



International Association for  
Food Protection®

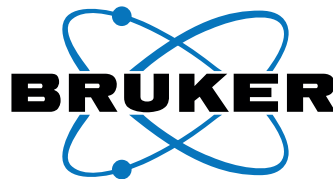
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# 2022 EXHIBITORS



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## CELL PHONE POLICY

As a courtesy to the presenters, we request that you silence your cell phone while attending sessions.

## RECORDING POLICY

Unauthorized video or still photography or audio recording will not be allowed without prior approval. Thank you for your cooperation.



**@IAFPFOOD**  
**#IAFPEURO22**

# ORGANISING COMMITTEE

## **Chairperson, Anett Winkler**

Cargill, Unterschleißheim, Germany

## **Vice Chairperson, Luca Cocolin**

University of Torino, Grugliasco, Italy

## **Committee Members**

Ana Allende Prieto

CEBAS-CSIC, Murcia, Spain

Peter Ben Embarek

World Health Organization, Geneva, Switzerland

Francois Bourdichon

Food Safety, Microbiology and Hygiene

Paris, France

Sara Bover-Cid

IRTA, Girona, Spain

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ANSES, Maisons-Alfort, France

Noemie Desriac

University of Brest, Quimper, France

Mariem Ellouze

Nestlé Research Center, Lausanne, Switzerland

Elissavet Gkogka

Arla Innovation Centre, Aarhus, Denmark

Liesbeth Jacxsens

Ghent University, Ghent, Belgium

Jeffrey LeJeune

Food & Agriculture Organization of the United Nations, Rome, Italy

Peter McClure

Consultant, Birmingham, United Kingdom

Lisa O'Connor

Food Safety Authority of Ireland, Dublin, Ireland

Angeliki Stavropoulou

ILSI Europe, Brussels, Belgium

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Marjon Wells-Bennik

NIZO, Ede, Netherlands

## **IAFP Executive Board Liasons**

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# IAFP EXECUTIVE BOARD



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# IAFP'S EUROPEAN SYMPOSIUM ON FOOD SAFETY PROGRAMME AT-A-GLANCE

Room	Ballsaal	Forum 6 + 7	Forum 8	Forum 4 + 5	Großer Saal
<b>Wednesday, 4 May 2022</b>					
Wednesday 8.30 - 10.00	Opening Session				
Wednesday 10.00 - 10.30	Coffee/Networking Break Exhibit Hall			Poster Session 1 – Communication Outreach and Education, Epidemiology, Food Chemical Hazards and Food Allergens, Food Safety Systems, Food Toxicology, Modeling and Risk Assessment, Molecular Analytics, Genomics and Microbiome, and Retail and Food Service Safety	Exhibits Open 10.00 - 18.00
Wednesday 10.30 - 12.00	RT1 – COVID-19: What Have We Learned to Make Our Food Systems More Resilient in the Future?	S1 – ESKAPE(d) into the Food Chain? Harnessing the Power of Whole Genome Sequencing in Fresh Produce Production from Farm to Retail for the Surveillance of Antimicrobial Resistant Foodborne Pathogens	Technical Session 1 – Food Law and Regulation and Food Safety Systems		
Wednesday 12.00 - 13.30	Lunch Exhibit Hall				
Wednesday 13.30 - 15.00	S2 – Getting the Science, Legal and Business Case Right: Incorporating Food Safety into the Enterprise Risk Management Process	RT2 – Rapid Methods and Automation in Food Microbiology: 40 Years of Developments, Promises, and Disappointments	Technical Session 2 – General Microbiology and Molecular Analytics, Genomics and Microbiome		
Wednesday 15.00 - 15.30	Coffee/Networking Break Exhibit Hall				
Wednesday 15.30 - 17.00	S3 – Process Analytical Technology at the Service of Food Protection; The "Ditect" Approach	RT3 – Methodological Considerations in the Design of Pathogen Inoculation Studies: Implications for Validity and Application of Results	Technical Session 3 – Modeling and Risk Assessment		
Wednesday 17.00 - 18.00	Exhibit Hall Reception				
<b>Thursday, 5 May 2022</b>					
Thursday 8.30 - 10.00	S4 – Plasmarter - Cold Plasma Functionalised Liquids as a Food Safety Intervention Technology	S5 – New Hazards and Old Threats; Foodborne Viruses and Risk Assessment in Food Safety	Technical Session 4 – Laboratory and Detection Methods		
Thursday 10.00 - 10.30	Coffee/Networking Break Exhibit Hall			Poster Session 2 – Beverages and Acid/Acidified Foods, Dairy, General Microbiology, Laboratory and Detection Methods, Low-Water Activity Foods, Meat, Poultry and Eggs, Microbial Food Spoilage, Packaging, Sanitation and Hygiene, and Seafood	Exhibits Open 10.00 - 16.00
Thursday 10.30 - 12.00	RT4 – Trust, Safety and Sustainability of Food: Key in Increasing Citizen Engagement in Food Systems	S6 – Determining the Efficacy of Control Measures Against Foodborne Viruses	Technical Session 5 – Communication Outreach and Education, Food Safety Systems and Modeling and Risk Assessment		
Thursday 12.00 - 13.30	Lunch Exhibit Hall				
Thursday 13.30 - 15.00	S7 – Plant Protein-Based Meat and Dairy Alternatives – Known Plant Sources But New Microbiological Risks?	RT5 – How Best to Leverage Partnerships in a Sea of Rapidly Evolving Technology	Technical Session 6 – Microbial Food Spoilage and Modeling and Risk Assessment		
Thursday 15.00 - 15.30	Coffee/Networking Break Exhibit Hall				
Thursday 15.30 - 17.00	S8 – Safety and Quality of Water Used and Reused in Fresh Produce Supply Chains	S9 – Shelf-Stable Fermented Sausages: A Food Safety Concern?	Technical Session 7 – Food Processing Technologies		
<b>Friday, 6 May 2022</b>					
Friday 8.30 - 10.00	RT6 – Environmental Pathogen Monitoring: Prospects, Challenges and Lessons Learned	S10 – Application of Food Allergen Risk Assessment and Management: Current Perspectives and Issues	Technical Session 8 – Antimicrobials and Foodborne Pathogens Control		
Friday 10.00 - 10.30	Coffee/Networking Break				
Friday 10.30 - 12.00	S11 – Leading from the Frontline: Should Food Safety Culture Improvement Start on the Shop Floor?	S12 – Biofilm Formation by Food- Associated Bacteria – Friend or Foe?	Technical Session 9 – Microbial Food Safety and Spoilage		
Friday 12.15 - 13.30	Closing Session				
Friday 13.30 - 14.30	Farewell Refreshments				

# Navigating Food Safety in a Changing World



October 26 – 27, 2022  
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Come join 500+ food safety leaders to learn, share, discuss and discover  
the most recent developments in....

Evidence-Based Risk Communications  
Regulatory Issues on Alternative Protein for Conventional Animal Meat  
Managing the Safety of Tomorrow's New Food & Technologies  
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Improving Food Safety Performance Through Setting and Measuring Food Safety KPIs  
Safe Food for Infants in China & EU (SAFFI)  
Rapid Microbial Detection & Sample Preparation  
Food Allergen Control in the Food Industry  
Risk Assessment for Multiple Chemicals Hazards  
Food & Drug Substances  
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Mycotoxin  
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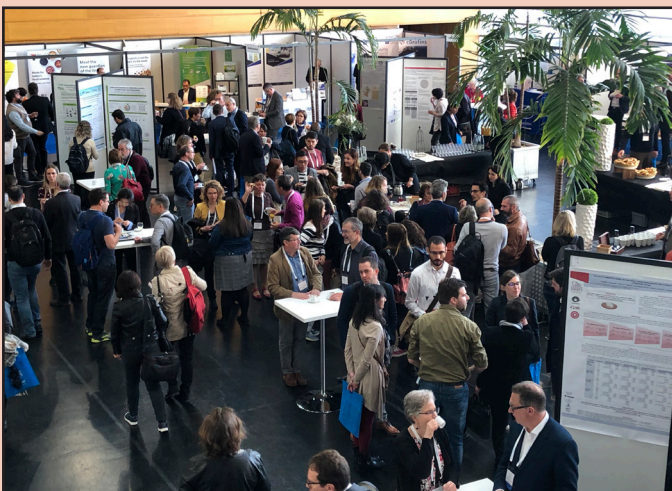
GERMANY 4-6 May

IAFP'S EUROPEAN SYMPOSIUM

— ON FOOD SAFETY —

# 2022

# PROGRAMME





# WELCOME TO THE IAFP EUROPEAN SYMPOSIUM

All times listed in Central European Time (CET).

## WEDNESDAY, 4 MAY 2022

7.30 – 17.00 Registration Open

7.30 – 8.30 Morning Coffee

10.00 – 18.00 Exhibit Hours

### OS Opening Session

*Ballsaal*

**Chairs: Anett Winkler, Luca Cocolin**

8.30 Introduction to IAFP  
DAVID W. THARP, International Association for  
Food Protection, Des Moines, IA, USA

8.40 Introduction to IAFP's European Symposium  
RUTH L. PETRAN, Ruth Petran Consulting, LLC,  
Eagan, MN, USA

8.50 Programme Notes and Recognition of the Organ-  
ising Committee  
ANETT WINKLER, Cargill, Unterschleißheim,  
Germany

9.00 Practical Application of Risk Assessment Out-  
comes Helps Ensure Food Safety  
RUTH L. PETRAN, Ruth Petran Consulting, LLC,  
Eagan, MN, USA

9.30 National Aspects of Food Safety in the Context of  
International Framework  
ANDREAS HENSEL, German Federal Institute  
for Risk Assessment, Berlin, Germany



## RT1 COVID-19: What Have We Learned to Make Our Food Systems More Resilient in the Future?

*Ballsaal*

**Organizers:** Lucia Anelich, Leon Gorris

**Convenors:** Jeffrey Farber, Leon Gorris

10.30 WAYNE A. ANDERSON, Food Safety Authority, Dublin, Ireland

JOHN DONAGHY, Nestec Ltd., Vevey, Switzerland

MICHELLE D. DANYLUK, University of Florida Crec, Lake Alfred, FL, USA

## 12.00 Lunch Available in the Exhibit Hall

### S1 ESKAPE(d) into the Food Chain? Harnessing the Power of Whole Genome Sequencing in Fresh Produce Production from Farm to Retail for the Surveillance of Antimicrobial-Resistant Foodborne Pathogens

*Forum 6 & 7*

**Organizers:** Shirley Micallef, Lise Korsten,

**Erika Du Plessis, Stacey Duvenage**

**Convenors:** Erika Du Plessis, Lise Korsten

10.30 Evaluating Extended Spectrum  $\beta$ -Lactamase Producing *E. coli* in U.S. Mid-Atlantic Surface and Reclaimed Water Available for Irrigation  
SHIRLEY A. MICALLEF, University of Maryland, College Park, MD, USA

11.00 Factors Influencing the Resistome in Plant Production  
KAY BURGESS, Teagasc, Dublin, Ireland

11.30 Occurrence of Extended Spectrum  $\beta$ -Lactamase-Producing Enterobacterales in South African Fresh Produce Supply from the Farm, through Processing up to the Point of Sale  
LOANDI RICHTER, University of Pretoria, Pretoria, South Africa

## 12.00 Lunch Available in the Exhibit Hall

### T1 Technical Session 1 – Food Law and Regulation and Food Safety Systems

*Forum 8*

**Convenor:** Edward L. Sliwinski

10.30 Development of a Framework for Evidence-based Decision Making on Dealing with Human Pathogens in the Microbiome of Leafy Greens

**T1-01** SOFIE SCHRYVERS, Liesbeth Jacxsens, Thomas De Bock, Ghent University, Ghent, Belgium

10.45 Regulatory Aspects of Novel Bio-based Ingredients for Use in Food, Feed, Pharma and Cosmetics

**T1-02** EDWARD L. SLIWINSKI, Rosalba Lanciotti, Davide Gottardi, Floriana Burgio, Laura Suter-Dick, Jose Luis Molto Marin, Helena McMahon, Jesus Rodriguez Gamero, Kim Windey, EFFoST, Wageningen, The Netherlands

11.00 Regulatory Aspects of Novel Protein-Rich Products and Bio-Actives from Marine Side-Streams for Use in Fitness, Health, and Animal Feed

**T1-03** EDWARD L. SLIWINSKI, Jose Gallego, Leo Staccioli, Katerina Kousoulaki, Tone Aspevik, Silje Steinsholm, Tor Andreas Samuelsen, Francisco Jose Barba, Houda Berrada, Emilia Ferrer, Jose Maria Lorenzo, Roberto Bermudez, Mirian Pateiro, Zoe Georgiu, Anna Kujumdzieva, Trayana Nedeva, EFFoST, Wageningen, The Netherlands

11.15 Food Safety Culture Roadmap: From Diagnosis Towards Intervention

**T1-04** PAULINE SPAGNOLI, Liesbeth Jacxsens, Peter Vlerick, Ghent University, Ghent, Belgium

11.30 Early Warning System and Prediction of Food Safety Risks

**T1-05** ASLI SOLMAZ-KAISER, Hakan Duman, iComplai UG, Garching, Germany

11.45 Data Analysis for the Identification of Emerging Food Safety Risks

**T1-06** Azos Jozwiak, ZSUZSA FARKAS, Tekla Engelhardt, Erika Ország, Szilveszter Csorba, Miklós Sűth, University of Veterinary Medicine Digital Food Institute, Budapest, Hungary

## 12.00 Lunch Available in the Exhibit Hall

### S2 Getting the Science, Legal and Business Case Right: Incorporating Food Safety into the Enterprise Risk Management Process

*Ballsaal*

**Organizers:** Melanie Neumann,

**Martin Wiedmann**

**Convenor:** Nic Sharman

13.30 Leveraging Enterprise Risk Management Tools and Terminology to Make Your Food Safety Program “Stick”

MELANIE J. NEUMANN, Matrix Sciences International, Inc., Chicago, IL, USA

- 14.00 The Role of Testing in an Enterprised-Based Food Safety Risk Management Program  
MARTIN WIEDMANN, Cornell University, Ithaca, NY, USA
- 14.30 Assigning and Tracking Food Safety and Quality KPI's: An Integral Part of Corporate Risk Management  
JOHN DONAGHY, Nestec Ltd., Vevey, Switzerland

## 15.00 Networking Coffee in the Exhibit Area

### RT2 Rapid Methods and Automation in Food Microbiology: 40 Years of Developments, Promises, and Disappointments

Forum 6 & 7

**Organizers: Purnendu Vasavada, Roy Betts**

**Convenor: Roy Betts**

- 13.30 GARY R. ACUFF, Acuff Consulting LLC, College Station, TX, USA
- ROY BETTS, Science Fellow, Campden BRI, Chipping Campden, United Kingdom
- DANIELE SOHIER, Thermo Fisher Scientific, Dardilly, France

## 15.00 Networking Coffee in the Exhibit Area

### T2 Technical Session 2 – General Microbiology and Molecular Analytics, Genomics and Microbiome

Forum 8

**Convenor: Clement Trunet**

- 13.30 Emetic *Bacillus cereus* – A Potential Risk for Plant-Based Dairy Alternatives  
**T2-01** ALINA KYRYLENKO, Robyn T. Eijlander, Jiansheng Wang, Giovanni Alliney, Marjon Wells-Bennik, NIZO Food Research, Ede, The Netherlands
- 13.45 Indole and Mucin Regulating Sporulation, Biofilm Formation and Virulence Gene Expression of Foodborne *Clostridium perfringens*  
**T2-02** CHAO WANG, Tom Defoirdt, Andreja Rajkovic, Laboratory of Food Microbiology and Food Preservation, Department of Food Technology, Safety and Health, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium

- 14.00 Is *Bacillus thuringiensis* a Species of the *Bacillus cereus* Group Like Any Others?  
**T2-03** CLEMENT TRUNET, Alexandra Cauquil, Nolwenn Hymery, Marie-Hélène Guinebretière, Florence Postollec, Louis Coroller, LUBEM UBO University – UMT ACTIA 19.03 ALTER'IX, Quimper, France
- 14.15 Whole Genome Sequencing of *Listeria monocytogenes* for Outbreak Investigation  
**T2-04** LARISSA MURR, Nancy Bretschneider, Melanie Pavlovic, Mareike Wenning, Ulrich Busch, Ingrid Huber, Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit, Oberschleißheim, Germany
- 14.30 *B. cereus* Can be Serious: A Comparative Evaluation of *Bacillus cereus* Group Genomic Taxonomies  
**T2-05** LAURA CARROLL, EMBL, Heidelberg, Germany
- 14.45 Genetic Diversity of Staphylococcal Strains Isolated from Food as Revealed by Whole Genome Sequencing  
**T2-06** MARINA CAVAIUOLO, Noémie Vingadassalon, Arnaud Felten, Yacine Nia, Jacques-Antoine Hennekinne, Laboratory fo Food Safety, French Agency for Food, Environmental and Occupational Health & Safety (ANSES), France, Paris, France

## 15.00 Networking Coffee in the Exhibit Area

### S3 Process Analytical Technology at the Service of Food Protection; The "Ditect" Approach

Ballsaal

**Organizer: George-John Nychas**

**Convenors: Alexandra Lianou, George-John Nychas**

- 15.30 Process Analytical Technology in the Food Industry: Principles, Methods and Applications  
ALEXANDRA LIANO, University of Patras, Department of Biology, Patras, Greece; George-John Nychas, Agricultural University of Athens, Department of Food Science and Human Nutrition, Athens, Greece
- 16.00 Detection of Contaminants in Raw Materials Using Multispectral Imaging  
JENS MICHAEL CARSTENSEN, Videometer A/S, Herlev, Denmark
- 16.30 Exploitation of Novel Information Technology Approaches in the Context of Process Analytical Technology in the Food Industry  
COLM O'DONNELL, University College Dublin, Dublin, Ireland

## 17.00 Reception in the Exhibit Area

## **RT3 Methodological Considerations in the Design of Pathogen Inoculation Studies: Implications for Validity and Application of Results**

Forum 6 & 7

**Organizers: Robson Machado, Jason Bolton**  
**Convenor: Douglas Marshall**

- 15.30 HELENE BERGIS, Anses, Maisons-Alfort, France  
ROY BETTS, Campden-BRI, Gloucestershire, United Kingdom  
LUCA COCOLIN, University of Turin, Grugliasco, Italy  
MICHELLE D. DANYLUK, University of Florida Crec, Lake Alfred, FL, USA  
DOUGLAS L. MARSHALL, Eurofins Scientific Inc., Fort Collins, CO, USA

## **17.00 Reception in the Exhibit Area**

### **T3 Technical Session 3 – Modeling and Risk Assessment**

Forum 8

**Convenor: Estefanía Noriega Fernández**

- 15.30 Quantitative Microbiological Risk Assessment  
**T3-01** Model for *Campylobacter* in Raw Milk  
ANNA-DELIA HERBSTMANN, Tasja Buschardt, Matthias Filter, Maarten Nauta, German Federal Institute for Risk Assessment, Department Biological Safety, Berlin, Germany
- 15.45 Overview on the Risk Assessment by the European  
**T3-02** Food Safety Authority (EFSA) of Microorganisms Intended as Novel Foods or Used in Their Production  
ESTEFANÍA NORIEGA FERNÁNDEZ, Patricia Romero Fernández, Irene Baratto, Gabriela Precup, Fabio Alfieri, Paolo Colombo, Fernando Rivero-Pino, Ruth Roldán Torres, Ermolaos Ververis, Panagiota Zakidou, Annamaria Rossi, European Food Safety Authority (EFSA), Parma, Italy
- 16.00 Development of a Quantitative Microbiological

- T3-03** Risk Assessment (QMRA) Model for Assessing the Spoilage Risk of Cooked Ham Products Sliced at Retail  
SOFIA TSALOUMI, Kostas Koutsoumanis, Laboratory of Food Microbiology and Hygiene, Department of Food Science and Technology, School of Agriculture, Aristotle University of Thessaloniki, Thessaloniki, Greece

- 16.15 Individual Cell Based Modelling of Growing  
**T3-04** Microcolonies  
STYLIANI DIMITRA PAPAGIANELI, Konstantina Stasinou, Zafeiro Aspidou, Kostas Koutsoumanis, Laboratory of Food Microbiology and Hygiene, Department of Food Science and Technology, School of Agriculture, Aristotle University of Thessaloniki, Thessaloniki, Greece, Thessaloniki, Greece

- 16.30 Development of a Predictive Model for *Listeria*  
**T3-05** *monocytogenes* Growth in Smoked Salmon Pâté  
ARACELI BOLÍVAR, Chajira Camila Garrote Achou, Iosune Cantalejo Diez, Fernando Perez-Rodriguez, Department of Food Science and Technology, University of Cordoba, Cordoba, Spain

- 16.45 Application of Predictive Models to Assess the  
**T3-06** Shelf Life of Traditional Spanish Fermented Sausages  
ARACELI BOLÍVAR, Rocío Rodríguez Romero, Laura Martín González, Fernando Perez-Rodriguez, Department of Food Science and Technology, University of Cordoba, Cordoba, Spain

## **17.00 Reception in the Exhibit Area**

## WEDNESDAY, 4 MAY 2022

### **P1 Communication Outreach and Education, Epidemiology, Food Chemical Hazards and Food Allergens, Food Processing Technologies, Food Safety Systems, Food Toxicology, Modeling and Risk Assessment, Molecular Analytics, Genomics and Microbiome, Retail and Food Service Safety, and Viruses and Parasites**

*Authors present during scheduled breaks.*

#### **Communication Outreach and Education**

- P1-01 Impact of Women Maternity Status on Their Food Safety Perception — Mojca Jevšnik, Anja Česen, Marina Šantić, ANDREJ OVCA, Faculty of Health Sciences, University of Ljubljana, Ljubljana, Slovenia
- P1-02 Withdrawn
- P1-03 Food Safety in Everyday Life for People with Intellectual Disabilities in Need of Support. — MARIE LANGE, Päivi Adolfsson, Ingela Marklinder, Katarina Galof, Andrej Ovca, Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden
- P1-04 Changing Behaviors: Educational Food Safety Intervention for Cancer Patients Receiving Treatment — Holly Paden, Dayssy Diaz Pardo, Erica Kim, Anna Beery, ELLEN W. EVANS, Sanja Ilic, The Ohio State University, Columbus, OH, USA
- P1-05 Food Safety Perceptions and Practices of Parents Regarding Children's School Lunchboxes — ELLEN W. EVANS, Alexandra Rose, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, United Kingdom
- P1-06 Understanding Food Safety Culture at a UK-Based Ready-to-Eat Food Manufacturing Company — ELIZABETH C. REDMOND, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, United Kingdom
- P1-07 "I Have Never Had a Complaint from a Dog about a Dirty Bowl": Following Guidelines for Safe Handling and Preparation of Raw Meat-Based Diets for Pets — VERONIKA BULOCHOVA, Ellen Evans, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, United Kingdom

#### **Retail and Food Service Safety**

- P1-08 Evaluation of Research Methods and Measures in Food Safety Studies Focused on Food-Service Sector — VERONIKA BULOCHOVA, Ellen Evans, Elizabeth C. Redmond, Claire Haven-Tang, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, United Kingdom
- P1-09 Food Safety Information Provision in UK-Based Children's Recipe Cookbooks and Online Resources — DAVID LLOYD, Elizabeth C. Redmond, Hannah Wadley, Hannah Bowen, Ruth Fairchild, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, United Kingdom

#### **Epidemiology**

- P1-10 Inferior Local Food Control Inspection Results Associate with Higher Incidence of Foodborne Diseases — MIKKO KOSOLA, Ruska Rimhanen-Finne, Annukka Markkula, Janne Lundén, University of Helsinki, Helsinki, Finland

#### **Food Chemical Hazards and Food Allergens**

- P1-11 Stability of Tropane Alkaloids as Chemical Hazards in Baby Foods — Berta Torrents, Albert Ribas-Agustí, Sara Bover-Cid, ANNA JOFRÉ, Massimo Castellari, IRTA (Institute of Agrifood Research and Technology), Food Safety and Functionality Program, Monells, Girona, Spain
- P1-12 Self-Reported Episode of Food Allergy: A Case Report of Collaboration between Analytical Lab and Patient to Improve Food Handling Practices — ELENA DALZINI, Alessandro Norton, Damiano Accurso, Barbara Bertasi, IZSLER, National Reference Centre for Emerging Risks in Food Safety, Brescia, Italy

#### **Food Safety Systems**

- P1-13 Quantitative Assessment of Food Integrity Climate in Food Businesses — Waeel Alrobaish, LIESBETH JACXSENS, Peter Vlerick, Ghent University, Ghent, Belgium
- P1-14 Use of Food Safety and Quality Measurement Data to Determine Food Safety Culture within a Food and Drink Manufacturing Business: An Historical Analysis — LAURA HEWITT, Arthur Tatham, Paul Hewlett, Elizabeth C. Redmond, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Northallerton, United Kingdom

P1-15 Evaluation of Food Samples Classified as Irregular Collected in Lombardy and Emilia Romagna during 2017–2021 — GUIDO FINAZZI, Matteo Gradassi, Irene Bertoletti, Paolo Bonilauri, Lia Bardasi, Franco Paterlini, Giuliana Cammi, Gianluca Rugna, Silva Rubini, Leonardo Marocchi, Silvia Colmegna, Elisabetta Raffini, Antonio Marco Maisano, Chiara Chiapponi, Cristina Sacchi, Giuseppina Andreoli, Laura Fiorentini, Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna "B. Ubertini" (IZSLER), Brescia, Italy

P1-16 *Listeria monocytogenes* Maximum Growth Rates on Commercial Desserts — ELENA COSCIANI-CUNICO, Elena Dalzini, Paola Monastero, Alessia Caproli, Enrico Pavoni, Marina-Nadia Losio, IZSLER, National Reference Centre for Emerging Risks in Food Safety, Brescia, Italy

## Food Toxicology

P1-17 The Impact of Sweeteners on Gene Expression of Pathogenic and Probiotic Bacteria; The SWEET Project — Evanthia Manthou, Agapi Doulgeraki, Chrysoula Tassou, Anne Raben, Jo Harrold, Jason Halford, GEORGE-JOHN NYCHAS, J. Alfredo Martinez, Agricultural University of Athens, Athens, Greece

P1-18 Growth Kinetics Analysis of Size and Shape Controllable Gold Nanoparticles for the Development of Immunochromatographic Assay — BILAL JAVED, Furong Tian, Technological University Dublin, Dublin, Ireland

## Modeling and Risk Assessment

P1-19 Potential of Oregano Essential Oils in Preventing the Health Risk of *E. coli*, *Salmonella enterica* and *Staphylococcus aureus* in Raw Pureed White Onion at 4°C — TEMITOPE CYRUS EKUNDAYO, Oluwatosin Ademola Ijabadeniyi, Department of Biotechnology and Food Science, Durban University of Technology, Durban, South Africa

P1-20 Characterizing the Variance of the Estimated Cardinal Temperature Values in Microbial Growth Modelling — OURANIA MISIOU, Mariem Ellouze, Kostas Koutsoumanis, Aristotle University of Thessaloniki, Thessaloniki, Greece

P1-21 Risk Assessment Database for *Escherichia coli* in Beef: Comparative Analysis in EU and China — KONSTANTINA STASINOY, Leonardos Stathas, Zafeiro Aspidou, Kostas Koutsoumanis, Aristotle University of Thessaloniki, Thessaloniki, Greece, Thessaloniki, Greece

P1-22 Estimation of the Microbiological Status of Chicken Burgers through Fourier Transform Infrared Spectroscopy (FT-IR) — Athena Grounta, Dimitra Dourou, GEORGE FROUTIS, Anthoula Argyri, Nikos Chorianopoulos, Agapi Doulgeraki, Chrysoula Tassou, Institute of Technology of Agricultural Products, Hellenic Agricultural Organization – DIMITRA, Attica, Greece

P1-23 Fourier-Transform Infrared Spectroscopy Coupled with Support Vector Machine Analysis for Chicken Liver Spoilage and Safety Assessment — Dimitra Dourou, Athena Grounta, Anthoula Argyri, George Frouitis, Panagiotis Tsakanikas, George-John Nychas, Agapi Doulgeraki, Nikos Chorianopoulos, CHRYSOULA TASSOU, Institute of Technology of Agricultural Products, Hellenic Agricultural Organization – DIMITRA, Attica, Greece

P1-24 A Predictive Model to Assess the Growth of *Listeria monocytogenes* in Rice Pudding Dessert — Abdelraheem Hussein, ARICIA POSSAS, Eman Shaker, Olga María Bonilla-Luque, Alshimaa Hassanien, Antonio Valero, University of Córdoba, Córdoba, Spain

P1-25 Modeling the Impact of a Microbial Consortium of Soft Cheeses on the Growth of *L. monocytogenes* and *E. coli* O157:H7 — Catherine Denis, AURELIE HANIN, Malvina Lefevre, Mickael Desvaux, Laurent Guillier, ACTALIA, Saint-Lô, France

## Molecular Analytics, Genomics and Microbiome

P1-26 Whole Genome Sequencing-Based Typing of *Listeria monocytogenes* Isolated from Seafood and Production Environments — Benjamin Duqué, François Gravey, Thomas Brauge, Malvina Lefevre, Estelle Sonnet, Guylaine Leleu, Simon Le Hello, Christophe Soumet, Arnaud Bridier, Graziella Midelet, AURELIE HANIN, ACTALIA, Food Safety Department, Saint-Lô, France

P1-27 Metagenomic Analysis of Yeast Communities Present on Table Olives Surface Could Indicate the Olive's Variety and Designation of Geographical Origin — AGAPI DOULGERAKI, Konstantina Argyri, Athena Grounta, Dimitra Dourou, Anthoula Argyri, Nikos Chorianopoulos, Chrysoula Tassou, Institute of Technology of Agricultural Products, Hellenic Agricultural Organization – DIMITRA, Attica, Greece

P1-28 Surveillance of *Listeria monocytogenes*: Early Detection, Population Dynamics and Quasimetagenomic Sequencing during Selective Enrichment — Eva Wagner, Annette Fagerlund, Solveig Langsrud, Trond Mørretrø, MERETE RUSÅS JENSEN, Birgitte Moen, Nofima, Ås, Norway

P1-29 WGS Analysis of *Listeria monocytogenes* from Rural, Urban, and Farm Environments in Norway: Genetic Diversity, Persistence, and Relation to Clinical and Food Isolates — ANNETTE FAGERLUND, Lene Idland, Even Heir, Trond Mørretrø, Marina Aspholm, Toril Lindbäck, Solveig Langsrud, Nofima, Ås, Norway

## Retail and Food Service Safety

P1-30 Response of *Salmonella* spp. and *E. coli* O157:H7 Heat-Shocked Cells during Inappropriate Storage of Under- and Adequately-Cooked Pork “Gyros” — Anastasia Kapetanakou, Konstantina Athanaseli, PANAGIOTIS SKANDAMIS, Agricultural University of Athens, Athens, Greece

P1-31 Management Perceptions of Factors Associated with Food Safety Culture in UK Food-Service Small and Medium-Sized Enterprises — OMOTAYO IRAWO, Arthur Tatham, Elizabeth C. Redmond, Cardiff Metropolitan University, Cardiff, United Kingdom

## 17.00 – 18.00 Exhibit Hall Reception

## THURSDAY, 5 MAY

7.30 – 17.00 Registration Open

7.30 – 8.30 Morning Coffee

10.00 – 16.00 Exhibit Hours

### S4 **Plasmarter – Cold Plasma Functionalised Liquids as a Food Safety Intervention Technology**

*Ballsaal*

**Organizer: Paula Bourke**

**Convenors: Jorg Ehlbeck, Paula Bourke**

- 8.30 Mechanistic Insights to Cold Plasma Functionalised Liquids: Antimicrobial Efficacy and Interactions with Processing and Storage Conditions  
DANIELA BOEHM, Technological University Dublin, Dublin, Ireland
- 9.00 Scaling Efficacy of Cold Plasma Functionalised Liquids from Bench to Pilot to Industry for Fresh Produce  
UTA SCHNABEL, Leibniz Institute for Plasma Science and Technology, Greifswald, Germany
- 9.30 Integrating Cold Plasma Functionalised Liquids to Control Microbiological Risks in Poultry Processing  
SOUKAINA BARROUG, Institute of Food and Health, University College Dublin, Dublin, Ireland

### 10.00 Networking Coffee in the Exhibit Area

### S5 **New Hazards and Old Threats; Foodborne Viruses and Risk Assessment in Food Safety**

*Forum 6 & 7*

**Organizers and Convenors: Kevin Hunt, David Rodríguez Lázaro, Monika Trzaskowska**

- 8.30 Risk Assessment and Foodborne Viruses: Is It Cold out There?  
CHIARA BALBO and CONSTANTINE-RICHARD STEFANO, EFSA EU-FORA Fellow, IBPRS State Research Institute, Warsaw, Poland
- 9.00 The Next Frontier in Risk Assessment in Food: Quantitative Viral Risk Assessment  
KEVIN HUNT, University College Dublin, School of Biosystems and Food Engineering, Dublin, Ireland
- 9.30 Control of Foodborne Virus Risk in the Context of Risk Assessment  
MONIKA TRZĄSKOWSKA, Warsaw University of Life Sciences, Institute of Human Nutrition, Warsaw, Poland

### 10.00 Networking Coffee in the Exhibit Area

### T4 **Technical Session 4 – Laboratory and Detection Methods**

*Forum 8*

**Convenor: Yacine Nia**

- 8.30 Metal Detectable Plastic Control in the Food Industry  
**T4-01** DEBRA SMITH, Vikan, EHEDG UK:IE, Swindon, United Kingdom
- 8.45 Subtyping of Food-Related *Listeria monocytogenes* Strains by MALDI-TOF Mass Spectrometry  
**T4-02** FELICE PANEBIANCO, Emanuele Rubiolo, Francesco Chiesa, Tiziana Civera, University of Turin, Torino, Italy
- 9.00 Lighting up Pathogen Detection: The Use of PNA FISH for the Detection of Pathogens in Food and Water Samples  
**T4-03** LAURA CERQUEIRA, Montserrat Nácher-Vázquez, Carina Almeida, Nuno Filipe Azevedo, LEPABE–Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
- 9.15 Detection of the Viable But Non-Culturable State (VBNC) of *Listeria monocytogenes* and *Listeria innocua* Induced by Biocide Stress Using Raman Microspectroscopy  
**T4-04** SYLVAIN TRIGUEROS, Tommy Dedole, Thomas Brauge, Véronique Rebuffel, Sophie Morales, Pierre R. Marcoux, Graziella Midelet, University Grenoble Alpes, CEA, LETI, Grenoble, France
- 9.30 Detection of Adulteration in Raw and Cooked Beef Using Multispectral Imaging  
**T4-05** George Myriss, LEMONIA-CHRISTINA FENGOU, Panagiotis Tsakanikas, Efsthathios Z. Panagou, George-John E. Nychas, Laboratory of Microbiology and Biotechnology of Foods, Department of Food Science and Human Nutrition, Agricultural University of Athens, Athens, Greece
- 9.45 Multiplex Detection of 24 Staphylococcal Enterotoxins Using Liquid Chromatography Coupled to High Resolution Mass Spectrometry  
**T4-06** Donatien Lefebvre, Kevin Blanco-Valle, Jacques-Antoine Hennekinne, François Fenaille, Stéphanie Simon, François Becher, YACINE NIA, Laboratory for Food Safety, French Agency for Food, Environmental and Occupational Health & Safety (ANSES), Maisons-Alfort, France

### 10.00 Networking Coffee in the Exhibit Area

## RT4 Trust, Safety and Sustainability of Food: Key in Increasing Citizen Engagement in Food Systems

*Ballsaal*

**Organizer and Convenor: Luca Cocolin**

- 10.30 MATTEO SABINI, European Food Information Council – EUFIC, FoodSafety4EU, Brussels, Belgium  
ALICE MAUCLINE, School of Agriculture, Policy & Development University of Reading, Reading, United Kingdom  
SASKIA NUIJTEN, Director of Public Engagement and Communication - EIT Food, Leuven, Belgium

### 12.00 Lunch Available in the Exhibit Hall

## S6 Determining the Efficacy of Control Measures Against Foodborne Viruses

*Forum 6 & 7*

**Organizer: Annette Sansom**

**Convenors: Roy Betts, John Holah**

- 10.30 The Trouble with Hepatitis E!  
LINDA SCOBIE, Glasgow Caledonian University, Glasgow, United Kingdom
- 11.00 Assessing the Efficacy of Control Measures Against Viruses Using Surrogates  
ANNETTE SANSOM, Campden BRI Ltd., Chipping Campden, United Kingdom
- 11.30 COVID-19: Practical Lessons Learned in Virus Control  
JOHN HOLAH, Holchem/Kersia, FS&PH, Bury, United Kingdom

### 12.00 Lunch Available in the Exhibit Hall

## T5 Technical Session 5 – Communication Outreach and Education, Food Safety Systems and Modeling and Risk Assessment

*Forum 8*

**Convenor: Ákos Józwiak**

- 10.30 Survey of New Zealand Poultry Consumers  
**T5-01** Handling of Raw Poultry and Food Safety Awareness to Provide Insight into Risk Factors for Campylobacteriosis  
ALI AL-SAKKAF, Elizabeth C. Redmond, Charles Brennan, Ravi Gooneratne, Lincoln University, Lincoln, New Zealand

- 10.45 Adoption of Milk Safety Practices: Empirical  
**T5-02** Evidence from Dairy Farmers in Ethiopia  
BEKELE WEGI FEYISA, Jemma Haji, Robert Scharff, Alisher Mirzabaev, Haramaya University, Dire Dawa, Ethiopia

- 11.00 Food Sector Perceptions of Using AI Technology to Support Hand Hygiene Compliance  
**T5-03** ELLEN W. EVANS, Veronika Bulochova, Ambikesh Jayal, Claire Haven-Tang, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, United Kingdom

- 11.15 Development of a Certified Reference Material (CRM) for *Staphylococcal enterotoxin B* (SEB)  
**T5-04** REINHARD ZELENY, Katrien Busschots, Martin Skiba, Bettina Kampa, Sylvia Worbs, Brigitte Dörner, Anne-Sophie Mierzala, Julien Lebreton, François Becher, Stéphanie Simon, Berivan Boran, Yacine Nia, Jacques-Antoine Hennekinne, Jasmin Weisemann, Nadja Krez, Andreas Rummel, Tomas Bergström, Daniel Jansson, Marc-André Avondet, Christian Müller, Matthias Wittwer, European Commission, Joint Research Centre (JRC), Geel, Belgium

- 11.30 Data Science in Food Chain Safety Decision Making: A European Perspective  
**T5-05** AKOS JOZWIAK, University of Veterinary Medicine Digital Food Institute, Budapest, Hungary

- 11.45 Food Safety Intervention Evaluations in Low- and Middle-Income Countries (LMICs)  
**T5-06** ROBERT SCHARFF, Kai Su, The Ohio State University, Columbus, OH, USA

### 12.00 Lunch Available in the Exhibit Hall

## S7 Plant Protein-Based Meat and Dairy Alternatives – Known Plant Sources But New Microbiological Risks?

*Ballsaal*

**Organizer: Marjon Wells-Bennik**

**Convenor: Masja Nierop Groot**

- 13.30 Safety of Plant-Based Meat Alternatives in a Reverse Engineering Approach  
MASJA NIEROP GROOT, Wageningen Food & Biobased Research, Wageningen, The Netherlands
- 14.00 Microbial Contaminants Relevant to Safety and Quality of Plant Protein-Based Dairy Alternatives  
MARJON WELLS-BENNIK, NIZO, Ede, The Netherlands



14.30 An Old Foe in New Plant-Based Products – *Clostridium botulinum*  
NOORA PERNU, University of Helsinki, Helsinki, Finland

## 15.00 Networking Coffee in the Exhibit Area

### RT5 How Best to Leverage Partnerships in a Sea of Rapidly Evolving Technology *Forum 6 & 7*

**Organizers:** Maria Hoffmann, Burkhard Malorny, Eric Stevens

**Convenors:** Maria Hoffmann, Burkhard Malorny

13.30 CHRISTOPHE CORDEVANT, ANSES, Maisons-Alfort, France

BARBARA GALLANI, European Food Safety Authority, Parma, Italy

ANDREAS HENSEL, German Federal Institute for Risk Assessment, Berlin, Germany

SASHA KOO-OSHIMA, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

ERIC STEVENS, U.S. Food and Drug Administration, College Park, MD, USA

## 15.00 Networking Coffee in the Exhibit Area

### T6 Technical Session 6 – Microbial Food Spoilage and Modeling and Risk Assessment *Forum 8*

**Convenor:** Alessia Delbrück

13.30 Could *Listeria monocytogenes* be a Concern for an Innovative Chicken-Based Dry-Fermented Sausage?  
**T6-01**

ANNA AUSTRICH-COMAS, Cristina Serra-Castelló, Anna Jofré, Pere Gou, Sara Bover-Cid, IRTA (Institute of Agrifood Research and Technology), Food Safety and Functionality Program, Monells, Girona, Spain

13.45 Insights into the Use of Electrolysed Water and Metataxonomic Profiling to Extend the Shelf Life of Ground Beef  
**T6-02**

CRISTIAN BOTTA, Ilario Ferrocino, Irene Franciosa, Valentina Alessandria, Vladimiro Cardenia, Jean Daniel Coisson, Antonio Colasanto, Marco Arlorio, Luca Cocolin, Kalliopi Rantsiou, Department of Agriculture, Forest and Food Sciences, University of Turin, Grugliasco, Italy

14.00 Comparative Genomics Reveals the *hyp* Gene Cluster as a Causative Function for Blown-Pack Spoilage of Vacuum Packed Meat by *Clostridium estertheticum* Complex  
**T6-03**

JOSEPH WAMBUI, Marc J.A. Stevens, Roger Stephan, Institute for Food Safety and Hygiene, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

14.15 Volatilomics in Tandem with Machine Learning for the Quality Assessment of Chicken Meat  
**T6-04**

ANASTASIA LYTOU, Eirini Lariou, Evgenia Spyrelli, Athanasios Mallouchos, Efstathios Z. Panagou, George-John E. Nychas, Agricultural University of Athens, Athens, Greece

14.30 High Intra- and Inter-Batch Variability in Raw Pork Challenge Test Studies and Their Consequences for Model Validation Efforts: An Intricate Interplay between *L. monocytogenes*, Background Flora, and Packaging Atmosphere  
**T6-05**

Niels Demaitre, KOEN DE REU, Ellen François, Lieven De Zutter, Geertrui Rasschaert, Annemie Geeraerd, Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Melle, Belgium

14.45 Investigating the Bottleneck of Pressure-Mediated Spore Germination-Inactivation Strategies: Properties of *Bacillus subtilis* Superdormant Spores and Potential Underlying Mechanisms  
**T6-06**

ALESSIA DELBRÜCK, Yifan Zhang, Rosa Heydenreich, Vera Hug, Yvette Tritten, Alexander Mathys, ETH Zurich, Institute of Food, Nutrition and Health, Sustainable Food Processing Laboratory, Zurich, Switzerland

## 15.00 Networking Coffee in the Exhibit Area

### S8 Safety and Quality of Water Used and Reused in Fresh Produce Supply Chains *Ballsaal*

**Organizer:** Leon Gorris

**Convenors:** Leon Gorris, Kang Zhou

3.30 Overview of Water (re-use) for Fresh Produce and Identifying Safe, Fit-for-Purpose Applications of Re-Usable Water Sources

ROB DE JONGE, RIVM (National Institute for Public Health), Bilthoven, The Netherlands

4.00 Bringing Fit-for-Purpose Applications into Fresh Produce Operations and Managing Control  
DIMA K. FAOUR-KLINGBEIL, DFK for Safe Food Environment, Hannover, Germany

- 4.30 Fit-for-Purpose Water (re-)Use Applications in the Context of Informal Produce Value Chains and Informal Markets in Low- and Middle-Income Countries  
ELISABETTA LAMBERTINI, GAIN – Global Alliance for Improved Nutrition, Rockville, MD, USA

## S9 Shelf-Stable Fermented Sausages: A Food Safety Concern?

Forum 6 & 7

**Organizers:** Anna Jofré, Sara Bover-Cid, Cristina Serra-Castelló

**Convenors:** Cristina Serra-Castelló, Anna Jofré

- 3.30 Occurrence of Foodborne Pathogens in Fermented Sausages and Involvement of Fermented Sausages in Foodborne Outbreaks in the EU  
VALENTINA RIZZI, Biological Hazards and Animal Health and Welfare (BIOHAW) Unit. European Food Safety Authority (EFSA), Parma, Italy
- 4.00 Squeezing the Most of the Hurdle Technology to Ensure the Safety in Shelf-Stable Fermented Sausages  
SARA BOVER-CID, IRTA (Institute of Agrifood Research and Technology), Food Safety and Functionality Program, Monells, Girona, Spain
- 4.30 Contribution of Predictive Microbiology to Control Dry-Fermented Sausage Safety  
LOUIS COROLLER, LUBEM UBO University - UMT ACTIA 19.03 ALTER'IX, Quimper, France

## T7 Technical Session 7 – Food Processing Technologies

Forum 8

- 15.30 Impact of Various Food Components on the STEC  
**T7-01** Inactivation Efficiency of Non-thermal Plasma  
KLAAS DE BAERDEMAEKER, Anton Nikiforov, Nathalie De Geyter, Frank Devlieghere, Ghent University, Ghent, Belgium
- 15.45 The Linkage between *Listeria monocytogenes* Genomic Characteristics and Their Ability to Proliferate at Low Temperature  
**T7-02** PETER MYINTZAW, Maire Begley, Olivia McAuliffe, Michael Callanan, Department of Biological Sciences, Munster Technological University, Bishopstown, Cork, Ireland, Cork, Ireland
- 16.00 Selection of Representative Strains of *Escherichia coli* O157:H7, *Listeria monocytogenes* and *Salmonella enterica* for Validation of High Pressure Processing  
**T7-03** MARIO GONZÁLEZ-ANGULO, Vinicio Serment-Moreno, Laura Clemente-García, Carole Tonello, Isabel Jaime, Jordi Rovira, Hiperbaric S.A., Burgos, Spain
- 16.15 Inactivation of Vegetative Pathogens Due to Acid Exposure and High Pressure Processing in Apple Puree  
**T7-04** BERTA TORRENTS, Anna Jofré, Albert Ribas-Agustí, Sara Bover-Cid, IRTA (Institute of Agrifood Research and Technology), Food Safety and Functionality Program, Monells, Girona, Spain
- 16.30 Identification of *Bacillus subtilis* Spore Proteins That Influence Moderate High-Pressure Germination (150 MPa)  
**T7-05** Alessia Delbrück, Paolo Nanni, ROSA HEYDENREICH, Alexander Mathys, ETH Zurich, Institute of Food, Nutrition and Health, Sustainable Food Processing Laboratory, Zurich, Switzerland
- 16.45 Germination and Outgrowth of *Bacillus weihenstephanensis* KBAB4 is Impaired by Environmental pH; A Quantitative Single Cell Analysis  
**T7-06** CLEMENT TRUNET, Norbert Vischer, Louis Coroller, Stanley Brul, LUBEM UBO University - UMT ACTIA 19.03 ALTER'IX, Quimper, France

## P2 Poster Session 2 – Beverages and Acid/Acidified Foods, Dairy, General Microbiology, Laboratory and Detection Methods, Low-Water Activity Foods, Meat, Poultry and Eggs, Microbial Food Spoilage, Packaging, Sanitation and Hygiene, and Seafood

Authors present during scheduled breaks.

### Beverages and Acid/Acidified Foods

P2-01 Impact of pH on the Growth of *Aspergillus niger*, *Byssoschlamys fulva*, *Saccharomyces cerevisiae*, and *Zygosaccharomyces parabaillii* in Liquid Media — FABIEN SAUBADE, Luc Giguelay-Gesret, Mariem Ellouze, Cédric Gérard, Olivier Couvert, Noemie Desriac, LUBEM UBO University - UMT ACTIA 19.03 ALTER'ix, Quimper, France

### Dairy

P2-02 An Exploration of Milking Practices on North Wales Dairy Farms: Potential Impact of Behaviour upon Microbiological Quality of Unpasteurised Milk — Cadi Mars Jones, Ruth Fairchild, ELLEN W. EVANS, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, United Kingdom

P2-03 Raw Milk Quality Under Hot Weather Conditions: Statistical Analysis of a Large Dataset — RODNEY FELICIANO, Géraldine Boué, Fahad Mohssin, Muhammad Mustafa Hussaini, Jeanne-Marie Membré, Secalim, INRAE, ONIRIS- Ecole Nationale Vétérinaire, Agroalimentaire et de l'alimentation de Nantes-Atlantique, Nantes, France

P2-04 Microbiological Quality of Raw Milk and Prevalence of Foodborne Pathogens — Evanthia Manthou, Gwenn Pinel, George Froustis, GEORGE-JOHN NYCHAS, Laboratory of Microbiology and Biotechnology of Foods, Department of Food Science and Human Nutrition, Agricultural University of Athens, Athens, Greece

### General Microbiology

P2-05 Bacterial Dynamics along Broiler Slaughterlines in Norway — GUNVOR ELISE NAGEL-ALNE, Sigrun Hauge, Gro Johannessen, Bjørn Spilberg, Solfrid Bjørnkøy, Merete Forseth, Eystein Skjerve, Ann-Katrin Llàrena, Janne Holthe, Ole-Johan Røtterud, Ole Alvseike, Animalia Ås, Oslo, Norway

P2-06 Detection of Enteric Viruses in Foodstuffs: A Six-Year Survey in Italy — ENRICO PAVONI, Barbara Bertasi, Elisa Galuppini, Lucia Mangeri, Francesca Meletti, Michela Tilola, Silvia Todeschi, Marina-Nadia Losio, Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia-Romagna (IZSLER), Brescia, Italy

P2-07 Impact of Carbon Dioxide on Radial Growth of Filamentous Fungi Encountered in Dairy Environment — Marion Valle, Nicolas Nguyen Van Long, Jean-Luc Jany, Loona Koullen, Olivier Couvert, Véronique Huchet, LOUIS COROLLER, Adria Développement and LUBEM - UMT ACTIA 19.03 ALTER'ix, Quimper, France

P2-08 Study of *Listeria innocua* Heat Resistance after Sublethal Heat Treatment with MALDI-TOF — Oktay Hakim, Csilla Mohacsi-Farkas, TEKLA ENGELHARDT, University of Veterinary Medicine Digital Food Institute, Budapest, Hungary

### Laboratory and Detection Methods

P2-09 Evaluating Performance of MC Media Pad Alternative Methods for Hygienic Indicators Enumeration in Foods — Amparo de Benito, Renaud Chollet, DAVID TOMAS, MERCK Life Science, Madrid, Spain

P2-10 Identification of Animal and Plant Species in Food-Based Products Using Next Generation Sequencing: Results from a European Interlaboratory Study — MARIO GADANHO, Nicole Prentice, Tiina Karla, Milja Tikkanen, Hanna Lehmusto, Cristina Barbosa, Sofia Pires, Franck Pandiani, Rita Alberty, Tiago Machado, Isabel Mâncio, Manuela Sol, Maelle Prorok-Hamon, Marika Ramassamy, Julien Gernigon, Paola De Santis, Ugo Marchesi, Daniela Verginelli, Katia Spinella, Bianca Maria Varcasia, Roberta Pellesi, Michele Suman, Geoffrey Cottenet, Carine Blancpain, Anne-Catrin Geuthner, Ralf Reiting, Anke Rullman, Stefanie Dobrovolny, Rupert Hohegger, Lotte Hougs, Birgitte Nauerby, Ines Vazquez, Chris Conyers, Edward Haynes, Thermo Fisher Scientific, Basingstoke, United Kingdom

P2-11 Optimisation of Culture Dependent and Independent Methods to Detect Pathogens in Infant Food Production Chain — DIMITRA TSOUREKI, Cristian Botta, Maria Rita Corvaglia, Ilario Ferrocino, Luca Cocolin, Kalliopi Rantsiou, Department of Agriculture, Forest and Food Sciences, University of Turin, Grugliasco, Italy

- P2-12 ISO 16140-2:2016 and AOAC-OMA Validation of a Real-Time PCR Workflow for *Salmonella* Detection in Cocoa and Chocolate Products — Evangelos J. Vandoros, David Crabtree, DANIELE SOHIER, Matthew Hahs, Wesley Thompson, Benjamin Bastin, Kateland Koch, Thermo Fisher Scientific, Dardilly, France
- P2-13 An ISO 16140-2:2016 Extension Study for a *Cronobacter* Species PCR Assay to Include 375 g Powdered Infant Formula, Infant Cereals and Related Ingredient Matrices — Nikki Faulds, Katharine Evans, DANIELE SOHIER, François Le Nestour, Guillaume Mesnard, Thermo Fisher Scientific, Dardilly, France
- P2-14 Validation of a Rapid Culture Media Workflow According to ISO 16140-2:2016 for the Detection of *Cronobacter* spp. from Selected Matrices — Nikki Faulds, Katharine Evans, DANIELE SOHIER, François Le Nestour, Guillaume Mesnard, Thermo Fisher Scientific, Dardilly, France
- P2-15 Impact of Environmental Stresses on the Viability State of *Listeria monocytogenes* and *Listeria innocua* Analyzed by Raman Microspectroscopy, Molecular Biology and Microbiology Techniques — SYLVAIN TRIGUEROS, Tommy Dedole, Thomas Brauge, Sabine Debuiche, Véronique Rebuffel, Sophie Morales, Pierre R. Marcoux, Graziella Midelet, University Grenoble Alpes, CEA, LETI, Grenoble, France
- P2-16 Evaluation of Viability of Cells of *Listeria innocua* with Raman Microspectroscopy after Incorporation of Heavy Water (D<sub>2</sub>O) — SYLVAIN TRIGUEROS, Thomas Brauge, Tommy Dedole, Sabine Debuiche, Véronique Rebuffel, Sophie Morales, Pierre R. Marcoux, Graziella Midelet, University Grenoble Alpes, CEA, LETI, Grenoble, France
- P2-18 Potassium Lactate as a Strategy for Sodium Content Reduction without Compromising Salt Associated Antimicrobial Activity in Salami — FRANCIS MUCHAAMBA, Helena Stoffers, Ralf Blase, Ueli von Ah, Roger Stephan, Taurai Tasara, Institute for Food Safety and Hygiene, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland
- P2-19 Differences of Thermal Inactivation Kinetics of *Cronobacter sakazakii* Using Fresh, Dry or Dry-Adapted Inoculum — ELENA DALZINI, Alessia Caproli, Francesco Righi, Daniela Merigo, Paola Monastero, Elena Cosciani-Cunico, Elisabetta Delibato, Antonietta Gattuso, Alfonsina Fiore, Marina-Nadia Losio, IZSLER, National Reference Centre for Emerging Risks in Food Safety, Brescia, Italy
- P2-20 Optimization of Assurance® G.D.S. *Salmonella* Enrichment Protocols for Cocoa and Chocolate — CHARLOTTE LINDHARDT, David Tomas, Michael Eastwood, Brian Connolly, Britta Kunz, Sascia Neumann, Lisa John, Merck KGaA, Darmstadt, Germany

## Meat, Poultry and Eggs

- P2-21 Verifying the Inactivation of *Salmonella* spp. in Poultry Feed Mills — ZOE LAMBERT, Phil Wells, Peter Goude, Rob Limburn, Madalina Smadoiu, Jess Crouch, Campden BRI, Chipping Campden, United Kingdom
- P2-22 Characterization and Composition Analysis of Biofilm and Extracellular Polymeric Substances (EPS) Produced by Seafood Pathogen *Tenacibaculum discolor* — Eirini Schoina, Laetitia Marchand, Agata Zykwinska, Corinne Siquin, Francoise Leroi, Veronique Verrez-Bagnis, GEORGE-JOHN NYCHAS, Christine Delbarre-Ladrat, Agricultural University of Athens, Athens, Attica, Greece
- P2-23 Data Fusion of Three Noninvasive Methods for the Quality Assessment of Chicken Marinated Souvlaki — Evgenia Spyrelli, Efstathios Panagou, GEORGE-JOHN NYCHAS, Agricultural University of Athens, Athens, Attica, Greece
- P2-24 The Potential of Machine Learning in the Assessment of the Microbiological Quality of Fish — Paschalitsa Tryfinopoulou, Eirini Lariou, Eirini Schoina, Evanthia Manthou, Efstathios Panagou, GEORGE-JOHN NYCHAS, Laboratory of Food Microbiology and Biotechnology, Department of Food Science and Human Nutrition, School of Food and Nutritional Sciences, Agricultural University of Athens, Athens, Attica, Greece

## Low-Water Activity Foods

- P2-17 Non-Invasive Detection of Microbial Growth in Aseptic Food Products Using Tunable Diode Laser Absorption Spectroscopy — PETER MYINTZAW, Johnson Nicholas Brian, Michael Callanan, Department of Biological Sciences, Munster Technological University, Bishopstown, Cork, Ireland, Cork, Ireland

P2-25 Transition of *Listeria monocytogenes* into Sublethal Injury during Frankfurters Reheating — MARIANNA ARVANITI, Anastasia Kapetanakou, Maria Kourteli, Eleni Vlachou, Panagiotis N. Skandamis, Laboratory of Food Quality Control and Hygiene, Department of Food Science and Human Nutrition, Agricultural University of Athens, Athens, Greece

## Microbial Food Spoilage

P2-26 Occurrence of Pathogenic Microorganisms in Fermented Foods — AJIBOLA OYEDEJI, Ezekiel Green, Yemisi Jeff Aboola, Afolake Olanbiwoninu, Esther Areo, Itohan Martins, Amina El-Imam, Oluwafemi Adebo, University of Johannesburg, Doornfontein Campus, Johannesburg, South Africa

P2-27 CO<sub>2</sub> Inhibits Several Spoilage Associated Bacteria and Reduce Off Odor Development of CO<sub>2</sub> Tolerant Bacteria during Storage of Raw Chicken Fillets — BIRGITTE MOEN, Anlaug Ådland Hansen, John-Erik Haugen, Mats Carlehøg, Solveig Langsrud, Nofima, Ås, Norway

P2-28 Biofilm Formation Diversity of *Brochothrix thermo-sphacta* a Major Food Spoiler — ANTOINE GAILLAC, Julien Deschamps, Romain Briandet, Evelyne Vigneau, Philippe Courcoux, Emmanuel Jaffrès, Herve Prevost, INRAE-Oniris, Nantes, France

## Packaging

P2-29 Effect of Edible Coating and Modified Atmosphere Packaging on the Microbiological and Physico-chemical Characteristics of Non-thermally Preserved Cv. Kalamata Natural Black Olives — Anna Loukanari, Georgios Tsekouras, Maria Georgiadou, Theofania Tsironi, George-John Nychas, EFSTATHIOS PANAGOOU, Agricultural University of Athens, Department of Food Science and Human Nutrition, Laboratory of Microbiology and Biotechnology of Foods, Athens, Greece

P2-30 Multispectral Imaging for Estimating the Microbiological Quality of Chicken Fillets Stored Under Different Packaging Conditions — George Tsekos, LEMONIA-CHRISTINA FENGOU, Efsthios Panagou, George-John Nychas, Laboratory of Microbiology and Biotechnology of Foods, Department of Food Science and Human Nutrition, Agricultural University of Athens, Athens, Greece

## Sanitation and Hygiene

P2-31 Cleaning and Disinfection. What Will be the Outcome Post-Pandemic? — PETER LITTLETON, Christeys Food Hygiene, Warrington, United Kingdom

P2-32 Bacteriophages-Based Enrichment Coupled to Chemiluminescence Reaction for Highly Specific, Sensitive and Single-Step *Listeria monocytogenes* and *Salmonella* spp. Detection — Anne Flore Imhaus, REDOUAN MAHOU, Mario Hupfeld, Lars Fieseler, NEMIS Technologies, Duebendorf, Switzerland

P2-33 A Microbiological and Hygiene Assessment of Vertical Hand-Dryer Cleanliness in Food Manufacturing Facilities — EMMA J. SAMUEL, Ellen W. Evans, Rowena E. Jenkins, Elizabeth C. Redmond, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, Wales, United Kingdom

## FRIDAY, 6 MAY

7.30 – 12.00 – Registration Open

7.30 – 8.30 – Morning Coffee

### RT6 Environmental Pathogen Monitoring: Prospects, Challenges and Lessons Learned

*Ballsaal*

**Organizers: Roy Betts, Alvin Lee, Purnendu Vasavada**

**Convenor: Alvin Lee**

8.30 ROY BETTS, Campden BRI, Chipping Campden, United Kingdom

JOHN DONAGHY, Nestec Ltd., Vevey, Switzerland

MATT HENDERSON, Land O'Frost, Inc., Munster, IN, USA

ANETT WINKLER, Cargill, Unterschleißheim, Germany

### 10.00 Networking Coffee

### S10 Application of Food Allergen Risk Assessment and Management: Current Perspectives and Issues

*Forum 6 & 7*

**Organizer: ILSI Europe**

**Convenors: ILSI Europe, Simon Flanagan**

8.30 Update on FAO/WHO and Codex Activities Regarding Food Allergens  
RENÉ CREVEL, René Crevel Consulting Ltd., Cople, United Kingdom

9.00 Practical Guidance on the Application of Allergen Quantitative Risk Assessment  
NEIL BUCK, General Mills Inc., Lausanne, Switzerland

9.30 Impact on Consumers with Food Allergies of Differing Public Health and Industry Risk Management Strategies  
BENJAMIN REMINGTON, Remington Consulting Group B.V., Utrecht, The Netherlands

### 10.00 Networking Coffee in the Exhibit Area

### T8 Technical Session 8 – Antimicrobials and Foodborne Pathogens Control

*Forum 8*

**Convenor: Anne Brisabois**

8.30  $\beta$ -Phenylethylamine as a Natural Food Additive

**T8-01** Shows Antimicrobial Activity against *Listeria monocytogenes* on Ready-to-Eat Foods  
FRANCIS MUCHAAMBA, Roger Stephan, Taurai Tasara, Institute for Food Safety and Hygiene, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

8.45 Fluorescence-Activated Cell Sorting Enables the Characterization of Sublethal Injury and VBNC State in *Listeria monocytogenes*

**T8-02** MARIANNA ARVANITI, Nikolaos Orogas-Stavrou, Ourania E. Tsitsilonis, Panagiotis N. Skandamis, Agricultural University of Athens, Athens, Greece

9.00 Impact of Disinfectants Neutralizing Buffers Used

**T8-03** for Sampling Methods on the Viability of *Listeria monocytogenes* Cells in Monospecies Biofilm  
THOMAS BRAUGE, Guylaine Leleu, Anthony Colas, Graziella Midelet, ANSES, Boulogne sur Mer, France

9.15 Targeted and Untargeted Monitoring of Pathogens Along Infant Food Processing Chain

**T8-04** DIMITRA TSOUREKI, Cristian Botta, Evangelia Kristalli, Dimitris Ladikos, Vasiliki Giatrakou, Vasilis Spiliotis, Ilario Ferrocino, Luca Cocolin, Katerina Pissaridi, Kalliopi Rantsiou, University of Turin, Grugliasco, Italy

### 10.00 Networking Coffee in the Exhibit Area

### S11 Leading from the Frontline: Should Food Safety Culture Improvement Start on the Shop Floor?

*Ballsaal*

**Organizers: Shingai Nyarugwe, Emma J. Samuel, Sophie Tongyu Wu**

**Convenor: Nic Sharman**

10.30 Alignment of Food Safety Priorities between Food Handlers and Management is Critical to Cultivating and Maintaining a Positive Food Safety Culture  
PAULINE SPAGNOLI, Ghent University, Ghent, Belgium

11.00 Exploring the Role of Food Safety Culture in Supporting or Hindering Frontline Hand Hygiene Behaviour in Food Manufacturing Environments  
EMMA J. SAMUEL, ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, Wales, United Kingdom

- 11.30 Creating Developmental and Transitional Culture Change Using Real-Time Feedback Technology in Food Manufacturing Companies  
LONE JESPERSEN, Cutlivate Food Safety, Hauterive, Switzerland; Carol Wallace, University of Central Lancashire, Preston, United Kingdom

## S12 Biofilm Formation by Food-Associated Bacteria – Friend or Foe?

Forum 6 & 7

**Organizer: Moshe Shemesh**

**Convenor: Romain Briandet**

- 10.30 Positive Biofilms to Guide Surface Microbial Ecology  
ROMAIN BRIANDET, INRAE, Jouy-en-Josas, France
- 11.00 Cheese Smear or the Ancestral Cultivation of a Beneficial Biofilm  
EMMANUELLE ARIAS, Agroscope, Bern, Switzerland
- 11.30 Role of Biofilm Formation in Developing the Symbiotic Food Promoting Well-Being and Health  
SATISH KUMAR RAJASEKHAREN, Agricultural Research Organisation, Rishon LeZion, Israel

## T9 Technical Session 9 – Microbial Food Safety and Spoilage

Forum 8

**Convenor: Liesbeth Jacxsens**

- 10.30 Impact of pH and CO<sub>2</sub> on the Thermal Resistance of *Aspergillus niger* Spores in a Carbonated Liquid Medium  
**T9-01** FABIEN SAUBADE, Luc Giguelay-Gesret, Noémie Cossec, Mariem Ellouze, Cédric Gérard, Olivier Couvert, Noemie Desriac, LUBEM UBO University - UMT ACTIA 19.03 ALTER'ix, Quimper, France
- 10.45 The Safety of Plant-based Proteins as Alternatives for Meat and Dairy Replacers  
**T9-02** JENNIFER BANACH, Jan Pieter van der Berg, Gijs Kleter, Hermien van Bokhorst-van de Veen, Shanna Bastiaan-Net, Laurice Pouvreau, Esther van Asselt, Wageningen Food Safety Research, Wageningen University & Research, Wageningen, The Netherlands

- 11.00 Genetic *Listeria monocytogenes* Types in the Pork Processing Plant Environment: From Occasional Introduction to Plausible Persistence in Harborage Sites  
**T9-03** Niels Demaître, Geertrui Rasschaert, Lieven De Zutter, Annemie Geeraerd, KOEN DE REU, Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Melle, Belgium

- 11.15 Different Behavior of Pathogen and Spoilage Bacteria in Response to Packaging and High Pressure Processing of Sliced Cooked Ham  
**T9-04** CRISTINA SERRA-CASTELLÓ, Anna Jofré, Berta Torrents, Sara Bover-Cid, IRTA (Institute of Agrifood Research and Technology), Food Safety and Functionality Program, Monells, Girona, Spain

- 11.30 Safe Seaweed in Changing Food Systems  
**T9-05** JENNIFER BANACH, Sophie Koch, Yvette Hoffmans, Sander van den Burg, Wageningen Food Safety Research, Wageningen University & Research, Wageningen, The Netherlands

- 11.45 Population Genetic Structure of *Listeria monocytogenes* Strains Isolated from Salmon and Trout Products and in Food Plants in France  
**T9-06** Thomas Brauge, Guylaine Leleu, Benjamin Félix, Karine Capitaine, GRAZIELLA MIDELET, ANSES, Laboratory for Food Safety, Bacteriology and Parasitology of Fishery and Aquaculture Products Unit, Boulogne-sur-Mer, France

## CS Closing Session

Ballsaal

**Chairs: Anett Winkler and Luca Cocolin**

- 12.15 Food Safety in the Military Context – From Viral Reservoirs to Mobile Detection  
ULRICH SCHOTTE, Zentrales Institut des Sanitätsdienstes der Bundeswehr, Kiel, Germany
- 12.45 EU Monitoring of Foodborne Outbreaks and Foodborne Diseases in 2020 and Impact of COVID-19 Pandemic  
GIUSI AMORE, European Food Safety Authority (EFSA), Parma, Italy
- 1.15 Award Presentation and Concluding Remarks  
MICHELLE D. DANYLUK, University of Florida CREC, Lake Alfred, FL, USA and RUTH L. PETRAN, Ruth Petran Consulting, LLC, Eagan, MN, USA

## 13.30 – 14.30 Farewell Refreshments

# FoodMicro 2022

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Munich

GERMANY 4-6 May

IAFP'S EUROPEAN SYMPOSIUM

— ON FOOD SAFETY —

2022

**INVITED SPEAKER  
BIOGRAPHIES**

# SPEAKER BIOGRAPHIES



## **Gary R. Acuff**

*Acuff Consulting LLC, USA*

Dr. Gary R. Acuff is the managing member of Acuff Consulting, LLC, founded in 2018 to provide food microbiology expertise in commercial food production systems. Previously, Dr. Acuff was a Professor of Food Microbiology at Texas A&M University and served on the faculty for 39 years. He was Director of the Texas A&M Center for Food Safety and served as Head of the Department of Animal Science. Dr. Acuff is an IAFP Fellow and a Fellow in the American Academy of Microbiology. He has been a member of IAFP since 1982 and was President from 2007–2008.



## **Giusi Amore**

*European Food Safety Authority (EFSA), Italy*

Giusi Amore is a Doctor in Veterinary Medicine with a Ph.D. in Epidemiology and more than 15 years of work experience in epidemiology of zoonoses and food safety. In July 2008 she joined EFSA as scientific officer. Dr. Amore works in the Unit on Biological Hazards and Animal Health and Welfare, where she actively contributes to the production of the annual European Union One Health report on zoonoses and foodborne outbreaks and of the EU summary report on antimicrobial resistance. She has been also involved for several years in the production of joint ECDC-EFSA Rapid Outbreak Assessments of multi-country foodborne events. Dr. Amore's main field of expertise includes monitoring and assessment of foodborne outbreaks in the European Union context.



## **Wayne Anderson**

*Food Safety Authority of Ireland, Ireland*

Dr. Wayne Anderson joined the Food Safety Authority of Ireland (FSAI) in 1999 from the food industry and is Director of Food Science and Standards with responsibility for food safety risk assessment and regulatory science. He is also an adjunct professor with University College Dublin (UCD). Dr. Anderson previously served 10 years with Unilever Research and a year as technical manager with Leitrim Foods. He holds a primary degree in biochemistry and a Ph.D. in predictive food microbiology. He is a member of the UK expert Advisory Committee for the Microbiology Safety of Food (ACMSF) and has also worked with WHO/FAO on several expert consultations. He is a member of the International Commission on Microbiological Specifications for Foods (ICMSF), a fellow of the Institute of Food Science and Technology Ireland (IFSTI) and a fellow of the Institute of Food Science and Technology UK (IFST).

## **Emmanuelle Arias-Roth**

*Agroscope, Switzerland*

Dr. Emmanuelle Arias-Roth received a Master of Science in Chemical Engineering and Biotechnology at EPFL Lausanne (2005). She has a Ph.D. in Food Microbiology from ETH in Zurich (2009). Dr. Arias-Roth is active as a scientist and in the coordination of projects at Agroscope (Berne, Switzerland). She has worked in the development of protective cultures for food application (cheese, vegetables, fruits) to prevent growth of pathogenic or spoilage bacteria (*Listeria monocytogenes*, *Escherichia coli*, *Clostridium tyrobutyricum*, moulds).



## **Chiara Balbo**

*EFSA EU-FORA Fellow, IBPRS State Research Institute, Warsaw, Poland*

Chiara Balbo is currently carrying out the European Food Risk Assessment (EU-FORA) Fellowship Programme organized by EFSA. In this context, she is conducting a research project on food chemical contaminants at the Institute of Agricultural and Food Biotechnology - State Research Institute (IBPRS-PIB) located in Warsaw, Poland. She earned a bachelor's degree in Food Technology from the University of Turin in 2016 and a master's degree in Food Science and Technology from the University of Parma in 2018.



## **Soukaina Barroug**

*University College Dublin, Ireland*

Soukaina Barroug is an early stage researcher developing cold plasma interventions to enhance microbiological safety within poultry processing



## **H el ene Bergis**

*ANSES, France*

H el ene Bergis is an Engineer in Food Microbiology at the Laboratory for Food Safety from the French Agency for Food Environmental and Occupational Health & Safety (ANSES) - Maisons-Alfort - France. She is a member of the EU-Reference Laboratory on *Listeria monocytogenes*; in the team in charge of shelf-life studies related to *Listeria monocytogenes* and predictive microbiology; in charge to advice National Reference Laboratories for *Listeria monocytogenes* in challenge testing, durability studies and in the use of growth modelling software. Ms. Bergis is also a member of the National Reference Laboratory for *Listeria monocytogenes*. In charge of audits related to challenge tests, of proficiency trials and training. She participates to ISO and Afnor standardisation working groups as well as a French Technical Network "Expertise in microbial determination of food products' shelf life."



## Roy Betts

*Campden BRI, United Kingdom*

Previously, Roy Betts has worked on research into cleaning systems in the food industry before managing a team working on, and evaluating automated and rapid test methods. His interests in methods continued with participation in ISO committees developing the test method validation standard ISO 16140, and involvement in the method validation body, MicroVal. Roy currently chairs the MicroVal General Committee, and sits on the British Standards Committee that deals with Microbiological Methods for foods and feeds. He has spoken and published widely on rapid test methods and retains a keen ongoing interest in the area.

## Daniela Boehm

*School of Food Science and Environmental Health, Technological University Dublin, Ireland*

Dr. Daniela Boehm is a Science Foundation Ireland Starting Investigator and Assistant Lecturer in the School of Food Science and Environmental Health at Technological University Dublin. Her research focuses on investigating plasma functionalized liquids and their applications in microbial decontamination, with an emphasis on understanding the translation of liquid chemistry to biological effect. The safety of plasma functionalized liquids is one of Dr. Boehm's topics of interest including studies on cytotoxic and genotoxic effects, the action of reactive oxygen and nitrogen species and development of resistances.



## Sara Bover-Cid

*IRTA (Institute of Agrifood Research and Technology). Food Safety and Functionality Program, Spain*

Dr. Sara Bover-Cid is Senior Researcher and Head of the Food Safety and Functionality Programme at the Institute of Agrifood Research and Technology (IRTA) in Monells (Girona, Spain). Her research activity focuses on improving the food safety and quality through processing and preservation technologies; particularly in the study and modelling of bacterial behaviour for its application in the microbiological risk assessment and management. She is the Secretary of the Executive Board of the International Committee of Food Microbiology and Hygiene (ICFMH) and an expert member of the BIOHAZ Panel of the European Food Safety Authority (EFSA).



## Romain Briandet

*INRAE, France*

Romain Briandet is a researcher at the Micalis Institute located on the INRAE campus in Jouy-en-Josas (France). He leads a research team entitled "Biofilms & Spatially Organized Communities" and is animator of the French biofilm network.



## Neil Buck

*General Mills Inc., Switzerland*

As Corporate Toxicologist with the global food company General Mills, Dr. Neil Buck spends most of his time on the safety aspects of bringing innovation to market and in managing technical regulatory affairs. At the start of his working life, Dr. Buck worked in the food industry, but went back to university to study toxicology via both a Master's degree and a Ph.D. in food additive safety. Subsequently, he has 20 years of experience in safety, regulatory and scientific affairs, and is active in various cross-industry fora as a part of activities to help enhance, harmonize and implement best practices for consumer safety.



## Jens Michael Carstensen

*Videometer A/S, Denmark*

Dr. Jens Michael Carstensen is CEO and co-founder of Videometer A/S. While founding and growing Videometer as a business over the last 20 years he has been part-time associate professor in imaging at the Technical University of Denmark. He was appointed adjunct professor of organism imaging at University of Copenhagen in 2009. Dr. Carstensen has been overall responsible for more than 700 commercial R&D projects. Videometer is today a leading company within spectral imaging, which involves the whole process from illumination, optics, camera technology, imaging control, calibration, drift correction, multivariate analysis, segmentation, and quantification. Dr. Carstensen has co-authored 80+ peer-reviewed scientific publications as well as 6 patents. He is a member of the Vision Award jury for the biggest vision technology exhibition in the world held biannually in Stuttgart, Germany.



## Luca Cocolin

*University of Turin, Italy*

Full Professor of Food Microbiology at the University of Torino, Italy, Dr. Luca Cocolin is also an executive board member of ICFMH, Editor-in-Chief of the *International Journal of Food Microbiology* and Academic Editor of *PLOS One*. Dr. Cocolin is a member of the editorial board of *Food Research International*, *Frontiers in Microbiology*, *Current Opinion in Food Science* and *Food Analytical Methods*. He is co-author of about 300 papers on national and international journals and an expert in (i) Molecular methods for the detection, quantification and characterization of foodborne pathogens; (ii) Study of the microbial ecology of foods by using culture independent and dependent methods; (iii) Bioprotection; (iv) Human microbiome.



### **Christophe Cordevant**

*ANSES, France*

Christophe Cordevant is a member of the Strategic & Programs Department of the General Direction at ANSES (FR), as Senior Scientific Advisor for Food Microbiology since 2014. The former head of the Molecular Typing Center at Institut Pasteur Lille, he has 20 years of experience in molecular microbiology and typing in the field of foodborne zoonoses. He is also experienced in the development and validation of rapid and innovative methods for the detection of foodborne pathogens during his professional experiences at the Institut Pasteur or within the Food Science division at Bio-Rad. Christophe was involved in the preparation of the One Health European Joint Programme, which brings together 44 partners from 22 European countries.

He is currently a member of the Scientific Steering Board of the OH EJP, a member of the Governing Board of the MedVetNet association. He is also implicated in many institutional initiatives at the national and international levels like SCAR Food Systems, JPI AMR French mirror group, EU Sewage Sentinel System for SARS-CoV-2. Indeed Christophe is involved in the COVID19 health crisis by representing ANSES within the French EMERGEN consortium as well as in SUMEAU for the surveillance of SARS-CoV-2 in wastewater treatment plants.



### **Louis Coroller**

*LUBEM UBO University - UMT ACTIA 19.03 ALTER'IX, France*

Dr. Louis Coroller is Professor at the University of Brest since 2016. He has worked as a researcher in the field of quantitative microbial risk assessment and predictive microbiology at the National Veterinary school of Alfort in 2001, at the ADRIA in 2002. In 2003, he moved to the university laboratory of biodiversity and ecology (LUBEM) to work on inactivation of *Listeria* and *Salmonella* populations which are submitted to acid and osmotic stress. He obtained his doctoral thesis (Ph.D.) in Microbiology from University of Brest in 2006. In 2007, he has working as an associated professor in food microbiology at the technological institute of the University of Brest, which is located in Quimper. In 2016, he moved to the "Ecole Supérieure d'Ingénieurs en Agroalimentaire Bretagne atlantique" as a professor in food sciences. His research activity focuses on quantitative description

of microbial behavior in food. Dr. Coroller is currently involved in projects on bacterial sporulation and outgrowth, inactivation during fermentation, integrative approach on the use of biomarkers in predictive microbiology. He has written 33 articles in peer review journal and 2 book chapters, and 41 oral presentations in international congress.



### **René Crevel**

*René Crevel Consulting Ltd., United Kingdom*

Dr. René Crevel runs a consultancy centred on food allergens and their management, and wider aspects of allergenicity as related to food safety. This followed a career at Unilever, where he was responsible for advice and guidance on food allergy and allergen risk assessment and management to Unilever, and for leading Unilever's food allergy research programme. Dr. Crevel holds appointments at the Universities of Manchester (UK) and Nebraska-Lincoln and serves on the UK's Committee on Toxicity (COT). He is Scientific Advisor to ILSI-Europe's Food Allergy Task Force and is a member of the FAO/WHO Expert Consultation on Allergens, chairing its second meeting.



### **Michelle Danyluk**

*University of Florida, Lake Alfred, Florida*

Dr. Michelle Danyluk is a Professor of Food Safety and Microbiology at the University of Florida. Her current research and extension interests include microbial food safety and quality, emphasizing the microbiology of fresh fruits, vegetables, nuts, and juices. Her primary research focuses on bacterial pathogens in produce, including production, packing, and processing environments, its movement and mitigation within these environments, and the subsequent implications for public health. Michelle was elected a member of the International Commission on Microbiological Specifications for Food in 2016 and to the IAFP Executive Board in 2019, where she is currently the President-Elect.



### **Rob de Jonge**

*RIVM (National Institute for Public Health), The Netherlands*

Dr. de Jonge is a risk assessor in microbiological food, feed and water safety and genetically modified organisms with great knowledge of food, food processing, food microbiology, microbial physiology, the effects of food on microbial behaviour (growth, survival and virulence) and HACCP. He also has relevant experience in microbiological quality testing of drinking water and washing water used in the food processing industry and in the safe design of technologies contributing to a circular economy. Nationally and internationally active as a CE, food, feed and water safety consultant for governments, Food Safety Authorities and WHO. Since 2017, he is a member of the joined FAO/WHO group of experts for safety and quality of water used in food production and processing.



### **John Donaghy**

*Nestlé Ltd., Switzerland*

Dr. John Donaghy is currently Head of Food Safety at Corporate Quality, Nestlé Switzerland. He previously spent 3 years as Senior Food Safety Microbiologist in Nestlé R&D. Prior to joining Nestlé (2011), worked (15 yrs) as Project Leader in food safety microbiology at Agri-Food & Biosciences Institute (AFBI), N. Ireland, and was formerly Head of Government food safety laboratory. Current responsibilities include global operational aspects of food safety microbiology, hygiene, allergens and other prerequisite programs across >350 factories and multiple food categories. He leads a team of global subject matter experts (SMEs) in HACCP, hygiene and thermal processing, overseeing horizontal implementation of key Nestlé food safety and quality programs at market and factory level.



### **Dima Faour-Klingbeil**

*DFK for Safe Food Environment, Germany*

Dr. Dima Faour-Klingbeil is an independent researcher specializing in the microbiological safety of fresh produce, food safety systems, and behavioural science in food safety. She is the director and principal consultant of DFK for Safe Food Environment, providing training, technical and advisory services in food safety. Dima brings over two decades of experience spanning private and public sectors, including non-profit organizations, holding managerial and leadership positions in various food industries and as an international food safety consultant and compliance auditor. Her previous engagements involved the development of an operational structure for a regional food assurance mechanism and agriculture certification scheme adapted to the needs of the Arab region and assessing the national food control system's resilience in Tunisia within the context of risk analysis. Dima is a member of the International Association for Food Protection, the Institute of Food Science and Technology and the IFST's food regulatory group. She served as a member of the FAO/WHO Joint Expert Meetings on Microbiological Risk Assessment (JEMRA, 2019; 2021), authored several scientific articles, and regularly contributes to global scientific meetings.



### **Barbara Gallani**

*European Food Safety Authority, Italy*

Barbara Gallani is Head of EFSA's Communication and Partnerships (ENGAGE) Department and has been a member of EFSA's senior management team since May 2016. Barbara has extensive experience of communicating complex issues in the areas of food safety, authenticity and research to lay audiences; managing incidents and food scares; and developing and delivering specialist training courses on risk communication for UK and global audiences. She was listed as one of the UK Top 100 Scientists by the Science Council in January 2014 for her work in regulatory science. Before joining EFSA, she worked in the UK at the Food and Drink Federation, at the British Retail Consortium and at the UK Food Standards Agency, including a secondment to the European Commission (DG SANCO) and a BA Media Fellowship on science communication at the Daily Telegraph. She also worked at the European Consumers' Organisation (BEUC) in Brussels. Barbara holds a Bachelor's Degree in Physics, a Post Graduate Certificate in Education PGCE (Physics and Sciences), a Master's Degree in Advanced Instrumentation Systems and a Professional Certificate in Executive Coaching.



### **Matt Henderson**

*Land O'Frost, Inc., USA*

Matt Henderson has worked with Land O'Frost for the past twenty years in multiple roles across the organization focused on food safety. As Sanitation Manager and Food Safety Manager, his job functions included managing the sanitation process, managing *Listeria* sampling programs, and chairing the Seek and Destroy and Facility Design Teams. In his current role as Vice President of Technical Services, Matt is responsible for leading the Land O'Frost Food Safety, Quality and Employee Safety teams toward safeguarding the health and safety of our consumers and employees. Matt graduated from Arkansas Tech University with a Bachelor's degree in Agribusiness and Michigan State University with a Master's Degree in Food Safety.



### **Andreas Hensel**

*German Federal Institute for Risk Assessment, Germany*

Dr. Andreas Hensel has been the first President of the German Federal Institute for Risk Assessment (BfR) since 2003. Its foundation was a response to the BSE crisis. As an independent authority – free from directives in its risk assessment, communication and research – BfR provides policy advice to the government on consumer health protection. By identifying, recognising and characterising risks, it protects human health. Its mandate includes risk communication and social science research on risk perception. Every day, BfR gains experience in crisis coordination and communication of socio-politically relevant fields, such as EHEC, dioxin, *Salmonella*, glyphosate, novel genetic engineering, fipronil or smoking.



### **John Holah**

*Holchem/Kersia, FS&PH, United Kingdom*

Dr. John Holah is an internationally recognised food safety expert and research scientist with experience and knowledge in factory design and production layout, hygienic design of food processing equipment, cleanability, cross-contamination sources and vectors, personnel hygiene, cleaning and disinfection, environmental sampling plans and the development of (rapid) hygiene assessment techniques. John is an Author or Co-author of 100 scientific publications and presentations and Editor of three books. He is a member of the Member of the EHEDG Executive Committee and the UK NHS RRP Panel.



### **Kevin Hunt**

*University College Dublin, School of Biosystems and Food Engineering, Ireland*

Kevin Hunt is a postdoctoral researcher at the Centre for Food Safety in University College Dublin. His research focuses on new and emerging methods in quantitative microbial risk assessment for food, with a particular interest in foodborne viruses.



### **Sasha Koo-Oshima**

*Food and Agriculture Organization of the United Nations (FAO), Italy*

Dr. Sasha Koo-Oshima is Head of FAO Water and Deputy Director, Land and Water Division. Sasha has nearly 30 years of experience in international assistance and policy development in agriculture water and environment/natural resource management. Currently, she is the Deputy Director and Head of Water at the UN Food & Agriculture Organization (FAO), leading programs on One Water, agricultural water development and governance, geospatial data, and integrated water resources management with linkages to climate, energy, health and nutrition. She formerly served as Senior Advisor at the U.S. EPA Office of Water, and Secretariat of the Organisation for Economic Cooperation and Development (OECD), where she directed and managed international water compacts with donors agencies; i.e., public-private-partnerships, climate resilience, multi-stakeholder and multi-programs/ jurisdictional policy engagements, blended financing/resource mobilization, and effective policy governance in sustainable water and natural resource-agriculture management. She serves in various Governing Boards of the World Water Council and the CGIAR's Water Land Ecosystems, and on

Steering Committees in Agri-Environment of the OECD and UNEP Global Partnerships on nutrients, circular economy, and has implemented and supervised a substantial set of country and river basin projects. She published, sponsored and peer-reviewed extensively on international water issues, such as the UN World Water Development Reports, FAO-WHO Wastewater Reuse Guidelines for Agriculture, FAO reports on Wealth of Waste: The Economics of Wastewater Reuse, Desalination and Agriculture, Agriculture Water Quality Guidelines for China, and the OECD Water Governance review of The Netherlands: Fit for the Future. In addition, she served on various international technical advisory panels for the GEF and the Ramsar Convention, in support of research and policy-making for planning and management.



### **Elisabetta Lambertini**

*GAIN - Global Alliance for Improved Nutrition, USA*

Dr. Elisabetta Lambertini is a research scientist with extensive applied experimental and analytical experience in food and water safety, health risk modeling, and quantitative decision analysis. Building upon a background in public health engineering, their work focuses on the development of risk-based modeling and decision support tools to control pathogen contamination in One Health and food supply systems. Their broader expertise and interests include the integration of food safety and nutrition in risk-benefit analyses, and approaches to better include behavioral variables in decision analysis. In their current role at GAIN they oversee the food safety research activities of the EatSafe Program.



### **Alexandra Lianou**

*University of Patras, Greece*

Dr. Alexandra Lianou holds a B.Sc. degree in Agricultural Biotechnology (Agricultural University of Athens, Greece), a M.Sc. degree in Animal Sciences (Meat Science/Food Safety program, Colorado State University, USA) and a Ph.D. in Food Microbiology (Aristotle University of Thessaloniki, Greece). Since 2020, she has been an Assistant Professor of Applied Microbiology at the Department of Biology of the University of Patras (Greece). Her research interests are related to the microbiological safety/quality of foods and microbial biotechnology. During her research activity she has been mainly involved in (i) the description of the behavior of foodborne pathogens using quantitative microbiology approaches, and (ii) the use of rapid, non-invasive analytical technologies in the evaluation of food spoilage.



### **Douglas Marshall**

*Eurofins Scientific Inc., USA*

Dr. Douglas L. Marshall is Chief Scientific Officer with Eurofins Microbiology Laboratories. Formerly he was Associate Dean and Professor of Public Health, College of Natural and Health Sciences, University of Northern Colorado and a Contributing Editor of the scientific journal *Food Microbiology*. His career focus is to improve the microbiological quality and safety of foods, with numerous publications and consultations in the area. He has received the Mississippi Chemical Corporation Award of Excellence for Outstanding Work and the International Association for Food Protection Educator and Harold Barnum Industry Awards. He is a Fellow of the Institute of Food Technologists.



### **Alice Mauchline**

*University of Reading, United Kingdom*

Dr. Alice Mauchline is a Senior Research Fellow in the School of Agriculture, Policy and Development at the University of Reading, UK. Dr. Mauchline's research has two interlinked strands with a common use of innovative technologies (i) Using participatory methodologies to develop sustainable management and regulation strategies for crop production and environmental protection and (ii) Researching educational strategies for the use of mobile technologies to enhance fieldwork teaching, the integration of citizen science approaches in research and teaching in Higher Education and the development of Open Online Courses to engage consumers with sustainable food production.



### **Shirley Micallef**

*University of Maryland, USA*

Dr. Shirley Micallef is an Associate Professor of Microbial Ecology and Food Safety at the University of Maryland, USA. Her team evaluates environmental, biotic and abiotic factors and agricultural practices that affect microbial dynamics, drive crop microbiomes and modulate enteric pathogen-plant associations. She has investigated surface and reclaimed water as reservoirs of human pathogens and antimicrobial resistance and adopted plant microbiome analyses to map the influence of irrigation on crop microbiota. She has a B.Sc. and M.Sc. in botany from the University of Malta, a Ph.D. in microbial ecology from the University of Massachusetts and did a postdoc at the University of Maryland School of Public Health.



### **Steven Musser**

*U.S. Food and Drug Administration, Center for Food Safety & Applied Nutrition, USA*

Dr. Musser is the Deputy Center Director for Scientific Operations at the U.S. Food and Drug Administration's (FDA) Center for Food Safety and Applied Nutrition (CFSAN). In addition to managing the Center's scientific operations, he oversees the Center's activities in cosmetics safety, color certification, pre-market review of food additives, food contact notifications and foods derived from bioengineered plants. He has directed the Center's research in precedent setting areas of food and cosmetic safety research, which include food allergen detection, methods for detecting chemical contaminants, dietary supplement analysis, and the use of whole genome sequencing during foodborne illness outbreak investigations. He has authored or co-authored more than 100 articles in the peer reviewed scientific literature and regularly speaks on CFSAN's research at national and international scientific meetings.

Dr. Musser received his B.S. degree in Biology from Millersville University and his Ph.D. in Medicinal Chemistry from the University of Maryland-Baltimore. He then completed a post-doctoral research fellowship at the National Institutes of Health, National Cancer Institute. He started his career at FDA in 1991 as a research chemist and became the Branch Chief of the Instrumentation and Biophysics Branch six years later. Prior to his current appointment, Dr. Musser was the Director of the Office of Regulatory Science at CFSAN.



### **Melanie Neumann**

*Matrix Sciences International, Inc., USA*

Melanie Neumann, J.D., M.S. is Executive Vice President and General Counsel of Matrix Sciences. Matrix Sciences is a dynamic, multi-disciplinary group of food safety and quality experts focusing on microbiological, chemistry, analytical, water, soil, residue and pesticide laboratory testing, sensory testing, data analytics and food safety risk management advisory services. Melanie assists the food and beverage industry with regulatory, operational and brand reputation risk management solutions, helping companies mitigate these risks in today's ever-changing regulatory landscape. Melanie also interacts with regulators, customers, media and plaintiff's attorneys in response to investigations, enforcement actions, outbreaks, recalls and alleged illness claims on behalf of her clients to resolve issues and identify appropriate corrective actions. Melanie is a magna cum laude graduate of Mitchell-Hamline Law School in St. Paul, MN for her juris doctorate degree, and Michigan State University for her M.S. in Food Safety.



### **Masja Nierop Groot**

*Wageningen Food & Biobased Research, The Netherlands*

Dr. Masja Nierop Groot is Senior Scientist leading the expertise field Applied Food Microbiology at Wageningen Food & Biobased Research. She obtained her MSc degree in Food Science at Wageningen University and a Ph.D. (microbiology) at Wageningen University. Her research activities focus on control of foodborne spoilage and pathogenic microorganisms along the food production chain.



### **Saskia Nuijten**

*EIT Food, Belgium*

Saskia Nuijten (1974, Dutch) joined EIT Food in September 2017 in the role of Director of Public Engagement and Communication, leading Corporate Communication, Public Affairs and Public Engagement. EIT Food is the world's largest food innovation community. She is a member of the Management Board of EIT Food. Saskia has over 20 years' experience in communications, branding and marketing at science and technology-focused multinationals. Before joining EIT Food, Saskia worked in the food sector in the role of Corporate Communications Director with Corbion/CSM and before Corbion/CSM she worked for DSM Food Specialties in the role of Global Marketing Communications Manager.



### **Colm O'Donnell**

*University College Dublin, Ireland*

Dr. Colm O'Donnell is Professor of Biosystems & Food Engineering and Head of the UCD School of Biosystems & Food Engineering. He also leads the Food Quality and Processing Pillar in UCD's Institute of Food & Health. Previously he was UCD College of Engineering & Architecture Vice-Principal (Teaching & Learning). He was awarded an EU Comett Research Fellowship in process analytical technology at the Institut National de Recherche Agronomique (INRA) in Paris and worked in the dairy processing industry prior to joining UCD. He has co-ordinated or led UCD's involvement in a wide range of internationally funded research and educational projects including EU H2020, Tempus, Comett, Erasmus, Marie Skłodowska-Curie and Alfa programmes with industry and academic partners.

Dr. O'Donnell's research group works on a range of Process Analytical Technology (Spectroscopy and Spectral Imaging) and Bioprocessing projects funded by EU H2020, Irish Research Council, Food Institutional Research Measure, Enterprise Ireland and industry. He has a strong track record of mentoring members of his research team for prestigious Marie Skłodowska-Curie and European Research Council awards. He is Principal Investigator and Head of Pillar IV (Process Quality & Safety by Design) in the Dairy Processing Technology Centre ([www.dptc.ie](http://www.dptc.ie)), Principal Investigator in the H2020 DiTECT project and Coordinator of the H2020 FreshProof project.

Dr. O'Donnell was designated as a Highly Cited Researcher by Thomson Reuters based on his rankings within the top 1% highly cited researchers. He was appointed Editor of the *International Journal of Food Properties* and Associate Editor of *Transactions of the American Society of Agricultural & Biological Engineers*. He is a member of the Editorial board of *Food Engineering Reviews* (Springer), *Foods* (MDPI) and the *Encyclopedia of Agricultural, Food & Biological Engineering* (Taylor & Francis). He is a member of the Food Processing Technical Committee of the American Society of Agricultural & Biological Engineers and Chair of the International Federation for Process Analysis & Control Dairy Processing Technical Committee.



### **Noora Pernu**

*University of Helsinki, Finland*

Noora Pernu, DVM, is doctoral researcher in Prof. Miia Lindström's group at the Department of Food Hygiene and Environmental Health in Faculty of Veterinary Medicine, University of Helsinki. Her research focuses on *Clostridium botulinum* risk in processed chilled foods.



### **Ruth Petran**

*Ruth Petran Consulting, LLC, USA*

Dr. Ruth Petran is Senior Advisor, Food Safety, for The Acheson Group. As a passionate yet practical food safety scientist, Ruth is also the Principal and Founder of Ruth Petran Consulting, LLC in suburban Minneapolis, Minnesota. Prior to starting her own business, Ruth held technical food safety and public health leadership roles at Ecolab, Pillsbury, and General Mills.

Dr. Petran is President of the International Association for Food Protection (IAFP) and served two terms on the U.S. National Advisory Committee for Microbiological Criteria for Foods. She is a Certified Food Scientist and member of the Institute of Food Technologists and chaired the Minnesota Food Safety and Defense Task Force. Her Bachelor's degree is in Consumer Food Science from Cornell University, and she holds an MS in Food Science and a Ph.D. in Public Health both from the University of Minnesota.



### **Massimo Pettoello-Mantovani**

*European Paediatric Association (EPA-UNEPSA) Union of National European Pediatric Societies and Associations, Germany*

No biography provided.



### **Satish Kumar Rajasekharan**

*Agricultural Research Organisation, Israel*

Satish Kumar Rajasekharan is a Microbiologist from India, who has been working on anti-biofilm chemotherapy for more than 10 years using various bacterial and fungal pathogen models, with a focus on the yeast pathogen, *Candida albicans*. After his doctoral studies, he worked as Assistant Professor at Yeungnam University, South Korea for 3 years where he researched and lectured on microbial biofilms and also started working with an anthelmintic approach to control plant-parasitic models. He has 34 publications and two Korean patents to his credits. He has developed a methodology based on LED technology to distinguish between live, dead, and paralysed nematodes. Presently, he is working in the Department of Food Science, Agricultural Research Organization, Israel, and is working on probiotic biofilm formation and methods to develop symbiotic foods. He is also addressing on use of probiotics as a strategy to control pathogen biofilms.



### **Benjamin Remington**

*Remington Consulting Group B.V., The Netherlands*

Dr. Benjamin Remington is an expert in food allergen thresholds and food allergen risk assessment, in both the clinical and food business operator settings. He currently participates in multiple international food allergy and allergen expert groups, and applies his knowledge through a dual role as an Adjunct Assistant Professor at the Food Allergy Research & Resource Program at the University of Nebraska (United States) and as a research & risk assessment consultant for the Remington Consulting Group B.V. (the The Netherlands).



### **Loandi Richter**

*University of Pretoria, South Africa*

Loandi Richter recently started a post-doctoral research fellowship at the University of Pretoria, focusing on a next generation approach to characterizing plant-associated bacteria from commonly consumed fruit and vegetables in a One Health perspective. She will be graduating in May 2022 after successful completion of her Ph.D. in Biotechnology. The unique results showed the significance of antibiotic-resistance genes and multidrug resistant potential foodborne pathogenic bacteria in the South African environment and fresh produce supply chains. Her doctoral research has been published as five original research articles in recognized international accredited journals.



### **Valentina Rizzi**

*Biological Hazards and Animal Health and Welfare (BIOHAW) Unit. European Food Safety Authority (EFSA), Italy*

Valentina Rizzi is a doctor in Veterinary Medicine with more than 20 years of work experience in food microbiology and food safety. In September 2008 she joined EFSA as senior scientific officer. Dr. Rizzi works in the Unit on Biological Hazards and Animal Health and Welfare, where she leads the Team responsible for the annual European Union Summary Reports on zoonoses, antimicrobial resistance and transmissible spongiform encephalopathies. She supervises the production of joint ECDC-EFSA Rapid Outbreak Assessments in the context of multi-country foodborne events. She also oversees the activities related to the collection of Whole Genome Sequencing data on foodborne isolates from food and animal samples.



### **Matteo Sabini**

*European Food Information Council – EUFIC, FoodSafety4EU, Brussels, Belgium*

Matteo Sabini works for EUFIC – European Food Information Council, as area lead of the Collaborative Projects Team, responsible for the implementation of communication, dissemination, networking, and stakeholders' engagement activities in the EU-funded projects. Moreover, he represents EUFIC on the FACCE-JPI Stakeholder Advisory Board. He has a Master's in Political Science, and he has been working as a project manager since 2016. In FoodSafety4EU (project funded by Horizon 2020, G.A. 101000613) he is involved in the definition of methods and tools for increasing consumers' awareness of food safety.



### **Emma J. Samuel**

*ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, United Kingdom*

Graduating in 2018 with first class honours in Environmental Health from Cardiff Metropolitan University, Dr. Emma Samuel received the Michael Morrison Memorial Award for best student performance as well as high commendation from the Chartered Institute of Environmental Health. In October 2018, Emma secured a Knowledge Economy Skills Scholarship (KESS2) Ph.D. studentship with Cardiff Metropolitan University's ZERO2FIVE<sup>®</sup> Food and Drink Research Unit. Dr. Samuel project is an in-depth assessment of food safety culture and hand hygiene compliance in food manufacturing including cognitive/behavioural evaluations, microbiological assessments and analysis of organisational characteristics. Findings informed development and implementation of bespoke hand hygiene interventions and training mechanisms to meet the business needs.





### **Annette Sansom**

*Campden BRI Ltd., United Kingdom*

Annette Sansom is the Section Lead for the Emerging Microbiology Group at Campden BRI, where she has been a member of the team since 1998. Annette has managed a range of research projects on the topics of assessing virus controls in food and in the food manufacturing industry. Investigating the effectiveness of control strategies against viruses in food, water, on a range of environmental surfaces and in air. Other research activities include investigation of microbial population dynamics in food factories using metagenomic analysis and accelerated microbiological shelf-life testing.



### **Uta Schnabel**

*Leibniz Institute for Plasma Science and Technology, Germany*

Dr. Uta Schnabel completed her Ph.D. entitled "Plasma-treated water – from bench to prototype for fresh-cut lettuce" at TU Dublin, Ireland, in 2020. She began her scientific career with a degree in Biology at the University of Rostock, Germany, in Plant Genetics (Cytoplasmic Male Sterility of *Helianthus annuus*), and continued her studies in Molecular and Clinical Science in Munich, Germany, specialising in Hepatocellular carcinoma. Dr. Schnabel's current research brought her back to her roots and focuses on non-thermal plasma applications for food and agricultural requirements at INP Greifswald, Germany, to optimise food safety and quality as well as shelf life.



### **Ulrich Schotte**

*Zentrales Institut des Sanitätsdienstes der Bundeswehr, Germany*

Dr. Ulrich Schotte is Oberfeldveterinär (LTC). In 1990, he received admission to the Bundeswehr candidate veterinary officer. From 1991-1996 he studied Veterinary Medicine at the University of Veterinary Medicine Hannover. After graduating he worked for CIBwMedS Kiel, focusing on food and drinking water microbiology. He then took Medical Command at Kiel, Division of Public Health Service, Department of Veterinary Medicine. In December 2009, he received his graduate degree in Veterinary Public Health from Stuttgart. Since 2010, Dr. Schotte has worked for CIBwMedS Kiel, on Diagnostics of Animal Diseases and Zoonoses. In 2017, he received specialization in Virology. He has served military missions to Bosnia-Herzegovina, Afghanistan, Turkey, and Africa. He is widowed and has three children.



### **Linda Scobie**

*Glasgow Caledonian University, United Kingdom*

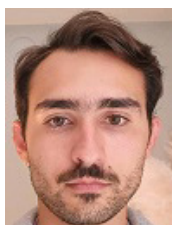
Professor Linda Scobie has been at GCU since 2007 and originally moved from Glasgow University Veterinary School. She is involved in teaching on the Biomedical Science and Microbiology programmes. Professor Scobie leads a research group interested in viral zoonoses and in emerging viral disease and potential routes of infection in particular, Hepatitis E virus is the main interest of the group along with other foodborne pathogens that may pose a risk to public health and the environment.



### **Daniele Sohier**

*Thermo Fisher Scientific, France*

Daniele Sohier joined Thermo Fisher (UK) in November 2019 to coordinate the scientific interaction with research scientists, laboratory and food safety managers, as well as the relationship with food safety authorities and certification bodies. She is responsible for developing the global food certification strategies and ensuring the recognition of Thermo Fisher solutions in food protection. Daniele is a member of the Board of Directors of AOAC International. She is strongly involved in international standardization with ISO and AOAC and convenes working groups. Daniele has certainly coordinated more than 100 validation studies of alternative methods according to the ISO 16140 standard and AOAC Guidelines through, introducing new validation or technology concepts whenever relevant. She has also been involved in more than 20 national and European R&D programs on method development, fingerprinting and other characterization of microorganisms, challenge-testing. She was the President of IAFP European Symposium Organising Committee in 2018 and has organized several international symposia and conferences. She has written more than 35 publications and run more than 70 international communications. Thanks to these various professional experiences and roles, Daniele has developed cross-geographical and functional leadership, as well as communication skills, ensuring successful program coordination.



### **Constantine-Richard Stefanou**

*EFSA EU-FORA Fellow, IBPRS State Research Institute, Poland*

Constantine-Richard Stefanou holds an Integrated Master's Degree in Agriculture and Food Science from the Aristotle University of Thessaloniki Greece and a Master's Degree in Food and Drink Legislation. He has worked in the agrifood and organic sector and is currently a research fellow of the EFSA European Food Risk Assessment fellowship programme (EU-FORA). His research project is being carried out at the Institute of Agricultural and Food Biotechnology - State Research Institute (IBPRS-PIB) in Poland and is focused on Quantitative Microbiological Risk Assessment and Predictive modelling in products of animal origin.



### **Monika Trzaskowska**

*Warsaw University of Life Sciences, Institute of Human Nutrition, Poland*

Dr. Monika Trzaskowska has been working since 2006 at Warsaw University of Life Sciences. She holds a primary degree and a Ph.D. in food technology and nutrition. Her research was focused on the development of new plant fermented foods, especially with the addition of probiotic bacteria. She investigated the impact of fermentation by lactic acid bacteria on food safety, i.e., co-fermentation pathogenic and probiotic microorganisms. Moreover, she researched the influence of the disinfection method on the pathogens' survival in food. She dealt with reducing food waste as well. Finally, the biofilm formation phenomena are the subject of her interests.



### **Marjon Wells-Bennik**

*NIZO, The Netherlands*

Dr. Marjon Wells-Bennik is Principal Scientist Food Safety at NIZO (The Netherlands). The focus of her work is on preventing and solving food safety and quality issues for customers in the food industry. Together with other NIZO experts, multidisciplinary approaches range from (high throughput) challenge testing, troubleshooting activities, process validations, microbial and chemical risk assessments, to in-depth genomics analysis of microbial diversity to detect problem-causing bacteria. She managed large programs on heat-resistant bacterial spores relevant to foods (*Bacillus* and *Clostridium* species) and on control of microbial contaminants in the food chain (spoilage and pathogens). Her broad expertise and background in food safety and quality was shaped by her MSc and Ph.D. research at Wageningen University, Postdoc at Harvard University, and work experience at Food and Biobased Research (Wageningen University and Research), the Institute of Food Research (Norwich, UK), and NIZO. She is an author on more than 60 scientific publications.



### **Martin Wiedmann**

*Cornell University, USA*

Dr. Martin Wiedmann received a veterinary degree and a doctorate in Veterinary Medicine from the Ludwig-Maximilians University in Munich, and a Ph.D. in Food Science from Cornell, where he currently is the Gellert Family Professor of Food Safety. His research interests focus on farm-to-table microbial food quality and food safety and the application of molecular tools to study the transmission of foodborne pathogens and spoilage organisms, including translation of the associated research findings into reducing foodborne illnesses and food spoilage. He and his team are also regularly asked to help industry with a range of microbial food safety and quality challenges. Students and staff that were previously associated with his team have pursued successful careers in a range of environments, including industry, government, academia, and non-for profits.



### **Anett Winkler**

*Cargill, Germany*

Dr. Anett Winkler joined Kraft Jacobs Suchard in December 1998 to head up the research microbiology laboratory in Munich. Later, she concentrated on chocolate, biscuits and other low-moisture foods including supplier developments and approvals. Dr. Winkler also consolidated the scientific basis for microbiological process controls in low-moisture foods by performing validation studies for nut and cocoa processing. Following a regional role for Microbiology in the Eastern European, Middle East and African Region, she was globally designing food safety programs, rolling out training modules related to food safety and further supporting supplier development. She was also the Global Expert for thermal processing within Mondelez International. In October 2017, Anett moved to a new position as EMEA Regional Food Microbiologist Lead at Cargill.



Munich

GERMANY 4-6 May

IAFP'S EUROPEAN SYMPOSIUM

— ON FOOD SAFETY —

2022

**SYMPOSIUM  
ABSTRACTS**

# SYMPOSIUM ABSTRACTS

## OS Opening Session – Practical Application of Risk Assessment Outcomes Helps Ensure Food Safety

Ruth L. Petran

Ruth Petran Consulting, LLC, Eagan, MN

As food safety professionals, we all strive to have a meaningful impact on food safety risks. This presentation will discuss the need to translate empirical and valid research information into practical approaches that can be reasonably implemented. Of the many food safety risks in need of management, practical examples include *Listeria monocytogenes* in manufacturing and norovirus in food service. It will be shown that applying optimal control measures reduces overall food safety risks from these illness agents.

### National Aspects of Food Safety in the Context of International Framework

Andreas Hensel

German Federal Institute for Risk Assessment, Berlin, Germany

Today, not a single country in the world can limit its actions in the field of food safety to a solely domestic perspective. Cross-border trade, and consequently the welfare of its own population is a direct function of the thorough legal regulation and practical execution of food safety. Evidently, however, not all countries enjoy equal abilities and resources to conduct research and development in this field and to engage in international institutions. Therefore, larger and more affluent countries have the obligation to set examples and provide blueprints to others.

The talk exemplifies this relationship by two current topics; the first being the enormous significance of genome sequencing techniques for biological food safety. This method will foreseeably be the standard in not only surveillance and monitoring but also authenticity testing. Worldwide databases and independent consortia that curate them are indispensable. The prerequisite is an internationally agreed framework of harmonised data formats, property rules, and transparency. The issue is contentious not merely between states, but also due to the diverging interests of ministries, authorities, researchers, and industry. While challenging, the problem is certainly solvable.

The second example concerns the cooperation between European and Tunisian authorities. Against the background of novel legislation in Tunisia, the aim is to spread this country's role model to its neighbours while avoiding detours that European partner institutions may have experienced in their decade-long history. The incentive for others to also adopt Tunisia's approach to food safety will derive from the markedly bolstered export opportunities for food products.

## S1 ESKAPE(d) into the Food Chain? Harnessing the Power of Whole Genome Sequencing in Fresh Produce Production from Farm to Retail for the Surveillance of Antimicrobial-Resistant Food-borne Pathogens

Antimicrobial resistance (AMR) is a complex global health threat that requires a united multisectoral approach. Although the environment is recognised as an important reservoir of AMR, a lack of relevant data regarding the role of plant-based agriculture in the holistic picture of AMR ecology remains worldwide. The One Health approach recognises that human health is closely connected to the health of animals and the shared environment. This includes the fresh produce production environment, where integrated surveillance of antimicrobial-resistant foodborne pathogens is needed. While vital for fresh produce production, irrigation water serves as one of the primary routes of contamination, threatening fresh produce safety along the farm to fork continuum. Six nosocomial pathogens (*Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Enterobacter* spp.) that exhibit multidrug resistance and virulence are often referred to as the ESKAPE pathogens. Moreover, multidrug-resistant extended-spectrum  $\beta$ -lactamase- (ESBL) producing *Enterobacteriaceae* (*Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella* and *Serratia* spp., among others) are listed as priority pathogens for research and development

in the new frontier of antibiotics. The occurrence of multidrug-resistant ESBL-producing *Enterobacteriaceae* and ESKAPE pathogens in fresh produce production environments are increasingly reported. Whole genome sequencing (WGS) is facilitating contamination source tracking, pathogen surveillance, and outbreak investigations in food safety, because of the high discriminatory power, rapid workflow, and relatively low cost. This symposium will elucidate the presence, dissemination, and WGS characterization of multidrug-resistant isolates in different crop production systems, highlighting the perspectives from scientists in multiple countries. The goal of the symposium is to provide a global perspective of antimicrobial resistance among potential foodborne pathogens in fresh produce production environments and to highlight the effective use of whole genome sequencing for comparison studies across continents.

### Evaluating Extended Spectrum $\beta$ -Lactamase Producing *E. coli* in U.S. Mid-Atlantic Surface and Reclaimed Water Available for Irrigation

Shirley A. Micallef

University of Maryland, College Park, MD

The threat of antimicrobial resistance (AMR) is one of the most pressing public health concerns of our time. Wider dissemination of antimicrobial resistance into the environment could augment the intra- and interspecies exchange of AMR traits and increase community-acquired infections. Despite this, environmental AMR is not closely monitored and data is lacking for various habitats, including agricultural environments. AMR bacteria in surface and reclaimed waters that serve as potential irrigation water sources for fruit and vegetables is one possible route of transmission of AMR bacteria to fresh produce crops. CONSERVE: A Center of Excellence at the Nexus of Sustainable Water Reuse, Food and Health gave us the opportunity to microbially characterise various water sources in the mid-Atlantic region of the U.S. We isolated *Escherichia coli*, *Enterococcus* spp., and *Salmonella* isolates from reclaimed and surface water sources (rivers and irrigation ponds) and assessed the phylogenetic distribution and antimicrobial resistance profiles of collected isolates as affected by season and water type, using phenotypic, molecular, and whole-genome sequencing approaches. Monitoring AMR accumulating in bacteria commonly found in irrigation water can be an additional criterion by which water quality for food safety is assessed.

### Factors Influencing the Resistome in Plant Production

Kaye Burgess

Teagasc, Dublin, Ireland

In South Africa (SA) as part of the prevalence study on antibiotic-resistant ESKAPE (i.e., *Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Enterobacter* spp.) pathogens, nosocomial multi-drug resistant *K. pneumoniae* have been found to be extended-spectrum  $\beta$ -lactamase (ESBL)-producing and harbouring several antimicrobial resistance genes. Globally, ESBL-producing *K. pneumoniae* has been associated with various food commodities, including a diverse range of fresh produce. The aim of a series of SA studies was to understand the prevalence of *K. pneumoniae* in the formal and informal supply chains and on handlers' hands. Overall, ESBL-producing *K. pneumoniae* was isolated from fresh produce and water in the formal vegetable supply chains (7.67% and 4.03%, respectively) and in the informal vegetable supply chains (4.26% and 1.29%, respectively). A total of 47 *K. pneumoniae* isolates from water (n=23), fresh produce (n=22), and handlers' hands (n=2) were analysed from various fresh produce supply chains in SA, using whole-genome sequencing. ESBL-producing *K. pneumoniae* isolates were present in irrigation water as well as on fresh produce in the field, at the point of sale as well as within the home prior to consumption. These isolates were multi-drug resistant and found to harbour between 5 and 19 antimicrobial resistance genes. Therefore, supporting the notion that contaminated water, fresh produce, and hands are a source of ESBL-producing *K. pneumoniae* and that fresh produce could be a reservoir of dissemination of antimicrobial resistance genes.

## Occurrence of Extended Spectrum $\beta$ -Lactamase-Producing Enterobacteriales in South African Fresh Produce Supply from the Farm, through Processing up to the Point of Sale

Loandi Richter<sup>1</sup>, Erika M. Du Plessis<sup>1</sup>, Stacey Duvenage<sup>2</sup>, Degracious Kgoale<sup>1</sup>, Thabang Msimango<sup>1</sup>, Manana Dlangalala<sup>1</sup>, Muneiswa Ratshilingano<sup>1</sup>, Tintswalo T. Baloyi<sup>1</sup> and Lise Korsten<sup>1</sup>

<sup>1</sup>University of Pretoria, Pretoria, South Africa,

<sup>2</sup>University of Greenwich, Kent, United Kingdom

The need for integrated surveillance of antimicrobial resistance (AMR) in foodborne bacteria is well recognised. When critically analysing fresh produce supply chains, several entry points of multidrug-resistant (MDR) bacteria onto fruit and vegetables can be noted, including manure-amended soil and contaminated irrigation water used in crop production. In South Africa (SA), different farming practices and distribution of fresh produce within formal and informal supply chains adds an additional layer to consider within food safety surveillance programs. Although limited information is available, a few recent SA studies have investigated the presence of ESBL/AmpC-producing Enterobacteriales from non-clinical sources. From these studies, selected isolates (n = 188) were subjected to whole genome sequencing (WGS) analysis. This included *Escherichia coli* (n = 70), *Klebsiella pneumoniae* (n = 53), *Salmonella* spp. (n = 55) and *Serratia fonticola* (n = 10) from six studies in three provinces (Mpumalanga, Gauteng and the North West Province). Where *E. coli* and *K. pneumoniae* were isolated from the same irrigation water sources, a greater number of resistance genes across more antibiotic classes were seen in the *K. pneumoniae* strains. Although all the *E. coli* isolates were MDR, limited shiga-toxin producing strains were present in the respective supply chains. *Salmonella* spp. belonging to six serotypes were predominantly isolated from fresh produce and associated irrigation water in the North West Province, with MDR observed in 100% of the isolates. The importance of a holistic One Health solution to assess risks and identify priority areas for intervention within SA food production and supply was highlighted.

## The Role of Testing in an Enterprised-Based Food Safety Risk Management Program

Martin Wiedmann

Cornell University, Ithaca, NY

With regard to management of microbial food safety risks, testing plays a key role in identifying and characterizing potential enterprise risks as well as providing assurance that risks are managed appropriately and as desired by an individual firm. However, testing of raw materials, the processing plant environment, and finished products typically simply identifies the presence of a hazard, as well as sometimes the level at which a hazard is found (e.g., 10 CFU/g of finished product). Therefore, food safety programs that solely rely on qualitative (YES/NO) testing data typically focus on managing hazards (such as *Listeria monocytogenes*), not risks (such as the risk of a recall due to *Listeria* and the associated financial and reputational risk for a firm).

For food safety to get its legitimate place amongst all enterprise risks (which may include, *inter alia*, cyber security, foreign currency exchange rate fluctuations), it is important for food safety professionals to use testing data to not only identify but also characterize and ideally quantify enterprise risks and associate control strategies. This can be achieved through a variety of strategies, including mathematical models. Transition from hazard to risk-based food safety systems, including the associated changes in collection and use of testing data, is essential to assure an appropriate place for food safety in a firm's overall risk management system, including appropriate resource allocation to food safety related efforts.

## Assigning and Tracking Food Safety and Quality KPI's: An Integral Part of Corporate Risk Management

John Donaghy

Nestec Ltd., Vevey, Switzerland

Past and recent food safety-related outbreaks and major public health incidents has highlighted the importance of food safety risk management being an integral part of a business's corporate risk management. Assigning Key Performance Indicators (KPI) or metrics on food safety and quality are paramount for any food business. These indicators should be visible and be regularly reviewed at top management level.

Key performance indicators should reflect the 'cost of non-quality to a business. The 'cost' may be public health consequences, brand or reputational damage, loss of market share, increased resource expenditure (e.g., increased testing, increased investigations, product disposal), etc. These KPIs, which tend to be lagging i.e., retrospective in nature, may include, for example, number of public recalls number of trade withdrawals, number/cost of internal food safety/quality incidents, consumer/customer complaints, *inter alia*.

A business must ensure food and quality risks are mitigated through 'cost of quality' i.e., through investment in training, appropriate food safety management systems, organizational food safety/quality culture, key partnerships with suppliers of materials and services, internal and external audit and other verification activities. 'Leading' performance metrics can ensure continuous improvement in the realm of food safety e.g., food safety audit scores, laboratory test proficiency scores, number/nature of trained food safety personnel.

Ownership of food safety and quality metrics and risk must go beyond a quality function – it must have multi-functional ownership including manufacturing, engineering, procurement, supply chain, and regulatory. Furthermore, access to, and interpretation of 'early warning' signals for emerging risks in food safety can ensure businesses put operational mitigation plans in place for imminent food safety/corporate risk. Tools and processes must be in place to horizon scan and early warning on such risks.

## S2 Getting the Science, Legal and Business Case Right: Incorporating Food Safety into the Enterprise Risk Management Process

What do a food scientist, a food lawyer, a food safety culture expert, and a food safety leader in one of the world's most notable brands have in common? No, it is not the start of a bad joke! They have a common dedication to integrating food safety into a larger corporate risk management framework often referred to as enterprise risk management (ERM). The presenters will deliver novel insights into the role that science, testing, data analytics, the changing legal and regulatory landscape, culture, and brand reputation play in shaping food safety program requirements and incorporating these into a corporate-wide, systematic approach to risk management. This session will provide attendees with the unique perspectives from a scientific, legal, and business lens to build a case for assessing food safety risk relative to other risks a food company faces and must manage, and demonstrate how to utilize these principles when identifying, assessing, mitigating and monitoring food safety risks. This presentation will provide attendees with more tools to leverage a more cross-functional, multi-disciplinary approach to food safety with increased opportunities for capital resourcing and overall success.

## Leveraging Enterprise Risk Management Tools and Terminology to Make Your Food Safety Program "Stick"

Melanie J. Neumann

Matrix Sciences International, Inc., Chicago, IL

Enterprise risk management (ERM) has been described in various ways, by individual companies to standard-setting bodies such as COSO -- the Committee of Sponsoring Organizations of the Treadway Commission.

As defined by COSO, ERM is summarized as: a process to assist resource allocation-based decision making designed to:

- (i) identify potential risks that may affect the enterprise;
- (ii) manage risks to fall within the identified risk appetite; and
- (iii) provide reasonable assurances that such risks are being managed.

Attendees will gain an understanding of ERM principles and how to leverage an ERM framework as a powerful strategy to enhance and advance your food safety program. Employing this risk-and-resource based holistic approach to managing food safety and quality risks within the context of all other corporate risks that must also be managed may be the game-changer for food safety professionals.

## S3 Process Analytical Technology at the Service of Food Protection; The "DiTECT" Approach

The process analytical technology (PAT) approach in food processing constitutes a complete and integrated system which aims at end-product quality assurance in an efficient, detectable, and environmentally friendly manner via real-time on-line/in-line measurements of critical parameters. Such parameters can be physical, chemical and/or microbiological, and the measurements should be conducted after appropriate sampling and, ideally, using non-invasive analytical technologies. Analytical technologies that have been shown to be propitious in food processing are mainly spectroscopy methods, as well as hybrid technologies combining spectroscopy and image analysis such as multispectral imaging.

Bringing together research, industrial and food authority partners representing the agro-food industry in the EU and China, the DiTECT project envisages to develop an integrative approach supported by

advanced authentication and traceability technologies, applicable throughout the farm-to-fork continuum. Specifically, the aim of the DiTECT project is to provide quantifiable evidence for the effective detection, assessment and mitigation of biological hazards, chemical hazards, and environmental contaminants, using the latest advances in software technologies and high throughput, rapid, non-invasive sensors.

This symposium aims at describing the principles, methods, and applications of PAT in the framework of the DiTECT project, providing state-of-the-art information regarding the technologies and sensors that have been shown to be promising for the appraisal of different food protection issues and, as such, are exploited in the certain project. Specifically, applications related to the detection and quantitative assessment of microbial contaminants in foods and of chemical contaminants (e.g., mycotoxins) in raw materials will be presented. Given the critical role of information technology (IT) in data management and analysis, novel IT approaches exploited in the context of PAT in the food industry will also be presented and discussed.

## Process Analytical Technology in the Food Industry: Principles, Methods and Applications

Alexandra Lianou<sup>1</sup> and George-John Nychas<sup>2</sup>

<sup>1</sup>University of Patras, Department of Biology, Patras, Greece, <sup>2</sup>Agricultural University of Athens, Department of Food Science and Human Nutrition, Athens, Greece

The process analytical technology (PAT) approach in food processing constitutes a complete and integrated system aiming at end-product quality assurance via real-time on-line/in-line measurements of critical parameters. Such parameters can be physical, chemical and/or microbiological, with their measurements being ideally conducted using non-invasive analytical technologies. Spectroscopy methods, as well as hybrid technologies combining spectroscopy and image analysis, have demonstrated important application potential as PAT tools in the food industry. Indeed, Fourier transform infrared (FTIR) spectroscopy and multispectral imaging (MSI) have been evaluated as holding a considerable potential for different food-related applications including raw food classification, assessment of the microbiological quality of various food commodities (i.e., produce, fish, meat, poultry), as well as for food authentication and fraud detection purposes. The PAT concept is solidly embraced in the context of the EU-China project "DiTECT", which envisages to develop an integrative farm-to-fork approach using the latest advances in software technologies and high throughput, rapid, non-invasive sensors. Examples of spectroscopy-based sensors' applications which, in tandem with multivariate data analysis, have been evaluated in the project's framework as rather promising include the utilization of FTIR spectroscopy, UV-Vis spectroscopy and/or MSI for: (i) the assessment of the microbiological spoilage of chicken products (i.e., burgers and liver), and (ii) the detection of minced red meat and poultry adulteration.

## Detection of Contaminants in Raw Materials Using Multispectral Imaging

Jens Michael Carstensen

Videometer A/S, Herlev, Denmark

LED spectral imaging systems is a mature technology for a very rich and versatile analysis of contaminants in powders, granules, and other materials. The technology is fast and non-destructive and with little or no sample preparation. LED spectral imaging share some principles with other hyperspectral and multispectral techniques and the major advantages of strobed LED systems are: 1) speed, 2) no mechanical movement, 3) no dependency on unstable broad-spectrum incandescent light source, 4) potential for high dynamic range imaging through the illumination, and 5) combined spectral reflectance imaging and spectral fluorescence imaging. All of the above advantages are exploited in the proposed system where the spectral illumination source is combined with an integrating sphere and a calibration model that provides traceability, high reproducibility, spatial homogeneity, and focus on chemical properties of a heterogeneous sample. Application areas of such systems are quite broad and high performance systems are seen within fields like agriculture, food, pharmaceuticals, medical devices, cosmetics, forensics, and general manufacturing. We will present the elements of our strobed LED imaging systems. The powerful multivariate analysis technique, normalized canonical discriminant analysis (nCDA) is used to optimize the application performance as well as to get information about the data/noise structure and importance of specific spectral ranges. The performance is illustrated on a number of real applications on contaminant detection in different materials.

## Exploitation of Novel Information Technology Approaches in the Context of Process Analytical Technology in the Food Industry

Colm O'Donnel

University College Dublin, Dublin, Ireland

Abstract not provided.

S4

## Plasmarter – Cold Plasma Functionalised Liquids as a Food Safety Intervention Technology

The theme of this session concerns cold plasma functionalized liquids and the scope and diversity of application for safety in food processing.

The purpose of this session is to present the significant advances in moving this intervention technology through from bench to prototype to industry, and how it provides a green technology for food safety, enabling a circular approach in food processing and food protection.

Cold plasma is increasingly investigated for translation to a wide range of applications. This has led to increased understanding and successful implementation as an intervention technology for decontamination at pilot scale in food processing. The flexibility of cold plasma technology provides a rich resource for innovative solutions to protect food safety along the entire food continuum. The emerging understanding of the longer-term role of cold plasma reactive species and their follow-on effects, reveals how cold plasma may be optimally applied to persistent problems across agricultural, food, and beverage sectors.

Important strides have been made over the last five years in the development and application of cold plasma treated or activated liquids. Exposing a liquid such as water to cold plasma can lead to retention of some of the main effectors in the water. Exposure of foods and beverages based on plant or animal tissues, as well as microbial cells as producers or contaminants of those foods, generates plasma-activated 'fluids' due to their high-water activity. The retention of effects in liquids treated with cold plasma offers exciting possibilities. Furthermore, it is possible to drive particular chemistries in plasma treated liquids through system design. This allows tailored functionality for specific uses to be developed in simple liquids such as water, or more complex foods and beverages. Significant developments in scale up for application to safety and spoilage protection in fresh foods will be described.

## Mechanistic Insights to Cold Plasma Functionalised Liquids: Antimicrobial Efficacy and Interactions with Processing and Storage Conditions

Daniela Boehm

School of Food Science and Environmental Health, Technological University Dublin, Dublin, Ireland

**Introduction:** Cold plasma functionalised liquids (PFL) are generated by exposing liquids to a cold plasma discharge, resulting in changes to the liquid chemistry with the generation and/or dissolution of reactive oxygen and nitrogen species. The reactive species chemistry depends on the plasma discharge used, treatment parameters, and target liquid chemistry and results in novel 'functions' of the liquid including antimicrobial activity.

**Purpose:** An understanding of these defining parameters allows PFL functionality to be modified and tuned to specific applications such as microbial decontamination. While the variety of plasma systems in use and the variability of resultant reactive species in the liquid provide challenges in terms of comparability and scale-up, they also present opportunities for tailoring PFL chemistry. Essential are in-depth knowledge of the plasma discharge and its interaction with the liquid on the one hand and understanding of the reactive species chemistry on the other.

**Methods:** The influence of different processing and storage conditions on PFL chemistry and antimicrobial efficacy have been investigated, including temperature and pressure, with important implications for integration of PFL into conventional food processing and cleaning procedures.

**Results:** The antimicrobial efficacy of PFL results from the low pH of these liquids and their content of reactive oxygen and nitrogen species, such as H<sub>2</sub>O<sub>2</sub>, nitrous, peroxyntic and peroxyntic acids and differs between microbial targets. Different PFL showed stability over medium-term storage at ambient temperatures and long-term storage (months-years) at low temperatures. The resistance to high temperatures and pressure further expand the potential of applications to scenarios where steaming or vaporization is desirable.

**Significance:** This talk will review the current understanding of PFL chemistry and antimicrobial efficacy and discuss its potential for food and processing practices.

## Scaling Efficacy of Cold Plasma Functionalised Liquids from Bench to Pilot to Industry for Fresh Produce

Uta Schnabel

Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

**Introduction:** Fresh-cut produce such as lettuce may contain a very high microbial load, and despite a good safety record overall, has been associated with major human pathogen-associated outbreaks.

**Purpose:** The need for sustainable, non-thermal interventions and effective antimicrobial agents at post-harvest stages remains. Sanitation steps based on non-thermal plasma (NTP) opens up innovative food processing possibilities through application at different points and modes of delivery along the food chain; for production, modification, and preservation, as well as in packaging of plant- and animal-originated food. Plasma contains plasma reactive species and free charge carriers caused by ionization processes of the gas atoms and molecules, which mediate effects either in gaseous or liquid forms of delivery.

**Methods:** This talk describes innovations in a plasma process that resulted in a complete industrial scale fresh produce (lettuce) processing line for cutting, washing and drying based on Plasma Treated Water (PTW). The treatment of natural products with changing parameters (size, surface, water content) is challenging for the design and optimization of non-thermal plasma processes. To overcome these challenges, a specific plasma process based on microwave plasma operated with compressed air was established to deliver Plasma Processed Air (PPA) as the antimicrobial agent to process tap water. This served to generate and scale the Plasma Treated Water (PTW) with antimicrobial properties. The primary process development focus was on the antimicrobial efficacy when used on the produce and in the washing water, but changes in product quality and potential by-products were also monitored.

**Results:** To successfully scale up the PTW-application, an understanding of the antimicrobial properties, the chemical composition of PTW and process water, and resultant food quality characteristics (texture, color, nitrite/nitrate content, Chlorophyll a/b, and ascorbic acid) was developed.

**Significance:** The optimized PTW production and decontamination process was implemented into an industrial-scale lettuce-processing line thus demonstrating the industrial scalability and applicability.

## Integrating Cold Plasma Functionalised Liquids to Control Microbiological Risks in Poultry Processing

Soukaina Barroug

School of Biosystems and Food Engineering, Institute of Food and Health, University College Dublin, Dublin, Ireland

**Introduction:** Post-slaughter poultry and processing surfaces provide ideal supports for microbial growth along the poultry processing chain. Cold plasma is an emerging non-thermal intervention technology under investigation for applications in food decontamination and preservation and can be flexibly applied in gaseous or liquid-mediated form.

**Purpose:** This work investigated the possible sites for plasma functionalized water (PFW) interventions within large-scale poultry processing to understand the technical requirements for mitigating cross-contamination and maintaining food safety.

**Methods:** The plasma setup and processes for the generation of PFW were developed. Three modes of PFW delivery; namely mixing, dipping, and misting were investigated to mimic current stages in commercial poultry processing where water is used in unit processes. Thus the antimicrobial efficacy of transient exposure or prolonged contact time to PFW was determined, aligned to the poultry processing stage. Target pathogens included *Campylobacter jejuni* NCTC 11168 and *Salmonella* Typhimurium ATCC 14028. The key plasma process parameters governing the antimicrobial efficacy of each mode of PFW application were identified against bacterial suspensions and attached cells in the form of biofilms generated on six different food contact surfaces. A product misting chamber was developed to mimic current processing steps.

**Results:** Results illustrated that PFW has a significant bactericidal effect on both *C. jejuni* and *S. Typhimurium* leading to reduction by respectively 10-9 and 8-7 log<sub>10</sub> CFU/ml within 15-sec mixing of bacterial suspensions in PFW. When the PFW was applied to contaminated chicken surfaces by misting, this enabled a 1 log bacterial reduction within seconds. For the eradication of mature *S. Typhimurium* biofilms on process surface materials, 15-min contact in PFW was required to reach a 7 log<sub>10</sub> reduction of viable cells.

**Significance:** PFW is an effective-scalable-sustainable approach that can be applied at individual or sequential process stages to rapidly control poultry-related pathogens present in suspension, biofilms attached to abiotic surfaces or to poultry meat surfaces. The delivery modes can be adjusted to several commonly used intervention points.

S5

## New Hazards and Old Threats; Foodborne Viruses and Risk Assessment in Food Safety

Foodborne illness is an important problem in food safety, which contributes a large percentage of total global disease burden. Over 200 hazards which cause food-related illness have been identified, including bacteria, viruses, chemicals, and parasites. Of these, the largest contribution to foodborne disease burden is gastroenteritis, the majority of which is caused by enteric viruses. Viruses of human and animal origin enter the food chain through contaminated waters or unhygienic handling.

The risk analysis framework has been adopted around the world to control and manage the threat of foodborne illness. This is a systematic approach to risk management, that provides quantitative understanding of the likelihoods and uncertainties of adverse public health outcomes caused by hazards in food. Hundreds of microbial risk assessments (MRA) have now been published. Combined with the tools of predictive microbiology, MRAs allow a scientific understanding for predicting and controlling microbial hazards. However, the potential use of MRAs in controlling foodborne viral risk has been limited, relative to bacteria. Reasons for this may include gaps in data availability, the relative difficulty of detection and monitoring compared with bacterial methods, and possible conceptual differences between quantitative MRA for bacteria and for viruses (QVRA).

The theme of this symposium is the challenge posed by foodborne viruses to risk analysts, the tools available to control these risks, and the opportunities ahead. It aims to cover the reasons for the unexplored potential of QVRA, and why it should be addressed. The general burden of foodborne viral illness will be explained, and the importance of virus risk assessment. Alongside this, the key differences between bacterial MRA and viral MRA will be presented, and the main difficulties in preparing quantitative risk assessments for viral hazards. Specific strategies for control or mitigation of viral hazards will be presented as well.

## Risk Assessment and Foodborne Viruses: Is It Cold out There?

Chiara Balbo and Constantine-Richard Stefanou, EFSA EU-FORA Fellow, IBPRS State Research Institute, Warsaw, Poland

Enteric viruses cause the majority of foodborne microbial disease burden and have been identified as a priority hazard by the FAO and WHO since at least 2008. Risk analysis and risk assessment are used by food safety regulators, both national and international, to set microbiological safety standards. Risk assessments were first widely adopted as a tool for managing chemical hazards, and later applied to microbial pathogens.

Despite the widespread prevalence of viruses as a foodborne microbial hazard, microbial risk assessments from the 1990s onward have focused on bacterial causes of illness. This focus has also applied to regulatory microbiological criteria, and other food safety. Food safety control measures for bacterial hazards have been shown insufficient to deal with virus risk.

This presentation will provide an overview of viruses as a foodborne hazard and of risk assessment as a discipline. The principles and history of microbial risk assessment will be explained, with reference to international guidelines. This includes key differences between risk assessments for chemical hazards, bacterial hazards, and viral hazards. The current state of the art in quantitative microbial risk assessment will be covered, and progress to date on applying QMRA to viral hazards.

The next generation of microbial risk assessment is already arriving, with new molecular and genomic tools. The tools of microbial risk assessment have not yet tackled the larger problem of foodborne viruses. The scope of the challenge ahead will be defined, and then addressed.

## The Next Frontier in Risk Assessment in Food: Quantitative Viral Risk Assessment

Kevin Hunt

University College Dublin, School of Biosystems and Food Engineering, Dublin, Ireland

Applying the tools of risk assessment to the problem of foodborne virus hazards is a necessary next step in advancing food safety. Foodborne viruses are among the biggest contributors to foodborne microbial illness. Bacteria-based control processes are not enough to address the risks posed by viral hazards. This is partly due to the

higher persistence and survival of viruses in food, as well as greater variability in virulence, infectivity rates, and host response. Given this, what steps must be taken to move forward?

The aim of this presentation is to review (1) the difficulties to date in applying microbial risk assessment to viral hazards, (2) the main differences between bacterial risk assessment and virus risk assessment, and (3) the opportunities for the future. The main challenges have been detection and culturing infectious viruses in food, and therefore modelling accurate concentrations for exposure assessment. Dose-response models are also an issue, with available data often not accounting for the full variability in host-virus interactions. Surrogate viruses can be an imperfect substitute for the main hazards of interest. The main differences between bacteria and viruses are the absence of growth and the higher persistence and resistance to inactivation and removal procedures. Recent advances in sequencing, cell culturing, and molecular detection will provide more direct data for risk assessment modelling, and the efficacy of virus control measures. The next frontier in microbial risk assessment is to face the problem of virus risk.

### **Control of Foodborne Virus Risk in the Context of Risk Assessment**

**Monika Trzaskowska**

*Warsaw University of Life Sciences, Institute of Human Nutrition, Warsaw, Poland*

Although managing the control of risk is not the purpose of risk assessment (RA), the results of RA can be used to compare and select between appropriate mitigation strategies. Combined with the tools of predictive microbiology, viral risk assessments (VRA) allow a scientific basis for predicting and controlling viral hazards. The practical question is how and when to use data and models in predicting virus behaviour during food processing. For example, using dose-response data to define critical control points and critical limits in a Hazard Analysis and Critical Control Point (HACCP) system.

This presentation will discuss the quantitative modelling of foodborne virus risk, including uncertainties. The main focus will be the effect of control measures, both prevention and inactivation. Preventive measures cover the application of rules and systems such as GAP, GHP, GMP and HACCP and food law. Preharvest and postharvest control strategies, as well as hygiene measures are also considered. These measures include physical procedures such as high temperature and pressure, as well as chemical treatments like ozone, or plant and microbial derivatives.

The morphological and physiological characteristics of viruses, including difficulties in testing their presence and infectivity, ultimately show the need for preventative measures, rather than relying solely on control measures.

### **The Trouble with Hepatitis E!**

**Linda Scobie**

*Glasgow Caledonian University, Glasgow, United Kingdom*

Hepatitis E virus (HEV) is an emerging zoonotic pathogen that has been identified in a number of animal species. The main genotypes (G) of concern that exist in Europe are G3 and G4. HEV G3 has long been known to be detectable in a number of foodstuffs, mainly from pork derived products, but there is less data on direct infection from food in humans. Despite this, infections are on the increase and the route of transmission, although not formally proven, is suspected to be foodborne. Indeed, the food industry has concerns that there could be economic impact and want to provide consumers with accurate advice on products.

There are many studies in the literature which have tried to determine the risk of foodborne Hepatitis E, however, there are no consistent methods or sources utilised to allow a formal comparison or data interpretation. To compound these factors, there is also no consistent assay for testing infectivity from food.

This presentation will focus on the background of HEV and the gaps in the knowledge preventing a true understanding of the risk of foodborne infection. Indeed, are surrogates of any use when studying HEV and what do we need to use as controls? Is HEV a special case with respect to foodborne viruses and how can we overcome the problems faced? Data will be presented on how we have attempted to deal with the trouble that is HEV.

### **Assessing the Efficacy of Control Measures Against Viruses Using Surrogates**

**Annette Sansom**

*Campden BRI Ltd., Chipping Campden, United Kingdom*

The control of viruses is an area of increasing importance for the food industry. A recent report by the UK FSA states that norovirus poses the highest burden to society out of 13 foodborne pathogens including *Campylobacter* and *Salmonella*. Traditionally, the effectiveness of food safety control measures has been assessed and verified against bacterial risk, however studies have shown that the resistance of viruses to these measures can be different to that of bacteria.

Currently it is not possible to easily culture the relevant target viruses in the laboratory, and we cannot test the effect of these controls have directly on the infectivity of the virus. Alternative approaches are required to determine virus stability, infectivity, and survivability, including the use of surrogates such as bacteriophage. These surrogate viruses can be easily cultured and used to give an indication of how the pathogens behave when they are subjected to control measures such as heat processes, acidification, changes to water activity, and disinfecting systems.

This presentation will give an overview of virus research carried out at Campden BRI. Using surrogates, such as MS2 and murine norovirus to assess the effectiveness of control strategies (e.g., pH, UVC technologies, chlorine washing), against viruses such as norovirus. Providing information on how surrogates can be used, instead of the target virus, to validate virus control measures.

### **COVID-19: Practical Lessons Learned in Virus Control**

**John Holah**

*Principal Corporate Scientist, Holchem/Kersia, FS&PH, Bury, United Kingdom*

Prior to COVID-19, viral control at the factory level was not routinely undertaken in the food industry, with perhaps decontamination following a norovirus incident being an exception. Historically, control of spoilage bacteria and pathogens has been recognised as a two-stage process with physical removal and bacterial cell damage via detergency and subsequent cell damage via disinfection. This presentation considers this principle for viruses and examines the effects of detergents and disinfectants on coronavirus and their surrogates. The evolution of European virus disinfectant testing is also noted. Whilst the decontamination of viruses on surfaces is shown to be effective, as would be predicted from historical microbial resistance studies, the decontamination of viruses in the air was largely unknown. This presentation goes on to assess the airborne decontamination of Phi6 and MS2 phages, as surrogates for coronavirus and norovirus, using industrial fogging systems and non-oxidative and oxidative biocides. Airborne disinfection was demonstrated, with the degree of disinfection being dependent on both the virus, with MS2 being more resistant, and the biocide used. The outcome of these studies are a series of practical cleaning and disinfection strategies that can be used for routine, end-of-production cleaning programmes and for factory decontamination following a viral airborne or foodborne incident.

## **S6 Determining the Efficacy of Control Measures Against Foodborne Viruses**

Viruses are a major contributor to the burden of foodborne disease around the world. Estimates by WHO in 2010 would suggest the norovirus was the leading cause of foodborne illness in the EU (14 million cases per year) and worldwide caused 20% of all foodborne illness (125 million cases per year). It is also clear that we have very limited knowledge of how viruses react to the common control measures used by the food industry to control bacteria; we do not fully understand how they will react to heat, pH,  $a_w$  or various hurdles that we commonly use.

There is a further challenge in that the common foodborne viruses are difficult, if not presently impossible to "culture," so our ability to determine if a control measure has rendered a virus non-infective is severely challenged. To overcome some of these issues much work has been done with surrogate viruses that can be cultured and that we can determine the effects of potential inactivation measures.

In this symposium we will look at the effects of control measures on human norovirus (HuNV), Hepatitis A (HAV) virus and Hepatitis E (HEV) virus. Considerations and results of work using surrogates for HuNV and HAV will show effects of key control measures, HEV will be considered separately, as a zoonoses it forms a different challenge to HuNV and HAV and its controls may be different. Finally the effects and requirements of cleaning and disinfection will be considered, including how methods to determine the efficacy of viral decontamination have been adapted, to verify strategies used to protect the workforce during the COVID-19 pandemic. The symposium will provide a fully up-to-date review of virus control measures using both published and unpublished data.



## S7 Plant Protein-Based Meat and Dairy Alternatives – Known Plant Sources But New Microbiological Risks?

The production of plant protein-based foods has increased strongly and this growth is foreseen to continue given the worldwide demand for sustainable food production. The use of plant protein ingredients in innovative food products may however have unexpected effects related to microbial contaminants in the food chain, which can lead to food spoilage and even foodborne illness.

While many plant protein sources are not new (e.g., soy, oat, pea), their use and application in innovative food product bring new challenges. Ingredients from different sources may be available in various forms (e.g., isolates, concentrates, kernels, flours) each with its own functional properties and applications. But what microbes do these ingredients harbour? Can risk organisms be inactivated without loss of functionality of the plant proteins (which often have limited solubility and do not tolerate high heat loads)? And how do post-processing and storage conditions affect microbes in newly formulated products?

Insight into the microbiological hazards and spoilage organisms is needed for the design of effective processing conditions and stable product formulations of plant-based foods, and to support troubleshooting activities in case microbial contaminants are encountered in finished products.

This symposium will focus on microbial challenges and approaches taken to ensure the safety and quality of innovative plant-based products throughout the chain. Presentations will focus on: approaches to design safe plant-based meat alternatives; microbes in plant protein-based ingredients that pose challenges to safety and quality of dairy alternatives (including spore formers such as *Bacillus cereus*); and lastly, on the occurrence of *Clostridium botulinum* in plant-based ingredients and control in finished products.

### Safety of Plant-Based Meat Alternatives in a Reverse Engineering Approach

#### Masja Nierop Groot

Wageningen Food & Biobased Research, Wageningen, The Netherlands

The ongoing interest in improved sustainability, healthfulness, quality, and safety of food is evident and the growing plant-based food market is a clear example of this trend. Traditionally, sustainability, health, and safety issues have been viewed as mutually exclusive. An assessment platform to navigate these complex issues in an integrated way can assist the agro-food industry in making informed and balanced decisions when innovating towards a more sustainable and secure food system.

This symposium contribution will discuss a reverse engineering approach used by Wageningen UR for plant-based burgers as a case study, with specific emphasis on requirements from the microbiological safety perspective. By linking information about the hazards relevant for product ingredients in an ingredient-hazard database, a hazard profile can be created for plant-based formulations, already at an early stage of product development. Insights on microbial contaminants of plant-based ingredients and their inactivation rates were collected in databases. This data together with processing and storage conditions and microbial growth models were used to identify the most likely hazards of different recipes for plant-based burgers included in the case study. For this purpose, the FSO/PO (Food Safety Objective/Performance Objective) approach defined by ICMSF was used.

Insights regarding safety, when combined and balanced with the other criteria such as sustainability and economic viability, at an early development stage, can reduce the development time, costs, and new product failures. This will aid in the development of safe plant-based products that meet sustainability and health objectives.

Acknowledgment: This work is part of the project Reverse Engineering of “KB Healthy and Safe food” program (KB-37-001-001), funded by the Dutch Ministry of Agriculture, Nature and Food Quality (Ministry of LNV).

### Microbial Contaminants Relevant to Safety and Quality of Plant Protein-Based Dairy Alternatives

#### Marjon Wells-Bennik

NIZO, Ede, The Netherlands

Many different ingredients and processes can be used to create plant-based dairy alternative products that offer similar mouthfeel and structure, taste, look, etc. as dairy versions. The main product categories are non-dairy milk, yogurt and cheese alternatives. From a microbiological point of view, information is currently limited with respect to the types and levels of microorganisms that are harbored by plant-based ingredients. Such contaminants, which are naturally present, may pose microbiological safety and quality risks depending on the processes that are applied, the product characteristics, and the shelf-life conditions.

In this seminar, information will be presented on microbial contaminants that were enumerated and identified in plant-based ingredients, including pea, mung bean, faba bean, and oat. As ingredients are heated during manufacturing of dairy alternatives, the study had a focus on spore-forming organisms in various sources. Potential microbial risks and knowledge gaps throughout the production chain of the major plant-based dairy alternative product categories will be discussed.

### An Old Foe in New Plant-Based Products – *Clostridium botulinum*

Noora Pernu, Riikka Keto-Timonen, Miia Lindström and Hannu Korkeala

Department of Food Hygiene and Environmental Health, Faculty of Veterinary Medicine, University of Helsinki, Helsinki, Finland

**Introduction:** While plant-based alternatives are becoming increasingly popular, there has been a growing interest in the microbial risks of new products. We focus on vegetarian sausages and one of the most feared food safety concerns, *Clostridium botulinum*, which produces resistant spores and a highly potent neurotoxin. The psychrotrophic *C. botulinum* Group II poses a safety risk in vacuum-packaged foods because of its ability to survive pasteurization, and outgrow into neurotoxinogenic cultures at refrigerated temperatures. Although vegetarian sausages have not been associated with botulism cases, preserved vegetables are a common source of botulism outbreaks, indicating that vegetables are relatively frequently contaminated with spores. Mild pasteurization of vegetarian sausages combined with long shelf-lives and limited use of NaCl and preservatives could lead to germination, growth and toxinogenesis.

**Purpose:** We determined the prevalence of *C. botulinum* in vegetarian sausages and assessed the botulism risk related to vegetarian sausage products.

**Methods:** Altogether 74 samples of vegetarian sausages from seven producers were studied for *C. botulinum* using PCR and the most probable number method (MPN). Attempts to isolate *C. botulinum* from the PCR-positive samples were made. Isolates were genotyped using amplified fragment length polymorphism (AFLP).

**Results:** We report high prevalence (32%) of *C. botulinum* in vacuum-packaged vegetarian sausages with original sample size of 20–111 g. Genes for neurotoxin types A, B, E and F and both Group I and II strains were detected. The MPN cell counts varied from 20 to 1200 cells/kg, with the highest counts observed for psychrotrophic *C. botulinum* Group II in a product with remaining shelf-life of 6 months at the time of purchase. Eight isolates were recovered and genotyped.

**Significance:** Vacuum-packaged vegetarian sausage products could be at risk of *C. botulinum* growth and toxin production due the frequent occurrence of *C. botulinum* spores in these products. Chilled storage below 3°C and thorough reheating before consumption are recommended.

## S8 Safety and Quality of Water Used and Reused in Fresh Produce Supply Chains

This symposium will discuss food safety and quality aspects of water use and reuse in the context of fresh produce value chains.

The use of clean water is a basic principle in fresh produce growing, handling and processing. To achieve a consumer safe product, it is critical to understand water use, potential contamination of water sources and the ways to best mitigate consumer risk.

We expect that water reuse increases dramatically in many parts of the world soon. As water scarcity pressures rise, well-informed decisions as to the safety of recycled or reclaimed water (including grey water, produced water, return flows, and recycled wastewater) used in fresh produce production is also necessary when promoting water reuse. To date, many sources of reusable water have not been widely explored and adequately assessed for their health risks at the detail required to ensure food safety and protect consumer health.

Various types of hazards are potentially introduced to fresh produce through water reuse; hence, these need to be thoroughly identified and evaluated for food safety risks. Where necessary, risks have to be reduced to acceptable levels through adequate treatment/technical intervention. Ultimately, criteria or thresholds to hazards/indicators may need to be established for day-to-day monitoring of an operation (re)using water, as well as for regulatory purposes such as public health protection. Question is whether such approaches can be easily adopted and implemented in Low- and Middle-Income-Countries, where water scarcity is frequent but resources typically low.

Potable water (i.e., water of drinking water quality) is safe but not always required to achieve safe consumer products. The first presentation will focus on the risk-based selection of water that is fit-for

purpose for the handling and processing of fresh fruit and vegetables. The second presentation will provide an overview of water use and reuse in the fresh vegetables processing industry, food safety problems to control and control strategies typical for high-resource environments. The third talk will provide examples of potential and actual water reuse, as well as associated food safety risks and mitigation options, in the context of informal produce supply chains in low-resource environments.

Questions in scope for the presentations and the discussion around them are, for instance: which potential reusable water sources can be used in a fit-for-purpose approach to alleviate water scarcity problems in the fresh produce value chain? What experience is there of water reuse for different commodities and in the context of different levels of resources and capabilities of countries? How can we best use testing and microbiological threshold values to monitor water quality/safety parameters and verify fit-for-purpose water applications?

### **Overview of Water (re-use) for Fresh Produce and Identifying Safe, Fit-for-Purpose Applications of Re-Usable Water Sources**

**Rob de Jonge**

*RIVM (National Institute for Public Health), Bilthoven, The Netherlands*

In food industries, water is used for several purposes, like for maintenance, gardening, for sanitary purposes, fire control, steam production and for handling and processing foods. According to the general principles of food hygiene, all water that comes into contact with food or food contact surfaces should be of drinking water quality. Few exceptions exist: intact fish and fresh produce may be handled with 'clean' water, chilling does not require the use of potable water and re-use of water for food handling and processing is allowed, as long as it does not compromise food safety.

As water scarcity pressure is rising, re-use of water and the concept of 'clean' water might gain importance. However, the high level of diversity in the products, the hazards, their interactions, and in the steps in the food chain make it impossible to have one system fit for all foods and each food has to be addressed in a context specific manner. Criteria for the microbiological quality of clean, safe water used in food handling and processing need to be addressed as currently there is a lack of guidance for the various types of water used in the food industry. And decision support systems are required to support risk managers in making decisions on the fitness-for-purpose of water and the required quality (potable water or other suitable quality) for use or reuse at a step in the supply chain, provided they are based on an assessment of final health risks of the food at consumption.

In this contribution, a worldwide applicable system for making decisions on the fitness for purpose of water used in food industries is presented.

### **Bringing Fit-for-Purpose Applications into Fresh Produce Operations and Managing Control**

**Dima K. Faour-Klingbeil**

*DFK for Safe Food Environment, Hannover, Germany*

Water scarcity is a global issue resulting from diminishing water availability with the increasing water demand, water overuse, pollution, and changes in water availability due to climate change. Industries from all sectors have critical roles in alleviating water scarcity. Particularly the food and agriculture sectors are under the pressure of being the largest consumers of water. Further challenges are read with the rising demands for healthy fresh food and the rapid growth of the ready-to-eat and fresh-cut vegetables markets in the developed economies; Hence, while increasing food production, it is imperative to adopt strategies for efficient water use in the fresh produce industry to conserve water resources and reduce costs and environmental impact of the high volume of generated wastewater. Water reuse is one of the measures deemed appropriate to mitigate high water consumption. It is advocated as a valuable resource by the United Nations World Water Development Report and the circular economy perspective. Ultimately, water quality should fit the purpose it is used for, and recycling or reuse applications will have to consider water suitability which depends on its source. Thus, cross-contamination and recontamination risks are likely to occur without validated and verified control steps, predisposing final products to hazards. This presentation will offer an overview of water reuse in the fresh produce industry, associated risks, and currently applied solutions to prevent cross-contamination. Technological limitations and research needs are also considered.

### **Fit-for-Purpose Water (re-)Use Applications in the Context of Informal Produce Value Chains and Informal Markets in Low and Middle Income Countries**

**Elisabetta Lambertini**

*GAIN - Global Alliance for Improved Nutrition, Rockville, MD, USA*

Lack of water of appropriate quality, attention to efficient use, and re-use or de facto reuse are a reality throughout food production chains in many low-resource or low-infrastructure settings. In traditional food markets, and along the informal supply chains of commodities sold at markets, water is used for preserving freshness, washing, surface and floor cleaning, and handwashing, among other purposes. However, current water use practices during food handling often pose a high risk of (cross-)contamination, in particular by bacterial hazards. Existing guidelines for markets or relevant settings include water use, but not usually in risk-benefit relation to water efficiency.

As part of a symposium on risk-based water reuse guidelines and applications, this presentation will cover practical examples of water-related contamination pathways and risk, as well as conditions or actions conducive to risk mitigation, in the context of traditional food markets and with a focus on fresh vegetables. Specific topics of discussion include: (a) how are common water (re)use practices in markets likely to change under water scarcity conditions? (b) how is the concentration of chemical vs. microbial hazards impacted by different water-related practices? (c) what is fit-for-purpose water quality in this context? (d) are current guidelines for food markets sufficiently clear in terms of both fit-for-purpose water (re)use in markets and sustainable water balance? What new guidelines have been developed? Case studies relevant to traditional food markets and associated supply chains in resource-scarce contexts will be used to illustrate and discuss these questions.

**S9**

### **Shelf-Stable Fermented Sausages: A Food Safety Concern?**

Dry-fermented sausages are traditional foods highly appreciated by the consumer. Dry-fermented sausages perfectly illustrate the hurdle technology (Leistner, 2000) as microbiologically stable products not requiring refrigeration. Being shelf-stable foods, their food safety relies mainly on the control of the production process, from raw materials to the post-processing. Nevertheless, in this case, it is not only necessary to inhibit the growth of pathogenic bacteria but most importantly also to achieve a sufficient inactivation of them. The traditional processing of dry-fermented sausages has evolved and keeps evolving under industrial settings linked to the market demands, costs and consumer preferences. Within the food safety management systems, the safety of modified formulations, fermentation and ripening processes need to be carefully assessed and proved.

In the last years, not only a number of alerts about the non-compliance with the food safety microbiological criteria (i.e., detection of pathogens) but several outbreaks associated with dry-fermented sausage consumption have been reported in the European Union (some recorded in the Rapid Alert System for Food and Feed, RASFF). Therefore, there is an increasing interest for food safety authorities and food business operators to better understand the current situation, the risk factors and suitable risk mitigation interventions to assure microbiological safety.

In this framework, we aim to address these issues from complementary perspectives, covering (1) the analysis of the data collected from EU member states reporting about pathogens in dry-fermented sausages (alerts, outbreaks, ...); (2) technological strategies for ensuring/improving the food safety of fermented sausages (formulation, bioprotective cultures, processing conditions, corrective storage, emerging technologies...) and (3) addressing quantitative aspects of the microbial behaviour in dry-fermented sausages with challenge testing, predictive modelling and quantitative risk assessment as useful tools and approaches to understand the relevance of the factors and design control measures.

### **Occurrence of Foodborne Pathogens in Fermented Sausages and Involvement of Fermented Sausages in Foodborne Outbreaks in the EU**

**Valentina Rizzi**

*Biological Hazards and Animal Health and Welfare (BIOHAW) Unit. European Food Safety Authority (EFSA), Parma, Italy*

At EU level, data about the contamination of food products are reported by the EU/EFTA countries to the European Food Safety Authority (EFSA) in accordance with the Directive 2003/99/EC. These data are summarised in the annual European Union One Health Zoonoses reports of EFSA and the European Centre for Disease Prevention and Control (ECDC) that describe the results of monitoring activities

carried out by the EU Member States and other reporting countries on zoonoses and zoonotic agents in animals, food and feed. Among the foods identified by the countries, fermented sausages are reported as contaminated with different zoonotic agents, mainly with *Salmonella* and *Listeria monocytogenes*. In addition, sausages have been identified as possible vehicle of infections in some foodborne outbreaks, with the main causative agent being *Salmonella*. However, the lack of detailed information on the type and characteristics of the sausages involved in the events hinders the estimation of the real contribution of this specific type of food (shelf-stable fermented sausages) to foodborne illnesses. At EU level, the notification of food products that are found to be contaminated and are traded between countries is done through the Rapid Alert System of Food and Feed (RASFF), the platform coordinated by DG SANTE of the European Commission. In this platform notifications on sausages regard mainly the contamination with *Salmonella* serovars.

### **Squeezing the Most of the Hurdle Technology to Ensure the Safety in Shelf-Stable Fermented Sausages**

**Sara Bover-Cid**

*IRTA (Institute of Agrifood Research and Technology), Food Safety and Functionality Program, Monells, Girona, Spain*

Dry-fermented sausages are traditional foods that are considered microbiologically stable thanks to the combination of antimicrobial factors (so-called hurdles). As shelf-stable foods their microbiological safety relies on (i) the control of the hygienic conditions of raw materials and processing environment to minimise the contamination by pathogenic bacteria as well as (ii) the application of a production process, from raw materials to post-processing operations, aiming not only to inhibit the growth of pathogenic bacteria but most importantly to achieve a sufficient inactivation. The traditional manufacture of dry-fermented sausages has evolved under industrial settings linked to the market demands, costs and consumer preferences. Within the food safety management systems, the impact of modified formulations and fermentation and ripening processes need to be carefully assessed and the microbiological safety of the product proved. In this respect, there is a need for food safety authorities and food business operators to better understand the risk factors and suitable risk mitigation interventions able to assure microbiological safety of dry-fermented sausages.

In this framework, the presentation will focus on the impact of technological strategies for dry-fermented sausage production on the behaviour of foodborne pathogenic bacteria. Besides the effect of the main processing parameters (determining the acidification and drying curves) and the complex interaction between factors; particular attention will be paid on emerging trends related to formulation (e.g., sodium reduction and clean labels without curing agents), the use of specific starter cultures with bioprotective effects and post-processing strategies including corrective storage, packaging and emerging technologies such as high pressure processing.

### **Contribution of Predictive Microbiology to Control Dry-Fermented Sausage Safety**

**Louis Coroller**

*LUBEM UBO University - UMT ACTIA 19.03  
ALTER'IX, Quimper, France*

Abstract not provided.

## **S10 Application of Food Allergen Risk Assessment and Management: Current Perspectives and Issues**

Food allergies were recognised as a significant, global public health issue over 25 years ago with the first FAO/WHO Consultation on allergens, which identified 8 priority allergenic foods or food groups. While this recognition implied a need to manage those allergens, the available tools severely limited what could be achieved at the time. In the intervening period, methodologies such as dose-distribution modelling have emerged and matured, together with a better understanding of the concept of tolerable risk. These developments and activities, together with the increasing global impact of food allergies on public health led to the recently concluded FAO/WHO Expert Consultation on Risk Assessment of Allergens as well as accompanying Codex activities.

The landscape of food allergen management is thus at an inflection point. The previously established practice is that allergen cross-contact is managed in a binary fashion, i.e., either allergen is potentially present or not. This binary approach, which lacked industry alignment on how it was implemented, has led to inaccurate information being passed along supply chains. It has therefore led to a disconnect between the reality of risk and precautionary allergen labelling, and contributed to the proliferation of uninformative labelling. Fortunately,

the current advent of allergen reference doses and their application in quantitative risk assessment can provide an opportunity to refresh how allergen risks are assessed and managed, but only if new tools are implemented consistently across businesses that produce food.

This session will present updates from recent food allergy-related activities within Codex committees and FAO/WHO joint expert consultations, explore tools and approaches to harmonize the data gathering process for food allergen risk assessments and their implementation, and investigate the impact on consumers with food allergy when differing risk management strategies for allergen labelling are implemented.

### **Update on FAO/Who and Codex Activities Regarding Food Allergens**

**René Crevel**

*René Crevel Consulting Ltd., Cople, United Kingdom*

Food allergens were first recognised by the Codex Alimentarius Commission (CAC) as potential hazards in food following a technical consultation by FAO/WHO in 1995. This led to the identification of 8 priority allergenic foods or food groups and the amendment of the Codex General Standard for the Labelling of Prepackaged Foods, requiring that these foods "shall always be declared."

Food allergy continued to grow as a public health issue, widening the number of regions and people affected, resulting in the CAC convening an Expert Consultation on Risk Assessment of Allergens under the aegis of FAO and WHO. This Expert Consultation was tasked with three principal objectives: (1) reviewing and, if appropriate, revising the list of priority allergens, (2) identifying thresholds for the management of priority allergens and (3) providing guiding principles for the application of precautionary allergen labelling.

The presentation will outline the recommendations put forward in fulfillment of each of those tasks and explain how they integrate to provide a robust approach to allergen risk management with a high degree of protection for allergic consumers at its core.

### **Practical Guidance on the Application of Allergen Quantitative Risk Assessment**

**Neil Buck**

*General Mills Inc., Lausanne, Switzerland*

Allergen quantitative risk assessment (QRA) can provide a better understanding of the risk presented to allergic consumers by cross-contact within supply chains, and therefore improve decision making on the use of precautionary allergen labelling (PAL). Moreover, as allergen QRA requires an understanding of the nature of cross-contact within supply chains (likelihood of allergen occurrence, physical form and distribution in affected food, unintended allergen concentration within that food), it drives improvement in the understanding of cross-contact risk and thereby increases opportunities for risk management measures that mitigate the potential allergen presence. Due to these benefits, there is a concomitant increase in both the maturity of allergen QRA techniques and the expectation by stakeholders that they should be applied by food business operators. However, to apply allergen QRA it is necessary to understand how the technique best fits within allergen control plans, and how to make decisions on variables needed to calculate exposure and risk. Unless there is a consistent approach to the application of allergen QRA across operators, the benefit to consumers in terms of an improvement in risk-based decision-making underlying PAL across the products they purchase, will not be realised. For this reason a guidance document has been constructed based on feedback from a wide stakeholder community that covers methods and decision making on the implementation of allergen QRA across both upstream supply chains, and in-house site operations, it also provides an approach to allergen QRA in the case of allergen incidents. An introduction to the guidance will be provided.

### **Impact on Consumers with Food Allergies of Differing Public Health and Industry Risk Management Strategies**

**Benjamin Remington**

*Remington Consulting Group B.V., Utrecht, The Netherlands*

Allergen reference doses and their application in quantitative risk assessment can provide an opportunity to refresh how allergen risks are assessed and managed. However, this is only possible if new tools are implemented consistently across businesses that produce food AND if public health authorities (food standards or food safety agencies) establish harmonized regulatory and risk management frameworks.

Currently there are no generally recognized international regulatory frameworks for the application allergen reference doses or management of precautionary allergen labelling (PAL). As a result, numerous widely varying risk management strategies have arisen for both daily management of operations and incident scenarios with regards to situations concerning an unintended allergen presence (UAP).

This presentation will use examples and case studies to highlight how these differing risk management strategies have been implemented across different countries/industries and examine their impact on consumers with food allergies

## S11 **Leading from the Frontline: Should Food Safety Culture Improvement Start on the Shop Floor?**

Frontline workers are considered essential in delivering food safety expectations. However, the alignment of food safety priorities between food handlers and management is critical to cultivating and maintaining a positive food safety culture. Such insights will be given from an intercontinental study focusing on Zimbabwe, Zambia, Tanzania, China and Greece. Recognising and incorporating the voice of the food handler in food safety culture strategy can therefore create stronger working relationships, improve communication streams, indicate underperforming control systems and identify workforce competencies which may otherwise be overlooked. Increasing management insight and awareness of everyday operational challenges through factory floor visits ensures that misalignment across hierarchies is reduced, food safety priorities remain consistent and improvements are duly recognised. Adopting a triangulated approach to assess hand hygiene as an essential food safety behaviour in food manufacturing facilities in Wales, will highlight strengths and weaknesses in the prevailing culture that impact management and frontline worker relationships and communication streams, demonstrating that management-frontline distance can have an adverse impact on hand hygiene practices. Snapshot audits are a good tool to use to understand the frontline voice and what they know about food safety practices and in turn this feeds into the business culture. Findings from audits demonstrate how much the frontline do and sometimes don't drive food safety culture improvements. In addition, frontline's feedback is also an engine force to prompt culture change. Preliminary findings from a study of food businesses in the United Kingdom utilising a novel real-time culture capture programme suggests that feedback from the frontline is essential to develop incremental and transitional cultural change. While businesses of different sizes often approach their food safety culture journeys differently, frontline voices are fundamental in identifying the 'right' action. Based on food workers' feedback, both incremental and transitional changes are necessary for organisational food safety culture improvement, with the weekly 'nudging' action to be especially crucial in maintaining momentum and establishing internal rhythm for consistent food safety communication.

### **Alignment of Food Safety Priorities between Food Handlers and Management is Critical to Cultivating and Maintaining a Positive Food Safety Culture**

**Pauline Spagnoli**

*Ghent University, Ghent, Belgium*

Food safety culture is crucial to an organisation's food safety performance and is a plausible direction to reduce the potential for food safety failures and assure food safety. Existing research has shown that deficiencies in food safety performance are often attributed to people characteristics. The food safety and hygiene-related behaviours, attitudes, knowledge, and perceptions of frontline workers often manifests in 'hard', tangible metrics such as food safety performance. Moreover, the decisions of these frontline workers are shaped by an organisation's food safety culture and are assumed to reflect the food safety culture at the strategic and tactical levels as both levels directly and indirectly influence how the operational level executes food safety and hygiene control activities. Therefore, the alignment of food safety priorities between food handlers and management is critical to cultivating and maintaining a positive food safety culture. Such insights will be given from findings on studies done in Zimbabwe, Zambia, Tanzania, China, and Greece. Recognising and incorporating the voice of the food handler in food safety culture strategy can therefore create stronger working relationships, improve communication streams, indicate underperforming control systems, and identify workforce competencies which may otherwise be overlooked.

### **Exploring the Role of Food Safety Culture in Supporting or Hindering Frontline Hand Hygiene Behaviour in Food Manufacturing Environments**

**Emma J. Samuel**

*ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Cardiff, Wales, United Kingdom*

In food manufacturing, frontline workers are constantly managing challenges to conducting their duties safely and productively. The working environment, production pressures, inconsistent instruction, and equipment availability for example can impact food safety decisions made in the moment. Applying a 'bottom-up' approach to

exploring hand hygiene practices in food production departments may therefore be suggestive of organisational food safety culture strengths and weaknesses that may be supporting or hindering frontline behaviour. Presenting findings from a study conducted in food manufacturing and processing facilities in Wales, hand hygiene compliance with company protocol was found to be low despite adequate handwashing equipment provision. However, consideration toward hand sink locations and accessibility did not align with frontline worker needs in practice and inconsistencies in company procedure contributed toward inadequate handwashing durations and frequencies. Senior management held unwritten expectations that food safety behaviours were routinely monitored and enforced, but seldom did subordinate managers have resources available to conduct surveillance. Discrepancies existed with regard to perceived company food safety priorities between management hierarchies indicating that communication strategies were weak. Increased management presence on the shop floor would enhance awareness of operational pressures and increase food safety accountability. From a senior management perspective, and in accordance with the Global Food Safety Initiative's food safety culture framework, improvements were necessary in dimensions associated with 'vision and mission', 'people' and 'consistency' aspects. As a consequence, frontline food safety behaviour manifested in poor 'consistency', 'adaptability' and 'hazard and risk awareness'.

### **Creating Developmental and Transitional Culture Change Using Real-Time Feedback Technology in Food Manufacturing Companies**

Sophie Tongyu Wu<sup>1</sup>, Lone Jespersen<sup>2</sup> and Carol Wallace<sup>1</sup>

*<sup>1</sup>University of Central Lancashire, Preston, United Kingdom, <sup>2</sup>Cultivate Food Safety, Hauterive, Switzerland*

Frontline food workers are key players in producing safe foods; being on the shopfloor for daily operations, they often have clearer vision of factory reality than people higher up in the hierarchy. However, food workers' feedback is not fully valued, utilised, and integrated for business insight and decision-making. Moreover, despite the rising popularity of the "nudging" theory in prompting behavioural change in recent decades, there are no empirical data in the food industry on how it is applied, how it could impact employees' behaviours and company actions, and influence organisational culture. Using validated, real-time machine-learning-based technology and method triangulation, this project collects organisation-wide feedback from every employee in ten UK food manufacturing companies through "one question per day," as a way to measure internal food safety culture, develop targeted actions, and assess the impact of those actions in a weekly change cycle, with the aim to continually improve food safety culture. Preliminary findings indicate that feedback from the frontline is essential to identify and develop developmental and transitional cultural change, and both types of change are necessary for organisational food safety culture improvement. Weekly "nudging" action is effective in keeping food safety among the company priorities and maintaining momentum and establishing internal rhythm for consistent food safety communication on site. While businesses of different sizes may approach their food safety culture journeys differently, frontline voices are fundamental in identifying the "right" action.

## S12 **Biofilm Formation by Food-Associated Bacteria – Friend or Foe?**

Biofilms are highly structured multicellular communities, which allow bacteria to successfully adapt and survive in hostile environments. Biofilm formation has been extensively related with the hygienic problems in the food industry as well as clinical settings. nonetheless, it becomes increasingly clear that in certain conditions biofilm formation could help in improving food quality and functionality. for instance, the probiotic biofilms' field is continuously developing since it has been lately related to positive microbiota promoting body healthiness and well-being. Therefore, possible manipulations of the microbiome composition of a host organism, specifically through consuming probiotic or synbiotic foods, become a potential remedy.

The proposed session will be dedicated to biofilm formation by the food-associated species, with special attention to the role of biofilms in developing novel probiotic formulations as well as probiotic food for potential application in clinical dietetics as well as agriculture and food industry.

## Positive Biofilms to Guide Surface Microbial Ecology

Romain Briandet

*INRAE, Jouy-en-Josas, France*

Biofilms are dynamic habitats that constantly evolve in response to environmental fluctuations and thereby constitute remarkable survival strategies for surface microbial communities. The modulation of biofilm functional properties is largely governed by the active remodelling of their composition and three-dimensional structure and involves an arsenal of microbial self-produced components and interconnected mechanisms. Beneficial bacteria able to guide surface microbial ecology to limit microbial pathogens settlement are promising tools that could complement existing biosecurity practices. This contribution will provide examples of in-used and envisioned applications of positive biofilms to battle pathogens and an overview of the associated modes of action.

## Cheese Smear or the Ancestral Cultivation of a Beneficial Biofilm

Emmanuelle Arias

*Agroscope, Bern, Switzerland*

Cheese smear is a biofilm created by regular brushing of cheese surface in ripening cellars. This process enables bacteria to outcompete molds that are more adapted to this acidic habitat. Cheese smear is by essence a friend, as it has been and still is cultivated through daily laborious work. It plays multiple roles for cheese quality, going from prevention of water loss through formation of aroma compounds, including a substantial contribution to food safety as shown in the last decades.

Numerous studies indeed showed that a mature biofilm can prevent the colonization by pathogens such as *Listeria monocytogenes*. NGS data give us today a more exhaustive view of the diversity of smear biofilms. Cheese smear contains up to 80 bacterial species with 20-30 species coexisting at dominant level. The antagonistic behavior is likely to act at various levels, ranging from competition for essential nutrients to production of antagonistic compounds. Our current work focuses on the detection of the key players. Inoculation of soft smear cheeses with three antagonistic species reduced or prevented the colonization of the cheese surface by the surrogate *Listeria innocua*, depending on the level of contamination.

Cheese smear biodiversity is one of the hurdles that enables the safe production of raw milk cheeses. Detection of the key players will help improve the safety of smear cheeses that harbor less bacterial diversity e.g., following heat treatment of the milk.

## Role of Biofilm Formation in Developing the Synbiotic Food Promoting Wellbeing and Health

Satish Kumar Rajeskkhaan

*Agricultural Research Organisation, Rishon LeZion, Israel*

Prebiotic food substances often induce the successful establishment of commensal microbiota, whose interrelationships with the host are complex and multidirectional. Predominantly, the healthy microbiota fosters the digestion of food and may boost the innate and adaptive immune system's functionalities. Therefore, live probiotic bacteria, for instance, probiotic *Bacilli* obtained together with prebiotic food, can help stimulate health in humans. Nonetheless, preserving the efficacy of probiotic *Bacilli* exhibits challenges that need to be addressed towards developing novel probiotics and synbiotic products. In this regard, the biofilm-inspired encapsulation could be applied to protect probiotic *Bacilli* coping with different environmental stresses. Besides, biofilm-forming *Bacilli* may mitigate pathogenic species, including their removal from the intestinal tract. Thus, we discuss how certain dietary fibers may preserve the probiotic efficacy by serving as the scaffold for probiotic *Bacilli* to colonize them through forming symbiotic inter-

actions. The fibers can essentially promote protection by encapsulating probiotic *Bacilli* against various environmental and physical stresses that might kill the free-living bacterial cells. Besides, these fibers would serve as prebiotic substances that would eventually be utilized for the proliferation of probiotic cells. It is believed that applying this conceptual idea provides a novel platform toward developing probiotic and synbiotic foods.

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## Closing Session – Food Safety in the Military Context – From Viral Reservoirs to Mobile Detection

Ulrich Schotte

*Zentrales Institut des Sanitätsdienstes der Bundeswehr, Kiel, Germany*

Infectious diseases in general and contaminated food, as well as drinking water in particular, can hardly compromise the execution of military orders. Therefore the production and supply of safe food and drinking water is essential in the military context not only at home but also during missions abroad. The Veterinary Service within the German Armed Forces maintains by order the control of production sites as well as adequate diagnostic capabilities. Due to multiple ways of contamination, the diagnostic capabilities have to complement food and drinking water microbiology by clinical microbiological methods sufficient for monitoring programs. The methods should focus on relevant bacterial, parasitic, and viral pathogens detected or excluded specifically. In the future, non-directed methods based on "Next Generation Sequencing" (NGS)-platforms can enhance the diagnostic potential through the investigation of foodborne outbreaks of unknown or new pathogens. The necessity to implement diagnostic capabilities not only in solid buildings at home but moreover in missions requires containerized laboratories and additional mobile elements, which enable the detection of selected pathogens of interest in the selected area or region.

## EU Monitoring of Foodborne Outbreaks and Foodborne Diseases in 2020 and Impact of COVID-19 Pandemic

Giusi Amore

*European Food Safety Authority (EFSA), Parma, Italy*

The annual monitoring and reporting of foodborne outbreak data to the European Food Safety Authority (EFSA) is mandatory for EU Member States (MSs), in compliance with Directive 2003/99/EC. The current system is known as European Union Foodborne Reporting System. The monitoring and reporting of human foodborne disease data from EU MSs are conducted in accordance with Decision 1082/2013/EU on serious cross-border threats to health. The EU/EEA countries report data on human cases to the European Centre for Disease Prevention and Control (ECDC) via The European Surveillance System (TESSy). Every year, EFSA and ECDC jointly produce the EU One Health Zoonoses report, which includes the results of zoonoses monitoring activities carried out in the EU. In 2020, the monitoring of foodborne outbreaks and foodborne disease surveillance in humans was impacted by the COVID-19 pandemic. To gather information on the possible impact of the pandemic on the zoonoses data collection, a questionnaire was submitted by EFSA and ECDC to the reporting countries. The answers received were used to support the interpretation of the 2020 monitoring and surveillance results. In 2020, the number of reported foodborne outbreaks dropped compared to 2019 by 47%, with implicated human cases falling by 61.3%. The EU notification rates of the reported foodborne diseases decreased from 7% to 53% in 2020 compared to 2019. These findings are mainly attributable to the indirect consequences of the COVID-19 pandemic among EU populations leading to reduced exposure of people to contaminated food and a higher under-reporting of outbreaks and human cases.

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2022

**ROUNDTABLE  
ABSTRACTS**

# ROUNDTABLE ABSTRACTS

## **RT1 COVID-19: What Have We Learned to Make Our Food Systems More Resilient in the Future?**

**Wayne Anderson**, *Food Safety Authority of Ireland, Dublin, Ireland*

**John Donaghy**, *Nestec Ltd., Vevey, Switzerland*

The globalization of food sourcing and trade, the extensive movement of people and intensive food production practices are challenging the resilience and sustainability of food systems and value chains around the world. Whilst COVID-19 is not a foodborne illness, the perception in many parts of the world was very different early on in the pandemic. International intergovernmental organizations such as FAO and WHO, supported by governments and science organizations, have made efforts to clarify the scientific insights and drive for risk-based management.

The pandemic illustrates the challenges for stakeholders to establish and communicate sound science- and risk-based information in a timely and understandable manner when confronted with a rapidly emerging issue. Additional challenges for stakeholders included organizational impacts of COVID-19 and the need to rapidly adapt and develop new ways of working to be able to discharge governance responsibilities and keep food supply chains operational.

Although the pandemic is still having a significant impact on society, it is important to start compiling and sharing the learnings from within government, industry and academics. These should be used to better manage consumer safety risks and potential disruptions of food supply chains within and across borders when faced with the next crisis, whether due to another influenza pandemic or a serious international foodborne outbreak.

This roundtable session is an initiative of the International Commission on Microbiological Specification of Foods. It brings together food professionals from around the globe representing several stakeholder groups that will share learnings from their perspectives and will discuss how these learnings are or can be used to make food safety management more resilient going forward and better control foodborne illnesses.

## **RT2 Rapid Methods and Automation in Food Microbiology, 40 Years of Developments, Promises, and Disappointments**

**Daniele Sohier**, *Thermo Fisher Scientific, Dardilly, France*

**Gary R. Acuff**, *Acuff Consulting LLC, College Station, TX, USA*

**Roy Betts**, *Science Fellow, Campden BRI, Chipping Campden, United Kingdom*

Rapid methods and automation in food microbiology has been an attractive and favorite target of research and development in food microbiology. The focus on food safety and quality and thus interest and need for testing of raw material and ingredients, in-process and finished products for microbiological contamination and chemical hazards such as allergens has never been greater. The overriding reason is the promise and prospect that better methods will result in safer foods. Over the past 40 years microbiologists have endeavored to develop new and "better" methods for enumeration and detection of organisms of concern. But what does "better" mean, Faster? More automated? More sensitive or specific? Cheaper, less user dependent, more objective? Since the 1980s, a plethora of methods based on a wide range of techniques have been introduced. Also, more recently, "culture independent" methods have been introduced to allow detection of viruses and other pathogens not detected by growth-based methods. While some of these methods have been successfully adopted by the industry and regulatory agencies, a vast majority of these methods have fallen by the wayside. A few have stood the test of time and become widely used and accepted by both industry users and regulatory authorities as definitive and trusted test methods. This roundtable is designed to develop answers to some of these questions and try to look at the future of rapid methods and automation in food microbiology. Panelists from the academia, industry, regulators and method developers will discuss test method development, evaluation, validation and use as well as try to *debate the importance of testing vis-à-vis prevention-based systems and approaches to assure food safety*. This interactive session will offer opportunity for audience participation and provide comments to develop a challenging view of microbiological testing in the food industry.

## **RT3 Methodological Considerations in the Design of Pathogen Inoculation Studies, Implications for Validity and Application of Results**

**Hélène Bergis**, *Anses, Maisons-Alfort, France*

**Luca Cocolin**, *University of Turin, Grugliasco, Italy*

**Douglas Marshall**, *Eurofins Scientific Inc., Fort Collins, CO, USA*

Pathogen contamination of human foodstuffs is relatively infrequent and usually involves very low viable cell counts. It is therefore logical that to study pathogen responses to processing and/or survival in various foods, the cells must be added artificially to the food matrix. Studies available in the literature feature a wide variety of approaches with regard to the number of pathogen strains employed, bacterial growth media used, cell suspension preparation and addition of cells to model foods (i.e., immersion, spot inoculation, spray), drying times, inoculum size, etc. Not only do these decisions have potentially significant effects on the resistance of cells to various bactericidal treatments and likelihood of survival during extended storage, but the lack of unified approach within the field also makes it very difficult to compare results from published studies or to extrapolate the applicability of laboratory work to commercial-scale production and processing environments. This roundtable will bring together experts in the field of microbial food safety to discuss the approaches that they are currently using to overcome these limitations, including discussion of the utility of harmonizing methodology and prior experiences in technology transfer to the food industry.

## **RT4 Trust, Safety and Sustainability of Food, Key in Increasing Citizen Engagement in Food Systems**

**Alice Mauchline**, *University of Reading, Reading, United Kingdom*

**Saskia Nuijten**, *EIT Food, Leuven, Belgium*

**Massimo Pettoello-Mantovani**, *European Pediatric Association (Epa-Unepsa) Union of National European Pediatric Societies and Associations, Berlin, Germany*

**Matteo Sabini**, *European Food Information Council – EUFIC, FoodSafety4EU, Brussels, Belgium*

Consumers have become active actors in the food system in the last 5 years. If in the past they were considered the last "ring" of the value chain, without having the possibility to contribute to processes involved in the design and production of food products, nowadays they have gained a relevant role and they are seen as important stakeholders by the food industry. We can only make a radical change in the food system, where ALL actors are involved and where the consumer is at the heart. More and more they are involved in activities, which help new food products to be defined and taken to the market. One example is consumer labs, an ecosystem where together with other important actors in the food system, they are asked to address issues like acceptability, willingness to pay and food culture, just to mention some of them.

This approach is rather innovative and implies that consumers are well aware of what food is and how it is produced. However, how can we make sure that consumer is properly educated and understands the system in order to contribute? We are living in a historical moment where trust in food is low, fake news are frequent, and on the other hand there are aspects related to food, such as nutritional benefits and sustainability which have attracted the attention of consumers and they are also strongly promoted by the media. In this roundtable we want to discuss about trust (how it has developed over the past years and how it affects consumer confidence), safety and sustainability of food and reconnecting consumers to their food. We will take the audience in a journey where the panelists, coming from different institutions and backgrounds will share their experience and knowledge to promote effective communication strategies to activate consumers.



**RT5**    **How Best to Leverage Partnerships in a Sea of Rapidly Evolving Technology**

**Christophe Cordevant**, *Anses, Maisons-Alfort, France*

**Barbara Gallani**, *European Food Safety Authority, Parma, Italy*

**Andreas Hensel**, *German Federal Institute for Risk Assessment, Berlin, Germany*

**Sasha Koo-Oshima**, *Food and Agriculture Organization of the United Nations (FAO), Rome, Italy*

**Eric Stevens**, *U.S. Food and Drug Administration, College Park, MD, USA*

New and emerging technologies are quickly revolutionizing the science of food safety and hold promise for improved public health outcomes. At the same time, the increasingly global nature of the food supply has created both opportunities and challenges to implement these technologies that include blockchain, big data, whole-genome sequencing and data sharing, artificial intelligence, and machine learning. One way in which national food safety control systems can harness the potential of these novel technologies is to form partnerships and other inter-governmental collaborations. Such engagement can help food safety authorities overcome barriers to using these technologies such as improvements in data sharing and harmonizing international standards. This roundtable will gather food safety experts and leaders to discuss the challenges, solutions, and benefits of a collaborative partnership approach to employing these new technologies and ultimately realizing their benefits for improved food safety and public health.

**RT6**    **Environmental Pathogen Monitoring, Prospects, Challenges and Lessons Learned**

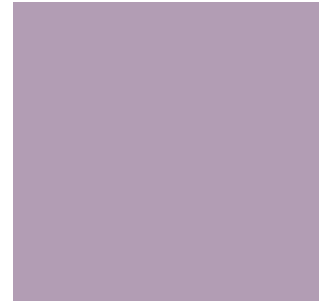
**Roy Betts**, *Science Fellow, Campden BRI, Chipping Campden, United Kingdom*

**John Donaghy**, *Nestec Ltd., Vevey, Switzerland*

**Matt Henderson**, *Land O’Frost, Inc., Munster, IN, USA*

**Anett Winkler**, *Cargill, Unterschleissheim, Germany*

Environmental pathogen monitoring (EMP) has become an important strategy in controlling pathogens such as *Listeria monocytogenes*, *Salmonella* and allergens in food factories, and in implementing prevention-based food safety assurance programs and regulatory compliance with prevention-based food safety regulations. Environmental monitoring is used as a verification activity when an environmental pathogen is identified as a hazard requiring a preventive control. It is especially useful in verifying that the control programs designed to significantly minimize or prevent environmental pathogen contamination of ready-to-eat foods are working effectively. This roundtable is designed to address key aspects of food safety issues in the processing environment, including detection and monitoring the presence of spoilage and pathogenic bacteria and allergens in the food plant environment, the role of hygienic design and effectiveness of cleaning and sanitation, sampling strategies and tools for monitoring pathogens and allergens as well regulatory compliance for controlling pathogens such as *Listeria monocytogenes* and *Salmonella* as well as the use of metagenomics as a tool in EMP. The roundtable features knowledgeable speakers from Europe and the USA to present latest information and perspectives on Environmental Pathogen Monitoring from the stand points of industry best practice for the detection, monitoring and controlling the risk of environmental pathogens and compliance with the regulatory requirements and industry certification for food safety assurance and lessons learned.



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**TECHNICAL  
ABSTRACTS**

# TECHNICAL ABSTRACTS

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## Technical Session 1 – Food Law and Regulation and Food Safety Systems

### T1-01 Development of a Framework for Evidence-based Decision Making on Dealing with Human Pathogens in the Microbiome of Leafy Greens

**Sofie Schryvers**, Liesbeth Jacxsens and Thomas De Bock  
*Ghent University, Ghent, Belgium*

**Introduction:** The washing procedure of minimally processed leafy greens remains a critical step within the production chain of leafy vegetables, as it is the only step where some reduction of the microbial load is possible. However, the wash water could act as a vector for cross-contamination. The use of chemical sanitizers in produce wash water as a means to prevent cross-contamination is divided over EU member states and regulations remain unharmonized. Here, multi-criteria decision analysis (MCDA) could serve as a decision support tool to make more evidence-informed decisions regarding this complex issue.

**Purpose:** The purpose of this research was to find out how to apply the principles of multi-criteria decision analysis in food safety risk management; apply an MCDA for the leafy greens case study.

**Methods:** The methodologies and evaluation criteria used in MCDA applications for food safety risk management were explored and assessed in a qualitative manner. These principles were applied in the leafy greens case study. Four washing methodologies, i.e. washing with potable water, wash water disinfection with NaOCl or PAA and wash water reconditioning with NaOCl, were ranked, based on an evaluation of weighted performance criteria. Belgian stakeholders' preferences were collected in an online stakeholder consultation. Information was aggregated with the PROMETHEE II algorithm.

**Results:** Stakeholder and expert input is lacking in current food safety risk management MCDA applications. Mainly deterministic methods are being used and an assessment of sources of bias and uncertainty is lacking. Weighting and quantification of evaluation criteria are standard procedure. The leafy greens case study revealed that washing with potable water, is considered the appropriate control strategy. The positive consumer perception, harmonized regulations and reduced costs in comparison to disinfection methodologies are the most important contributors towards the prime position.

**Significance:** Development of a structured and evidence-based methodology for the selection of food safety risk management options.

### T1-02 Regulatory Aspects of Novel Bio-Based Ingredients for Use in Food, Feed, Pharma and Cosmetics

**Edward L. Sliwinski**<sup>1</sup>, Rosalba Lanciotti<sup>2</sup>, Davide Gottardi<sup>2</sup>, Floriana Burgio<sup>3</sup>, Laura Suter-Dick<sup>3</sup>, Jose Luis Molto Marin<sup>4</sup>, Helena McMahon<sup>5</sup>, Jesus Rodriguez Gamero<sup>6</sup> and Kim Windey<sup>7</sup>

<sup>1</sup>EFFoST, Wageningen, The Netherlands, <sup>2</sup>UNIBO, Bologna, Italy, <sup>3</sup>FHNW, Basel, Switzerland, <sup>4</sup>Activatec, Nottingham, United Kingdom, <sup>5</sup>MTU, Tralee, Ireland, <sup>6</sup>Innoven, Verona, Italy, <sup>7</sup>Avecom, Wondelgem, Belgium

**Introduction:** The INGREEN project intends to develop functional innovative ingredients from paper and agro-food by-products for applications in food, feed, pharma, and cosmetics.

**Purpose:** The four-year project aims to promote the efficient valorisation of these side streams through sustainable and efficient tailor-made biotechnological processes, which involved the use of specific microorganisms and eco-friendly processes.

**Methods:** Different methods were used to study the nutritional composition, the bioactivity, the levels of contaminants and toxicological aspects of the starting materials (paper mill wastewater,

cheese whey, and wheat and rye bran), which were used to develop new final product applications in food, feed, pharma, and cosmetics. The composition of the new bio-based ingredients was compared with the regulatory requirements for safe use in the different application areas.

**Results:** As the starting materials, the modification processes and the final product applications are quite different, there is a wide range of regulatory requirements that need to be fulfilled. They need to address a wide range of requirements, including (i) the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), (ii) the Food Additives Legislation Guidance and EFSA requirements for novel foods, (iii) the European Environmental Agency (EEA) and ICCR Document on Principles of Cosmetic Product Safety Assessment, and (iv) EU guidelines for the presentation of data to demonstrate substantial equivalence between a novel food or food ingredient and an existing counterpart.

**Significance:** The fulfilment of these requirements is not only relevant for the authorization of the new ingredients, but also for the product claims that producers of the final products would be allowed to make. In this paper we discuss the prospects of bio-based food ingredients in relation to the current regulatory environment.

### T1-03 Regulatory Aspects of Novel Protein-Rich Products and Bio-Actives from Marine Side-Streams for Use in Fitness, Health, and Animal Feed

**Edward L. Sliwinski**<sup>1</sup>, Jose Gallego<sup>2</sup>, Leo Staccioli<sup>2</sup>, Katerina Kousoulaki<sup>3</sup>, Tone Aspevik<sup>3</sup>, Silje Steinsholm<sup>3</sup>, Tor Andreas Samuelsen<sup>3</sup>, Francisco Jose Barba<sup>4</sup>, Houda Berrada<sup>4</sup>, Emilia Ferrer<sup>4</sup>, Jose Maria Lorenzo<sup>5</sup>, Roberto Bermudez<sup>5</sup>, Miriam Pateiro<sup>5</sup>, Zoe Georgiu<sup>6</sup>, Anna Kujumdzieva<sup>7</sup> and Trayana Nedeva<sup>7</sup>

<sup>1</sup>EFFoST, Wageningen, The Netherlands, <sup>2</sup>Arditec, Nice, France, <sup>3</sup>Nofima, Bergen, Norway, <sup>4</sup>University of Valencia, Valencia, Spain, <sup>5</sup>Ceteca, San Cibrao das Vinas, Spain, <sup>6</sup>Biognosis, Volos, Greece, <sup>7</sup>Biointech, Sofia, Bulgaria

**Introduction:** AQUABIOPRO-FIT is a BBI JU Horizon 2020-funded project that develops high-quality protein-rich products and bio-actives from European aquaculture, fisheries, and agriculture side streams for applications in fitness, health and animal feed.

**Purpose:** The four-year project aims to promote the efficient utilisation of marine biomass side streams through the upconcentration and transformation of nutrients and functional compounds.

**Methods:** Different methods were used to study the nutritional composition, the bioavailability, bioactivity, and the presence of contaminants of the new proteins and bio-actives. After being tested in animal studies the new functional compounds are currently being tested in human trials. The composition of the new fish-based ingredients was compared with the regulatory requirements for safe use in human nutrition.

**Results:** A wide range of regulatory requirements needs to be fulfilled, since the raw materials and final products in the different applications are quite distinct. Results will be shown on the compliance to specific regulations for the different ingredients, their modification processes and product applications, such as: (i) the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), (ii) the Food Additives Legislation Guidance, (iii) the European Environmental Agency (EEA) and ICCR Document on Principles of Cosmetic Product Safety Assessment, (iv) the guidance on safety evaluation of sources of nutrients and bioavailability of nutrient from the sources (EC 178/2002), (v) the Food Supplements Directive (FSD) Directive 2002/46/EC.

**Significance:** The fulfilment of these requirements is not only relevant for the authorization of the new ingredients, but also for the product claims that producers of the final products would be allowed to make, which constitutes an important challenge for the industry.

## T1-04 Food Safety Culture Roadmap: From Diagnosis Towards Intervention

**Pauline Spagnoli**, Liesbeth Jaxsens and Peter Vlerick  
*Ghent University, Ghent, Belgium*

**Introduction:** Current research in food safety culture is mainly focused on assessment. However, it is important to take the next step towards food safety culture improvement.

**Purpose:** This study formulates a food safety culture diagnosis and gap analysis, as the foundation for food safety culture interventions. These are the first steps in the food safety culture improvement roadmap.

**Methods:** A conceptual framework was developed, using a literature mapping review. A mixed-method assessment was designed to evaluate a company's prevailing food safety culture's building blocks and layers. The gap analysis of a food company's food safety culture is proposed as a method for integrating and interpreting data collected in the mixed-method assessment. The mixed-methods approach and gap analysis were illustrated in a case study of a ready-to-eat meal-producing company (SME, 75 employees, 13 managers).

**Results:** The presented food safety culture conceptual framework distinguishes three key building blocks, i.e., the techno-managerial, human-individual, and human-organizational building blocks, each containing multiple dimensions. A diagnostic tool (Luning et al., 2011) was applied to evaluate the techno-managerial building block. The human-organization building block was assessed using the food safety climate self-assessment tool (De Boeck et al., 2015), a card-aided management interview, and on-site evidence collection visits (observations, interviews, and document analysis). The latter two tools are newly presented in this paper. The human-individual building block was assessed using self-assessment questions (Neal et al., 2000, Schaufeli and Van Dierendonck (2000)), complemented with four questions to evaluate knowledge objectively. The gap analysis of the mixed-methods assessment applied in the case study revealed seven important gaps. This profound diagnosis can now be applied to the development of improvement strategies, which is the final step in the improvement roadmap.

**Significance:** Through the food safety culture diagnosis, food companies can identify gaps and develop targeted food safety culture interventions.

## T1-05 Early Warning System and Prediction of Food Safety Risks

**Asli Solmaz-Kaiser** and Hakan Duman  
*iComplai UG, Garching, Germany*

**Introduction:** Increasing liberalization of the global economy has led to an increase in food imports, underscoring the importance of effective food risk management. Early warning and prediction of food hazards are critical to food safety for preventing (high-cost) product recalls and protecting consumer health.

**Purpose:** This study aimed at providing a fully-automated cloud platform for the development and use of data-driven AI-infused services, such as anomaly detection and food recall prediction, for creating a traceable, preventive and safer food risk management, from farm to fork.

**Methods:** The proposed solution leverages the use of structured and unstructured big data on food safety (i.e., over 240 million test results from 60+ online sources). Using the latest Artificial Intelligence (AI) and Machine Learning (ML) technologies, such as Natural Language Processing (NLP), data is first checked for quality and integrity, pre-processed and classified using taxonomy mapping. The prepared data is then used together with the previous 13+ billion possible historical data to train and test an AI engine coupled with an early warning system to detect anomalies, assess and foresee risks and corresponding impact. Various ML models (regression/classification) has been evaluated and the most appropriate in terms of accuracy and interpretability was selected. The AI engine trains itself continuously and improves the accuracy of the forecast quality over time.

**Results:** The use of AI-infused capabilities demonstrated measurable quantitative and qualitative results: 1) The time and consequently cost saving of a risk analyst approximates around €30k per year and person. 2) Prevention and saving of potential food recall of around €10 million.

**Significance:** The presented study enables food producers to switch from a reactive to proactive anticipation of potential food safety risks and effectively evaluate their possible effects, thereby reducing and reducing the risk of recalls and consumer health issues.

## T1-06 Data Analysis for the Identification of Emerging Food Safety Risks

Akos Jozwiak, **Zsuzsa Farkas**, Tekla Engelhardt, Erika Országh, Szilveszter Csorba and Miklós Sűth  
*University of Veterinary Medicine Digital Food Institute, Budapest, Hungary*

**Introduction:** The agri-food chain is a highly complex system, involving many actors, products, and dynamic flows. Early anticipation of emerging issues and the ability to predict risks is of vital importance. It helps to protect human, animal, and plant health and contributes to strategic planning and analysis, decision-making processes, surveillance planning, and serves as input for risk management, mitigation, and prevention measures. However, there are several factors that make this process a complex, interdisciplinary task. Risks may arise from different emerging hazards, which are well defined, yet to be examined, however, complex, driver-induced early signals and the increase of exposure for known hazards also must be considered. Timescale of the risk occurring may also vary and is often hard to estimate.

**Purpose:** Such a dynamic complexity needs also complex solutions. With the arrival of the large and growing amount of available data and advanced data analysis methodologies and tools, there is an increasing promise of achieving a deeper understanding of the food chain processes like never before.

**Methods:** A systematic approach, that accounts for these difficulties regarding emerging risk identification has been elaborated and used in practice. The application of different data analytical methodologies, referred to as knowledge-based analyses will be presented:

- Text mining and topic detection methodologies for analysing food safety news
- Different approaches for network analysis (structural hole analysis, Bray-Curtis analysis) of patent databases

**Results:** Besides the theoretical background itself and the practical examples of emerging risk identification, the identified emerging risks will be presented.

**Significance:** These methodologies help us to acquire valuable insight out of a very noisy and biased environment, leading to better preparedness for emerging food safety risks and decision-making.

## Technical Session 2 – General Microbiology and Molecular Analytics, Genomics and Microbiome

### T2-01 Emetic *Bacillus cereus* – A Potential Risk for Plant-Based Dairy Alternatives

**Alina Kyrylenko**<sup>1</sup>, Robyn T. Eijlander<sup>1</sup>, Jiansheng Wang<sup>2</sup>, Giovanni Alliney<sup>2</sup> and Marjon H. J. Wells-Bennik<sup>1</sup>  
<sup>1</sup>NIZO Food Research, Ede, The Netherlands, <sup>2</sup>Wageningen University & Research, Wageningen, The Netherlands

**Introduction:** Consumers' demand for plant protein-based foods is rapidly increasing as part of a sustainable and healthy diet. Formulations of such products include a wide array of new plant protein ingredients with chemical, nutritional, and microbiological compositions different from animal protein-based products. Understanding these differences is crucial for controlling microbial safety and spoilage risks throughout the production chain of these products.

**Purpose:** The aim of this study was to assess the levels and types of microbial contaminants in 41 different plant-based ingredients with a focus on spore formers and to evaluate the toxicogenic potential of isolated *Bacillus cereus* strains.

**Methods:** Microbial loads in pea, mung bean, fava bean, chickpea, oat, cashew, almond and coconut-based ingredients were determined using plate counting methods. Predominant bacterial species were identified by 16S rRNA and MALDI-TOF analysis. Bacterial isolates confirmed as *Bacillus cereus* were evaluated for *hbl*, *nhe*, *cytK* and *ces* gene presence using PCR. The ability of a psychrotolerant *Bacillus weihenstephanensis* strain to grow and produce the emetic toxin was subsequently evaluated in coconut and oat/pea drinks and in semi-skimmed milk (reference) at 12°C and at 30°C. Cereulide levels were determined using LC/MS-MS analysis.

**Results:** *Bacillus licheniformis* and *B. cereus* were dominant species detected in 38 out of 41 studied ingredients. Of 115 *B. cereus* isolates, 75% harboured *nhe* genes, 41% *cytK*, 25% *hbl* and 13% were *ces*-positive with the potential to produce cereulide. In 9% of all isolates no toxin genes were detected. All drinks supported growth and cereulide formation by the *B. weihenstephanensis* strain, with significantly lower toxin levels at 12°C than at 30°C.

## \* Student Award Competitor

**Significance:** These findings provide valuable knowledge related to potential risks of toxin production by spore formers in novel plant-based products, pointing out that adequate microbial control strategies must be in place to prevent the presence and outgrowth of such bacteria in finished products.

## T2-02\* Indole and Mucin Regulating Sporulation, Biofilm Formation and Virulence Gene Expression of Foodborne *Clostridium perfringens*

Chao Wang<sup>1</sup>, Tom Defoirdt<sup>2</sup> and Andreja Rajkovic<sup>1</sup>

<sup>1</sup>Laboratory of Food Microbiology and Food Preservation, Department of Food Technology, Safety and Health, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium, <sup>2</sup>Center for Microbial Ecology and Technology, Department of Biotechnology, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium

**Introduction:** *C. perfringens* enterotoxin (CPE) infection is contributed to be top of the list of foodborne outbreaks for several countries. Although many compounds have been identified to regulate toxin production in *C. perfringens*, the role of naturally existing indole and mucin in the intestine has not been well-studied.

**Purpose:** To investigate the role of indole and mucin on *C. perfringens* sporulation, biofilm formation, virulence gene expression and CPE formation.

**Methods:** The sporulation and biofilm formation of *C. perfringens* LMG 453 were induced in mDSM with 400 mM indole and 240 mg/L mucin; also, the expression level of eight relevant virulence genes was assessed during sporulation (from 6h, 12h and 24h) and biofilm formation (both planktonic cells (PC) and biofilms (BF) at 48h), respectively. The level of biofilm formation was determined by 0.1% crystal violet. Moreover, the effect of indole and mucin on CPE production at different time points was examined by the CPE-RPLA kit.

**Results:** Biofilm formation was enhanced by indole ( $P < 0.0001$ ) and mucin ( $P < 0.0001$ ), meanwhile, the impact of mucin was more significant ( $P < 0.0001$ ) than indole. The expression level of *cpe* was not regulated by indole and mucin during sporulation; this gene was downregulated in PC and upregulated by mucin in BF during biofilm formation. Transcriptional regulator gene *abrB* expression increased in the presence of mucin at 6h but reduced at 12h and 24h, while it increased in both PC and BF. The collagenase gene *colA* was decreased at 12h and 24h sporulation but significantly increased in BF and kept the same level in PC. CPE was positive(+) after 7h sporulation with and without indole, while CPE was strong positive (+++) after 6h sporulation with mucin.

**Significance:** Indole and mucin can influence CPE production and other selected virulence genes through regulating sporulation and biofilm formation of *C. perfringens*, which offers new horizons to manage this pathogen.

## T2-03 Is *Bacillus thuringiensis* a Species of the *Bacillus cereus* Group Like Any Others?

Clement Trunet<sup>1</sup>, Alexandra Cauquil<sup>2</sup>, Nolwenn Hymery<sup>3</sup>, Marie-Hélène Guinebretière<sup>4</sup>, Florence Postollec<sup>5</sup> and Louis Coroller<sup>1</sup>

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**Introduction:** *B. thuringiensis* (Bt) is a spore-forming bacterium producing a protein crystal that has insecticide power. Bt belongs to *Bacillus cereus* group (Bc group), some strains are used as an agent to eliminate insects.

**Purpose:** The aim of this study was to characterize the phenotype of 90 strains belonging to Bc group, half of them were Bt. Knowing that Bt strains belong to different phylogenetic Bc groups, do Bt strains have the same phenotype than other Bc group strains?

**Methods:** Five phenotypic parameters have been estimated for 90 strains from Bc group, including 43 Bt. The growth boundary and optimal growth temperature were estimated by cultural methods. Cytotoxicity was tested on Caco-2 cells with supernatants obtained at early stationary phase, at optimal growth temperature and 37°C. The heat resistance of spores obtained at optimal growth temperature were estimated from survival kinetics at 90°C and 95°C. All the data set was processed by principal component analysis.

**Results:** This analysis revealed 53% of the variance of the profiles corresponded to factors linked to growth, heat resistance and cytotoxicity. The phenotype profiles followed the phylogenetic groups as already proposed by Guinebretiere et al. (2008). The group VI

encompassed the most psychrotrophic strains, with the less resistant spores. The strains of group VII were the most thermotropic, highly heat resistant and highly cytotoxic. The other groups were mesophilic and showed a median heat resistance. No differences could be pointed out between the studied strains of Bt and the other tested species of the Bc group. The bio-insecticide commercial strains were mesophilic with low heat resistance.

**Significance:** These data give insight on the diversity of Bt among Bc group strains and a first approach to characterize the risk of food poisoning associated with this species. This study is part of BtID project, supported by the French ministry CASDAR program.

## T2-04 Whole Genome Sequencing of *Listeria monocytogenes* for Outbreak Investigation

Larissa Murr, Nancy Bretschneider, Melanie Pavlovic, Mareike Wenning, Ulrich Busch and Ingrid Huber  
Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit, Oberschleißheim, Germany

**Introduction:** Consumption of food contaminated with the pathogen *Listeria (L.) monocytogenes* can cause listeriosis, one of the most serious foodborne diseases worldwide. Therefore, surveillance of *L. monocytogenes* represents a major task for food safety authorities.

**Purpose:** The talk aims to provide insights in molecular characterization and outbreak analysis of *L. monocytogenes* isolates from food and food production plants collected within the official control of foodstuffs at the Bavarian Health and Food Safety Authority.

**Methods:** Whole genome sequencing (WGS) of 260 *L. monocytogenes* isolates was performed using Illumina technology. Phylogenetic relationships of potential outbreak isolates were investigated via 1.701 loci cgMLST and backed using SNP and pangenome analyses. For molecular characterization, the genomes were screened for genes related with persistence and virulence.

**Results:** Regarding data analysis, cgMLST proved beneficial for the identification of potential outbreak isolates. Here we show data that illustrate in which contexts SNP and pangenome analyses contributed to confirm the cgMLST results.

**Significance:** WGS enables high-resolution comparison of bacterial isolates. Optimization of the workflow is essential for the generation of reliable data, which are the basis for molecular epidemiology. Attribution of the clinical isolates to the potentially causative food by cgMLST should be verified by additional approaches covering intergenic and accessory genome regions and finally needs to match the findings of classic epidemiology.

## T2-05 *B. cereus* Can be Serious: A Comparative Evaluation of *Bacillus cereus* Group Genomic Taxonomies

Laura Carroll  
EMBL, Heidelberg, Germany

**Introduction:** Whole-genome sequencing (WGS) is being increasingly employed to characterize members of the *Bacillus cereus* group, a complex of closely related species that includes foodborne pathogen *B. cereus*, biocontrol agent *B. thuringiensis*, and bioterrorism weapon *B. anthracis*. Species-level taxonomic classification of *B. cereus* group strains is thus essential for proper communication and risk evaluation; however, numerous contemporary WGS-based *B. cereus* group taxonomies exist.

**Purpose:** The purpose of this study was to provide a large-scale comparison of contemporary *B. cereus* group genomic taxonomies.

**Methods:** Publicly available *B. cereus* group genomes ( $n = 2,231$ ) were characterized using (i) a standardized *B. cereus* group genomospecies/subspecies/biovar taxonomy proposed in 2020 (2020 GSB) via BTyper3 v3.1.0; (ii) the Genome Taxonomy Database Release 05-RS95 (GTDB R95) taxonomy via GTDB-Tk v1.3.0; (iii) the phylogenetic marker gene-based mOTU/spec taxonomies via the mOTU taxonomy database v2.5; (iv) an eight-group *panC* typing framework implemented in BTyper3; (v) seven-gene multi-locus sequence typing (MLST) via PubMLST and BTyper3.

**Results:** The 2020 GSB, GTDB R95, and mOTU/spec taxonomies partitioned the *B. cereus* group into 18, 40, and 10 genomospecies, respectively. Sequence types obtained via MLST could be used for genomospecies assignment within all taxonomies. *panC* could not be used for assignment of most GTDB genomospecies, as *panC* Groups II, III, IV, VI, and VIII encompassed multiple GTDB genomospecies. *panC* could be used for assignment of most *B. cereus* group genomospecies within the 2020 GSB and mOTU/spec taxonomies, except for (i) Groups II and VI, which could not differentiate *B. mosaicus/luti* and *B. mycoides/paramycoides* within the 2020 GSB taxonomy, respectively; (ii) Group VI, which encompassed species Clusters 328 and 329.

**Significance:** The work presented here provides a large-scale comparison of genomic taxonomic assignment tools as applied to the *B. cereus* group, which can aid scientists and other professionals in interpreting genospecies assignments across nomenclatures.

## T2-06 Genetic Diversity of Staphylococcal Strains Isolated from Food as Revealed by Whole Genome Sequencing

Marina Cavaiuolo<sup>1</sup>, Noémie Vingadassalon<sup>2</sup>, Arnaud Felten<sup>3</sup>, Yacine Nia<sup>4</sup> and Jacques-Antoine Hennekinne<sup>4</sup>

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**Introduction:** The precise identification and characterization of pathogens responsible for a food outbreak is necessary in public health and quality control in industries. *Staphylococcus aureus* is a pathogenic bacteria species that can produce toxins in food, leading to staphylococcal food poisoning outbreaks (SFPO).

**Purpose:** We used whole genome sequencing (WGS) as a tool to assess the genetic diversity of *S. aureus* strains responsible for SFPO and to profile the staphylococcal enterotoxin genes (SEs) content in these strains.

**Methods:** A collection of ~300 genomes was sequenced using the Illumina technology. This collection was composed of strains responsible for SFPO in France and isolated from food, environment or humans.

**Results:** Toxin profiles were established on 33 enterotoxin genes available in the literature by using our recently developed in-house workflow NAuRA (Nice Automatic Research of Alleles) that detects SEs genes and creates a database of toxin protein variants (Merda, et al., *Frontiers of Microbiology*, 2020). Moreover, we used single nucleotide polymorphism (SNP)-based approaches to cluster the strains responsible of SFPO into distinct genetic clusters.

**Significance:** Our results based on WGS- approaches are relevant for food safety as they i) highlight the presence of enterotoxin coding genes not currently detected by PCR tools; ii) provide new targets for the development of rapid detection methods such as liquid chromatography–mass spectrometry (LC–MS) and iii) improve typing methods of pathogenic strains to single nucleotide resolution.

## Technical Session 3 – Modeling and Risk Assessment

### T3-01\* Quantitative Microbiological Risk Assessment Model for *Campylobacter* in Raw Milk

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**Introduction:** The consumer demand for raw milk is increasing and local sales via vending machines have been intensified. Most foodborne outbreaks in Germany were caused by consumption of unboiled raw milk contaminated with *Campylobacter* in 2017, 2018 and 2020. Different mitigation options along the supply chain need to be assessed in order to reduce the public health risk associated with the consumption of *Campylobacter*-contaminated raw milk.

**Purpose:** A quantitative microbiological risk assessment (QMRA) model for *Campylobacter* in raw milk was developed to support risk managers in controlling this pathogen. Therefore, the effect of different risk mitigation scenarios along the supply chain were evaluated.

**Methods:** The QMRA is based on samples taken and analyzed from a dairy farm in Germany from 2021. The samples examined were rectal fecal samples, udder swabs, raw milk, milk filters, milking parlor swabs and boot socks. These were microbiologically analyzed for *Campylobacter*.

The developed stochastic QMRA model estimates the human exposure to *Campylobacter* from raw milk and the number of human cases. Probability distributions were used to represent the data whenever possible and probabilistic risk estimation was performed using Monte Carlo simulations.

**Results:** A baseline model was developed using the classic model for the dose-response of *Campylobacter*. Based on this model it was estimated that two cases will occur for one thousand consumed raw milk servings with a mean portion size of 250 ml. Using a novel raw milk outbreak dose-response model, 197 cases for one thousand consumed raw milk servings were predicted.

Scenario analysis demonstrated that the initial concentration of *Campylobacter* in cow faeces had the highest impact on the relative risk. Another influential parameter is the cleaning of udders. These could therefore be important targets for establishing control measures.

**Significance:** This is the first QMRA for *Campylobacter* in raw milk that explicitly includes steps for contamination during milking.

### T3-02 Overview on the Risk Assessment by the European Food Safety Authority (EFSA) of Microorganisms Intended as Novel Foods or Used in Their Production

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**Introduction:** The new Novel Food (NF) Regulation (EU) 2015/2283 applies to the placing on the EU market of foods not used for human consumption to a significant degree in the EU before May 1997. Critical regulatory advances to ensure protection of human health and consumers' interests include: [a] centralised safety evaluation by EFSA, strengthened by the Transparency Regulation (EU) 2019/1381; [b] establishment of the Union list of authorised NFs; and [c] inclusion of new NF categories and/or data protection provisions to promote innovation. Among others, "foods consisting of, isolated from, or produced from microorganisms" fall within the definition of NFs, with food enzymes of microbial origin, falling under Regulation (EC) 1332/2008, being often used in their production.

**Purpose:** Provide insight into the risk assessment (RA) of microorganisms intended as NFs or used in their production.

**Methods:** Relevant EFSA outputs and ongoing NF applications were retrieved from the EFSA Journal and Open EFSA portal in order to [a] estimate the ratio of NFs falling within the relevant categories and [b] correlate them with EFSA guidance documents on the RA of microorganisms intentionally used in the food chain.

**Results:** 63 relevant EFSA outputs and NF applications were recorded out of 153 screened. 16% correspond to NFs consisting of microorganisms and 84% to NFs produced from microorganisms or enzymes of microbial origin. Scientific requirements for the RA of microorganisms intended as NFs or used in their production are based on up-to-date methodologies (e.g., Whole-Genome-Sequence analysis) and include: [a] unequivocal taxonomic identification; [b] description of genetic modifications; [c] characterisation of functional traits of concern (antimicrobial resistance, virulence factors, toxin production); [d] antimicrobial production; and [e] absence of the production strain (viable cells and recombinant DNA) in the NF. Different approaches will apply depending on the "Qualified Presumption of Safety" status of the microbial species.

**Significance:** Raise awareness of EFSA's approach to evaluate the safety of microorganisms intended as NFs or used in their production.

### T3-03\* Development of a Quantitative Microbiological Risk Assessment (QMRA) Model for Assessing the Spoilage Risk of Cooked Ham Products Sliced at Retail

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**Introduction:** Over the last decade, food spoilage has become a major issue with approximately 1.3 billion tons of food per year lost or wasted globally due to spoilage. The control of food spoilage is a great challenge for reducing economic losses and improve efficiency within food businesses by developing a holistic quality and safety management system.

## \* Student Award Competitor

**Purpose:** To develop a probabilistic QMRA model that assess the probability of spoilage of cooked ham.

**Methods:** A survey on Lactic Acid Bacteria (LAB) concentration in non-prepackaged cooked ham at the time of slicing at retail was carried out. Data on the intrinsic factors (pH,  $a_w$ ,  $\text{NaNO}_2$  concentration) and domestic temperature conditions in Greece affecting LAB growth were also collected. By combining microbiological and sensory analysis, the consumers' perception of spoilage was evaluated. The above data were introduced to a validated model growth for LAB's growth in cooked ham in order to assess the risk of spoilage.

**Results:** A risk assessment model was developed for predicting the risk of cooked ham spoilage. The model takes into account the variability and uncertainty of all factors affecting spoilage including initial contamination level, domestic storage temperature and time and consumer perception of spoilage. The use of the developed model as the basis for an effective shelf-life assessment is demonstrated.

**Significance:** The application of QMRA to food spoilage is expected to support the FBOs in selecting an effective expiration date, leading to the maximum exploitation of the "true" product's shelf life, while minimizing the risk of spoilage.

### T3-04\* Individual Cell Based Modelling of Growing Microcolonies

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**Introduction:** Conventional bacterial growth studies employ deterministic mathematical models where large microbial populations are considered as a whole. However, individual cells show heterogeneous behavior. The heterogeneity of individual cell behavior stresses the need for stochastic modelling where single cells individuality is considered to simulate microbial growth at realistic contamination events with a very low number of cells of bacterial pathogens.

**Purpose:** To assess single-cell growth behavior and model the growth dynamics of microcolonies originating from single or a few cells.

**Methods:** Colonial growth of *Escherichia coli* cells on solid media was studied using (phase-contrast) time-lapse microscopy. Z-stacked images were acquired every 5 min for 24h. Individual images were compiled giving a sequence of frames showing the behavior of the same cell over time. Division times for 5-6 generations and growth kinetic parameters for each microcolony originating from a single cell were assessed and used for the development of stochastic models for colonial growth of single cells.

**Results:** A birth model was used to simulate the growth of microcolonies originated from a single cell based on the division times of single cells. The division times for the different generations were considered independent. Growth was predicted for 100 microcolonies using Monte Carlo simulation and the growth kinetics were compared to those derived from fitting the growth curves observed from the time-lapse microscopy. The results of the comparison reveal the relation between the division times of single cells and the growth kinetics of microcolonies.

**Significance:** The results of the present study improve understanding of the biological mechanisms behind growth dynamics of microcolonies and can lead to more accurate stochastic growth models.

### T3-05 Development of a Predictive Model for *Listeria monocytogenes* Growth in Smoked Salmon Pâté

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**Introduction:** Ready-to-eat (RTE) fish products are among the highest-risk category products regarding *Listeria monocytogenes* at the EU level. Recent studies have shown that fat content together with specific microstructural and rheological characteristics of the food matrix can enhance *L. monocytogenes* growth, thus compromising the safety of fat-containing RTE food products. Product-oriented approaches are recommended for the development of more accurate predictive microbiology models. In addition, for obtaining more representative and reliable results predictive models should be

developed using *L. monocytogenes* isolates from particular foods as these strains would be better adapted to the microecological conditions of the target food.

**Purpose:** The objective of this study was to quantify and model the kinetic behaviour of six *L. monocytogenes* strains isolated from fish products in smoked salmon pâté during storage at different isothermal conditions.

**Methods:** Challenge tests were carried out using six different strains of *L. monocytogenes*: LMG 23773, LMG 23774 (both isolated from smoked salmon), LMG 26484 (isolated from tuna salad), 12MOB101LM (isolated from hareng), 12MOB102LM (isolated from salmon) and 12MOB107LM (isolated from trout). After inoculation with ca. 100 CFU/g *L. monocytogenes*, pâté samples were stored at 2, 8, 14 and 20°C. The Baranyi and Roberts model was fitted to the obtained growth curves to estimate the kinetic parameters ( $\lambda$ ,  $\mu_{max}$ ,  $N_{max}$ ) for each strain. The effect of storage temperature on maximum growth rate ( $\mu_{max}$ ) was determined using the Ratkowsky square root model.

**Results:** Significant differences in growth kinetics were found among the different strains ( $P < 0.05$ ) at all temperatures except at 2°C. The relationship between  $\sqrt{\mu_{max}}$  and storage temperature was linear with a high  $R^2$  value ( $> 0.98$ ), indicating that the square root-type model adequately described this temperature dependence. A global theoretical minimum growth temperature for *L. monocytogenes* of -4.03°C was obtained.

**Significance:** The present study provides predictive models for the growth of *L. monocytogenes* in fish-based pâtés to support shelf life and risk assessment studies.

### T3-06 Application of Predictive Models to Assess the Shelf Life of Traditional Spanish Fermented Sausages

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**Introduction:** Predictive microbiology models are useful tools to assess and manage the growth potential of foodborne pathogens in processed and ready-to-eat (RTE) foods. This study focused on two types of traditional Spanish fermented meat sausages, "Salchichón Málaga" and "Fuet", both characterised by mild fermentation/ripening processes (final pH  $> 5.3$ ), which allow the growth and/or survival of foodborne pathogens such as *Staphylococcus aureus* and *Listeria monocytogenes*.

**Purpose:** The objective of this study was to select and apply available predictive models to estimate the growth of *S. aureus* and *L. monocytogenes* in traditional fermented meat sausages during shelf life.

**Methods:** An exhaustive systematic review was performed aiming to identify existing predictive microbial models for their application in fermented meat sausages. For that, a well-characterization of the manufacturing process and food products was carried out. The selection process of the models was based on defined criteria, i.e., microorganism, type of model, food matrix, environmental factors, effect of competing microbiota, range of applicability, validation and uncertainty assessment.

**Results:** An extensive model developed by Meijlholm et al. (2010) was found to be appropriate for predicting *L. monocytogenes* growth in the studied food products according to the aforementioned criteria. Based on model predictions at 7°C, the shelf life of fermented sausages was ca. 100 days. However, available predictive models for *S. aureus* did not accomplish with the selection criteria. An existing model was then calibrated using data obtained in similar food products. The new calibrated model did not predict growth of *S. aureus* in fermented sausages at 7°C, while at 20°C the pathogen reached the critical limit for enterotoxin production (5 log CFU/g) at 58 days of storage.

**Significance:** This study provides a systematic process based on a criteria set to properly apply predictive microbiology models to assess the shelf life of traditional fermented meat products.

## Technical Session 4 – Laboratory and Detection Methods

### T4-01 Metal Detectable Plastic Control in the Food Industry

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**Introduction:** Foreign body contamination of foods can be a safety and/or quality issue. Regardless, if food is contaminated the repercussions for the business can be expensive and damaging. Between 2010-2020 foreign body incidence in the food industry trended upwards, with metal and plastic presenting the biggest challenges (FOODAKA!).



Metal detection is a well-established and effective method for reducing the risk of metal in commercial food products. However, the metal detectability of any metal-containing foreign body will depend on many things including,

- quantity/type of metal present
- food product – size, composition
- food packaging
- detector calibration

These interfering factors are variable and often cumulative.

Consequently, metal detection systems do not give 100% security, even in the detection of metal.

Metal detectable plastics for use in the food industry have been developed with the intention that they too can be detected by metal detectors, but how detectable are they?

**Purpose:** This study provides information on the uses and limitations of metal detectable plastics to aid in the risk-based control of foreign bodies in food.

**Methods:** Six types of metal-detectable plastic used in the food industry were independently assessed for detectability by Detetriconic (using their balanced coil system, Model No. 606-250) and Mettler Toledo (using their Profile Advantage multi-frequency Metal Detector).

**Results:** The results show that the detectability of metal detectable plastics varies greatly, and that metal detectable plastic brush bristles were not detectable in the presence of food. They also show that even the best-detected metal detectable plastics needed to be over seven times the size of an iron sample to generate a similar reading.

**Significance:** If the use of metal detectable plastic equipment is deemed necessary both an understanding of the uses and limitations of metal detection technology, and the selection of equipment made of appropriately detectable materials is essential to minimise foreign body risk.

#### T4-02 Subtyping of Food-Related *Listeria monocytogenes* Strains by MALDI-TOF Mass Spectrometry

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*University of Turin, Torino, Italy*

**Introduction:** *Listeria monocytogenes* is a major food safety concern as it can grow in foods and persist in processing environments. Subtyping is crucial for understanding the adaptability and virulence of *L. monocytogenes*. Studies based on multi-locus sequence typing allowed the grouping of bacteria into clonal complexes (CCs), which comprise clusters of sequence types with a recent common ancestor. A rapid and cost-effective alternative typing method could be MALDI-TOF MS, but there are no relevant studies on its application for the differentiation of *L. monocytogenes* CCs.

**Purpose:** This study aimed to evaluate the potential of MALDI-TOF MS in discriminating the main *L. monocytogenes* CCs present in foods and processing environments.

**Methods:** Twenty-four food-related *L. monocytogenes* (CC9=10; CC31=10; CC121=4) were used for the descriptive analysis. Thirty-five strains, divided in reference (CC9=10; CC31=10) and validation (CC9=10; CC31=5) sets, were selected for the predictive analysis. After culturing in Brain Heart Infusion and Chromogenic *Listeria* Agar (Oxoid), ethanol-formic extracts of colonies were spotted (10 replicates) onto a MALDI target plate, overlaid with a saturated matrix solution and analysed on Microflex LT (Bruker). Mean spectra were subjected to descriptive statistical analyses (ANOVA, SAM, PCA, PLS-DA) on MetaboAnalyst 5.0 (<https://www.metaboanalyst.ca/>), while predictive analyses were performed on Clin Pro Tools comparing three models (GA=Genetic Algorithm; SNN=Supervised Neural Network; QC=Quick Classifier).

**Results:** ANOVA and SAM identified 9 peaks that significantly differentiated ( $P < 0.05$ ) the CCs. PCA resulted in a non-satisfactory clusterization, while PLS-DA led to a precise grouping of strains. Regarding predictive analyses, SSN model was the most performant (correct classification = 80% for CC9, 86.7% for CC31).

**Significance:** MALDI-TOF MS could be useful for a preliminary and rapid categorization into different CCs of food-related *L. monocytogenes*. Further studies including more strains and CCs are needed to increase the predictive potential of the models.

#### T4-03 Lighting up Pathogen Detection: The Use of PNA-FISH for the Detection of Pathogens in Food and Water Samples

**Laura Cerqueira**<sup>1</sup>, Montserrat Nacher-Vázquez<sup>2</sup>, Carina Almeida<sup>3</sup> and Nuno Filipe Azevedo<sup>4</sup>

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**Introduction:** Food- and water-borne pathogen outbreaks and their economic and social implications indicate an urgent need for new rapid analytical methodologies. However, the methods currently used for microbial detection do not fully answer the scientific and industrial needs, namely in terms of time-to-result, portability, ease-of-use, versatility, and price. FISH is a molecular method that uses specific probes targeting rRNA for the *in situ* identification of microorganisms. New synthetic DNA mimics, as peptide nucleic acid (PNA) are becoming more widespread in FISH methodologies, enhancing specificity of the hybridization reaction, meaning that faster applications for food and water diagnostics are now emerging.

**Purpose:** In here, several PNA-FISH methods for the detection of different food and water bacteria (e.g., *Salmonella* spp., *Legionella* spp.) are being developed.

**Methods:** After *in silico* probe design, an optimization of the hybridization conditions (temperature; formamide concentrations), was performed. To ensure specificity and sensitivity, probes have been tested against target and non-target strains. Artificially contaminated or real food and water samples were tested with the developed PNA-FISH methods and compared against standard methods.

**Results:** For *Salmonella* spp. 102/103 target strains produced positive results, while all 30 non-target strains produced negative results (99% sensitivity; 100% specificity). Enriched (BPW and RambaQUICK™, 24-48h) raw ground beef samples were used to perform PNA-FISH and the results were confirmed by ISO 6579-1:2017, with no statistically significant differences between both methods.

For *Legionella* spp., all 17 target strains produced positive results, along with 2/19 non-target probes (100% sensitivity; 88% specificity). Several filtrates of artificially contaminated water samples were used with *Legionella* spp. concentrations ranging from 10<sup>6</sup> - 10<sup>2</sup> CFU mL<sup>-1</sup>. It was possible to identify cells at the microscope from 10<sup>4</sup> CFU mL<sup>-1</sup>.

**Significance:** The optimization of these PNA-FISH methods, combined with portable visualization devices (e.g., smartphone microscope) will allow the application of versatile microbial detection solutions in different industrial settings.

#### T4-04\* Detection of the Viable But Non-Culturable State (VBNC) of *Listeria monocytogenes* and *Listeria innocua* Induced by Biocide Stress Using Raman Microspectroscopy

**Sylvain Trigueros**<sup>1</sup>, Tommy Dedole<sup>1</sup>, Thomas Brauge<sup>2</sup>, Véronique Rebuffel<sup>1</sup>, Sophie Morales<sup>1</sup>, Pierre R. Marcoux<sup>1</sup> and Graziella Midelet<sup>2</sup>

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**Introduction:** *Listeria innocua* is a Gram-positive ubiquitous bacteria, non-pathogenic, widely distributed in a range of environments (vegetation, water, soil). *L. innocua* is frequently found in the food-processing environments with other species, such as *Listeria monocytogenes*. *L. monocytogenes* is an important foodborne pathogen and the etiological agent of human listeriosis, a rare but frequently fatal disease. *L. monocytogenes* can also persist in the industrial environment and (re)contaminate food, which has already been evidenced in several epidemics. The bacterial persistence may be due to their resistance to cleaning and disinfection procedures, that may induce a viable but non-culturable (VBNC) state of bacteria. Bacteria in the VBNC state have very low metabolic activity and are not detected by standard culture-based methods. These bacteria retain the ability to recover. Raman microspectroscopy coupled with deuterium isotopic probing (Raman-DIP) offers metabolic labelling. DIP appears to be a powerful technique for the *in situ* study of bacterial metabolism, through vibrational spectroscopies.

## \* Student Award Competitor

**Purpose:** We evaluated the capacities of the Raman-DIP to discriminate between different states of viability (VC, VBNC, dead) found in *L. innocua* after biocide (P3-topactive DES) treatment.

**Methods:** We treated the bacteria with biocides used in the seafood industrial sector and we analysed their impact on bacterial viability by qPCR, PMA-qPCR, and plate count agar (total, viable and VC population respectively) and by Raman-DIP microspectroscopy. We selected different concentrations of biocide to ensure a VC/VBNC/dead population.

**Results:** Dead bacteria can't be analyzed using Raman-DIP. For viable bacteria, the Raman-DIP results showed that the VC population metabolised the isotope and showed measurable labelling, with a high C-D peak in the Raman spectra ( $2150\text{cm}^{-1}$ ), which was not the case for the VBNC state, where no labelling was observed without C-D peak on the bacteria.

**Significance:** We were able to discriminate each viability status of *L. innocua* and *Listeria monocytogenes* after a biocide stress, and use this technique to measure the viability status after application of other stresses.

## T4-05 Detection of Adulteration in Raw and Cooked Beef Using Multispectral Imaging

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**Introduction:** Nowadays major priority for food industries and authorities is food fraud control. The high price/value and continuously increasing demand of meat and ready to eat meals (containing meat) make these food categories vulnerable to adulteration. So rapid detection of such practices is of great importance for the protection of consumers.

**Purpose:** The aim of this study was the discrimination of minced beef from pork in raw and cooked samples using multispectral imaging (MSI).

**Methods:** Pork and beef were purchased five independent times (batches: b1-b5), were minced and portions of each meat type were mixed to obtain different levels of adulteration. A maximum of 9 levels with 10% increment were prepared for b2 and b3, whereas 4 levels were prepared for b1 and 6 levels for batches 4 and 5. Samples of pork (0%) and beef (100%) were added for each batch and at least 6 samples were prepared per level of adulteration/pure meat. A total of 322 images were acquired from meat samples (raw). Also, MSI data were acquired for oven cooked and pan-grilled meat samples (n=171 for each case). Subsequently, the spectral data from b2, b4, b5 were used for training and b1, b3 for external validation of the models. Partial Least Square Regression (PLS-R) was applied to data (spectral data, percentage of adulteration).

**Results:** The PLS-R models for raw, oven cooked and pan-grilled samples showed potential in predicting the adulteration level of external validation with R<sup>2</sup> values 0.907, 0.938, 0.687 and RMSE values 10.79, 8.38, 18.79%, respectively. Poorer performance was obtained when pan-grilled meat samples were used.

**Significance:** MSI appears to be a promising method for the detection of adulteration in raw and cooked minced beef. Further investigation of different machine learning approaches and food commodities would allow addressing the limitations of these methods compared to classical methods (e.g., molecular methods). This work has been funded by the project DiTECT(861915).

## T4-06 Multiplex Detection of 24 Staphylococcal Enterotoxins Using Liquid Chromatography Coupled to High Resolution Mass Spectrometry

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**Introduction:** Staphylococcal food poisoning outbreaks are caused by the ingestion of food(s) contaminated with staphylococcal enterotoxins (SEs). Among the 27 SEs described so far in the literature, only a few enterotoxins can be detected using immunoenzymatic based methods that are strongly dependent on the availability of antibodies. Liquid chromatography coupled to high-resolution mass spectrometry (LC-HRMS) has therefore been put forward as a relevant complementary method, but only for the detection of a limited number of enterotoxins.

**Purpose:** In this work, LC-HRMS was developed for the detection and quantification of 24 SEs.

**Methods:** A database of 93 specific signature peptides and LC-HRMS parameters were optimized using sequences from 24 SEs including their 162 variants. A label-free quantification protocol was established to overcome the absence of calibration standards.

**Results:** The LC-HRMS method showed high performance in terms of specificity, sensitivity and accuracy when applied to 49 enterotoxin-producing strains. SEs concentrations measured depended both on SEs type and on the *Staphylococcus aureus* strains. This study indicates that LC-MS is a relevant alternative and complementary tool to ELISA methods mainly used for SEs detection.

**Significance:** The advantages of LC-MS clearly lie both in the multiplex analysis of a large number of SEs, and in the automated analysis of a large number of samples.

## Technical Session 5 – Communication Outreach and Education, Food Safety Systems and Modeling and Risk Assessment

### T5-01\* Survey of New Zealand Poultry Consumers Handling of Raw Poultry and Food Safety Awareness to Provide Insight into Risk Factors for Campylobacteriosis

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**Introduction:** New Zealand (NZ) has a high rate of reported campylobacteriosis cases. Cross-contamination in home kitchens during poultry handling is considered to be the main factor in campylobacteriosis transmission.

**Purpose:** The main aim of this study was to measure NZ consumers' food safety awareness and self-reported food safety practices associated with handling raw poultry. This study will contribute to the existing knowledge to explain the reasons behind the increase of campylobacteriosis incidents. Findings can help inform future consumer education campaigns to help reduce the incidence of campylobacteriosis in NZ.

**Methods:** A cross-sectional survey comprised of 31 multiple-choice questions was designed, piloted, and utilised to collect information about the last time consumers purchased and prepared raw poultry at home. A street-intercept survey in public places, such as supermarkets in the Canterbury region, was used to recruit respondents for this study. A descriptive and inferential data analysis was performed, including a one-way ANOVA test used to compare the mean scored responses between the respondents among different socio-demographics.

**Results:** Overall, 301 valid responses were obtained. Scores, representing reported safe food safety practices ranged between 2 and 19 (maximum 21) with a mean score of 9.83 (standard deviation 3.50 with a standard error of 0.20). There was some variation of correctly answered questions by the respondents for food hygiene (25%), cross-contamination prevention (55%), temperature control and storage practices (49%), and food safety (52%). Approximately 30% of the respondents reported symptoms of a food-borne disease experience once to four times during the past 12 months. The study identified low adherence to current recommended food safety practices, including safe food storage and temperature control.

A further understanding of NZ consumers is needed to effectively target informed and potentially more effective consumer food safety initiatives.

**Significance:** The findings can be used to inform a communication campaign regarding food safety needs to be designed urgently in NZ to reduce the rate of campylobacteriosis.

## T5-02\* Adoption of Milk Safety Practices: Empirical Evidence from Dairy Farmers in Ethiopia

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**Introduction:** Although dairy products are nutritionally rich and play a vital role in improving food security, foodborne zoonotic diseases stemming from insufficient on-farm controls are an important global public health concern. Consequently, it is important to understand factors driving the adoption of dairy safety practices at the farm level.

**Purpose:** To identify milk safety practices implemented on smallholder dairy farms and to assess factors affecting farm-level adoption of these practices by dairy farmers in Ethiopia.

**Methods:** A semi-structured questionnaire, focus group discussions and personal observations were employed to collect quantitative and qualitative primary data from 424 randomly selected dairy farmers in five districts in Ethiopia, of which 410 were used in the analysis. A milk safety index was developed based on reported adoption of 49 recommended food safety measures (animal health, milking hygiene, milk storage, and other hygiene practices). Other collected data included household demographics, farm characteristics, and institutional services. Descriptive and inferential statistics are used to describe and compare key variables. Truncated Poisson and two-limit Tobit models are used to identify factors affecting the adoption of food safety measures.

**Results:** Smallholder dairy farms in Ethiopia adopted 60.53% of the 49 food safety measures, with considerable variation across dairy farmers. Households with more education, dairy farming experience, dairy production training, access to milk safety information, experience with milk safety inspections, and high-risk perceptions adopted significantly more food safety measures ( $P < 0.05$ ). The effect of education and experience were largely due to the use of more positive animal health practices, while dairy production training improved general hygiene. Milk safety and risk perceptions had a more general effect. Experience with inspections had a positive effect on both animal health and other hygiene.

**Significance:** The findings suggest that promoting and providing food safety training, education, and strengthening food safety inspections at the farm may improve smallholder dairy farm food safety practices in Ethiopia and other similarly situated countries.

## T5-03 Food Sector Perceptions of Using AI Technology to Support Hand Hygiene Compliance

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**Introduction:** Despite vast differences in food manufacturing and food service businesses, hand hygiene is critically important to ensure the safety of food for consumers. Food handlers indicate knowledge regarding the importance of hand hygiene and self-report the implementation of hand hygiene practices, however, such data, while informative, are not indicative of actual behaviour. Consequently, observed behavioural data is superior. Nevertheless, researcher presence in direct-observation increases reactivity-bias; conversely, covert video-observation gives unobtrusive/comprehensive data. Recent research has conducted observational studies of hand hygiene practices in food manufacturing businesses using CCTV cameras and, although findings are meaningful and useful for industry, the method is extremely time-consuming and conducting frequent and structured observation is costly. Artificial Intelligence (AI) may provide a solution by distinguishing between compliant and non-compliant hand hygiene attempts and providing real-time compliance data.

**Purpose:** There is a need to explore food manufacturing and food service sector perceptions of using AI technology to obtain real-time hand hygiene compliance data, before developing such technology.

**Methods:** In-depth interviews ( $n=12$ ) were conducted with representatives from food manufacturing and food service sectors, to explore their perceptions of using AI.

**Results:** Both sectors were supportive of the proposed technology and indicated it would be beneficial for constant monitoring, longitudinal data, informing training needs, and assessing the impact of training on behaviour. Differing opinions were expressed regarding identification of individuals. In food service, there was interest in capturing general hand washing trends; whereas, food manufacturers wanted to identify non-compliant individuals to support disciplinary action. Obtaining compliance data for different shifts in manufacturing businesses, to reward, recognise and promote compliant behaviour, may enhance the food safety culture of businesses. The technology was perceived to be particularly useful for high-risk food production environments.

**Significance:** Development of the proposed technology, informed by these findings, could single-handedly revolutionise hand hygiene compliance, thus reducing the potential risk of foodborne illness and safeguarding food manufacturing and food service sector businesses.

## T5-04 Development of a Certified Reference Material (CRM) for Staphylococcal Enterotoxin B (SEB)

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**Introduction:** Staphylococcal enterotoxin B (SEB), excreted by *Staphylococcus aureus*, is one of twenty-six known Staphylococcal enterotoxins and has a well-documented history as causative agent in food poisoning outbreaks in the EU and elsewhere. However, it has also been exploited as so-called incapacitating agent in the military sector and is explicitly regulated in the biological weapons convention.

**Purpose:** The Horizon 2020 biosecurity project EuroBioTox aims to improve the preparedness of expert laboratories to correctly detect, identify and quantify several biological toxins, among which SEB. The presentation describes key points in the development and production of a certified reference material for SEB.

**Methods:** A variety of immunochemical, mass spectrometry-based, and functional methods were applied to assess the purity and identity of the prepared recombinant SEB candidate reference material (RM). Moreover, amino acid analysis (AAA) methods based on acidic hydrolysis, liquid or gas chromatography and mass spectrometry were applied for accurate quantification of SEB.

**Results:** It could be shown that the candidate RM had a purity better than native SEB preparations that were co-analysed. Also, the identity could be confirmed by intact mass LC-MS/MS. AAA methods applied in two laboratories showed agreeing results and allowed the assignment of certified values for SEB mass fraction and mass concentration.

**Significance:** The CRM will be used for calibration of methods and assays. In addition, it can be used for quality control, in method validation studies and for establishing control charts. It will thus contribute to improving and safeguarding reliable measurements of this toxin in the areas of food safety, public health, and the military sector.

## T5-05 Data Science in Food Chain Safety Decision Making: A European Perspective

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**Introduction:** The food chain is becoming more and more complex, and a lot of various drivers have constant influence on it. Such a dynamic complexity needs also complex solutions in decision making.

## \* Student Award Competitor

**Purpose:** With the arrival of large and growing amount of available data and advanced data analysis methodologies and tools, there is an increasing promise of achieving a deeper understanding of the food chain processes like never before. However, the breakthrough solutions are still missing. Where are we in this process? What to expect and what not? The main objective of the EFSA Advisory Forum Task Force on Data Collection and Modelling was to overview the European food safety data collection and reporting processes and the data model and IT infrastructure used, from a strategic perspective, and to formulate recommendations at a strategic level.

**Methods:** The experience from the European Food Safety Authority (EFSA) Advisory Forum Task Force on Data Collection and Modelling will be shared. The Task Force collected information and expert opinion from multiple EU Member States, through several interview and workshop sessions of the Task Force, during 14 meetings over the period of September 2018 to March 2020.

**Results:** The Task Force developed 21 strategic and 25 operational recommendations in 5 key areas for future management and analysis of data. The outcomes of the discussions were published in a report according to the data-related priorities identified: data collection and reporting, data modelling, IT architecture and data analysis.

**Significance:** It is conceivable that by 2027 the EU food safety system will be a network of highly digitalised, securely connected and interoperable food safety systems at national and EU levels, opening up access to real-time data in all parts of the network. However, this transition to become a data-driven organisation implies organisational, procedural and capacity-building changes for all stakeholders. This change, already in progress throughout the EU community, involves careful expectation management and change management as well.

## T5-06 Food Safety Intervention Evaluations in Low- and Middle-Income Countries (LMICs)

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**Introduction:** Current frameworks for evaluating food safety problems in Low- and Middle-Income Countries often lead to adoption of programs that ultimately fail because they do not adequately address many of the unique institutional and cultural features of Low- and Middle-Income Countries (LMICs).

**Purpose:** This study examines features of LMICs and suggests a framework for evaluating proposed interventions to maximize the probability of adoption and sustained success in a specified country.

**Methods:** Evaluations of proposed food safety interventions typically involve, at best, a pilot project (with pathogen testing) combined with a risk assessment, and (possibly) a cost-effectiveness analysis to yield expected benefits from widespread adoption of the proposed program. This study subsumes the standard approach in a broader framework that considers institutional constraints, food system and household resilience, culture, incentives for adoption, and risk tradeoffs. The model is constructed based on an examination of literature from multiple disciplines; including risk analysis, economics, and consumer behavior.

**Results:** The resulting framework has the following broad attributes. First, there is an initial assessment of institutional capacity prior to intervention development. Intervention design and evaluation are then guided, in part, by a recursive process of examining cultural compatibility, incentive compatibility, risk tradeoffs, and newly obtained information about institutions. Finally, an implementation strategy is recommended based on similar factors.

**Significance:** The proposed framework is a first step towards formalizing what is generally understood by development specialists. Formal implementation will lead to better designed interventions, higher rates of sustainable adoption, and, ultimately, fewer foodborne illnesses in LMICs.

## Technical Session 6 – Microbial Food Spoilage and Modeling and Risk Assessment

### T6-01 Could *Listeria monocytogenes* be a Concern for an Innovative Chicken-Based Dry-Fermented Sausage?

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**Introduction:** *Listeria monocytogenes* may survive during the production process and subsequent storage of dry-fermented sausages, being a challenge for the food industry to comply with

microbiological criteria of  $\leq 100$  CFU/g in EU or not detected/25g depending on the regulatory or market requirement.

**Purpose:** To assess the behaviour of *L. monocytogenes* in two types of chicken-based dry-fermented sausages of different calibre (ST: snack-type and FT: "fuet"-type) during (1) their manufacture with or without starter culture (*Lactobacillus sakei* CTC494) and (2) the subsequent high pressure processing (HPP) and/or corrective storage period.

**Methods:** Meat batter inoculated with *L. monocytogenes* and mixed with other ingredients was stuffed into small (ST) or medium (FT) casings. ST was fermented (22°C/3d) and ripened (14°C/7d) while FT was ripened (13°C/16d). At the end of ripening, HPP (600MPa/5min) and/or corrective storage (4 or 15°C/7d) were applied. *L. monocytogenes* was periodically enumerated on Chromogenic Agar. Different predictive models available in the literature were used to simulate the pathogen behaviour.

**Results:** During manufacturing, pathogen growth was observed only for ST without starter, achieving 3.24 log<sub>10</sub> increase. Contrary, *L. monocytogenes* reductions up to 1.55 and 0.86 log<sub>10</sub> in FT with and without starter, respectively, were observed. The starter promoted pH <5.11 and undissociated lactic acid production >5.5%. In general, predictive model outputs were in good agreement (i.e.  $\pm 1$  log<sub>10</sub>) with the experimental results. HPP only caused a significant reduction of *L. monocytogenes* in ST, which showed higher a<sub>w</sub>. Regardless of temperature, corrective storage did not promote the inactivation extent of the pathogen.

**Significance:** Production process conditions and starter culture application are key factors affecting the behaviour of *L. monocytogenes* in chicken dry-fermented sausages.

### T6-02 Insights into the Use of Electrolysed Water and Metataxonomic Profiling to Extend the Shelf Life of Ground Beef

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**Introduction:** Nowadays the product losses caused by premature microbiological spoilage along meat distribution chain are still high and pose a serious sustainability issue. In this frame low initial contamination levels and the deep knowledge of meat microbiota composition are the *sine qua non* to extend its shelf life, especially in the case of ground beef.

**Purpose:** Therefore, effectiveness of pre-grinding treatment of beef with neutral-electrolysed water (EW) was here assessed on-site.

**Methods:** Hundreds of samples were collected from carcasses, cuts and ground beef in different production runs. Metataxonomic analysis targeting the 16S rRNA was coupled with plate counts and volatiliomic/spoilage profiles during shelf-life under vacuum.

**Results:** Pre-grinding immersion of meat in EW (100 ppm of free-chlorine) produced a transient decontamination, as it did not modify the microbiota composition of ground beef and its further spoilage fate. Instead, microbiological succession patterns of spoilage species and volatiliomic profiles differed significantly in relation to the production runs monitored and meat origin. Discrimination according to the origin has been further observed by profiling the microbiota of ground beef and carcasses processed in the same plant and production run, while microbiological and physical-chemical profiles did not significantly differ between batches. This fine discriminatory capability allowed to decipher which metataxonomic signatures may indicate a faster spoilage tendency from the early storage phases, namely: greater  $\alpha$ -diversity parameters and *Streptococcaceae* abundances; high co-occurring presence of *Carnobacterium-Pseudomonas* on carcasses soon after slaughtering. Moreover, the development of *Lactococcus piscium* and acetoin formation have been identified as the main shelf-life endpoint indicators in ground beef.

**Significance:** In summary, decontamination with EW did not prolong the shelf life of ground beef. On the contrary, metataxonomic-based profiling of the meat from the early productive stages might represent an effective approach to sharply discriminate between batches with faster or slower spoilage tendency.

## T6-03\* Comparative Genomics Reveals the *hyp* Gene Cluster as a Causative Function for Blown-Pack Spoilage of Vacuum Packed Meat by *Clostridium estertheticum* Complex

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**Introduction:** The spoilage of vacuum-packed meat by *Clostridium estertheticum* complex (CEC) is attributed to utilization of intramuscular carbohydrates and occurs with or without gas production, but the mechanism behind the variable gas production has not been fully elucidated. This can be attributed to unavailability of CEC genomes, which has limited the reconstruction and comparison of CEC metabolic pathways.

**Purpose:** Sequence and determine the metabolic diversity of CEC related to meat spoilage through comprehensive comparative genomics.

**Methods:** The pangenome of 50 CEC genomes was created and the presence/absence of key metabolic genes between two CEC phylogroups (PG1 and PG2) investigated. The distribution of carbohydrate-active enzymes (Cazymes), acetone-butyrate-ethanol fermentation genes and hydrogenases in *C. estertheticum* and *C. tagluense* genomes, representing PG1 and PG2, respectively, was determined. Gas production in vacuum-packed meat and utilization of different substrates at 8°C was determined amongst in-house *C. estertheticum* and *C. tagluense* strains.

**Results:** Pangenome analysis revealed eight carbohydrate metabolic genes that were only present in PG1 and identified four and one hydrogenase genes that were specific to PG1 and PG2, respectively. Detailed analysis revealed glycoside hydrolases were significantly higher ( $P < 0.05$ ) in *C. estertheticum* than *C. tagluense* and corresponded with a wider range of substrates utilized by *C. estertheticum*. Five different hydrogenase gene clusters, *hyd*, *hya*, *hyb*, *hyc* and *hyp*, were identified in both species. Phenotypic analysis revealed the inter- and intra-species variable gas production in meat by *C. estertheticum* and *C. tagluense* was associated with the distribution of the *hyp* gene cluster whose absence or presence was associated with occurrence or lack of pack distention, respectively.

**Significance:** Through comparative genomics, we have shown variable substrate utilization and gas production in CEC can be linked to variable Cazymes and the presence/absence of the *hyp* hydrogenase gene cluster, respectively.

## T6-04 Volatilomics in Tandem with Machine Learning for the Quality Assessment of Chicken Meat

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**Introduction:** The term 'volatilome' is related to all the volatile compounds (VOCs) found in an organism, an ecosystem or a food matrix. The determination of VOCs in tandem with machine learning could contribute to the rapid and reliable quality assessment.

**Purpose:** To investigate the potential of gas chromatography-mass spectroscopy (GC-MS) and e-nose in combination with different regression models to estimate the microbial load in chicken fillets.

**Methods:** Chicken fillets ( $n=120$ ) were aerobically stored at different temperature conditions (0, 5, 10 and 15°C) for specific time intervals and were microbiologically analyzed for the determination of aerobic plate counts (APC). Additionally, solid phase microextraction (SPME) combined with GC-MS and e-nose analyses were performed for the estimation of VOCs. Different machine learning regression models (Partial Least Squares, Multilinear, Bayesian, k nearest neighbors, Support Vector Machines, Random Forests and Extra Trees regression) were generated and validated to assess the correlation between GC-MS, e-nose and microbiological data. The models' performance was evaluated based on statistical indices such as the

slope of the regression line, the root mean squared error (RMSE) and the coefficient of determination ( $R^2$ ) of the linear regression between the predicted and measured APC.

**Results:** Microbial counts ranged from 3.0 to 6.7 log CFU/cm<sup>2</sup>. Results from GC-MS showed a more satisfactory model performance compared to e-nose for all tested algorithms. Tree-based algorithms (Random Forest, Extra Trees Regression) were more efficient in predicting the microbial populations both for GC-MS and e-nose as indicated by the performance indices on the validation dataset (slope: 0.98 and 0.83;  $R^2$ : 0.94 and 0.69; RMSE: 0.27 and 0.63 for the GC-MS and e-nose, respectively).

**Significance:** The combination of machine learning with volatilomics could be effectively used for the estimation of microbial population in chicken meat.

## T6-05 High Intra- and Inter-Batch Variability in Raw Pork Challenge Test Studies and Their Consequences for Model Validation Efforts: An Intricate Interplay between *L. monocytogenes*, Background Flora, and Packaging Atmosphere

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**Introduction:** As raw pork meat is an important source for *Listeria monocytogenes* contamination, research concerning the lack of insights in the growth potential of the pathogen on raw pork meat is needed.

**Purpose:** Growth potential of *L. monocytogenes* was assessed on self-cut pork chops and in-house prepared pure minced pork, both in air and in MAP (70% O<sub>2</sub>/30% CO<sub>2</sub>) packaging.

**Methods:** The challenge studies were conducted in accordance with the 2014 EURL technical guidance document for conducting shelf-life studies on *L. monocytogenes*.

**Results:** Pork chops did not support the growth of the pathogen throughout the shelf life, with growth potential values of 0.28 and 0.46 log CFU/g, respectively, under both air and MAP. Substantial growth was obtained in minced pork, with growth potential values of 1.69 and 0.80 log CFU/g, for both air and MAP. However, significant intra- and inter batch variability was observed. Maximum growth rate in minced pork at 7°C was estimated at  $\mu_{max} = 0.680$  log CFU/day and  $\mu_{max} = 0.489$  log CFU/day in air and MAP, respectively. Model validation estimating growth potential showed acceptable predictions for air-packed minced pork with better accuracy when the lag phase was implemented as indicated in the renewed EURL protocol. In MAP, all models used, including the Combase Growth model and to a lesser extent the DMRI dynamic safety model, overestimate the growth potential primarily due to a lack of CO<sub>2</sub> effect integration.

**Significance:** The predictive models used in this study do not adequately account for the dynamics in the raw pork matrix, which may have an inhibitory effect on the growth of *L. monocytogenes*, including interaction with background flora and CO<sub>2</sub>. This underscores the need to critically examine predictive model outcomes. The calculation method used for growth potential in the EURL document of 2014 masked, due to high intra- and inter-batch variability, the observed instances of elevated growth, leading to underestimations.

## T6-06 Investigating the Bottleneck of Pressure-Mediated Spore Germination-Inactivation Strategies: Properties of *Bacillus subtilis* Superdormant Spores and Potential Underlying Mechanisms

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**Introduction:** The extreme resistance of bacterial spores requires harsh conditions to directly inactivate them, often resulting in significant quality losses. An approach termed pressure-mediated germination-inactivation strategy has the potential to bridge between food quality and safety. This strategy aims to germinate spores by pressure to mitigate their resistance to inactivation processes.

## \* Student Award Competitor

However, the successful implementation of this strategy is hampered by heterogeneous germination, with some so-called superdormant (SD) spores germinating very poorly.

**Purpose:** The aim of this work was to characterize SD spores to better understand the cause of superdormancy.

**Methods:** A flow-cytometry based pipeline was developed to study heterogeneity in germination at 150 MPa/37°C. SD spores were isolated by Buoyant density centrifugation and compared to the initial dormant population. Potential structural causes of superdormancy were investigated by transmission electron microscopy ( $n > 50$ ), the water and DPA content of SD spores were determined by Buoyant density centrifugation and a terbium-fluorescence assay respectively ( $n \geq 3$ ). A potential genetic cause was investigated by resporulation, and the role of various proteins in germination was investigated by proteomic analysis ( $n = 4$ ,  $\log_2(\text{fold change}) \geq |1|$ , adjusted  $P$ -value  $< 0.05$ ) and deletion mutants ( $n \geq 3$ ).

**Results:** Four subpopulations of spores were observed after pressure germination. Superdormancy was shown to *not* be caused by visible structural changes, a reduced water content ( $33.3 \pm 0.3$  and  $32.9 \pm 0.9$  g/100 g wet weight for dormant and SD spores) or an increased DPA content ( $16.9 \times 10^{-14} \pm 2.6 \times 10^{-14}$  and  $18.3 \times 10^{-14} \pm 2.5 \times 10^{-14}$  for dormant and SD spores). A genetic change could be excluded as cause of superdormancy, while 52 proteins were identified with significantly different expression in SD spores ( $n = 4$ ). The absence of protein YhcN caused a 6x reduced germination compared to the wildtype.

**Significance:** The present work provides a comprehensive overview of pressure germination and potential superdormancy mechanisms and outlines future perspectives to advance mild spore germination-inactivation strategies.

## Technical Session 7 – Food Processing Technologies

### T7-01 Impact of Various Food Components on the STEC Inactivation Efficiency of Non-thermal Plasma

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**Introduction:** In recent years, the interest of the consumer and food industry in minimally processed products with high quality has grown. As classical heat treatment causes a significant nutrient loss, new technologies are required for obtaining sufficient microbial decontamination and subsequently food products that are safe to consume. Non-thermal plasma (NTP) as novel technology might be a solution. Even though part of the underlying processes has been revealed in recent studies, additional research is required.

**Purpose:** NTP consists of a wide range of reactive elements ( $O_3$ ,  $NO_x$ ,...). These can react with microorganisms ensuring the decontamination process, but also have affinity for biomolecules inherent to food products. This affinity might vary between types of biomolecules. As the food matrix is complex and the composition differs for all products, microbial inactivation depends on the exact product to be treated. This study investigates the degree to which the NTP inactivation of bacteria is influenced by various food components in different concentrations.

**Methods:** Multi-Hollow Surface Dielectric Barrier Discharge (MDD), operated at  $25.7 \pm 1.6$  W, was used for plasma generation. Agar plates supplemented with no, low, middle-high and/or high concentrations of casein, refined oil, stripped oil, glucose, starch and NaCl were inoculated with STEC. Recovery from treated (30 seconds, 5 standard L/min air input) and untreated plates was compared.

**Results:** All selected biomolecules induced a decrease in the NTP decontamination efficiency, although this was only significant for stripped and refined oil ( $P \leq 0.05$ ). Furthermore, this observation was more pronounced for the latter, which contained natural anti-oxidants (inactivation of  $1.0 \pm 0.2$  log and  $0.4 \pm 0.1$  log after addition of 21% of oil, respectively).

**Significance:** As certain biomolecules, mainly lipids, have a clear impact on the bactericidal effect, NTP application for e.g., high-fat products will be considerably less effective regarding (pathogen) inactivation.

### T7-02\* Different Behavior of Pathogen and Spoilage Bacteria in Response to Packaging and High Pressure Processing of Sliced Cooked Ham

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**Introduction:** High pressure processing (HPP) is a non-thermal preservation technology applied to foods in their final packaging to inactivate pathogens and spoilage microorganisms, thus enhancing safety and extending shelf life. HPP efficacy highly depends on the product characteristics, but little is known about the effect of packaging conditions.

**Purpose:** To assess the effect of different packaging systems (vacuum and modified atmosphere packaging, MAP) on the HPP-inactivation kinetics of *Listeria monocytogenes* and spoilage lactic acid bacteria in cooked ham with standard (ST) and sodium-reduced (SR) formulation.

**Methods:** *L. monocytogenes* CTC1034 and *Lactobacillus sakei* CTC746 (previously *Lactobacillus sakei*, slime producer) were inoculated on slices of cooked ham with ST and SR formulations, packaged in vacuum and MAP ( $CO_2:N_2$ , 20:80) and pressurized (400MPa/0-15min) after 1h (vacuum, MAP) or 24h (MAP-exposed). *L. monocytogenes* and *L. sakei* were enumerated on chromogenic agar and MRS, respectively. HPP-inactivation kinetics were characterized with the Weibull model.

**Results:** For both microorganisms HPP-inactivation was lower in SR than in ST cooked ham, while higher in MAP compared with vacuum packaged products. The effect of the prolonged exposure to MAP conditions (24h vs 1h) prior to HPP differed between microorganisms. In MAP-exposed samples a piezo-protective effect on *L. monocytogenes* inactivation by HPP was observed, increasing up to 26% the time needed to reduce the first log ( $\delta$ ) compared to MAP samples. On the contrary, an enhanced *L. sakei* inactivation by HPP was observed in MAP-exposed products, reducing  $\delta$  up to 65% compared to that of products pressurized 1h after MAP application.

**Significance:** Besides the influence of the product formulation, the type of packaging and the time period between packaging and HPP raise as relevant factors affecting the HPP-inactivation in cooked ham, though with different impact for the pathogen (protecting) and the spoilage (enhancing) bacteria.

### T7-03 Selection of Representative Strains of Escherichia coli O157:H7, Listeria monocytogenes and Salmonella enterica for Validation of High-Pressure Processing

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**Introduction:** High Pressure Processing (HPP) is the most widely implemented nonthermal preservation technology in the food industry. Despite decades of commercial success, process validation is still required by some regulatory agencies. However, there is no consensus on the use of representative pathogenic strains to conduct such studies.

**Purpose:** To assess the pressure resistance and adaptation phenotype of multiple strains of *E. coli* O157:H7, *L. monocytogenes* and *S. enterica* for the identification of representative strains that can be used in the validation of HPP.

**Methods:** Model solutions consisting of TSBYE adjusted to pH 6.0 and 4.5 by addition of citric acid were used to evaluate the pressure resistance (500 MPa, 1 min) and recovery patterns over 14 days at 12°C of 34 strains of *E. coli* O157:H7, 44 strains of *L. monocytogenes* and 45 strains of *S. enterica*, covering a wide genetic range. Principal component and cluster analyses identified representative strains for potential process validation.

**Results:** At pH 6.0, pressure resistance varied greatly between species and between strains of the same species. Count range given by maximum and minimum cell concentration after HPP spread between  $< 2.0$  and  $6.5$  log CFU/ml for *E. coli* O157:H7 and *L. monocytogenes*, which were the most pressure resistant species. On the other hand, 82% of *S. enterica* isolates displayed counts below the detection limit ( $< 2.0$  log CFU/ml) after HPP. Interestingly, *E. coli* O157:H7 was the only species with strains displaying counts above detection limit immediately after HPP at pH 4.5. Eventually, all strains of the three species recovered at pH 6.0 during storage at 12°C with a median count range between 8.3 and 8.9 log CFU/ml after 14 days at 12°C. Multivariate analyses served to propose strain cocktails for each species based on their pressure resistance and adaptation phenotypes.

**Significance:** The use of the strain cocktails proposed for each species would make HPP process validation more robust, as required by some regulatory agencies.

#### T7-04\* Inactivation of Vegetative Pathogens Due to Acid Exposure and High-Pressure Processing in Apple Puree

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**Introduction:** Non-thermal technologies aiming to inactivate foodborne pathogens such as high-pressure processing (HPP) allow to better preserve nutritional properties and fresh-like attributes compared to heat processing. Though HPP is being extensively used by the ready-to-eat food industry, its implementation in the infant food sector is still scarce. Being fruit purees very important in infant's diet, these products could benefit from the advantages provided by HPP.

**Purpose:** The objective of this research was to quantify inactivation and assess the sublethal injury in four strains of *Salmonella* spp. (CTC1003, GN9, GN85 and GN82) and *Escherichia coli* (LMG:2092, CTC1029, CTC1030 and CETC 5947) exposed to acidic fruit purees such as apple (pH=3.35) and/or submitted to a HPP treatment.

**Methods:** Apple puree was independently inoculated with each strain at 7-8 log CFU/g and submitted to 300MPa for 2 min. The effect of 24h-acid exposure before HPP was also evaluated. Survival and sublethal injury were quantified by plate count on TSAYE and TSAYE+4% NaCl, immediately after HPP and after 24h under refrigeration.

**Results:** Acid-exposure tended to piezo-protect *E. coli* and *Salmonella*, as the HPP inactivation was up to 1 log less compared to non-exposed. Sampling 24h after HPP caused additional inactivation and sublethal injury on the two pathogens. Moreover, higher inactivation and sublethal injury was observed in *Salmonella* (around 3 log reduction after acid-exposure and treated with HPP) than *E. coli*. The most resistant strain was *E. coli* CECT5947, showing <1 log reduction after acid-exposure and immediately after HPP.

**Significance:** The impact of HPP on the survival and sublethal injury of the evaluated pathogens highly depends on the exposure of bacteria to acid and the time after HPP before sampling, which should be taken into account by puree producers aiming to apply this technology.

#### T7-05\* Identification of *Bacillus subtilis* Spore Proteins That Influence Moderate High Pressure Germination (150 MPa)

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**Introduction:** Extremely resistant bacterial spores often require intensive food processing for their inactivation. A mild high pressure (HP) based spore inactivation strategy relies on germinating spores by HP to allow for a subsequently milder inactivation for better food quality retention. So-called 'superdormant' (SD) spores, that resist the HP germination trigger, prevent the implementation of the germination-inactivation strategy as they may germinate later during storage causing safety related issues.

**Purpose:** The present study aims at revealing proteins that influence moderate high-pressure (mHP, 150 MPa, 37°C) germination and may cause mHP superdormancy of spores.

**Methods:** SD *Bacillus subtilis* spores were isolated after a HP treatment at 150 MPa, 37°C and 4 min in ACES buffer (pH 7). The proteome of SD and untreated dormant spores was quantitatively compared using liquid chromatography mass spectrometry analysis to identify significantly differently expressed proteins in SD spores ( $\log_2(\text{fold change}) \geq 1$ , adjusted *P*-value <0.05). Five identified proteins were chosen for further analysis. Their role in HP germination was validated by assessing the HP germination capacity (150 MPa, 37°C, 3 min, ACES buffer pH 7) of deletion mutants lacking these proteins compared to a wildtype strain using flow cytometry.

**Results:** The proteomic analysis found 52 out of approx. 1500 identified proteins to be significantly differentially expressed in HP germination deficient SD spores (n=4). The HP germination capacity was reduced by a factor of 1.5±0.3 – 6.0±0.7 for strains lacking MinC, cse60, SspK or YhcN in comparison to the wildtype (n≥3). The strain lacking YfkT germinated equally well as the wildtype. Hence, for MinC, cse60, SspK and especially YhcN a role in mHP germination could be validated.

**Significance:** This study identified proteins that have not yet been associated to a decreased spore germination at mHP. Our research promotes the understanding of HP germination and the development of milder spore inactivation strategies.

#### T7-06 Germination and Outgrowth of *Bacillus weihenstephanensis* KBAB4 is Impaired by Environmental pH; A Quantitative Single Cell Analysis

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**Introduction:** Bacterial spore germination and outgrowth is known to be a highly heterogeneous phenomenon. Quantifying this heterogeneity is challenging. The study at single cell level should provide supplementary knowledge, particularly regarding the impact of unfavorable incubation conditions on the germination and outgrowth dynamics.

**Purpose:** The aim of this work was to quantify the impact of pH on spore germination and outgrowth at single cell level, investigating the behavior of individual spore crops, produced under optimal and suboptimal culture conditions.

**Methods:** Spores of *Bacillus weihenstephanensis* KBAB4, produced at optimal pH 7.4 and at pH 5.5 were incubated at 6 different pH, from pH 5.2 to 7.4. Spores were monitored using a temperature-controlled boxed incubation system for live imaging, at 30°C, and the observation was performed using a CellObserver. The images were analyzed using SporeTracker, a macro running with ImageJ designed to determine the state of single cells: dormant spores, germinated spores or vegetative cells. The impact of pH on germination and outgrowth times and rates were estimated and the correlation between these parameters were quantified.

**Results:** As expected, low pH leads to higher heterogeneity of germination and outgrowth of *Bacillus weihenstephanensis* spores. These results are consistent with previous observations at population level, now confirmed and extended to single cell level. In addition, correlation between germination and outgrowth times was significantly higher at low pH and for spores produced at low pH. These results suggest that an environmental pressure, due to low pH, highlights the heterogeneity within the spore population.

**Significance:** Single cell level analyses allows quantifying heterogeneity of spore germination and outgrowth, which is of interest in order to control the development of sporeforming bacteria, responsible for food safety issues.

### Technical Session 8 – Antimicrobials and Foodborne Pathogens Control

#### T8-01\* B-Phenylethylamine as a Natural Food Additive Shows Antimicrobial Activity against *Listeria monocytogenes* on Ready-to-Eat Foods

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**Introduction:** *Listeria monocytogenes* (*Lm*) is an important foodborne pathogen and a major cause of death associated with bacterial foodborne infections. Its control on ready-to-eat (RTE) foods remains a challenge.

**Purpose:** To evaluate β-phenylethylamine (PEA) as a potential organic antimicrobial for *Lm* control.

**Methods:** Using sixty-two clinical and food-related isolates we determined the minimum inhibitory concentration (MIC) of PEA against *Lm* in a meat simulation media, and Brain heart infusion (BHI) broth, and agar. Challenge tests using bologna-type sausage (lyoner) and smoked salmon as food model systems supplemented with PEA (0 to 20 mg/g) were done at appropriate storage (4°C) and abusive temperature (10°C) to validate the *in vitro* findings. Transcriptomics was employed to identify PEA mechanism of action. Statistical analysis of data was done using ANOVA and post-hoc tests.

**Results:** PEA had a significant (*P* < 0.05) growth-inhibitory (growth rate 0.28 in PEA [1.56 mg/mL] vs 0.31 OD<sub>600</sub>/hour in BHI) and bactericidal effect against *Lm* both in *in vitro* experiments and on lyoner and cold smoked salmon. In broth and agar, the MICs were 8 mg/mL (1/62), 10 mg/mL (57/62), and 12.5 mg/mL (4/62 strains). PEA treatment caused 0 to 2.1 log CFU and 0 to 0.35 log CFU reduction in bacterial counts at concentrations between 7.5 mg/g to 20 mg/g on lyoner and smoked salmon, respectively, in comparison to the non-PEA treated controls. Furthermore, PEA also significantly (*P* < 0.05) inhibited *Lm* biofilm formation at sub-MIC levels (3.13 and 6.25 mg/mL). PEA exposure was associated with expression induction of the cold shock protein family genes (*csp*: >2-fold change).

## \* Student Award Competitor

**Significance:** Based on good manufacturing practices as a prerequisite, PEA application to RTE products might be an additional hurdle to limit *Lm* growth in foods whereas its biofilm inhibitory effects suggest a potential role for PEA as a surface disinfectant in food processing environments.

### T8-02\* Fluorescence-Activated Cell Sorting Enables the Characterization of Sublethal Injury and VBNC State in *Listeria monocytogenes*

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**Introduction:** Exposure of *Listeria monocytogenes* to sub-lethal stressors related with food processing may induce sub-lethal injury and the viable-but-non-culturable (VBNC) state that is stochastically expressed at single-cell level, with varying resuscitation capacity.

**Purpose:** i) To outline the proportion of metabolically active, injured, VBNC and dead cells using flow cytometry and CFDA/PI staining; ii) to evaluate the physiological state and resuscitation capacity of sorted cells on agar versus Broth; and iii) to determine single-cell lag times.

**Methods:** Acetic (AA) and hydrochloric acid (HCl) (adjusted to pH 2.5-3.0; 20°C for 5h) and peracetic acid (PAA) (20, 30, 40 ppm; 20°C for 3h) were used to evaluate the induction of injury and VBNC state of *L. monocytogenes* Scott-A. To define injured (CFDA<sup>+</sup>/PI<sup>+</sup>) and VBNC (CFDA<sup>+</sup>/PI<sup>-</sup>) cells, flow cytometry coupled with CFDA (metabolically active) and PI (dead) staining was used. Stressed CFDA<sup>+</sup>/PI<sup>-</sup> or CFDA<sup>+</sup>/PI<sup>+</sup> cells were sorted on Tryptic Soy Agar or Broth supplemented with 0.6% Yeast Extract (TSAYE or TSBYE), to evaluate culturability. Resuscitation capacity was monitored by visual inspection on TSAYE and by optical density measurement on TSBYE for 5 days at 37°C. The time to detection (Td), time to reach OD 0.2, was calculated for each experiment and individual cell's lag time was determined by the formula  $lag = Td - (\log ND - \log No) / \mu_{max}$ .

**Results:** AA pH 2.8 induced VBNC state after 240min and 300min of exposure. 30% of sub-lethally injured (CFDA<sup>+</sup>/PI<sup>+</sup>) / AA-treated cells (pH 2.8) were non-culturable on TSAYE and 39% on TSBYE after incubation at 37°C for 120h. PAA 20, 30 and 40ppm induced the VBNC state. As stress intensity increased from 20 to 40ppm, the distribution of the lag times for different times of exposure presented a bimodal pattern.

**Significance:** Assessing the heterogeneity and dormancy in *L. monocytogenes* sheds light into risks of underestimation of a product's actual microbial status.

### T8-03 Impact of Disinfectants Neutralizing Buffers Used for Sampling Methods on the Viability of *Listeria monocytogenes* Cells in Monospecies Biofilm

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**Introduction:** The ready-to-eat products can be contaminated during processing by pathogen and/or spoilage bacteria, which persist in the industrial environment. To check the bacterial contamination present on the surfaces in the food processing plants, the professionals must regularly use surface sampling methods (sponge, swab, gauze pad...) to detect the pathogen such as *Listeria monocytogenes*. Due to the presence of disinfectant residues on the surface, many sampling methods are moistened in a nutrient broth combined with a neutralizing buffer to inactivate disinfectant residues that can have a slight deleterious impact on bacterial cells. This could be a source of false negatives.

**Purpose:** The objective of this study was to evaluate the impact of the neutralizing buffer on the viability of *L. monocytogenes* after sampling.

**Methods:** In this study, biofilms of *L. monocytogenes* were cultivated on stainless steel for 24 hours at 8°C or 20°C. The biofilms were treated with two different disinfectants or with sterilized water (control) and then were neutralized with 6 different commercially neutralizing buffers. The bacterial populations were detached by swab and analyzed directly after sampling and after 24 hours of incubation at

8°C to simulate the transport time before samples analysis (EN ISO 18593 standard, 2018). The analyses included agar enumeration to quantify the viable culturable (VC) population and qPCR and PMA-qPCR assays to quantify the p dead and viable populations of *L. monocytogenes*.

**Results:** This study showed that in our conditions tested, neutralizers have a variable effect depending on the type of biocide used (quaternary ammonium or hydrogen peroxide), the culture temperature and the type of neutralizer. No neutralizer systematically allowed us to enumerate only the VC population of *L. monocytogenes*.

**Significance:** The Dey-Engley and sponge neutralizer were the most suitable neutralizers in the majority of the conditions tested to enumerate the maximum of the VC cells of *L. monocytogenes* in monospecies biofilm.

### T8-04\* Targeted and Untargeted Monitoring of Pathogens Along Infant Food Processing Chain

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**Introduction:** Pathogens that persist after various stages of the process line is a crucial challenge for food industries and more specific those of infant food as the absence of them is indispensable. The focus is on infant food as it reaches a group of the population that has not yet thoroughly developed its immune system.

**Purpose:** The aim of this work was to shed light on how the untargeted metataxonomic analysis can decipher the prevalence of pathogens complementing the targeted detection of each pathogen by isolation through enrichment and Real-Time PCR approaches.

**Methods:** More than a hundred samples were collected during various infant food process runs in a commercial facility and more specifically environmental samples, raw material, intermediate and final products. On each sample, 16S rRNA amplicon-based sequencing has been performed and Amplicon Sequence Variants (ASVs) distribution was investigated. The presence of *Listeria monocytogenes*, *Bacillus cereus*, *Salmonella enterica*, *Staphylococcus aureus* and *Clostridium perfringens*, was examined before and after twenty-four hours of enrichment, with pathogens isolation and Real-Time PCR.

**Results:** Different bacterial communities have been observed in between the samples in relation to the product's composition, while less clear segregation was seen in the environment. It is worth noting that detection through metataxonomic analysis is unlikely to be sufficient for the identification of low abundant ASVs, which is the case of the pathogen. However, this does not exclude the possibility to correlate specific metataxonomic profiles with the potential presence of a pathogen.

**Significance:** Undoubtedly, when we focus only in specific targeted method, we need to consider the risk of underestimating the presence of other emerging microorganisms. This gap could be filled by the implementation of an untargeted metataxonomic technique.

## Technical Session 9 – Microbial Food Safety and Spoilage

### T9-01 Impact of pH and CO<sub>2</sub> on the Thermal Resistance of *Aspergillus niger* Spores in a Carbonated Liquid Medium

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**Introduction:** Carbonated beverages include several types of drinks, such as carbonated soft drinks and waters, beers, and sparkling wines. They are characterized by the presence of carbon dioxide (CO<sub>2</sub>), and a pH usually comprised between 2 and 6. While the CO<sub>2</sub> has firstly been added for organoleptic reasons, it might also have an impact on the resistance of spoilage microorganisms to thermal treatments. Indeed, carbonated beverages can be pasteurised (up to 70°C for 20 min). However, as far as the authors are aware, the impact of CO<sub>2</sub> on the thermal resistance of microorganisms has never been studied.



**Purpose:** The purpose of this study is to assess the impact of both pH and CO<sub>2</sub> on the thermal resistance of a mould.

**Methods:** Gas-tight "tailor-made" stainless steel tubes that can resist to pressure have been designed and produced. For each thermal treatment, Potato dextrose broth was carbonated by adding sodium bicarbonate and then inoculated with spores of *Aspergillus niger*. The thermal resistance of these spores was studied at five temperatures (49.7, 51.8, 53.8, 55.9, and 57.9°C) where a reduction was observable, 4 pH (2.8, 3.2, 3.8, and 4.1), and 6 dissolved CO<sub>2</sub> concentrations (0, 4, 4.5, 5, 6, and 7 g/L). No interactions were studied, and the central point selected was: 51 °C, pH 3.2, and 4.5 g/L.

**Results:** According to the results, the dissolved CO<sub>2</sub> concentration has a significant impact on the thermal resistance of the spores, but not the pH. Indeed, the D value (time to observe a loss of 90% of the microbial population) at 51°C with 4.5 g/L of dissolved CO<sub>2</sub> was estimated at 19.7 minutes [16.1;23.2], against 182.4 minutes [124.5;240.2] for 0 g/L.

**Significance:** Studying the impact of dissolved CO<sub>2</sub> on several spoilage microorganisms commonly found in carbonated beverages might help the industries to improve their process.

environment and on meat cuts. Some customer specifications include the absence of the pathogen in the raw material. The contamination sources and routes are complex and difficult to characterize in these plants, hindering them from drawing up adequate action plans.

**Purpose:** The purpose of this study was to investigate the *L. monocytogenes* occurrence and genetic diversity in three Belgian pork cutting plants. We specifically aim to identify harborage sites and niche locations where this pathogen might occur.

**Methods:** A total of 868 samples were taken from a large diversity of food and non-food contact surfaces after cleaning and disinfection (C&D) and during processing.

**Results:** A total of 13% (110/868) environmental samples tested positive for *L. monocytogenes*. When looking in more detail, type 3 non-food contact surfaces were contaminated more often (26%; 72/278) at typical harborage sites, such as floors, drains, and cleaning materials. Food contact surfaces (type 1) were less frequently contaminated (6%; 25/436), also after C&D. PFGE analysis exhibited low genetic heterogeneity, revealing 11 assigned clonal complexes (CC), four of which (CC8, CC9, CC31, and CC121) were predominant and widespread.

**Significance:** Our data suggest (i) the occasional introduction and repeated contamination and/or (ii) the establishment of some persistent meat-adapted clones in all cutting plants. Further, we highlight the importance of well-designed extensive sampling programs combined with genetic characterization to help these facilities take corrective actions to prevent transfer of this pathogen from the environment to the meat.

## T9-02 The Safety of Plant-based Proteins as Alternatives for Meat and Dairy Replacers

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**Introduction:** Meat and dairy products are traditionally considered important protein sources for human consumption. Consumer trends and circular agriculture have increased the demand for alternative protein sources, including plant-based proteins. Alongside the beneficial effects of a protein transition, it can also result in the emergence of food safety hazards.

**Purpose:** To identify chemical and microbiological food safety hazards of plant-based proteins using literature review and expert interviews. Given their increasing use in the European Union, the focus was on cereals, legumes, seeds, nuts, potatoes, mushrooms, and green leaves.

**Methods:** Data on the effects of plant-based protein processing and food safety were collected through literature and expert interviews (n=15). Literature was from scientific publications and reports from organizations like the European Food Safety Authority. The interviews were conducted with researchers to deduce trends, processing techniques, the safety of alternative proteins, among others.

**Results:** Typical food safety hazards related to the plant or product itself or processing are relevant to monitor in meat and dairy replacers. For example, mycotoxins, plant toxins and bioactive compounds may be present in the ingredients, while spore-forming bacteria, *Listeria* spp., and *Salmonella* spp. might be a risk after processing into plant-based proteins. In addition, given the intended increase in protein alternatives in consumers' diets, the risk of allergens is apparent; however, there are knowledge gaps on allergens in proteins as well as the effects of processing on food safety hazards.

**Significance:** Since current trends show that plant-based proteins are increasing globally, evaluating the hazards related to these proteins should take precedence in EU monitoring programs. Our findings can aid industry and governmental authorities in understanding current trends and prioritizing hazards for future monitoring.

## T9-03 Genetic *Listeria monocytogenes* Types in the Pork Processing Plant Environment: From Occasional Introduction to Plausible Persistence in Harborage Sites

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**Introduction:** Despite the efforts already made by the sector, pork processing plants are still confronted with the foodborne pathogen *Listeria monocytogenes* on the incoming carcasses, the production

## T9-04\* The Linkage between *Listeria monocytogenes* Genomic Characteristics and Their Ability to Proliferate at Low Temperature

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**Introduction:** The capabilities of *Listeria monocytogenes* to proliferate at refrigeration temperature remains a significant food safety concern and a public health issue.

**Purpose:** The research aims to gain a better understanding of the variance of *Listeria monocytogenes* in the ability to proliferate at a refrigerated temperature and their genetic profile linkage at the pangenome level.

**Methods:** A total of 150 *L. monocytogenes* isolates from various foods, food production environments, and clinical sources available at the *Listeria* collection, Teagasc Food Research Centre, Moorepark, Co Cork were assessed for their ability to grow at 4 and 7°C.

**Results:** A large variation in growth ability profiles at low temperature was observed amongst isolates and overall clinical isolates exhibited a significantly higher growth rate ( $P \leq 0.05$ ) at 7°C than the other isolates. Analysis of variance (ANOVA) tests on ability growth at cold temperature amongst CC groups revealed that CC18 isolates were significantly ( $P \leq 0.05$ ) more tolerant of cold at 4°C than CC121 and CC5 types while CC101, CC18, CC8, CC37 and CC14 were higher cold tolerance amongst other CC types at 7°C. Euclidian distance and Ward method based hierarchical clustering determined 33.33% of the isolates exhibited fast growth. Pangenome-wide association analysis identified six candidate genes that are associated with fast growth in cold conditions. Likewise, source-specific genes of thirteen dairy, eleven clinical, five environments, five meat, two seafood and one vegetable were identified.

**Significance:** In this study, the candidate genes linked to fast growth in cold conditions were characterised in depth. Results are important for refining predictive microbiology and microbiology risk management.

## T9-05 Safe Seaweed in Changing Food Systems

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**Introduction:** Seaweed can be part of the solution to feed the growing world population and can diversify our food systems. Over the last years, seaweeds have attracted attention in the West, as seen by the increasing market developments for seaweed production, especially considering its use for food and feed purposes. With the expansion of seaweed into our food systems, there is an emphasis on safe practices, including food safety and environmental safety, in the value chain.

## \* Student Award Competitor

**Purpose:** To identify (i) relevant hazards for the seaweed sector, (ii) monitoring measures and/or mitigation strategies currently implemented, and (iii) data gaps and actions needed.

**Methods:** A scientific literature review, online survey (n = 36), and industry interviews (n = 12) were conducted to identify relevant hazards. The review and interviews aimed at pinpointing current monitoring measures and mitigation strategies applied, while the survey revealed data gaps and further actions needed for the seaweed sector.

**Results:** Relevant food safety hazards include (inorganic) arsenic, iodine, and heavy metals, among others like pathogenic bacteria, while environmental hazards include microbial pathogens and parasites introduced into the ecosystem by domesticated seaweed, among others like synthetic compounds (pesticides, antifoulants, pharmaceuticals, etc.) and non-synthetic compounds (heavy metals, hydrocarbons, etc.). Mitigation strategies aimed at preventing the hazards through good hygienic or manufacturing practices, food-safe procedures or protocols, or pre-site farm selection were sometimes followed while monitoring microbial quality, product temperature, and blanching were currently practiced. Although the needs for the sector are varying, developing protocols that align with the changing food system are recommended.

**Significance:** The seaweed food system includes several stakeholders whose cumulative actions to monitor and mitigate hazards and ensure safe food are not yet well understood among one another. Our findings aim to align the sector's food safety needs.

## T9-06 Population Genetic Structure of *Listeria monocytogenes* Strains Isolated from Salmon and Trout Products and in Food Plants in France

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**Introduction:** *Listeria monocytogenes* is a ubiquitous pathogenic bacterium. Salmon and trout have been considered to be at risk from this pathogen. In 2018, the salmon production sector was affected by a multi-country outbreak of 22 listeriosis cases caused by *Listeria monocytogenes* sequence type 1247. Clonal complex (CC) 8 has been identified through whole genome sequencing (WGS) in five EU countries. Several patients have died due to the disease. This has led to several questions about the occurrence of hypervirulent or persistent CC in salmon and trout production. Knowledge of the genetic diversity of strains circulating in the salmon and trout production sector is necessary to assess the risk associated with this pathogen. Until now, no typing data have been available on strains isolated through the salmon and trout production chain.

**Purpose:** We have analysed here the genetic structure of the population of more than 700 strains of *L. monocytogenes* isolated from 2006 to 2017 imported on the French market and coming from different salmon and trout European producers.

**Methods:** The genetic structure has been described on the basis of CC of Multilocus sequence typing (MLST). Most of the CCs were obtained by mapping the PFGE profiles of the strains. Another small part of the CCs were determined in the GENOLISTERIA project. The distribution of CCs was first compared between the strains in the study and then with bibliographic and database data.

**Results:** Eleven CCs were identified with variable distribution depending on the producing country and the processing company. Overall, the two most common CCs in the salmon and trout compartments were CC121 and CC9. Two CCs (CC1 and CC6) considered as potentially dangerous because characterized as hypervirulent were identified. No CC was exclusively associated with the salmon sector.

**Significance:** This project allowed us to evaluate the diversity of CCs of *L. monocytogenes* in the salmon and trout industry and to provide strains for the GENOLISTERIA project.



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IAFP'S EUROPEAN SYMPOSIUM

— ON FOOD SAFETY —

**2022**

**POSTER  
ABSTRACTS**

# POSTER ABSTRACTS

\* Student Award Competitor

## Poster Session 1 – Communication Outreach and Education, Epidemiology, Food Chemical Hazards and Food Allergens, Food Safety Systems, Food Toxicology, Modeling and Risk Assessment, Molecular Analytics, Genomics and Microbiome, and Retail and Food Service Safety

### P1-01 Impact of Women Maternity Status on Their Food Safety Perception

Mojca Jevšnik<sup>1</sup>, Anja Česen<sup>1</sup>, Marina Šantič<sup>2</sup> and Andrej Ovca<sup>1</sup>

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**Introduction:** Pregnancy is a time when women are more sensitive to food safety issues because they are concerned about their health and that of the child. Many organisations stress the importance of educating pregnant women about food safety.

**Purpose:** The purpose of the current study is to examine the self-reported food safety knowledge and practices of pregnant women and postpartum mothers compared with nonpregnant women.

**Methods:** Cross-sectional data for this study were collected using an anonymous online questionnaire distributed to the target population. Initially, a linear snowball approach was used and because of the relatively low response rate, the questionnaire was distributed also to closed groups with pregnant women and postpartum mothers as members of the social networks.

**Results:** A total of 898 women accepted the invitation, with 426 (145 pregnant women, 191 nonpregnant women, and 90 postpartum mothers) completing the questionnaire and being included in the data analyses. The results showed that in general pregnant women performed better than the postpartum group, and both groups performed better than the group of nonpregnant women. There is no influence of maternity status on the recognition of occasions requiring hand washing and the washing technique itself, however, the largest and significant ( $P = 0.027$ ) difference is observed in relation to hand washing after handling eggs, where the nonpregnant women report much riskier practice. The media (TV, radio, magazines) was most frequently cited (63.8%) as a source of food safety information, especially by the pregnant group ( $P = 0.011$ ).

**Significance:** There is a need to develop tailored educational materials to be provided to pregnant women in parenting classes. Providing information about food safety issues through trained health workers (e.g., midwives) with credible resources is critical for consistency of messages and increasing awareness of food safety among vulnerable consumer groups.

### P1-02 The Impact of Digitizing Training Management Process, Audit, and Assessment on Approval of Food Safety Training Center and Trainers in Dubai United Arab Emirates

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**Introduction:** The Food safety department has mandated two trainings for food handlers working in food establishments in the Emirates of Dubai. To conduct these training, the food permits unit of food safety department approves training centers based on the criteria set by the department. Annually more than 100,000 food handlers get trained on best practices while operating in the food establishment, which is crucial for ensuring that the food is not contaminated at any point across the food chain

**Purpose:** The purpose of this study is to ensure the training center's provide impactful training with proper training materials and the trainers are competent to deliver training to enhance the knowledge of food handlers, therefore significantly reducing the number of violations that correlate to personnel behaviors.

**Methods:** Food safety department introduced an online digital platform called "Foodwatch" to digitalize food safety training management, approval of the training center, and the trainers. The system has completely digitalized registration, attendance, time management, location tracking etc as part of this system For approval of trainers, an assessment process have been introduced;

**Results:** The results are divided into two main factors:

*Trainers with incompetent profile:* 12.6% of applicants previously approved were without appropriate or prior food industry experience, in addition to 15.3% percent trainers that lacked educational background.

*Incompetency of training centers:* the training centers lacked proper management that lead to ineffective trainings. The main contributing factors for this were observed to be 30% training were conducted in area that lack proper training facilities, 15% training had trainees with different languages clubbed in one class conducted in one language and 25% trainings were conducted with reduced training hours.

**Significance:** The findings can be a significant enabler of future works towards improving the quality of training and compliance of training centers and trainers to significantly enhance the knowledge and competency of food handlers to ensure reduction in foodborne illness in the Emirates of Dubai.

### P1-03 Food Safety in Everyday Life for People with Intellectual Disabilities in Need of Support

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**Introduction:** People with intellectual disabilities (ID) in Sweden as well as in Slovenia live in society within their own homes, often in supported housing assisted by staff with everyday chores such as food and food handling. People with ID are a heterogeneous group, which means the need for support differs between individuals. Regardless of the need for support, their food handling and cooking are hypothetically affected by the supporting staff's personal food safety routines, attitudes, and knowledge.

**Purpose:** To investigate and compare food safety routines, attitudes, knowledge, and sources of them among staff supporting people with ID in Slovenia and Sweden.

**Methods:** Cross-sectional data were collected using an anonymous online questionnaire distributed to the target population via an email invitation. The questionnaire included 39 questions related to the staff's routines, attitudes, knowledge and sources of them but also the impact of the Corona pandemic.

**Results:** A total of 111 respondents (82 in Sweden and 29 in Slovenia) employed by public or private service providers and by nongovernmental organisations completed the questionnaire. The results are analysed as a total group and for each country separately and indicate deficiencies in staff's food safety, routines, attitudes, and knowledge i.e. about a quarter (19%), considered that all minced meat should be served cooked through. In Sweden, the most trusted source for food safety information was the National Food Authority; similar in Slovenia were reference and textbooks. The ongoing Corona pandemic has brought disadvantages such as changed food shopping routines, more frequently reported in Sweden (67%) than in Slovenia (28%). At the same time, the pandemic has implied new hygiene knowledge and routines among the staff, most reported by the Swedish (91%) but also among the Slovenian (62%) participants.

**Significance:** Deficiencies in the staff's routines, attitudes, and knowledge highlights the need for food safety education.

### P1-04\* Changing Behaviors: Educational Food Safety Intervention for Cancer Patients Receiving Treatment

Holly Paden<sup>1</sup>, Dayssy Diaz Pardo<sup>2</sup>, Erica Kim<sup>1</sup>, Anna Beery<sup>2</sup>, Ellen W. Evans<sup>3</sup> and Sanja Ilic<sup>1</sup>

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**Introduction:** Over 14 million Americans are diagnosed with cancer and have increased risk of foodborne infection, due to their immunocompromised state. The gaps in knowledge concerning their susceptibility and appropriate safe food actions have been identified. Targeted food safety education is lacking for cancer patients in treatment.

**Purpose:** To describe the development of an educational intervention utilizing the food safety risk knowledge, attitudes, and behaviors of cancer patients seeking treatment, and to evaluate its efficacy, feasibility, and acceptability.

**Methods:** In a cross-sectional study with Midwestern metropolitan hospital patients, food safety knowledge, behaviors, attitudes, and food security were assessed. The data were modelled according to the Theory of Planned Behavior to develop a targeted 10-minute food safety education program for cancer patients. The graphic design of the intervention was based on previously identified patient preferences.

**Results:** In the survey of 288 patients, 49.4% were unaware that cancer diagnosis and treatment increased their risk of foodborne infections. The awareness was addressed in 2-minute-long module including the impact of cancer therapies on immune system and the increased risk of infections. Most patients consumed high-risk salad bar items (69.1%) and cold deli meats (88.4%). A 1-minute segment details specific high-risk foods to avoid and targets these behaviors. High-risk food acquisition, like removing spoiled parts of produce (46.3%) or cooking with other people (84.9%), led to the inclusion of a module describing avoidance of high-risk practices. Food storage knowledge had the lowest knowledge score (69.53%±17.47%) and so was addressed, together with thermometer use. Follow-up surveys will be conducted 5-weeks post-intervention to assess knowledge retention and experiential sampling will measure behavior change.

**Significance:** This study will be used for up-scaling food safety education for cancer patients and will be easily administered and distributed by healthcare providers early in treatment.

**Purpose:** To support BRCS compliance and inform company food safety improvements, the purpose of this study was to explore current food safety culture in a UK-based, medium-sized, ready-to-eat food manufacturing company using document review and qualitative approaches.

**Methods:** Key documentation (e.g., job descriptions/internal audits/hygiene and training records) ( $n=15$ ) was reviewed to identify food safety references and factors associated with food safety culture. In-depth face-to-face interviews ( $n=17$ ) were conducted with key management. A content-analysis approach, structured using the Global Food Safety Initiative's five dimensions of food safety culture was adopted.

**Results:** Overall, findings identified key concerns related to 'adaptability' whereby the majority of management indicated that the company was "reluctant to change" and "did not deal with change well". In terms of 'vision and mission', it was suggested the company may "prioritize completing orders over food safety commitments". Training and education are essential to the 'people' dimension, despite the company's food safety policy stating "all employees will be fully trained and training needs will be reviewed periodically"; this was not in line with what was identified during staff interviews, the majority stated there was a "lack of training" within the company and "no refresher training".

**Significance:** Comparisons of management perceptions of food safety culture factors with company documents has enabled an in-depth exploration of the company's food safety culture. Important shortcomings relating to the dimensions of food safety culture were determined, including an inability to change and failure to deliver appropriate food safety training. Addressing these identified areas of concern will enable the company to enhance and improve food safety culture and performance.

## P1-05 Food Safety Perceptions and Practices of Parents Regarding Children's School Lunchboxes

Ellen W. Evans and Alexandra Rose  
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**Introduction:** Welsh Government guidelines indicate that primary schools should ensure that children's lunchboxes are stored away from heat and sunlight, and encourages parents to use insulated lunchboxes/bags with icepacks. Currently, data detailing the food safety perceptions and practices of parents regarding children's lunchboxes are lacking.

**Purpose:** To explore parents' self-reported practices regarding children's lunchbox preparation and to pilot a method to establish lunchbox storage temperature in schools.

**Methods:** An online questionnaire was completed by parents of children who take lunchboxes to primary school ( $n=130$ ) to establish their perceptions and practices regarding food safety. A method was developed and piloted utilising dataloggers to record internal temperatures of lunchboxes and storage areas during a school week (5 days).

**Results:** Nearly two-thirds (64%) of parents reported being concerned about food safety when preparing children's lunchboxes. A number of positive practices were self-reported, for example, 87% reported washing their hands before preparing lunchboxes and 75% reported encouraging their child/children to wash hands before eating lunch at school. More-than-half (62%) reported using insulated lunchboxes, however, only 26% reported using icepacks. Only 48% of parents knew where lunchboxes would be stored whilst in school; the vast majority of which (97%) reported lunchboxes would be stored on trolleys in corridors, cloakrooms and classrooms. Only two parents reported that lunchboxes would be stored in refrigerators. During the pilot study an insulated lunchbox (containing a sandwich, yoghurt, piece of fruit and an ice-pack), was stored in a classroom at ambient temperature (range: 17-23°C). Between arrival and lunchtime (<4 hours), internal lunchbox temperatures were consistently at unsafe temperatures (range: 12-21°C).

**Significance:** This study has addressed a research gap detailing parent's perceptions and practice regarding children's lunchboxes. Although the pilot study does not report on the core temperature of food products, it does demonstrate that children's lunchboxes are stored at unsafe temperature that can dramatically increase the growth rate of foodborne pathogens.

## P1-06 Understanding Food Safety Culture at a UK-Based Ready-to-Eat Food Manufacturing Company

Elizabeth C. Redmond and Ellen W. Evans  
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**Introduction:** Understanding food safety culture is essential within the food industry; a positive culture helps enforce positive attitudes and behaviours. Furthermore, to obtain and maintain certification against the Brand Reputation through Compliance Global Standards (BRCS) for food safety, senior management shall define and maintain a plan for improving food safety culture.

## P1-07 "I Have Never Had a Complaint from a Dog about a Dirty Bowl": Following Guidelines for Safe Handling and Preparation of Raw Meat-Based Diets for Pets

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**Introduction:** Providing raw meat-based diets to companion pets is popular in the UK. The preparation of raw diets does not involve steps to kill pathogens that may be present in raw meat and if handled improperly, may pose a risk to human health. Safe raw pet food preparation and handling guidelines developed by the UK Government and the Pet Food Manufacturer's Association, include: hand hygiene; avoiding cross-contamination; safe freezing, thawing and refrigeration; and cleaning and disinfecting.

**Purpose:** The purpose of this study was to explore the raw pet food preparation practices of pet owners, to compare practices with raw pet feeding guidelines and identify potential malpractices.

**Methods:** A netnographic analysis of posts from the "Pet Forums Community" regarding raw food diets for pets and food safety ( $n=308$ ) was performed. An online questionnaire was completed by pet owners providing raw meat-based diets to pets ( $n=174$ ). Qualitative and quantitative findings were compared to raw pet feeding guidelines.

**Results:** Whilst pet owners reported awareness of hygiene and food safety, confusion regarding appropriate practices was evident in reviewed forum posts. Although correct handwashing was self-reported by 94% of questionnaire respondents, malpractices such as not separating utensils and kitchen areas (52%); rinsing meat (27%); incorrect thawing (57%) and not washing pet bowl after each raw meal (41%) were reported. Statements indicated optimistic bias and perception of invulnerability: "It never bothers me using human plates, forks etc for dog food - I mean, I snog the dog anyway, and the washing process kills any germs."

**Significance:** Findings indicate that malpractices, which may increase the risk of foodborne illness, were reported among pet owners. Awareness of guidelines informing pet owners of appropriate handling and preparation of raw meat-based pet diets needs to be raised to reduce potential risks.

## P1-08 Evaluation of Research Methods and Measures in Food Safety Studies Focused on Food-Service Sector

Veronika Bulochova<sup>1</sup>, Ellen W. Evans<sup>1</sup>, Elizabeth C. Redmond<sup>1</sup> and Claire Haven-Tang<sup>2</sup>

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**Introduction:** There is a concern regarding foodborne outbreaks associated with food-service establishments in the light of popularity of eating out. Ensuring appropriate food safety practices and positive food safety culture is key to safeguarding the consumers' health. In recent years a number of studies have been conducted exploring food safety behaviours of food-service employees utilising various methods.

## \* Student Award Competitor

**Purpose:** This study aimed to identify and analyse primary research studies, focused on food-handler food safety behaviour and cognition in food-service establishments, and to determine the gap in the current body of research related to factors influencing food safety culture.

**Methods:** A content analysis of primary research studies ( $n=50$ ), conducted in the last 20 years (2001–2021), detailing the food-handler food safety cognition and behaviour in the food-service sector was performed.

**Results:** The majority of studies originated from the United States (40%) and Brazil (14%). Reviewed studies were mostly conducted in restaurants (88%). Whilst 22% of studies utilised mixed method approaches, majority (64%) relied only on self-completed questionnaires for data collection. Only 22% of studies used observational data to determine food-handler food safety practices. Cognitive measures: food safety knowledge (58%) and attitude (38%) were most often captured in studies. Self-reported food safety practices were captured in 34% of studies. Measures related to food safety culture were explored in 22% of studies. Microbiological testing was utilised in 6% of studies. Only 18% of studies relied on application of social cognitive models.

**Significance:** This review identified a gap relating to specific food safety practices and food safety culture components. Data related to cognitive measures, such as risk perception, were lacking. Only a few studies relied on the application of social cognitive frameworks. Whilst the associations between measures were investigated, a lack of triangulation of data was evident. There is a need for data triangulation to increase understanding of cognitive and behavioural factors influencing compliance.

### P1-09 Food Safety Information Provision in UK-Based Children's Recipe Cookbooks and Online Resources

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**Introduction:** Implementation of risk-reducing food safety behaviours during food handling/preparation is important for prevention of food-borne illness (FBI). Children's behaviours can be reportedly easily influenced, and positive food-handling practices adopted at a young age are more likely to be carried through life. In recent years a reduction of food-related education within the UK school curriculum has affirmed the need for food safety information provision from alternative sources to equip children with applied knowledge and behaviours to safeguard against FBI.

**Purpose:** This study aims to evaluate the provision of food safety information delivered in recipes in children's cookbooks and online resources.

**Methods:** A total of 33 children's cookbooks with 108 cookbook recipes (CBRs) and 10 online website resources 90 children's online recipes (ORs) were reviewed. Recipes selected for review included raw animal ingredients and required a cooking process-step. Food safety information was recorded in a checklist structured according to UK Food Standards Agency 'cooking, chill, clean, cross-contamination' recommendations.

**Results:** Overall, children's cookbooks, CBRs and ORs provided limited food safety information. Hand-hygiene information was lacking in cookbooks, with 36% providing information on how to handwash and 9% advising hand-drying; only one reviewed OR provided information about how to handwash and dry. Findings indicated that <1% of CBRs and ORs advised handwashing prior to food preparation. Handwashing during food preparation was required on <230 occasions in cumulative reviewed recipes and only advised on two occasions in CBRs. Use of separate chopping boards for raw meat and vegetables was advised in 15% of cookbooks and 20% of online recipe websites but was not instructed in any CBRs and only in one OR.

**Significance:** Children's cookbooks and online recipes may provide an accessible, applied and valuable source of information for children engaged in food preparation activities; however, findings indicate them to be an under-utilised source of food safety information.

### P1-10 Inferior Local Food Control Inspection Results Associate with Higher Incidence of Foodborne Diseases

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**Introduction:** Prevention of foodborne diseases is the major aim of food control. It has been shown that food control is effective in the reduction of non-compliances towards food safety legislation. However, knowledge about the impact of food control on the incidence of foodborne diseases remains scarce.

**Purpose:** We studied food control inspection grades of local food business operators and local incidence of *Campylobacter* and *Salmonella* infections based on register data from 2014–2019 in Finland to find out whether inferior inspection grades are associated to higher incidence of *Campylobacter* and *Salmonella* infections.

**Methods:** Materials included all food control inspection reports ( $n=119$  469; four-level inspection scale) from 62 local food control units and data from national Infectious Disease Register from 2014–2019. In cases where country of origin of infection was missing, we did multiple imputation that was based on domestic/foreign/missing ratios utilizing information from April–December 2020 when majority of infections were domestic due to travel restrictions caused by COVID-19 pandemic. Each imputed dataset was analyzed with linear/robust regression, and result were pooled. Dependent variable was incidence of infections at the area, and independent variable was average inspection grade at the area.

**Results:** Association between overall inspection grades and incidence of *Salmonella* infections was observed – inferior grades associated to higher incidence (mean incidence 4.17 infections / 10,000 persons;  $b=-1.88$ ;  $P=0.04$ ). Inferior grades of cleanliness of facilities, surfaces and equipment were associated to higher incidence of *Salmonella* infections ( $b=-3.26$ ;  $P=0.048$ ). For *Campylobacter*, largest regression coefficient was also seen on cleanliness (mean incidence 28.07 infections / 10,000 persons;  $b=-10.20$ ), however, this result was not statistically significant ( $P=0.08$ ).

**Significance:** The results indicate that food control recognizes non-compliances in cleanliness that predispose to foodborne diseases. However, more research is needed on the relevance of inspections of other topics. We also conclude that food control should take more stringent actions if non-compliances in cleanliness are observed.

### P1-11\* Stability of Tropane Alkaloids as Chemical Hazards in Baby Foods

Berta Torrents, Albert Ribas-Agustí, Sara Bover-Cid, Anna Jofré and Massimo Castellari

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**Introduction:** Tropane alkaloids (TAs) are secondary metabolites from weeds that can contaminate cereals and vegetables during harvest. As acetylcholine receptor antagonists, TAs have toxic effects (e.g., nausea, dizziness, dry mouth, blurred vision and mydriasis). The Regulation (EU) 2016/239 sets maximum levels of atropine and scopolamine in cereal-based foods for infants containing millet, sorghum, buckwheat or their derived products. Therefore, TAs in baby food need to be controlled during food processing.

**Purpose:** The aim of this study was to determine the effect of pH, temperature and time as possible processing parameters controlling TAs fate during heating steps of food processing.

**Methods:** Mixed TAs standard solutions (6-hydroxytropine, nortropine, pseudotropine, scopine, scopolamine, tropine, tropinone, acetylscopolamine, anisadamine, anisodine, apoatropine, aposcopolamine, atropine, convalamine, convolidine, convolvine, fillalbin, homatropine, littorine, noratropine, norscopolamine, scopolamine) (50 µg/kg) in 0.01 M citrate pH 4 or 0.01 M phosphate pH 7 buffers were treated at 80 or 100°C for 30 or 60 min, and TAs contents were determined by UHPLC-MS/MS.

**Results:** The fate of TAs was variable depending on the specific compound, pH, temperature and treatment time. Higher degradation was found at 100°C, and in general, TAs were more thermosensitive at pH 7 than pH 4. The most sensitive TAs were acetylscopolamine, littorine and homatropine, with final concentrations of  $0.1 \pm 0.0$  µg/kg (99.8% decrease),  $3.6 \pm 0.3$  µg/kg (92.7% decrease) and  $4.5 \pm 0.1$  µg/kg (90.8% decrease), respectively, at pH 7 and 100°C for 60 min. On the contrary, scopolamine and atropine, whose maximum contents are set by the EU regulation, showed high stability with reduction rates lower than 25%.

**Significance:** It can be concluded that TAs would remain as chemical hazards in baby food after processing under the assayed conditions and their contents need to be monitored.

## P1-12 Self-Reported Episode of Food Allergy: A Case Report of Collaboration between Analytical Lab and Patient to Improve Food Handling Practices

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**Introduction:** Hen's egg is an important component of human nutrition, and at the same time, one of the most common food allergens. A considerable number of countries have introduced labeling directions for processed food products. However, poor food handling practices can cause allergic reactions in susceptible individuals.

**Purpose:** We report a case of a collaborative study between analytical lab and allergic patient, to detect the source and to improve the food practices in domestic scenario.

**Methods:** Case: Food allergy reaction episode in seventeen year old boy (allergic to hen's egg white protein) after eating home-made Ravioli (filled fresh pasta) made by grandmother with pasta (boiling water and durum wheat semolina) stuffed with ricotta, spinach and hard cheese (Parmigiano Reggiano cheese).

**Interview:** The grandmother declares that she knows her grandson's allergy and that she does not use eggs in the preparation of the Ravioli.

**Request:** The grandmother request the analyzes for all the ingredients used to produce the Ravioli, to detect the presence of hen's egg white proteins.

**Analyzes:** A portion of Ravioli was provided to the laboratory for the detection of egg proteins. The fresh pasta, the filling, cheese and semolina were analyzed separately using sandwich ELISA kits for the detection of egg (RIDASCREEN®FAST Ei/Egg R6402) (R-Biopharm AG, Darmstadt, Germany).

**Results:** Hen's egg white proteins were detected in fresh pasta ( $\geq 0.40$  mg/kg). Conversely, proteins were not detected (below the detection limit of 0.40 mg/kg) in the other analyzed ingredients. A second interview was performed to the grandmother and she declared to have not used egg in Ravioli pasta.

**Significance:** Allergen cross-contamination can happen unintentionally in homemade products. The analyses of single-ingredient, separately, could provide useful information of the source contamination. The consumer information of possible risks related to poor food handling can improve these practices to prevent food allergy episodes.

## P1-13 Quantitative Assessment of Food Integrity Climate in Food Businesses

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**Introduction:** Due to the deceptive nature of food fraud, the fight to prevent the increasing intentional food adulteration and counterfeiting threats requires an approach that goes beyond the common food safety strategies and falls into the more comprehensive discipline of food integrity.

**Purpose:** The aim of this study was to assess food integrity climate across countries considering various organizational characteristics of food businesses, by analyzing how the food integrity climate is perceived by quality managers of food companies and whether organizational characteristics of the participating companies affect the quality managers' estimation of their companies' food integrity climate.

**Methods:** The food integrity climate (FIC) self-assessment tool was applied on 43 food companies operative in Belgium and Saudi Arabia. The FIC tool was applied alongside with a set of introductory questions to classify the participating companies based on specific organizational characteristics (i.e. sector, product composition, supply chain step, presence of (inter)national branches, company size and certification status).

**Results:** The food integrity climate in the participating 15 Saudi Arabian and 28 Belgian food companies was estimated overall as medium-high. Scores were ranging substantially across organizations, but only slightly between the two countries. The companies' certification status was found statistically significantly related to the perceived food integrity climate. Quality managers in food companies certified for multiple standards perceived a higher food integrity climate than their counterparts in organizations certified for no or only a single certificate.

**Significance:** The novelty in this research is in the topic addressed (food integrity climate), in the measurement tool used (the FIC tool) and, consequently, in the important and remarkable findings obtained, which could help both practitioners and researchers in promoting food integrity as a more comprehensive and effective system to prevent food fraud along the international food supply chain.

## P1-14 Use of Food Safety and Quality Measurement Data to Determine Food Safety Culture within a Food and Drink Manufacturing Business: An Historical Analysis

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**Introduction:** Food-safety culture (FSC) is increasingly important within the food and drink manufacturing and processing (FDMP) industry and forms underlying foundations of a food-safety management system (FSMS). Measurement/improvement requirements have now been introduced into legislation, customer requirements and Global-Food-Safety-Initiative recognised certifications. Research suggests to achieve a better understanding of FSC, in-depth analysis of existing food-safety data alongside quantitative questionnaire data if required for a holistic understanding of the baseline FSC of a business.

**Purpose:** Assessment of the baseline FSC of a low-risk FDMP business and identify areas for improvement including analysis of existing company data.

**Methods:** Existing FSMS outputs from the past 13 years were identified, including customer complaints and non-conformances. Each system output was linked to FSC parameters and dimensions. Descriptive statistics were used to identify frequencies in each output category associated with FSC.

**Results:** Cumulatively, findings from customer-complaints indicating key insights into potential food-safety issues and are often the sole feedback garnered post-production. Monitoring/analysis of complaints demonstrated consideration of key FSC parameters and dimensions including awareness, control, learning and metrics. A gradual upwards trend was noted in the ratio of complaints to sales (increase of +2.36 complaints per 100,000 from 2017 to 2021). With increasing sales in the company, emphasis on efficiency/output could lead to a decrease of food-safety/quality indicating a need for improvement of control and consistency associated with FSC. Non-conformances accounted for 22.4% of FSMS (n=810). Non-conformances indicate alignment with FSC dimensions proactivity, systems, learning and co-ordination. Frequent non-conformances related to general hygiene (n=118,21.81%) and incomplete documentation (n=77,14.23%). This may indicate a lack of resource relating to FSC dimension investment or a need for improvement in training.

**Significance:** Cumulatively, the data identified has indicated focus for FSC improvement within a low-risk FDMP business. Targeted interventions will contribute to ongoing development of a positive FSC.

## P1-15 Evaluation of Food Samples Classified as Irregular Collected in Lombardy and Emilia Romagna during 2017–2021

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**Introduction:** The Italian Ministry of Health establishes annual control plans in order to verify the safety of different food matrices in all stages of production, distribution and sales. The samples collected by Official Authorities are divided into the most strategically important food categories and distributed within the National territory.

**Purpose:** The aim of this study was to resume the results of samples classified as irregular in the last 5 years in Lombardy and Emilia Romagna, belonging to Official Plans established for the verification of accordance to Food Safety Criteria indicated in EU Regulation, additional Criteria indicated in National Guidelines such as pathogenic *Vibrio* spp., STEC, Norovirus, and other criteria such as presence of allergens, which make the food not suitable for human consumption. Chemical hazards weren't included in this work.

**Methods:** Each year the Competent Authorities of Lombardy and Emilia Romagna performed more than 5000 samples to verify Food safety criteria such as *Salmonella*, *L. monocytogenes*, STEC, *Vibrio* spp., *E. coli* in LEM and others. Samples were analysed from the network of 17 Official Regional Laboratories of IZSLER according to the methods indicated in EU Regulation or other accredited methods.

**Results:** The minimum number of irregular samples (137) was observed in 2020 and the maximum, (200) found in 2021. Detection of major *Salmonella* spp. in fresh poultry meat or *Salmonella* spp. in all other food matrices represent the main cause of irregularity, (respectively 18,7% and 32,7%) followed by detection of *Lm* in RTE (17,4%), *E. coli* in LEM (8,5%) STEC in dairy or meat products (3,6%). The detection of insects or other foreign bodies in food wasn't insignificant (6,7%).

**Significance:** The detection of non-compliance with food safety legislation resulted in consequent actions implemented throughout the food chain by the Official Authorities in order to prevent food poisoning and provide consumer protection from food hazards.

## P1-16 *Listeria monocytogenes* Maximum Growth Rates on Commercial Desserts

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**Introduction:** *Listeria monocytogenes* (Lm) is a ubiquitous foodborne pathogen that can cause death. Lm is involved in post-process contamination of food.

**Purpose:** Aims of the study were 1) to calculate Lm Maximum Growth Rate (Vmax) in Tiramisù (D1) and in Caramel-dessert (D2) by challenge test (ISO 20976-1:2019); 2) establish the time to reach 2 log CFU/g during the shelf life.

**Methods:** Three batches of D1 and D2 were considered. a<sub>w</sub>, pH and Lactic Acid Bacteria (LAB) concentration were measured in triplicate; the batch with highest pH for each dessert was selected. D1 and D2 were separately inoculated (1/100 W/v) with: A) physiological solution, B) Lm registered strain, C) Lm wild strain. a<sub>w</sub>, pH and LAB were measured in A, Lm concentration in B and C. Isothermal Lm curves have been determined at 8°C for 30 days. Vmax and statistic parameters were obtained by DMfit tool, based on Baranyi primary model. Ratkowsky secondary model was used to establish the time to reach 2 log CFU/g, considering 1) 1 CFU/25g Lm initial concentration; 2) storage temperatures recommend in Europe (EURL, 2021).

**Results:** a<sub>w</sub> value was 0.956±0.004 and 0.96±0.002 in D1 and D2 respectively. pH values went from 6.26±0.04 to 6.32±0.03, LAB concentration increased by 4-5 log CFU/g in D1. Contrarily, pH values dropped from 6.14±0.04 to 4.78±0.08, LAB concentration increased by more than 6 log CFU/g in D2. Vmax have been: Lm registered 0.005±0.0006 log CFU/g \*h<sup>-1</sup> and Lm wild 0.0055±0.0004 log CFU/g \*h<sup>-1</sup> in D1, Lm registered 0.001±0.0003 Log CFU/g \*h<sup>-1</sup> and Lm wild 0.005±0.0006 log CFU/g \*h<sup>-1</sup> in D2. The suggested shelf life was 14 days for D1 and 20 days for D2.

**Significance:** Improve the knowledge on Lm behavior on complex food.

## P1-17 The Impact of Sweeteners on Gene Expression of Pathogenic and Probiotic Bacteria; The SWEET Project

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**Introduction:** The current dietary recommendations together with the growing consumer health awareness have led to the increasing consumption of foods containing low-calorie or non-caloric sweeteners. While it has been reported that sugar substitution may change the characteristic properties of food products and affect the growth dynamics of food bacteria, the potential effects of sweeteners addition on food safety and functionality have not been sufficiently ascertained.

**Purpose:** The aim of this study within the SWEET project was to assess the impact of sweeteners on the gene expression response of selected pathogenic and probiotic bacteria

**Methods:** *Listeria monocytogenes* and *Salmonella enterica* serovar Enteritidis as well as, *Lactiplantibacillus pentosus* and *L. plantarum* strains with probiotic potential were inoculated (10<sup>2</sup> CFU/mL) in culture broth supplemented with i) glucose (control) and ii) the selected sweeteners in different concentrations (comparable to 2.5 and 5.0% w/v glucose). The inoculated broths were incubated at 30°C and bacterial kinetics were determined. During incubation, samples derived from different growth phases were collected and analysed for targeted gene expression through real-time Reverse Transcription Polymerase Chain Reaction. The relative expression levels of specific genes involved in virulence, QS, biofilm formation and probiotic features were determined.

**Results:** The findings revealed different patterns in growth behaviour of the tested bacteria in the various treatments (glucose versus sweeteners). This was also evident in the targeted gene expression analysis, in which important information about the bacterial genetic responses associated with the above-mentioned functional roles were revealed.

**Significance:** Summing up, the available research data on the potential effects of commonly used sweeteners on food bacteria are limited, and thus an in-depth investigation is required to ensure optimal food safety, quality and functionality. The SWEET project ([www.sweetproject.eu](http://www.sweetproject.eu)) is funded from the EU Horizon 2020 (No 774293).

## P1-18 Growth Kinetics Analysis of Size and Shape Controllable Gold Nanoparticles for the Development of Immunochromatographic Assay

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**Introduction:** Gold nanoparticles (AuNPs) of different shapes and sizes represent significant color changes in a reaction mixture that act as a promising biosensing tool to develop the rapid Lateral Flow Immunochromatographic Assay (LFIA) for the detection of fungal toxins in food samples.

**Purpose:** Surface Plasmon Resonance (SPR) of anisotropic nanoparticles is dependent on their geometry. Herein we report that the growth transformations of AuNPs are a function of physicochemical reaction parameters. In this study, we have synthesized the AuNPs by using various molar ratios of HEPES and HAuCl<sub>4</sub>. The addition of the Na<sub>2</sub>HPO<sub>4</sub> in the reaction mixture resulted in the acceleration of the rate of reaction.

**Methods:** The shape and the geometry of the AuNPs were modulated under the influence of pH (5, 7, and 9) of the HEPES, molar concentrations of HEPES to HAuCl<sub>4</sub>, and temperature ranges (20°C, 40°C, and 60°C). The change in the color of the reaction mixtures over time was recorded in terms of the absorbance of the UV-Visible light in the range of 300-900 nm.

**Results:** The scanning transmission electron microscopic images employed that the gold nanostructures exist in various shapes and corroborate with the UV-Visible spectrum. It was observed that the nanostructures are anisotropic and exist in the size range of 1 nm to



100 nm. The present study confirms that the change in the color of the nanostructures reactions mixtures is a function of SPR bands under the influence of physicochemical reaction conditions. Physicochemical parameters such as temperature, pH, the molar concentration of the reactants act synergistically to influence the reaction kinetics, molecular mechanics, and enzymatic catalysis that aid to affect the size, shape, and biochemical corona of nanoparticles.

**Significance:** The AuNPs of various colors can be observed by unaided eyes and have promising applications for the development of the rapid LFIA for the detection of mycotoxins in food samples.

## P1-19 Potential of Oregano Essential Oils in Preventing the Health Risk of *E. coli*, *Salmonella enterica* and *Staphylococcus aureus* in Raw Pureed White Onion at 4°C

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**Introduction:** Onions are preferably eaten in raw forms or under-cooked. However, several outbreaks have been linked to the consumption of raw onions in foods.

**Purpose:** The present study investigated the capability of oregano essential oils (OEO) to minimize microbial risk in pureed raw white onions (PRWO) for direct consumption.

**Methods:** White onion samples purchased from a supermarket in Durban, South Africa were graded, peeled, washed under running tap water and disinfected by immersion in hot water (100°C) for 2 min. The disinfected whole onions were blended in a sterile kitchen blender. A 40 g portion of the PRWO was dispensed into sterile bottles and inoculated with an 18 – 24 h culture of *Escherichia coli*, *Salmonella enterica* and *Staphylococcus aureus* to a final risk (probability of illness) of  $7.50 \times 10^{-1} \pm 1.57 \times 10^{-3}/g$ ,  $9.49 \times 10^{-1} \pm 3.10 \times 10^{-4}/g$  and  $9.99 \times 10^{-1} \pm 1.47 \times 10^{-6}/g$ , respectively. Different concentrations of OEO (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 2, 3, 4 and 5 mg/g) were introduced into the preparations and stored at 4°C. Each treatment was triplicated. After 4 days of storage, the probability of illness of the inoculated microorganisms associated with the consumption of the PRWO was determined using standard selective microbiological assays and corresponding dose-response models.

**Results:** OEO at  $\geq 0.1$  mg/g completely eliminated the risk of *E. coli* and *S. aureus* in the PRWO. *S. enterica* risk was reduced by OEO to  $9.43 \times 10^{-8} \pm 2.35 \times 10^{-9}/g$ ,  $6.86 \times 10^{-8} \pm 2.2 \times 10^{-9}/g$  and completely at 0.1 mg/g, 0.2 mg/g, and  $\geq 0.3$  mg/g, respectively.

**Significance:** In conclusion, OEO improved the microbiological safety of PRWO after 4 days' storage at 4°C. Thus, OEO-supplemented PRWO serves as an alternative form for preserving onions for raw consumptions with enhanced microbial food safety and security.

## P1-20\* Characterizing the Variance of the Estimated Cardinal Temperature Values in Microbial Growth Modelling

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**Introduction:** The effect of temperature on the growth rate of a bacterium is usually studied indirectly through optical density measurements. Mathematical models are fitted to determine the cardinal temperature values. Although this principal is widely applied, a precise harmonized methodology does not exist. Hence, several protocols are available which results in increased variability in the models' parameters estimates leading to possible erroneous simulations and conclusions.

**Purpose:** This study aims to assess the effect of different factors (methodology, equipment and replication) on the variance observed for growth rates obtained at different temperatures and evaluate its impact on the values of the cardinal values for temperature and their associated standard errors.

**Methods:** The effects of temperature (12 and 41°C), equipment (Two BioScreen C instruments), method (OD-based binary or decimal dilutions) as well as replication (2 biological with 4 or 10 technical replicates) on the growth rates of *Paenibacillus polymyxa* DSM 36 was assessed. Then for pre-defined scenarios, the effect of the same factors was evaluated on the estimates of the cardinal temperature for growth and their associated standard deviation.

**Results:** The obtained results indicated that technical replicates and equipment used bring significant variance on the estimation of growth rate, while the method used and the biological replicates do not significantly influence. The latter indicates that the observed variance on cardinal values estimation is mostly related to uncertainty rather than variability. A significantly lower value of minimum temperature of growth was estimated when binary dilution method was applied

**Significance:** This study is of a great importance since it provides useful information that can form the basis for the development of a standard method for the accurate assessment of the cardinal values. In addition, separating uncertainty and variability in cardinal values estimation is of great interest for risk assessment purposes.

## P1-21\* Risk Assessment Database for *Escherichia coli* in Beef: Comparative Analysis in EU and China

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**Introduction:** *Escherichia coli* is a major concern for food safety. A lot of research efforts are dedicated to the detection/quantification of the hazard along the food chain focusing on beef. Nevertheless, this information is not easily accessible in a well-organized manner which is of high relevance for risk assessment. Given the complexity of the agri-food global trade, China is one of the largest markets for EU food export/import while the existing differences for food safety are highlighted. Ensuring and enhancing food safety seems to be high priority through collaboration and information exchange.

**Purpose:** The objective of the present study was the collection of data required for assessing the risk of *E. coli* in beef and beef products in the EU and China and the development of a database providing quantitative data with information such as food type, chain stage, packaging, etc.

**Methods:** A systematic review was conducted on the Scopus electronic database. The review considered articles published between 1991-2021. Papers were deemed eligible for inclusion based on several criteria. Prisma statement was employed for reporting the screening process.

**Results:** For Europe, 919 papers were retrieved and, finally, 222 were selected. A database was developed and formatted according to the sampling site/stage, type of product, method of analysis and prevalence and concentration. In addition, various supplementary information for each study were also recorded to improve the flexibility of the database.

**Significance:** The compilation of the data and the construction of the database will constitute a valuable tool for the development of risk assessment models providing comparative data for EU and China. The database offers ease of access to well-organized, harmonized, and pooled data which enable the study of various scenarios along the farm to fork continuum and support food safety in the EU-China trade.

## P1-22 Estimation of the Microbiological Status of Chicken Burgers through Fourier Transform Infrared Spectroscopy (FT-IR)

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**Introduction:** Fourier Transform Infrared Spectroscopy (FT-IR) has been reported in numerous studies as a rapid and nondestructive method to study the spoilage of microbiologically susceptible products, including meat.

**Purpose:** FT-IR spectroscopy was used as a rapid tool to predict the microbial deterioration of chicken burgers, a highly consumed yet highly perishable meat product.

**Methods:** Commercial chicken burgers of two independent batches were stored aerobically at isothermal (4,8,12 and 16°C) and dynamic (4-8-12°C/8h) conditions. Throughout storage, the population of total viable counts (TVC), *Pseudomonas* spp., *Brochothrix thermosphacta*, lactic acid bacteria (LAB), and *Enterobacteriaceae* were enumerated and correlated with FT-IR spectra through partial least squares

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regression (PLS-R) models. The models were calibrated with the data collected from isothermal conditions and then externally validated with the data from dynamic conditions.

**Results:** In all cases, the microbial counts of *Pseudomonas* spp. were in accordance with TVC, suggesting them as the dominant group, followed by *Br. thermosphacta*. Also, LAB reached high populations by the end of storage at all conditions. The best performances were observed for the PLS-R models of TVC, *Pseudomonas* and *Br. thermosphacta*, where the values of B<sub>1</sub> factor were always close to unity, indicating no systematic over/under-prediction (0.996, 1.034, and 1.038 for TVC, *Pseudomonas*, and *Br. thermosphacta*, respectively). Good A<sub>1</sub> values were also obtained, showing that estimations were close to observations (1.052, 1.084, and 1.080 for TVC, *Pseudomonas* and *Br. thermosphacta*, respectively). For these microbial groups, R<sup>2</sup> values were higher than 0.80, while the percentage prediction error (%PE) values were found higher than 70%. For the cases of LAB and *Enterobacteriaceae*, less satisfactory performances of the models were observed.

**Significance:** FT-IR spectroscopy may serve as a rapid tool to estimate the spoilage of chicken burgers, with the populations of TVC, *Pseudomonas* and *Br. thermosphacta* being better estimated by the PLS-R models.

## P1-23 Fourier-Transform Infrared Spectroscopy Coupled with Support Vector Machine Analysis for Chicken Liver Spoilage and Safety Assessment

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**Introduction:** Despite the technological and processing advances in the food industry for preventing bacterial growth, high-risk foods such as chicken liver, still get easily contaminated by pathogenic and spoilage bacteria.

**Purpose:** To rapidly assess chicken liver microbial spoilage under conditions simulating possible *Salmonella* cross-contamination, through Fourier-transform infrared spectroscopy (FTIR) and support vector machine (SVM) analysis.

**Methods:** Liver samples, non-inoculated and inoculated with *Salmonella* (ca. 10<sup>3</sup> CFU/g), were stored under isothermal (0, 4, and 8°C) and dynamic temperature scenarios. Periodically, samples were analyzed microbiologically (n=4, two batches) for the enumeration of total mesophilic bacteria, *Pseudomonas* sp., *Brochothrix thermosphacta*, lactic acid bacteria (LAB), *Enterobacteriaceae* and *Salmonella*, and spectroscopically (n=12). Spectral analysis and prediction model building workflow incorporated an initial feature selection step based on extra-trees algorithm to overcome the high dimensionality of data. An SVM analysis with radial basis function kernel was then applied for model development and validation. The three datasets, i.e., non-inoculated, inoculated with *Salmonella* and their combination, were randomly partitioned over 50 iterations into training and test datasets (70% and 30% of samples, respectively) for model building and validation.

**Results:** The developed models incorporated different sources of variability, including the variability within chicken samples/batches, the different storage temperatures encountered in the cold-chain and the biochemical fingerprint of *Salmonella* in the case of cross-contamination incident. Models achieved a satisfactory prediction accuracy between the measured and the estimated microbial populations (71.76 – 85.67%). The calculated R<sup>2</sup> and RMSE values ranged from 0.708 to 0.828 and 0.664 to 0.949, respectively, depending on the microbial group and chicken liver samples, indicating a satisfactory relationship between spectra and microbial populations studied.

**Significance:** Results demonstrated the considerable potential of FTIR spectroscopy in tandem with the proposed spectral analysis and prediction model building workflow to determine chicken liver spoilage in the presence or absence of inoculated *Salmonella*.

## P1-24 A Predictive Model to Assess the Growth of *Listeria monocytogenes* in Rice Pudding Dessert

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**Introduction:** Rice pudding is a widespread artisanal dairy dessert, highly consumed in the main rice-producing countries, including Egypt. Considering that rice pudding is a refrigerated ready-to-eat product, it could entail a potential health risk due to contamination with psychrotrophic pathogens, such as *Listeria monocytogenes*.

**Purpose:** This study aimed to evaluate and model the growth of *L. monocytogenes* in rice pudding dessert stored at different temperatures (4-25°C) over its shelf life.

**Methods:** Lab-scale rice pudding samples were prepared following a traditional Egyptian recipe and inoculated with a three-strain cocktail of *L. monocytogenes* at 3x10<sup>2</sup> CFU/g. Inoculated rice pudding samples (pH=6.7 and a<sub>w</sub>=0.99) were stored at different isothermal temperatures (4, 8, 12, 18, and 25°C) and microbiologically analysed for up to 30 days for pathogen quantification by plate count methodology. A one-step modelling procedure was carried out to relate *L. monocytogenes* maximum growth rates ( $\mu_{max}$ , log CFU/h) with storage temperature, by fitting the Ratkowsky and Baranyi models to growth data using R. Model validation was performed using published independent data, by assessing the Accuracy and Bias factors (A<sub>p</sub> and B<sub>p</sub>).

**Results:** *L. monocytogenes* growth potential increased by increasing storage temperature. The estimated Ratkowsky model parameters were  $b=0.082\pm0.0017$  and  $T_{min}=-3.277\pm0.2054$ °C. The model RMSE=0.39 indicated a good agreement between the experimental and the model predictions. The estimated  $\mu_{max}$  values ranged between 0.003 to 3.165 log CFU/day at 4 to 25°C. The model was successfully validated using published *L. monocytogenes* Scott A and California growth data in rice pudding samples stored at 5-22°C, as evidenced by the estimated A<sub>p</sub> and B<sub>p</sub>, which varied from 1.04-1.14.

**Significance:** The predictive model developed and validated in this study will aid in decision-making regarding the microbiological safety of rice pudding dessert with respect to *L. monocytogenes* growth, considering a wide range of storage temperatures.

## P1-25 Modeling the Impact of a Microbial Consortium of Soft Cheeses on the Growth of *L. monocytogenes* and *E. coli* O157:H7

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**Introduction:** In a food matrix, different microenvironments coexist and are distinguished by their physicochemical and biochemical properties as well as their endogenous microbial communities. This complex environment strongly impacts the development of pathogenic bacteria.

**Purpose:** The ANR PathoFood project aims to characterize the growth of *Listeria monocytogenes* and *Escherichia coli* O157:H7 with the presence of a microbial consortium representative of soft cheeses (lactic acid bacteria, ripening bacteria and yeasts) in order to model their effects.

**Methods:** The growth of a strain of *L. monocytogenes* (EGDe) and *E. coli* O157:H7 (CM454) was studied in pure and in co-culture with a complex microbial consortium representative of the ferments used in the manufacture of soft cheese with washed or bloomy rind. Besides, different initial concentration ratios between the pathogenic bacteria and the consortium were also taken into account. The growth was studied under conditions of early cheese ripening in semi-agar medium at pH 5.5, with 1% lactic acid, at 12°C.

**Results:** Growth parameters, growth rate, lag time and maximum rate reached (N<sub>max</sub>) were determined. The results show that the presence of the cheese consortium modulates the N<sub>max</sub> for the two pathogens studied due to a microbial competition linked to a Jameson effect.

**Significance:** The developed model will be then validated on cheese and provide new data for a better prediction of pathogens growth in this type of food matrices.

## P1-26 Whole Genome Sequencing-Based Typing of *Listeria monocytogenes* Isolated from Seafood and Production Environments

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**Introduction:** *Listeria monocytogenes* is a foodborne pathogen that is frequently isolated from seafood. To reduce prevalence in these ready-to-use products and ensure consumers' safety, monitoring of *L. monocytogenes* in seafood processing environments is important.

**Purpose:** This study aimed to gain a better understanding of the diversity of *Listeria* in the cooked shrimp and smoked fish sectors and appreciate the value of whole genome sequencing (WGS)-based typing for environmental monitoring.

**Methods:** Eighty-eight isolates from 8 different industries were characterized by WGS. Core genome multilocus sequence typing (cgMLST) analysis was implemented and compared to pulse-field gel electrophoresis (PFGE) data.

**Results:** Most isolates belonged to the group IIa (72%). The others were part of groups IIb (10%), IIc (11%) and IVb (7%). *L. monocytogenes* strains were distributed in 15 clonal complexes (CC). CC121, CC321 and CC9 were the most represented CC (n=34, 17 and 10, respectively). CC121 isolates were further subtyped and divided in 4 cgMLST types, each of which being specific to a production site. Most CC321 isolates are grouped into a single cgMLST type, demonstrating the survival of a *Listeria monocytogenes* strain in the manufacturing environment for at least 4.5 years. All the sequenced isolates carried at least 6 out of the 7 LIPI-1 genes. But LIPI-3 and LIPI-4 genes were detected in only 9 and 1 genomes, respectively, and were less frequently detected in not persistent strains. Isolates clustering achieved with cgMLST and predicted serotypes were shown consistent with previously obtained PFGE and molecular serotyping results.

**Significance:** WGS-based typing provided information on the large genetic diversity of *Listeria monocytogenes* strains in the cooked shrimp and smoked fish sectors and demonstrated the ability of this foodborne pathogen to persist in the production environment for many years. This observation supports the need for further research on mechanisms underlying persistence of *Listeria* in food industries.

## P1-27 Metagenomic Analysis of Yeast Communities Present on Table Olives Surface Could Indicate the Olive's Variety and Designation of Geographical Origin

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**Introduction:** Nowadays, next generation sequencing (NGS) technology is successfully applied to assess the microbial communities of several foods.

**Purpose:** To examine the hypothesis that yeast ecology is capable of providing information regarding the olive variety and designation of geographical origin of table olives.

**Methods:** The yeast communities of 34 table olive samples of cv. Halkidiki (Kavala and Halkidiki regions) and cv. Konservolia (Magnesia and Fthiotida regions) collected two different seasons were identified by NGS analysis.

**Results:** *Pichiaceae* was the most abundant detected family in most of the cases. In brief, *Pichiaceae* was detected in higher percentage in Halkidiki olives regardless the region of origin or season. However, differences were observed at species level, where *Pichia manshurica* was the most abundant species in 3 (out of 6) and 6 (out of 9) samples from Kavala and Halkidiki region, respectively. Moreover, *Pichia membranifaciens* was the most abundant species in 4 samples collected the first and second season. In the rest 3 samples from Kavala, *Brettanomyces custersianus* was the most abundant species. In the case of Konservolia olives, *Phaffomycetaceae* was the most abundant

family in 4 samples from the Magnesia region, while *Pichiaceae* dominated the yeasts microbiota in 2 samples from Magnesia and Fthiotida. Specifically, *Wickerhamomyces anomalus* was detected in 4 samples and *Pichia membranifaciens* in 4 samples from Magnesia. In olives collected the first season from Fthiotida, different species i.e., *Pichia manshurica*, *Pichia membranifaciens*, *Brettanomyces custersianus* and *Aureobasidium pullulans* dominated the yeast community. Contrarily, *Candida boidinii* was the most abundant species detected in Konservolia olives of second period

**Significance:** The results obtained reveal the complex structure of the yeast microbiota in table olives and the microbial key taxa that may be linked to specific geographic areas.

## P1-28 Surveillance of *Listeria monocytogenes*: Early Detection, Population Dynamics and Quasimetagenomic Sequencing during Selective Enrichment

Eva Wagner, Annette Fagerlund, Solveig Langsrud, Trond Mørretrø, Merete Rusås Jensen and Birgitte Moen Nofima, Ås, Norway

**Introduction:** The time from sampling to detection and subsequent subtyping should be as short as possible for *L. monocytogenes* both in terms of preventing listeriosis outbreaks as well as substantial economic losses and food waste. To enable better pathogen source tracking and quality surveillance, there is a need to test and implement new methods and approaches to increase the speed and resolution of pathogen detection and subtyping.

**Purpose:** Different aspects regarding the implementation of quasimetagenomic sequencing as a hybrid surveillance method in combination with enrichment for early detection of *Listeria monocytogenes* in the food industry were addressed.

**Methods:** Different experimental enrichment cultures were used, comprising seven *L. monocytogenes* strains of different sequence types (STs), with and without a background microbiota community. The growth and population dynamics were assessed using *dapE* colony sequencing and *dapE* and 16S rRNA amplicon sequencing. Quasimetagenomic sequencing was performed early during enrichment in the presence of the background microbiota using Oxford Nanopore Flongle and Illumina MiSeq sequencing.

**Results:** There was a tendency of some STs to have a higher relative abundance during the late stage of enrichment when *L. monocytogenes* was enriched without background microbiota. When co-enriched with background microbiota, the population dynamics of the different STs was more consistent over time. The application of multiple displacement amplification (MDA) of DNA enabled detection of *L. monocytogenes* after only 4 h of enrichment using both applied sequencing approaches. The MiSeq sequencing data additionally enabled the prediction of co-occurring *L. monocytogenes* strains in the samples.

**Significance:** Routine application of quasimetagenomic sequencing could lead to more efficient and proactive actions in the food industry that prevent contamination and subsequent product recalls and food destruction, economic and reputational losses and human listeriosis cases.

## P1-29 WGS Analysis of *Listeria monocytogenes* from Rural, Urban, and Farm Environments in Norway: Genetic Diversity, Persistence, and Relation to Clinical and Food Isolates

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**Introduction:** *Listeria monocytogenes* is a ubiquitous environmental bacterium associated with a wide variety of environments, such as soil, vegetation, livestock, food processing environments, and urban areas. Consequently, a total absence of *L. monocytogenes* in non-heat-treated foods is difficult, perhaps impossible, to achieve. For effective management, both public health authorities and food producers need reliable tools for source tracking, surveillance, and risk assessment.

**Purpose:** This study aimed to gain knowledge about the presence and diversity of *L. monocytogenes* in environmental sources, to better understand factors affecting its occurrence and spread to humans, and to more effectively track and control it in the food chain.

**Methods:** *L. monocytogenes* was collected from various rural and urban environments and subjected to whole genome sequencing (WGS) and genomic MLST analyses, along with isolates collected from Norwegian dairy farms and slugs, in total 218 isolates. The data was compared with available WGS datasets from clinical and food associated sources in Norway collected within the last decade.

## \* Student Award Competitor

**Results:** Multiple examples of clusters of isolates with 08 wgMLST allelic differences were collected over time in the same location, demonstrating persistence of *L. monocytogenes* in natural, urban and farm environments. Clusters of almost identical isolates, with genetic distances within the thresholds often suggested for defining an outbreak cluster, were collected from apparently unrelated samples. The most ubiquitous clones found in soil and other natural and animal ecosystems were distinct from clones predominating among both clinical and food isolates.

**Significance:** The work highlights the need for a greater knowledge of the genetic relationships between clinical isolates and isolates of *L. monocytogenes* from a wide range of natural and man-made environments in order to correctly interpret and use results from WGS analyses.

### P1-30 Response of *Salmonella* spp. and *E. coli* O157:H7 Heat-Shocked Cells during Inappropriate Storage of Under- and Adequately-Cooked Pork “Gyros”

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**Introduction:** “Gyros” is composed of marinated non-cured pieces of meat and fat, roasted in a vertical revolving spit in front of an open broiler at grill houses, while is carved from outside to the core and served as meat slices. Its peculiar roasting may induce heat-stress and/or potential inappropriate storage practices prior to serving may compromise its safety.

**Purpose:** To assess the response of heat-shocked *Salmonella* spp. or *E. coli* O157:H7 cells on under- and adequately-cooked pork “gyros” during their subsequent residence under inappropriate storage at abuse temperatures prior to consumption.

**Methods:** Composites of *Salmonella* spp. or *E. coli* O157:H7 cells (heat-shocked cells and controls) were surface inoculated (3.5–4.0 log CFU/g) on 10 g portions of under- and adequately-cooked pork “gyros”. Samples were stored for 0–6 h at 30°C and 40°C. Adequately-cooked “gyros” ( $a_w$  0.80–0.81) was prepared following cooking directions of commercial semi-cooked pieces (microwave heating; 700 W; 2 min), while “gyros” coded as under-cooked ( $a_w$  0.94–0.95) was represented by the thawed semi-cooked pieces (n=6). *Salmonella* spp., *E. coli* O157:H7, and TVC were enumerated on XLD (37°C; 24h), CT-SMAC (37°C; 48h), and TSA (30°C; 48h), respectively, while pH and  $a_w$  were also monitored.

**Results:** On under-cooked “gyros”, *Salmonella* spp. population remained close to the initial inoculation levels throughout the 6 h-storage, regardless of cells’ state and temperature. On the contrary, *E. coli* O157:H7 heat-shocked cells showed a significant population increase of ca. 1.2–1.5 log CFU/g ( $P < 0.05$ ) at both temperatures, while controls population remained close to initial inoculum. Regarding adequately-cooked “gyros”, control cells of both pathogens significantly decreased by ca. 1.5 log CFU/g ( $P < 0.05$ ) after 6 h-storage, especially at 40°C, while heat-shocked cells showed no growth, revealing a significant resistance to “gyros” low  $a_w$ .

**Significance:** Studying resistance of heat-shocked pathogenic cells on “gyros” during inappropriate practices may provide significant information to food safety authorities to update recommendations for “gyros” storage and/or relevant products like döner, kebab.

### P1-31 Management Perceptions of Factors Associated with Food Safety Culture in UK Food Service Small and Medium-Sized Enterprises

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**Introduction:** Food safety compliance in food-service small and medium-sized enterprises (SMEs) is essential for public health and minimising the risk of foodborne disease (FBD). It can be influenced by a multitude of characteristics, including business size, organisational structure, physical design, resource availability, inspection frequency, and factors associated with food safety culture (FSC). It has been suggested that in food-service outlets where FSC is ‘enhanced’, food-handlers are likely to make fewer violations, thus reducing the risk of FBD.

**Purpose:** This study aims to develop an understanding of food safety culture (FSC) in food-service SMEs, identify key factors that influence food safety culture, and determine sector-specific improvement requirements.

**Methods:** Semi-structured, in-depth interviews (n=12) were conducted with management employees from food-service SME establishments to explore perceptions of food safety procedures and factors that influence FSC such as leadership, commitment, communication, provision of resources, training, and risk awareness. A thematic analysis of transcribed interviews was undertaken using NVivo.

**Results:** Personal responsibility for food safety was recognised by many food-service SME managers, for example, one manager indicated “If anything did go wrong, something happened, I would be directly responsible”. Setting the standards was seen as important, one manager remarked, “I’m particular – I don’t want to see dirty dishes left out”. There was a consensus that the Food Hygiene Rating (FHR) is a good indicator of FSC, the purpose according to one manager is to “reassure the general public that where they are purchasing their food from is safe”. Rewarding a job well done was recognised as important and peer pressure was perceived by some managers to have a tangible effect on FSC, one manager observed “If one person in the team isn’t doing something, then no one else will bother.”

**Significance:** Improved understanding of FSC dimensions in the food-service sector will assist in the development of targeted interventions.

## Poster Session 2 – Beverages and Acid/Acidified Foods, Dairy, General Microbiology, Laboratory and Detection Methods, Low-Water Activity Foods, Meat, Poultry and Eggs, Microbial Food Spoilage, Packaging, Sanitation and Hygiene, and Seafood

### P2-01 Impact of pH on the Growth of *Aspergillus niger*, *Byssoschlamys fulva*, *Saccharomyces cerevisiae*, and *Zygosaccharomyces parabaillii* in Liquid Media

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**Introduction:** Soft drinks and carbonated beverages usually exhibit an acidic pH (from 2 to 6). A precise understanding of the impact of pH on the spoilage microorganisms, such as moulds and yeasts, might allow to improve the beverage process. In addition, the growth of moulds is usually studied on solid media (radial growth), which might differ to the growth in a liquid medium.

**Purpose:** This study aim is to assess the impact of pH on the growth of two moulds (*Aspergillus niger*, and *Byssoschlamys fulva*), and two yeasts (*Saccharomyces cerevisiae*, and *Zygosaccharomyces parabaillii*) in liquid media.

**Methods:** For the moulds, spores were inoculated in Potato Dextrose Broth (pH 2 to 9). The growth (at 25°C) was followed by measuring the increase of the dry mycelial weight. For the yeasts, vegetative cells were inoculated in Yeast extract, Peptone, Dextrose broth. Growth rates at 30°C and pH 3, 3.5, 4, 5, 6, 7, and 8 were obtained by spectrophotometry using a Bioscreen. For pH 2, 2.5, 8.5, and 9, growth were followed by plate counting. Models were used to evaluate the growth and when possible the impact of pH on the growth rate.

**Results:** Both moulds grew at all the tested pH. However, the growth of *B. fulva* was significantly affected for pH 2, 8, and 9 ( $P = 0.01$ ). For *S. cerevisiae*  $pH_{min}$  was estimated at 2.36 [2.32;2.40] and  $pH_{max}$  at 8.18 [8.12;8.25], while *Z. parabaillii* can grow between  $pH_{min}$  2.33 [2.225;2.42] and  $pH_{max}$  8.67 [8.59;8.74].

**Significance:** This study improved our understanding of the impact of pH on the growth of moulds in a liquid medium. Furthermore, to our knowledge, the impact of pH on *Z. parabaillii* growth and of basic pH for *S. cerevisiae* had never been studied. This data may be used as support making tool to better control spoilage risk.

### P2-02 An Exploration of Milking Practices on North Wales Dairy Farms: Potential Impact of Behaviour upon Microbiological Quality of Unpasteurised Milk

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**Introduction:** In Wales, there is currently, no standard milking procedure; therefore, methods are decided by farmers, which may impact the microbiological quality of milk. When harvested from the mammary gland of a healthy cow, milk is sterile; however, potential contamination can occur during milking and from the environment.

**Purpose:** To explore the potential impact of on-farm milking practices upon the microbiological quality of unpasteurised cow's milk.

**Methods:** An observational survey was conducted in the milking-parlours of dairy farms in North Wales ( $n=15$ ). The survey included a hygiene index and captured data detailing the maintenance of machinery; cleanliness of the surrounding environment; and the milking procedure undertaken. Unpasteurised milk samples were analysed for *Enterobacteriaceae*, *Escherichia coli*, *Staphylococci*, *Salmonella* spp., *Listeria* spp., and *Campylobacter* spp. Analysis was undertaken to identify potential association between microbiological quality observations.

**Results:** The herd sizes on visited farms ranged from 60–324 cows, which included purebred and crossbred Holstein, Friesian and Jersey cows. The majority (87%) of farms had herringbone milking parlours. *Salmonella* spp., *Campylobacter* spp., and *Listeria* spp. were not detected in the milk samples analysed in this study. Counts of *Enterobacteriaceae*, *E. coli*, *Staphylococci*, and Aerobic Plate Count varied for each individual farm raw milk samples. Associations in microbiological content were identified according to the hygiene index scoring of the environmental, herd, and equipment. Trends apparent in the data indicated that lower *E. coli* counts were associated with farms of 'pastured cows' than 'housed cows'. Farms with parlour floors in 'excellent condition' had lower counts of Aerobic Plate Count. No significant association were determined microbiological content according to herd size, breed, milking frequently

**Significance:** Previous research has focused on the effect of milking practices on the efficiency of milking, however, completion of this study has explore the potential impact of on-farm hygiene practices and milking practices on North Wales farms upon the microbiological quality of unpasteurised cow's milk.

## P2-03\* Raw Milk Quality Under Hot Weather Conditions: Statistical Analysis of a Large Dataset

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**Introduction:** Raw milk quality, such as microbial counts and physicochemical properties, impacts the quality of derived dairy products including the payment of milk to the producer. Moreover, conditions of dairy production under hot weather conditions (temperature, relative humidity, cow feeding, barn organisation, etc) may have negative impacts on these qualities.

**Purpose:** This study aimed to decipher the structure of a raw milk dataset, based on microbial counts and physicochemical properties, produced under hot weather conditions. In particular, the presence of a seasonal pattern was sought.

**Methods:** One-year raw milk quality control data, composed of microbial counts (Total aerobic counts thermophilic and *E. coli* counts) and physicochemical data (e.g., protein, fat, total solids, solids not fat) were obtained from a large-scale dairy farm (having several locations) operating under hot weather conditions. Daily temperature and relative humidity were collected and added to the dataset as "environmental variables." Finally, a data set of 473 rows and 18 columns was obtained. Correlation analysis, Principal Component Analysis (PCA) and Partial Least-Squares (PLS) regression were performed to analyse the trends and dataset structure.

**Results:** Positive correlations were observed between microbial counts, physicochemical properties, and environmental variables. However, no high correlations between these three blocks of variables were observed. Likewise, PCA did not indicate a high structure within the dataset but interestingly revealed a seasonal pattern (more or less pronounced according to the dairy farm locations). Finally, PLS enabled to predict percent fat and protein, two variables associated with the payment of milk to the producer, by a subset of physicochemical properties and environmental variables. On the opposite, microbial counts could not be predicted by physicochemical properties or environmental variables.

**Significance:** This study highlights that combinations of statistical techniques help in deciphering the safety and quality of raw milk production as shown by quality control data sets and consequently aid decision-making processes.

## P2-04 Microbiological Quality of Raw Milk and Prevalence of Foodborne Pathogens

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**Introduction:** Raw milk harbours a diverse and complex microbial community that directly impacts on the organoleptic properties as well as, the shelf life and safety of milk and dairy products. Given the above and together with the growing popularity of the consumption of raw milk, the microbiological monitoring is required for quality and safety assurance of the final products.

**Purpose:** The objective was to assess the microbiological quality of raw milk and the prevalence of significant pathogens.

**Methods:** Raw ( $n=96$ ) samples of cow, sheep and goat milk were collected from Greek local farmers. The samples were analyzed for the determination of the total mesophilic microbial populations, lactic acid bacteria, *Pseudomonas* spp., molds and yeasts, and bacteria of the Enterobacteriaceae family. The enumeration and detection of *Bacillus cereus* group and *Listeria monocytogenes* was also performed according to the relevant ISO protocols and the results were further validated through molecular identification.

**Results:** The *Pseudomonas* genus was the most dominant microbial group for all the types of raw milk. Cow milk performed overall lower microbial levels compared to goat and sheep samples. However, there was difficulty in enumerating and in some cases also detecting the studied pathogens. Although, *L. monocytogenes* typical colonies were isolated, none of them was characterized as such, while the majority were members of the genera *Enterococcus* and *Vagococcus*. With regard to *B. cereus* group, the prevalence was 26% for all three types of raw milk samples.

**Significance:** This study highlighted the inefficacy of culture-based methods, still used in the industry as gold standards, to determine significant pathogens in a diverse microbial community, such as that of raw milk - This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (FOODSENS- T2EDK-01934).

## P2-05 Bacterial Dynamics along Broiler Slaughterlines in Norway

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**Introduction:** Contamination on broiler carcasses might include *Campylobacter* and other pathogenic bacteria, which pose a risk for meat safety and public health.

**Purpose:** The aim was to investigate bacterial dynamics along the slaughter line for broilers. Detecting the levels of bacterial contamination of carcasses along the slaughter line gives information on where to address sanitary measures.

**Methods:** The study was performed at two commercial broiler slaughter lines in Norway over three sampling days. In total 120 neck skin samples, i.e., excision of 10 grams each, were collected from four locations along the slaughter line namely before scolding, after plucking, after evisceration and after chilling. The samples were examined for total plate count (TPC), *Enterobacteriaceae*, *E. coli*, and *Campylobacter* spp. Statistical analyses were conducted in Stata/MP 17.0 using ANOVA and regression models with TPC, *Enterobacteriaceae*, and *E. coli* as response variables and sampling point and *Campylobacter* status (positive or negative flock tested on-farm) as explanatory variables.

**Results:** The means of TPC were respectively 6.82, 5.63, 5.32, and 4.78 log CFU/g at the four locations for combined sampling from both slaughter lines. Correspondingly, the means for *Enterobacteriaceae* were 5.16, 5.07, 4.64, and 3.99 and for *E. coli* 5.13, 5.05, 4.65, 4.03 log CFU/g. The standard deviation ranged from 0.29 to 0.91 for all groups. *Campylobacter* means were 1.27, 1.68, 1.65, and 0.32 log cfu/g along the slaughter line. The standard deviation ranged from 0.73 to 1.44.

## \* Student Award Competitor

The regression analysis showed that *Campylobacter*-positive flocks tested on-farm, had a significantly ( $P < 0.05$ ) lower mean of TPC, *Enterobacteriaceae*, and *E. coli* on carcass surfaces at all four locations.

**Significance:** The results from this study show there is a significant reduction of *Enterobacteriaceae* and *E. coli* from before evisceration to after chilling and confirm the importance of chilling to secure food safety and increase shelf life.

## P2-06 Detection of Enteric Viruses in Foodstuffs: A Six-Year Survey in Italy

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**Introduction:** To observe the prevalence of contamination by hepatitis A virus (HAV) and norovirus (NoV) in different food types, 9,242 samples were analyzed over a six-year period (2014–2019). Samples were from routine official activities by Competent Authorities and Food Business Operators, according to their HACCP plans.

**Purpose:** The aim was to investigate the prevalence of HAV and NoV in Italian foodstuffs, examining possible correlations between their circulation and particular factors, such as food matrices, single-year periods, and seasonality.

**Methods:** Food types were obtained from different production/distribution areas of Italy, and ranged from mollusks, ready-to-eat (RTE) and packaged vegetables, frozen berries, tap water, fruit, and RTE fruit salads, and processed and preserved foods. No sampling plans were set by the authors' laboratory because they were still adopted by conferring customers. Analyses were conducted according to ISO/TS 15216-2:2013.

**Results:** The data showed that 2.25% (95% CI: 2.0–2.6) of samples were contaminated by at least one virus type at least and that the most detected pathogen was NoV GII (89.50% of all positives). Mollusks (filter-feeding animals) were the most contaminated category (92.31% of all positives) not only by NoV or HAV individually, but also by multiple HAV/NoV contaminations consisting of 22.59% of all positives. For NoV, there was a significant correlation between shellfish positivity and season, with the autumn-winter period being the most associated with risk. Conversely, berries, drinking water, and RTE vegetables, previously linked to several outbreaks, showed a low rate of contamination.

**Significance:** These results from data collection have implications for the improvement of sampling plans for HAV and NoV by Italian Competent Authorities, and by Food Business Operators. Moreover, these findings obtained by a standardized qualitative method contribute the collection of data aimed at establishing new microbiological criteria not yet foreseen by current European rules.

## P2-07\* Impact of Carbon Dioxide on Radial Growth of Filamentous Fungi Encountered in Dairy Environment

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**Introduction:** Filamentous fungi are used as starters in fermented products, but they can also spoil food leading to waste and economic losses. Modified Atmospheres Packaging (MAP) is recognized to delay the spoilage while there is a lack of information about the growth of fungi in foods as a function of MAP gas composition.

**Purpose:** The present study investigated the impact of carbon dioxide (CO<sub>2</sub>) on the radial growth of fourteen starters or spoilers encountered in dairy products.

**Methods:** The experiments were performed on Potato Dextrose Agar medium at pH 4.7 inoculated with conidia suspension and placed into a controlled atmosphere chamber during 70 days at 25°C. All studied atmospheres were composed of 5% of oxygen, 8 CO<sub>2</sub> levels between 0 and 70% and supplemented with nitrogen. The atmosphere was renewed each hour to ensure the stability of chamber gas composition. The growth rates were estimated on thallus growth kinetics and modelled as a function of undissociated carbonic acid concentration ([AH]). For each strain, the [AH]<sub>50</sub> which allowed to reduce the growth rate by 50% was estimated.

**Results:** *Penicillium bialowiezense* was the most sensitive strain to CO<sub>2</sub>, no observed growth at 50% CO<sub>2</sub>, followed by *Cladosporium herbarum* and *Bisfusarium domesticum* with no observed growth at 70% CO<sub>2</sub>. All other strains were able to grow at 70% CO<sub>2</sub>. Several behaviours were observed like a linear decrease of  $\mu_{max}$  or the presence of an optimal growth value of CO<sub>2</sub>. *Mucor lanceolatus* was the less sensitive strain to CO<sub>2</sub>.

**Significance:** This study may help to understand the fungal diversity adaptation to modified atmospheres and allows to model mycelial growth under MAP conditions which could provide a better control of fungal spoilage of dairy products.

## P2-08 Study of *Listeria innocua* Heat Resistance after Sublethal Heat Treatment with MALDI-TOF

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**Introduction:** Its ability to survive in different environmental conditions makes *Listeria monocytogenes* a critical concern in food safety. Numerous study available about the *Listeria* spp. behaviour of heat treatments, but still have gaps. When the microorganisms are exposed to sublethal heat treatment above their optimum growth temperature, they enhance stress adaptation for further heat treatments.

**Purpose:** The aim was to examine proteomic changes of pre-exposed and control samples by analyzing the mass spectra obtained from MALDI-TOF MS.

**Methods:** In order to investigate heat stress resistance of *L. monocytogenes*, *L. innocua* as a surrogate was sublethal heat exposed at 46°C for 30 and 60 min, prior to heat treatment of 60°C. Cluster analysis of mass spectra obtained from MALDI-TOF was analyzed by discriminant analysis of principal components (DAPC) for sublethal heat treatment of 46°C for 30 min and control group to check stress response in proteomic level.

**Results:** D<sub>60°C</sub> values for control samples and sub-lethal heat exposed samples at 46°C for 30 min were 4.03 min and 4.26 min, respectively. There was no significant difference in D<sub>60°C</sub> values between the samples after prior exposure of 46°C for 30 min and the control ( $P > 0.05$ ). Instead, treatment of 46°C for 60 min enhanced survival of the strain at 60°C ( $P < 0.05$ ). D<sub>60°C</sub> value of control samples was 3.66 min; while it was 5.71 min for pre-exposed at 46°C for 60 min samples. Cluster analysis of these peaks was performed to investigate possible differences between the control and sub-lethal heat exposed samples at the proteomic level. In the survival pattern, there was no difference in D<sub>60°C</sub> values between the samples after prior exposure of 46°C for 30 min and the control.

**Significance:** According to the results, no differentiation was observed between stress responses by DAPC. Further heat treatment experiments need to examine the stress adaption and refine the DAPC method.

## P2-09 Evaluating Performance of MC Media Pad Alternative Methods for Hygienic Indicators Enumeration in Foods

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**Introduction:** European Regulation and microbiological quality control plans include the requirement to perform analysis for assuring food safety and hygiene. Evaluation of reference and alternative methods for different food commodities including challenging food items is crucial to demonstrate fitness for purpose.

**Purpose:** Compare reference and alternative methods for aerobic enumeration, coliforms, *E. coli* and yeasts & molds, evaluating fitness for purpose in different challenging food items and categories.

**Methods:** Four different reference methods (ISO 4833-1:2013; ISO 4832:2006; ISO 16649-2:2001 and ISO 21527-1&2:2008), four MC Media Pad<sup>®</sup> alternative validated methods and four alternative validated methods based in ready to use rehydratable media were tested for 135 different samples including challenging food items belonging to 8 food categories (meat, fish, bakery, dairy, fruits and vegetables, spices & seasoning, multicomponent foods and environmental samples). Results were evaluated following relative trueness study design included in ISO 16140-2:2016.

**Results:** Results for aerobic counts (n=135) yeast and molds (n= 105) and coliforms (n=135) provided equivalent results for all three methods tested, with non-significant bias. For *E. coli* (n=135), the recovery obtained in the ISO 16649-2:2001 in TBX agar (known to produce a low recovery of stressed cells) was consistently lower than for the Media Pad and the other alternative method tested. Both alternative methods provided similar results and close to the spiked levels. Aerobic counts

performed with MC Media Pad at 30°C (validated against ISO) and 37°C (validated against AOAC) in natural contaminated samples showed relevant differences.

**Significance:** Evaluation of challenging food items from a broad range of food categories is crucial to confirm fitness for purpose of alternative and reference methods, allowing a better understanding of method performance and limitations.

## P2-10 Identification of Animal and Plant Species in Food-Based Products Using Next Generation Sequencing: Results from a European Interlaboratory Study

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**Introduction:** The complexity of the food supply chain is challenging the abilities of analytical tools used for traceability of ingredients for food production. Although there is no reference method for food authenticity analysis, the introduction of Next Generation Sequencing (NGS) in recent years has demonstrated the suitability of this method to verify species composition of food products.

**Purpose:** An interlaboratory study involving 11 European laboratories from eight countries was conducted to support the implementation of NGS for routine food authenticity analysis. In this study the Thermo Scientific™ NGS Food Authenticity Workflow, was used to determine the species composition in a range of different samples

**Methods:** A total of 72 samples were received by each participant. The targets included meat, fish, and plant. All the experiments were carried out in duplicate. Each participant used the Thermo Scientific NGS Food Authenticity Workflow using the Ion Chef and Ion GeneStudio™ S5 instruments and sequence data analysis was done with the SGS® All Species ID software. Then, the performance of each participant was scored, and the robustness and reliability of the workflow was evaluated.

**Results:** The overall scores calculated ranged from 84.4% to 100% for fish samples, 77.8% to 97.8% for meat samples and 80.8% to 98.1% for plant samples. The real food samples produced the most variable results which can be explained by the possible heterogeneity of the samples. Among artificial DNA mixtures, a total of 10 meat species, 15 fish species and 18 plant species were successfully identified. Some of the species were identified at low concentration levels (1%).

**Significance:** This is the largest NGS interlaboratory study performed that included meat, fish and plants. The results obtained demonstrated the high performance and robustness of the Workflow. This study, together with recent developments at ISO and AOAC about the use of NGS for animal and plant species identification, supports the routine implementation of NGS for food authenticity analysis.

## P2-11\* Optimisation of Culture Dependent and Independent Methods to Detect Pathogens in Infant Food Production Chain

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**Introduction:** The continuous effort for the development of optimum detection approaches of pathogens in food responds to public health and regulatory demands. This is particularly true for infant food indus-

tries given the nature and sensitivity of infants. Therefore, finding the way to explain the microbial prevalence with tangible elements that could enhance the decision support system and risk assessment is essential.

**Purpose:** This study aimed to develop a fast and reliable approach to detect the presence of foodborne pathogens that can cause severe illness and death in infants.

**Methods:** *Listeria monocytogenes*, *Bacillus cereus*, *Salmonella enterica*, *Staphylococcus aureus* and *Clostridium perfringens*, were artificially inoculated at the lowest possible cell concentration, in different infant food matrices. Different generic broths were subsequently employed for enrichment purposes. Detection was performed through microbial counts (culture dependent), Real-Time PCR, and metataxonomic analysis (culture-independent methods). Moreover, different DNA extraction approaches were tested in order to select the one with the better purity and quality of nucleic acids.

**Results:** Real-Time PCR detected all pathogens, but only after one day of enrichment. Detection however varied for the different target pathogens and was influenced by the composition of the microbial community. Based on their detection, a common enrichment broth was chosen for all the pathogens, except for the anaerobic *Clostridium perfringens* that were dealt with separately. Differences were observed in the metataxonomic analysis and the resultant microbial composition of the samples based on the DNA extraction kit used. Therefore, the best-performing kit was chosen for further analysis of naturally contaminated samples.

**Significance:** The optimisation of the multiple enrichment methods and the identification of the most suitable DNA extraction approach feasible for both Real-Time PCR and metataxonomic analysis leads the way to a massive survey of pathogens detection in different foods.

## P2-12 ISO 16140-2:2016 and AOAC-OMA Validation of a Real-Time PCR Workflow for Salmonella Detection in Cocoa and Chocolate Products

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**Introduction:** *Salmonella* is major global foodborne pathogen and has been associated with several outbreaks due to consumption of low-moisture food products, including cocoa and chocolate products. Detecting *Salmonella* in such foods is crucial to preventing infection. The Thermo Scientific™ SureTect™ *Salmonella* species PCR Assay (candidate method) is a rapid method for the detection of *Salmonella* in large sample sizes of cocoa and chocolate products.

**Purpose:** To present the accuracy, reliability and reproducibility of the candidate method for the detection of *Salmonella* in cocoa and chocolate products.

**Methods:** Four matrices were evaluated in the validation studies including 375 g of cocoa powder, cocoa butter, cocoa liquor, and dark chocolate (>70% cocoa solids). Method validation studies were conducted according to ISO 16140-2:2016 (AFNOR) requirements and AOAC Appendix J guidelines (PTM and OMA). In the ISO 16140-2:2016 study, the candidate method was compared to the ISO 6579-1:2017 reference method using UHT milk or non-fat dried milk (NFDM) (paired study) and using pre-warmed Buffered Peptone Water (BPW) (unpaired study). For the AOAC studies, the candidate method was compared to the United States Food and Drug Administration/ Bacteriological Analytical Manual (FDA/BAM) Chapter 5 *Salmonella* reference method using NFDM (paired study) and pre-warmed BPW (unpaired study). Cocoa powder (375 g) was also used in the AOAC OMA collaborative study of the candidate method.

**Results:** The candidate method performed statically equivalently or better than the reference method it was compared to for each enrichment in the respective study designs. The candidate method met all requirements outlined in ISO 16140-2:2016 (AFNOR) and AOAC Appendix J.

**Significance:** The candidate method is an accurate, reliable and reproducible method for the detection of *Salmonella* in large sample sizes of cocoa and chocolate products and now holds NF VALIDATION, AOAC PTM certification, and AOAC OMA First Action.

## P2-13 An ISO 16140-2:2016 Extension Study for a *Cronobacter* Species PCR Assay to Include 375 g Powdered Infant Formula, Infant Cereals and Related Ingredient Matrices

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**Introduction:** *Cronobacter* spp. are opportunistic pathogens predominantly found in dried powders, specifically powdered infant formula (PIF). *Cronobacter* infections are of concern for patients with weakened immune systems particularly neonates, with case mortality ranging between 50-80% for those vulnerable groups. Therefore, detection of *Cronobacter* spp. before contaminated foodstuffs reach patients is of marked importance.

**Purpose:** To extend the scope of validated matrices for the Thermo Scientific™ SureTect™ *Cronobacter* PCR Assay (alternative method) to include up to 375 g PIF with and without probiotics and infant cereals and related ingredients.

**Methods:** The alternative method was examined against the ISO 22964:2017 reference method using an unpaired study design. The sensitivity study comprised of 66 samples for the extension study PIF category, and the relative limit of detection (RLOD) study comprised of 30 samples across three levels of contamination. Inclusivity/exclusivity data from the initial validation study was used, which comprised of 57 inclusivity isolates and 31 non-target strains.

**Results:** The sensitivity study detected 7 positive deviations compared to 4 negative deviations, meaning the sensitivity study was below the acceptability limit (AL) of 3 for an unpaired study. The RLOD study data was below the AL of 2.5 for unpaired studies showing that the alternative and reference method perform comparably. The inclusivity/exclusivity study successfully detected and excluded all target and non-target isolates during the initial validation.

**Significance:** The alternative method demonstrates comparable performance to the reference method and was granted NF VALIDATION status. The alternative method constitutes a rapid and reliable workflow for the detection of *Cronobacter* spp. from up to 375 g infant formula with and without probiotics, and also allows for enrichment harmonisation for *Salmonella* testing.

## P2-14 Validation of a Rapid Culture Media Workflow According to ISO 16140-2:2016 for the Detection of *Cronobacter* spp. from Selected Matrices

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**Introduction:** *Cronobacter* species are ubiquitous organisms that are found in dried powders, specifically powdered infant formula (PIF). *Cronobacter* infections are particularly concerning for patients with lower immune systems such as neonates, with case mortality reported to be between 50-80% for those at-risk groups.

**Purpose:** To evaluate the Thermo Scientific™ Cronobacter Precis™ method (alternative method) according to the EN ISO 16140-2:2016 for detection of *Cronobacter* in PIF and environmental samples for MicroVal accreditation.

**Methods:** The validation study evaluated 10 g PIF (with and without probiotics) against the ISO 22964:2017 reference method using a paired study design, and 375 g PIF (with and without probiotics) and 25 g environmental samples using an unpaired study design. The sensitivity study contained a total of 199 samples according to ISO 16140-2 guidelines. The relative limit of detection (RLOD) study contained 3 categories, with 3 levels of contamination per category. The inclusivity and exclusivity analyzed 57 and 31 isolates, respectively.

**Results:** The sensitivity study gave a total of 12 positive deviations and 7 negative deviations which were below the acceptability limits (AL) for each category, showing comparable performance to the reference method. The alternative method demonstrates improved sensitivity (92.3%) compared to the reference method (86.8%). For the RLOD study the values were below the AL of 2.5 for an unpaired study and 1.5 for a paired study demonstrating comparable detection to the reference method. All study data met the ISO 16140-2:2016 requirements, and the alternative method was granted MicroVal certification

**Significance:** The alternative method constitutes a rapid and reliable workflow for the detection of *Cronobacter* spp. from PIF with and without probiotics and environmental samples and provides a markedly improved time to result compared to traditional reference techniques.

## P2-15\* Impact of Environmental Stresses on the Viability State of *Listeria monocytogenes* and *Listeria innocua* Analyzed by Raman Microspectroscopy, Molecular Biology and Microbiology Techniques

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**Introduction:** Food-processing plants are a hostile environment for bacteria, which are exposed to various stresses, such as osmotic, nutritional, alkaline, acidic, thermal, chemical and oxidative. These stresses may cause some of the bacterial population to enter the VBNC state. Once in this metabolic state and became non detectable by the culture-based methods, which only target viable cultivable (VC) population. These VBNC bacteria retain their ability to become pathogenic again under favourable conditions. In recent years, Raman microspectroscopy has emerged as one of the most innovative tools in the research and characterization of bacteria. Coupled with deuterium isotope probing (Raman-DIP), this technique allows to measure the metabolism of a bacterium and to evaluate its viability.

**Purpose:** We evaluated the impact of different environmental stresses present in the seafood processing industry such as low food storage temperatures (4°C), salting step (20% of salt), and biocide procedures (P3-topactive DES at 2% v/v) on *L. monocytogenes* and *L. innocua* populations.

**Methods:** We treated the suspensions of *L. monocytogenes* and *L. innocua* with these different stresses, alone or combined. We analyzed their metabolism by Raman-DIP microspectroscopy and we quantified the total, viable and VC population respectively by qPCR, PMA-qPCR and plate count agar.

**Results:** After biocide treatment, the total population was in VBNC state for *L. monocytogenes* with a significantly lower C-D peak than VC bacteria observed by Raman microspectroscopy and the total population was dead for *L. innocua*. For salt and temperature treatment, the whole population was in VC state. For combined stress mixing low incubation temperature and biocide treatment, we observed an antagonistic effect where the bacterial population was more photo resistant to the laser beam of the Raman microspectroscope than when these two stresses were applied separately.

**Significance:** We measure the impact of environmental stresses on the viability state of *L. monocytogenes* and *L. innocua* by Raman microspectroscopy with a better accuracy than molecular biology and microbiology techniques do.

## P2-16\* Evaluation of Viability of Cells of *Listeria innocua* with Raman Microspectroscopy after Incorporation of Heavy Water (D<sub>2</sub>O)

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**Introduction:** *Listeria innocua* is a Gram-positive ubiquitous bacteria, widely distributed in a range of environments and in food-processing environments. Different environmental stresses can induce the viable but non-culturable (VBNC) state of this bacteria during food processing, such as cleaning and disinfection procedures. Bacteria in the VBNC state have very low metabolic activity and do not divide. Consequently, VBNC cells do not grow on culture media but retain the ability to recover. To detect these VBNC bacteria, an innovative approach is to use Raman microspectroscopy coupled with deuterium isotope probing (Raman-DIP). This technique allows evaluating the metabolism of bacteria, but requires to feed bacterial cells with deuterated nutrient medium. Since biochemical reactions are slower with deuterated molecules, such a treatment may cause a metabolic stress that can alter the state of bacteria from Viable Culturable (VC) to VBNC or dead state. If we want to further investigate Raman-DIP for the detection of VBNC, it is of crucial importance to assess the harmlessness of DIP.



**Purpose:** We evaluated the impact of heavy water incorporation on the viability state of *L. innocua* cells (VC, VBNC, dead).

**Methods:** We exposed the *L. innocua* bacterial suspension to different heavy water concentrations (0%, 25%, 50% and 75%) during different times of incubation (from 0h30 to 72h). For each heavy water concentrations, total, viable (VC and VBNC) and VC populations were quantified by qPCR, PMA-qPCR and plate count agar respectively. In parallel, we analyzed heavy water absorption by Raman microspectroscopy.

**Results:** We showed that exposure to heavy water does not affect the viability of *L. innocua* cells. In parallel, we quantified metabolic probing through measuring deuterium incorporation by Raman microspectroscopy. The height of the C-D peak was monotonously correlated with the fraction of D<sub>2</sub>O in the medium. Nevertheless, a maximum level of labelling was reached after 2 hours, whatever the D<sub>2</sub>O fraction.

**Significance:** We can further investigate Raman-DIP for the detection of VBNC of foodborne pathogens.

(4% NaCl) or low salt (2.8% NaCl plus 1.6% KL). *Listeria* and starter culture growth profiles were monitored through periodic plate counts on selective media. Furthermore, salami pH, water activity, proximate composition, and Warner-Bratzler measurements were determined. Data were evaluated using ANOVA.

**Results:** The *L. innocua* strains selected are appropriate *L. monocytogenes* surrogates (growth rate under osmotic stress 0.39 vs 0.31 OD<sub>600</sub>/hour, respectively). MSB and beef salami-ripening simulation models showed that the low NaCl plus KL combination retained similar to superior anti-*Listeria* activity compared to the high salt concentration treatment [growth potential on beef -0.2 (2.8% NaCl plus 1.6% KL) vs +1 log CFU/g (4% NaCl)]. Salami challenge tests showed that NaCl plus KL combination had significantly ( $P < 0.05$ ) superior anti-*Listeria* activity as high NaCl concentration during ripening and storage (growth potential -1.73 vs -1.14 log CFU/g). No significant differences were detected in product characteristics and starter culture growth profiles between 4% NaCl and 2.8% NaCl plus KL treated salami. For instance, water activity was 0.894 in 4% NaCl vs 0.892 in the 2.8% NaCl-KL treated salami.

**Significance:** KL is an effective NaCl replacer allowing 30% NaCl reduction without compromising product quality and antimicrobial benefits of high NaCl concentration.

## P2-17 Non-Invasive Detection of Microbial Growth in Aseptic Food Products Using Tunable Diode Laser Absorption Spectroscopy

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**Introduction:** The capability of the TDLAS system to detect the growth of spoilage and safety organisms in real food matrices was explored.

**Purpose:** This study aimed to provide detailed scientific evidence for the application of TDLAS technology as a method to determine product sterility in real food products.

**Methods:** TDLAS was used to detect the growth of *Bacillus fengqi- uensis* (sporeformer), *Candida albicans* (yeast), *Lactococcus lactis*, *Microbacterium luteolum* (Actinomycete), *Paenibacillus chitinolyticus* (sporeformer), *Staphylococcus pasteurii*, and *Listeria monocytogenes* in various dairy-based commercially sterile drinks. Detection of growth was correlated with cell numbers and the reliability of detection was tested using multiple inoculum levels. In addition, Time to Detection (TTD) methodology was used to determine the specific growth rate, which was compared to viable plate count and optical density approaches.

**Results:** TDLAS detected growth of *Lactococcus lactis* within 20 h and *Staphylococcus pasteurii* in 55 h when contaminated as low as  $\approx 100$  CFU/mL. However, the sporeformer *B. fengqi uensis* was not detected within 72 h in two matrices when inoculated at low levels. The lowest cell density detected at 4.47 CFU/ml was for the yeast (*C. albicans*) after  $28.99 \pm 1.82$  h and the highest at 8.53 CFU/mL was for the Actinomycete (*M. luteolum*) at  $37.02 \pm 1.84$  h in non-hydrolysed dairy-based matrices. A strong linear relationship ( $R^2$  value  $\geq 0.827$ ) between initial inoculum and TTD for multiple inoculum levels was observed and growth rate calculation was comparable with optical density and viable plate count methods for *L. monocytogenes* but showed higher variability for *L. lactis*.

**Significance:** Overall, the reliability and limitations of TDLAS in identifying microbiological contamination by typical spoilage and safety microbes in dairy-based commercially sterile drinks were detailed in this study.

## P2-18\* Potassium Lactate as a Strategy for Sodium Content Reduction without Compromising Salt Associated Antimicrobial Activity in Salami

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**Introduction:** Reformulating recipes of ready-to-eat products such as salami to reduce salt content can mitigate the negative health impacts of a high salt diet.

**Purpose:** To evaluate the potential of potassium lactate (KL) as a sodium chloride (NaCl) replacer during salami production.

**Methods:** Four *Listeria innocua* food isolates were compared to seven reference outbreak-related *L. monocytogenes* strains based on stress tolerance (4 and 6% NaCl, 2.8% NaCl plus 1.6% KL) to validate their suitability as *L. monocytogenes* surrogates. Using the selected *L. innocua* strains, challenge tests were carried out in meat simulation broth (MSB), beef, and salami supplemented with high salt

## P2-19 Differences of Thermal Inactivation Kinetics of *Cronobacter sakazakii* Using Fresh, Dry or Dry-Adapted Inoculum

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**Introduction:** The risk of outbreaks involving the preparation of powdered infant milk has been documented and principally associated to *Salmonella* spp. and *Cronobacter sakazakii* (Cr). Fresh-liquid cultures are commonly used to inoculate the foods. However, liquid-inoculation may generate unsafe results due to an increased resistance of pathogens in dried foods.

**Purpose:** The objectives of this study were to evaluate the thermal inactivation kinetics of the strain Cr PT\_163 using fresh, dry and dry-adapted inoculum calculating the respective decimal reduction times ( $D_{\text{values}}$ ).

**Methods:** Ten ml of skim milk were mixed with Cr PT\_163 strain previously spread (1 ml of 9 log CFU/ml) on Blood Agar (BA) plates incubated at 37°C for 48 h. The obtained inoculum was used: as it was (Fresh inoculum, FI), freeze-dried (Dry inoculum, DI) or freeze-dried and maintained for 14 days at room temperature (Dry-Adapted inoculum, DAI). Each inoculum was diluted (1:10) in physiological solution and the survival kinetics at 55°C were evaluated on selective (Chromogenic *Cronobacter* Isolation agar (CCI)) and on nutritive (BA) media for three replicate experiments. The Geeraerd-tail model (Geeraerd et al., 2000) was used to estimate the  $K_{\text{max}}$  (specific inactivation rate) and the respective  $D_{\text{values}}$ .

**Results:** In CCI media, the  $D_{\text{values}}$  of Cr were  $1.7 \pm 0.1 < 4.7 \pm 1.3 < 9.5 \pm 1.6$  min using FI, DI and DAI respectively, showing an under-estimated  $D_{\text{value}}$  of  $82.5 \pm 2.5$  % when FI was used respect of the DAI. A similar trend was observed using the BA media, where  $D_{\text{values}}$  were  $2.5 \pm 0.4 < 7.4 \pm 0.1 < 12.5 \pm 0.1$  min using FI, DI and DAI, and the under-estimated  $D_{\text{value}}$  was  $79.6 \pm 3.4$  % when FI was used respect of the DAI.

**Significance:** The dry-inoculation of milk powder using DAI allow to consider the increased heat resistance of Cr and to evaluate the effectiveness of thermal inactivation practices.

## P2-20 Optimization of Assurance® G.D.S. Salmonella Enrichment Protocols for Cocoa and Chocolate

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**Introduction:** Cocoa and chocolate are challenging matrices for detection of *Salmonella* by qPCR. A study of the enrichment method was undertaken to explore possible optimization and simplification of the workflow.

**Purpose:** To optimize enrichment protocols of cocoa and chocolate products using a qPCR-based *Salmonella* detection assay.

## \* Student Award Competitor

**Methods:** Enrichment cultures were seeded with dried *Salmonella*. Optimization was performed on 25g samples of cocoa powder, cocoa nibs, cocoa mass and 85% chocolate. We compared three enrichment media: ultrahigh temperature (UHT) pasteurized milk, 10% reconstituted milk powder and buffered peptone water (BPW). We also investigated pH adjustment time, addition of Brilliant Green, and neutralizing agents. Enrichment steps were optimized independently, and performance was primarily judged on threshold cycle (Ct) values from qPCR.

**Results:** We found UHT milk to improve *Salmonella* detection relative to reconstituted milk powder ( $P < 0.001$ ;  $n=48$ ). The addition of Brilliant Green did not show a statistically significant difference in *Salmonella* detection ( $P = 0.415$ ;  $n=48$ ). For milk enrichments, the 1-hour incubation prior to adjustment of pH, as recommended in reference methods, did not improve PCR signal compared to immediate adjustment ( $P = 0.719$ ,  $0.900$ ;  $n=24$  in UHT and powdered milk, respectively). We were able to significantly improve *Salmonella* detection in BPW enrichments by adding neutralizing agents ( $P < 0.001$ ;  $n=12$ ). Statistical tests indicated are unpaired, two-tailed t-tests on cocoa nibs and cocoa powder.

**Significance:** Optimization of enrichment protocols can significantly improve method performance. qPCR Ct values are useful for numerical comparison of growth in mixed enrichments where plate count cannot be used.

## P2-21 Verifying the Inactivation of *Salmonella* spp. in Poultry Feed Mills

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**Introduction:** Due to the nature of ingredients used in their manufacture, poultry feeds are prone to contamination with salmonellae.

New guidance published by the Agricultural Industries Confederation (AIC), has introduced the requirement that kill steps used to control *Salmonella* in poultry feeds and feed ingredients via heat or chemical treatments should be validated to confirm that a suitable log reduction is achieved.

**Purpose:** This project aims to provide a validated protocol allowing determination of the lethality achieved towards *Salmonella* in poultry feeds by heat and chemical processes, including inoculation of large quantities of material and qualification of surrogate organisms for use in feed mill challenge tests.

**Methods:** D- and z-values of target (*Salmonella*) and surrogate (*Enterococcus faecium* ATCC 8459) organisms to steam heating were determined in 3 poultry feeds and data was used to validate the surrogate.

Assessments of 3 organic acid treatments were conducted to provide comparative data assessing the suitability of the potential *Salmonella* surrogate *Enterococcus faecium*.

**Results:**

### 1. Heat treatment results:

The following z-values were calculated in each feed assessed for *Enterococcus faecium* and *Salmonella*, respectively.

- **Layer feed** 12.21°C and 12.22°C
- **Broiler breeder** 11.43°C and 11.79°C
- **Sunflower seed feed** 11.61°C and 10.33°C

In all feeds, *Enterococcus faecium* showed slightly higher thermal resistance than *Salmonella* throughout the temperature range typically applied during steam heating of poultry feed, and similar z-values, confirming its suitability as a surrogate organism for use in challenge testing of these processes.

### 2. Bactericidal study results:

Log reductions of both *Salmonella* and *Enterococcus faecium* of between 1 & 2-log were observed for feeds treated with 0.1% powdered bacteriocides over a 7-day period. Both liquid treatments assessed yielded either very small reductions (<0.5 log) or no reduction across the 7-day test period.

**Significance:** Data supporting the use of *E. faecium* as a surrogate organism for use in assessment of Poultry Feed Mill steam treatments.

## P2-22 Characterization and Composition Analysis of Biofilm and Extracellular Polymeric Substances (EPS) Produced by Seafood Pathogen *Tenacibaculum discolor*

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**Introduction:** Tenacibaculosis is an important bacterial disease which causes significant losses in the marine aquaculture production. *Tenacibaculum discolor* has been identified as a causative agent of tenacibaculosis. Biofilms developed on aquaculture surfaces may host pathogenic bacteria such as the latter and act as a reservoir for repeated infections. However, little is known about the biofilm characteristics of *T. discolor*.

**Purpose:** To investigate the composition of the biofilm matrix and EPS produced by *T. discolor*.

**Methods:** *T. discolor* strain FMCC B487, identified by whole genome sequencing, was isolated from a marine recirculated aquaculture system, where adult seabass were exhibiting symptoms of tenacibaculosis. Biofilm development was performed with Zobell medium on petri dishes and recovery was realized after scraping with a sterile cell scraper. The production of extracellular polymeric substances (EPS) was performed under two different growth conditions with glucose (G-EPS) or mannose (M-EPS), in a small-scale bioreactor. A series of aqueous extracts were prepared from planktonic and biofilm cell broths. Compositional analyses included colorimetric methods for the quantification of proteins, total carbohydrates, lipids and DNA. Carbohydrates and proteins were analyzed by electrophoreses (agarose gel, PAGE and SDS-PAGE), while the osidic composition was determined by GC.

**Results:** Biofilm matrix was characterized by the dominance of proteins and lipids, while EPS from planktonic cells exhibited high content in proteins and carbohydrates. G-EPS had a high lipid content, whereas M-EPS had high protein content. Electrophoretic analyses revealed the absence of high-molecular-weight polysaccharides, and the presence of many proteins in all extracts was observed. GC confirmed the low carbohydrate content in all extracts and revealed the dominance of mannose in extracellular carbohydrates both from planktonic and biofilm cultures.

**Significance:** Understanding biofilm formation by *T. discolor* would provide the basis for considering anti-biofilm strategies in aquaculture.

## P2-23 Data Fusion of Three Noninvasive Methods for the Quality Assessment of Chicken Marinated Souvlaki

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**Introduction:** Multispectral imaging (MSI), Fourier Transformed Infrared spectroscopy (FT-IR) and Electronic nose (E-nose) have been employed in tandem with multivariate data analysis for the detection of spoilage in the early stages of meat and poultry deterioration.

**Purpose:** The objective of this study was the evaluation of Partial Least Squares-Regression (PLS-R) and Support Vector Machines-Regression (SVM-R) models for the estimation of the microbiological quality on chicken marinated souvlaki via MSI, FT-IR and E-nose data fusion.

**Methods:** Chicken marinated souvlaki ( $n=169$ , three independent experiments) samples were stored aerobically at 0, 5, and 10°C and in a dynamic temperature profile (12 h at 0°C, 8 h at 5°C and 4 h at 10°C). Samples were subjected to microbiological analysis (enumeration of Total Viable Counts, TVCs) while simultaneously FT-IR, MSI and E-nose analyses were performed. PLS-R and SVM-R models were optimized for the assessment of TVCs for each sensor. Mid-level data fusion (First step: Principal Component Analysis, PCA; Second step: PLS-R or SVM-R) was implemented for the evaluation of these three methods combined for the determination of TVCs on stored chicken products.

**Results:** PLS-R models for FT-IR/MSI spectral data demonstrated the most accurate estimation of TVCs, with a Root Mean Squared Error value of 0.983 log CFU/g, followed by MSI model (RMSE: 0.998 log CFU/g). Similarly, the combination of FT-IR/MSI data with SVM-R model provided an efficient prediction of TVCs, where the calculated RMSE was 0.973 log CFU/g. For SVM-R and MSI data, RMSE was estimated at 0.999 log CFU/g.

**Significance:** These PLS-R and SVM-R models coupled to MSI data and FT-IR/MSI data could be implemented by poultry industries for the rapid quality assessment and subsequently could assist to the reduction of food loss.

## P2-24 The Potential of Machine Learning in the Assessment of the Microbiological Quality of Fish

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**Introduction:** Aquaculture production is developing, and it is expected to present an increase of 37% by 2030, producing 60% of fish for human consumption. Among the cultured species, gilthead sea bream and sea bass are two of the most economically important fish species in the European Union, which produces almost 67 and 92% of global production, respectively. Greece is the main producer country of both species in the EU and worldwide.

**Purpose:** To develop and validate machine learning models based on Fourier Transform Infrared (FTIR) spectral data for the rapid and non-invasive assessment of fish quality.

**Methods:** Whole exfoliated and non-gutted sea bream and sea bass fish samples were aerobically stored at 0, 4, 8, and 12°C. Total Viable Counts (TVC) were obtained throughout storage using conventional microbiological techniques, in parallel with FTIR spectral data, and were further used to build: Partial Least Square, Support Vector Machines, Random Forests, and Extra-Trees Regression models. Python programming language was used to implement the workflow and the scikit-learn library was employed for model development.

**Results:** The TVC predictive performance of the developed models was evaluated based on statistical indices between the predicted and measured TVC counts. Spectral data analyzed by Extra-Trees regression model showed that for sea bass, the value of RMSE and the coefficient of determination  $R^2$  were both 0.50 and 0.91 for calibration and prediction, respectively. Additionally, for sea bream, RMSE was 0.45 and 0.49 and the  $R^2$  was 0.93 and 0.89 for calibration and prediction, respectively. The remaining models presented less satisfactory performance.

**Significance:** Machine learning models could be effectively employed in the analysis of FTIR spectral data to assess fish's quality. This research was financially supported funded by the EU and Greek national funds through the Rapid Fish Freshness Assessment Methodology (ReFRAME), grant number MIS: 5028331.

## P2-25 Transition of *Listeria monocytogenes* into Sublethal Injury during Frankfurters Reheating

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**Introduction:** *Listeria monocytogenes* is a ubiquitous foodborne hazard that may contaminate the surface of ready-to-eat cooked meat products, like frankfurters. As such, the majority of manufacturing companies recommend a mild reheating in water prior to consumption. However, such a treatment may be sub-lethal for well-embedded cells in niches on or below the product surface.

**Purpose:** (i) To evaluate the sub-lethal thermal injury of *L. monocytogenes* on frankfurters surface at single cell *versus* population level, at temperatures that may occur on product surface during reheating; and (ii) to estimate the proportion of metabolically active, injured and dead cells during exposure to heat stress, using culture-based methods and fluorescence microscopy.

**Methods:** Frankfurters were inoculated (7.0 log CFU/cm<sup>2</sup>) of *L. monocytogenes* strain EGD-e. Reheating of frankfurters was simulated in a water bath at 61°C (60 min) and 64°C (20 min). Temperature changes were monitored by placing a K-type thermocouple on the surface of frankfurters prior to vacuum packaging. Determination of injured sub-populations was performed by subtracting the number of colonies on Tryptic Soy Agar with 0.6% Yeast Extract (TSAYE) supplemented with 5% NaCl from those on TSAYE with 0.5% NaCl. Sub-lethally injured cells were detected by comparing plate counts with fluorescence microscopy, using CFDA/PI staining.

**Results:** At population level, induction of sublethal injury was recorded after 2 and 4 min of exposure at 64°C and 6 min 61°C. This was confirmed microscopically, at single cell level. Tailing has been detected in the inactivation curve of 64°C, indicating heterogeneity and robustness of single cells toward sub-lethal heating. After exposure to 61°C for 60 min, the whole population was below the detection limit; however, a considerable number of single cells appeared as CFDA+/PI+, indicating induction of sub-lethal injury.

**Significance:** Evaluation of *in situ L. monocytogenes* sub-lethal injury could be crucial for food microbiology, offering insights on the risks associated with overestimation of a process lethality.

## P2-26 Occurrence of Pathogenic Microorganisms in Fermented Foods

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**Introduction:** Fermented foods are usually associated with acidic pH, and in some cases, basic pH, thereby creating possible hindrances to the growth of pathogenic microorganisms. However, these pathogens have been found to survive these hurdles and exist in fermented foods.

**Purpose:** This study was carried out to check the occurrence of pathogenic and spoilage microorganisms in different classes of tropical fermented foods.

**Methods:** Established literature between 2000-2021 on the occurrence of pathogenic and spoilage microorganisms of tropical origin was critically reviewed and synthesized to understand the presence of these organisms in different classes of fermented foods from different locations and regions within tropical climates, especially Africa. These classes of foods include cereals, roots and tubers, dairy, vegetables and fruits, as well as legumes, pulses, and oilseeds.

**Results:** The occurrence of different groups of pathogenic and spoilage microorganisms, including spore-forming pathogenic bacteria (such as *Bacillus* spp., *Clostridium* spp.), non-spore-forming pathogenic bacteria (such as *Salmonella* spp., *Shigella* spp.), bacterial toxin producers (*Staphylococcus aureus*), yeasts (such as *Listeria monocytogenes*, *Candida* spp., *Saccharomyces cerevisiae*), molds (such as *Rhizopus* spp., *Penicillium* spp.) and toxigenic fungi (such as *Aspergillus* spp.) has been reported in fermented foods. The presence of these pathogenic organisms in fermented tropical foods was added mainly to poor handling and production practices and the native microflora of fermenting foods.

**Significance:** This study underscores the importance of the awareness of the occurrence of pathogenic and spoilage microorganisms, their effects, and the conditions responsible for their activities and survival in tropical fermented foods. Therefore, ensuring proper handling, adequate hygiene of food processors, as well as equipment and utensils in line with established food safety management systems, are needed to ensure that tropical fermented foods are less frequently contaminated by pathogenic microorganisms.

## \* Student Award Competitor

### P2-27 CO<sub>2</sub> Inhibits Several Spoilage Associated Bacteria and Reduce Off Odor Development of CO<sub>2</sub> Tolerant Bacteria during Storage of Raw Chicken Fillets

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**Introduction:** Chicken meat is regarded as a sustainable alternative to red meat but is more vulnerable for spoilage. Both packaging with CO<sub>2</sub> and vacuum packaging is commonly used to increase the shelf life, but the literature is not consistent about the spoilage microbiota.

**Purpose:** The purpose of this work was to determine which bacterial genera that spoil raw chicken fillets packaged under two common packaging conditions and how the packaging gas itself affects the production of off-odors for these genera.

**Methods:** The spoilage potential of bacteria from six different genera (*Pseudomonas*, *Carnobacterium*, *Hafnia*, *Serratia*, *Brochothrix*, and *Shewanella*) isolated from spoiled chicken fillets of different origins were evaluated by inoculating fresh chicken fillets (4 log CFU/cm<sup>2</sup>) with mono- and multigenre strain cocktails. The inoculated fillets and non-inoculated control fillets were packed and stored at 4°C. Samples were analyzed after 8 and 11 days and the spoilage potential was evaluated based on growth and sensory profiling (expert sensory panel).

**Results:** All bacterial cocktails grew relatively well in chicken meat packed with 100% N<sub>2</sub>, while 60% CO<sub>2</sub>/40% N<sub>2</sub> resulted in a lower growth rate of all isolates compared to 100% N<sub>2</sub> and reduced growth of *Serratia* spp. All genera except *Serratia* and *Pseudomonas* gave rise to off-odors during storage in 100% N<sub>2</sub>. During storage in 60% CO<sub>2</sub>/40% N<sub>2</sub> only fillets with *Carnobacterium* spp. and *Brochothrix* sp. showed significantly higher intensities of off-odors compared to the control fillets. *Shewanella* spp. and *Brochothrix* sp. also exhibited significantly higher intensities of negative odor attributes during storage in 100% N<sub>2</sub> compared to 60% CO<sub>2</sub>/40% N<sub>2</sub>. Thus, CO<sub>2</sub> improves shelf life not only by reduction of the growth rate of CO<sub>2</sub> tolerant and sensitive bacteria but also through inhibition of the production of off-odors.

**Significance:** Optimized packaging conditions to improve the shelf life of chicken fillets is important to prevent food spoilage and food waste.

### P2-28\* Biofilm Formation Diversity of *Brochothrix thermosphacta* a Major Food Spoiler

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**Introduction:** Biofilms play an important role in residence and persistence of microorganisms in food industry. *Brochothrix thermosphacta* is considered as a major food spoilage bacteria (Ilikoud et al., 2019). This bacteria has been identified in biofilms on multiple surfaces of the food processing environment (Wagner et al., 2021, 2020).

**Purpose:** The study of *B. thermosphacta* ability to form biofilm is necessary to better understand the residence and persistence of this bacteria in food processing environment and finally to better control food contamination from the industrial surfaces.

**Methods:** Biofilms formation diversity at 25°C of a *B. thermosphacta* strains collection (i.e., 31 strains) was characterized by using the biofilm ring test (cBRT), the crystal violet staining and the laser scanning confocal microscopy (LSCM), with the images analysis by BiofilmQ (Hartmann et al., 2021).

**Results:** Using cBRT, the 31 strains were classified in 4 groups, according to biofilm formation. Fourteen were classified as poor biofilm producer and represent 65% of the strains. Four strains as weak (12.5%), five as medium (15.5%), and two as high biofilm producer (6%). This shown a predominance of poor and weak early biofilm stage producer strains. The ability to form a mature biofilm was analysed with crystal violet staining. A statistical analysis shows seven significant different group of mature biofilm formation ( $P < 0.05$ ). The five higher biofilm producer groups are composed by the same 6 strains already classified as high and medium biofilm early stage producer by cBRT.

The analysis of LSCM images by BiofilmQ identified 10 parameters that influence the diversity. Biofilm are flat with high cell density, biofilm volume, biovolume, number of cells, and substrate coverage.

**Significance:** This study is to our knowledge the first describing biofilm formation by *B. thermosphacta* showing 7 high biofilm producing strains.

### P2-29 Effect of Edible Coating and Modified Atmosphere Packaging on the Microbiological and Physicochemical Characteristics of Non-Thermally Preserved Cv. Kalamata Natural Black Olives

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**Introduction:** Natural black olives are among the major commercial preparations in the international market. Nowadays, the table olive industry tends to use multi-layered plastic pouches for table olive packaging at retail level due to reduced weight, lower cost, flexibility and convenience for use by consumers. Moreover, edible coatings have been extensively employed to preserve and extend the shelf life of fresh fruits and vegetables.

**Purpose:** The aim of this work was to investigate the effect of edible coatings combined with modified atmosphere packaging on the microbiological and physicochemical characteristics of cv. Kalamata natural black olives packaged in multi-layered plastic pouches.

**Methods:** Natural black cv. Kalamata olives were initially immersed in an aqueous solution of 1% (w/v) carboxymethyl cellulose (CMC), 1% (w/v) sodium alginate (SA) and 1% (w/v) glycerol and subsequently packaged in multi-layered polyamide (PA)/polyethylene (PE) pouches under aerobic conditions and modified atmospheres (100% N<sub>2</sub>). In addition, a control treatment of table olives without edible coating was prepared and packaged in the same conditions. All packages were stored at room temperature (20-22°C) and subjected to microbiological (lactic acid bacteria-LAB, yeasts) and physicochemical (pH, acidity, salt content, texture, color) analyses.

**Results:** The initial LAB and yeast populations were 4.5 and 3.9 log CFU/g, respectively. LAB decreased during storage on olives subjected to edible coating (EC) compared to control (C) treatment in both aerobic and 100% N<sub>2</sub> atmosphere. The same pattern was observed for yeasts, especially in 100% N<sub>2</sub>, whereas in aerobic conditions the difference between EC and C samples was not significant. The initial pH was 3.82 and it did not present considerable changes during storage regardless of packaging condition and EC treatment. However, olives treated with the edible coating combined with 100% N<sub>2</sub> maintained higher levels of titratable acidity, salt content, firmness and surface color compared with aerobically packaged olives.

**Significance:** The use of edible coatings and modified atmosphere packaging act synergistically in the preservation of natural black table olives.

### P2-30 Multispectral Imaging for Estimating the Microbiological Quality of Chicken Fillets Stored Under Different Packaging Conditions

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**Introduction:** Current safety and quality controls in industries are mainly based on chemical and microbiological analyses which are time consuming and tedious. The development of analytical approaches for estimating microbial load, such as multispectral imaging coupled with data analysis, is very important for the rapid examination of high numbers of food samples in real-time.

**Purpose:** The aim of the study is to develop methods for the estimation of microbial spoilage in chicken fillets using multispectral imaging (MSI).

**Methods:** Chicken thigh fillets were stored aerobically (wrapped with cling film) (air) and under vacuum packaging at three isothermal conditions (0, 5 and 10°C). At predetermined time intervals, samples were enumerated for total viable counts (TVC), whereas MSI were acquired at the same time points as for microbiological analyses. For air and vacuum packaging condition two independent experiments

were undertaken at all isothermal conditions. In total 311 chicken filets were used. The collected MSI data were subjected to standard normal variate (SNV) transformation. The data acquired from storage at 0, 10°C were used for calibration and from 5°C for (external) validation of the models. Subsequently, the correlation between microbiological counts and spectral data was determined using partial least squares regression (PLS-R). MSI data were used as input and TVC as output variables.

**Results:** PLS-R models were calibrated and validated with the data collected from air (n=149) and vacuum (n=162) conditions. The performance of the developed models for cross validation was similar in both cases of packaging, air (R<sup>2</sup>= 0.824, RMSE= 0.661) and vacuum (R<sup>2</sup>= 0.724, RMSE= 0.615). The values (R<sup>2</sup>, RMSE) for external validation of air condition were 0.865 and 0.573, as well as of vacuum 0.830 and 0.575, respectively.

**Significance:** MSI spectral data combined with PLS-R could adequately predict TVC on the surface of chicken thigh filets regardless of packaging condition. This work has been funded by the project DITECT (861915).

## P2-31 Cleaning and Disinfection. What Will be the Outcome Post-Pandemic?

Peter M. Littleton

Christeys Food Hygiene, Warrington, United Kingdom

**Introduction:** Cleaning and disinfection practices have understandably been centre-stage over the past 18 months with a clear focus on non-food contact surfaces aka "common touchpoints." However, what will be the view of these practices post-pandemic when our lives return to normality?

**Purpose:** For many businesses, whilst cleaning and disinfection have been regularly, diligently, and effectively undertaken there has too often been the view that they are a "necessary evil" and on-cost draining resources, time, and money straight from the bottom line. Over the past couple of years, the realisation that actually cleaning and disinfection is of great benefit in maintaining the health and well-being of the workforce and public at large has been evident with many businesses switching to enhanced procedures.

**Methods:** As we emerge from the pandemic will these views persist or will we slip back into the old habits of viewing the hygiene team as a hindrance to production leading to the inevitable reductions in budgets and potential slipping of standards?

**Results:** In this presentation, Littleton will champion the call for cleaning and disinfection procedures to be viewed as essential elements of the food safety programme worthy of investment in terms of both resources and time.

**Significance:** Our industry has had a clear wake-up call to the importance of cleaning and disinfection, will we learn from this lesson or simple return to bad habits?

## P2-32 Bacteriophages-Based Enrichment Coupled to Chemiluminescence Reaction for Highly Specific, Sensitive and Single-Step *Listeria monocytogenes* and *Salmonella* spp. Detection

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**Introduction:** A comprehensive environmental monitoring program is the best method to reduce the risk of microbial contamination in the food industry. However, most screening methods to detect pathogenic microorganisms are incompatible with daily on-site routines since they are complex, performed by qualified technicians in external laboratories, and take several days to result. NEMIS Technologies recently developed two detection kits for *L. monocytogenes* and *Salmonella* spp. Respectively. The protocol based on the chemiluminescent AquaSpark™ technology can be performed safely by anyone on-site and give reliable results in only 24 hours. The method relies on a one-step bacterial growth in bacteriophages-based media able to control the growth of competitive microflora followed by chemiluminescence-based detection of the activity of inositol phosphatase and alpha-galactosidase, respectively, specific for *L. monocytogenes* and *Salmonella* spp.

**Purpose:** The objective of this study was to evaluate the performance of bacteriophages in selective media for *Listeria monocytogenes* and *Salmonella*, respectively.

**Methods:** Swabbing experiments of dried bacteria (16-18h) on stainless steel were performed with target and competitor microflora. Growth and detection signals were analyzed with and without bacteriophage cocktail within selective growth media. Furthermore, the range of bacteriophage targeting was determined in AOAC protocols for exclusivity determination.

**Results:** Data from two studies presented here show that phage cocktails can increase nutrient broth selectivity beyond 30 exclusivity species (AOAC PTM<sup>SM</sup>). Furthermore, we demonstrate that when grown in competitive microflora, bacteriophages can eliminate the growth of competitors such as *Enterococcus faecalis* effectively within a 24 hours enrichment period, thereby increasing the signal-to-noise ratios for target organisms by up to two orders of magnitude.

**Significance:** By combining optimized bacteriophages cocktail and ultrasensitive chemiluminescence probes, NEMIS successfully developed innovative test kits for the detection of the two most feared food-borne pathogens within 24 hours. The AquaSpark™ platform technology will be further leveraged to detect a wide range of relevant bacteria in food safety and beyond.

## P2-33 A Microbiological and Hygiene Assessment of Vertical Hand-Dryer Cleanliness in Food Manufacturing Facilities

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**Introduction:** Wet hands can transfer contamination to hand contact surfaces more readily than dry and so effective hand-drying in the hand hygiene regimen is an essential step. Similarly, a sufficient hand-drying attempt provides additional opportunity to reduce remaining hand contamination following the wash routine. Consensus as to whether vertical hand-dryers are a potential hand contamination vector in food manufacturing facilities remains unclear.

**Purpose:** To determine microbiological contamination and organic residue of vertical hand-drying units in a multi-site food manufacturing business with reference to situational factors.

**Methods:** Vertical hand-dryers, adjacent walls and hand-dryer air were sampled (n=32) post-cleaning and post-production on repeated occasions using dipslides to assess total viable count (TVC) (n=74) and presumptive *Enterobacteriaceae* (n=73) and adenosine triphosphate (ATP) (n=74) bioluminescence. Visual assessment according to a pre-defined grading index recorded condition/cleanliness and surface appearance (wet/dry) as well as examination of the hand-dryer high efficiency particulate air-filter (HEPA).

**Results:** Following company protocol and manufacturer guidelines, unacceptable ATP values at relative light unit (RLU) ≥300 were found on 82% of all occasions; 76% post-cleaning, 89% post-production. Post-cleaning, 86% of TVC samples ≥12CFU/cm<sup>2</sup> and 29% *Enterobacteriaceae* at ≥40CFU/cm<sup>2</sup> were detected. Sampling locations were classified as good condition (89%), dry (92%) with only 40% displaying small/moderate food soilage. Wall surfaces adjacent to hand-dryers rarely exceeded 12CFU/cm<sup>2</sup> for TVC or *Enterobacteriaceae* however, 69% of all wall ATP measurements exceeded 500 RLU. While no evidence of *Enterobacteriaceae* was detected in any hand-dryer air sample, TVCs ranged from ≥2.5CFU/cm<sup>2</sup> to 40CFU/cm<sup>2</sup> with dipslides presenting similar colony appearance and even dispersion regardless of location. HEPA filter examination potentially suggested discrepancies in relation to hand-dryer filtration capabilities dependent on brand.

**Significance:** Vertical hand-dryers may potentially act as a vector for hand contamination. Regular inspection (HEPA filter), cleaning and environmental sampling of hand-dryers and surrounding surfaces may be advisable to mitigate potential hand hygiene risks.

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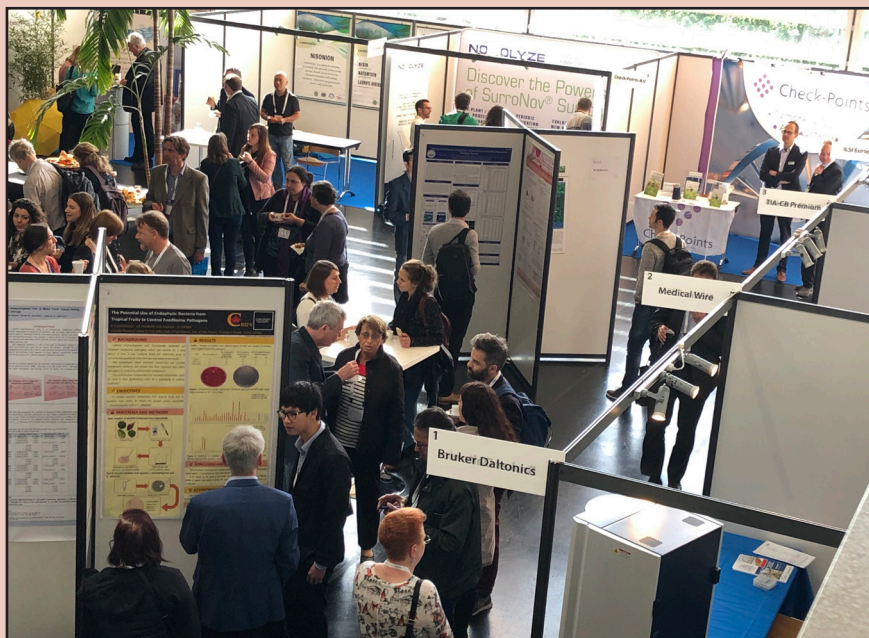
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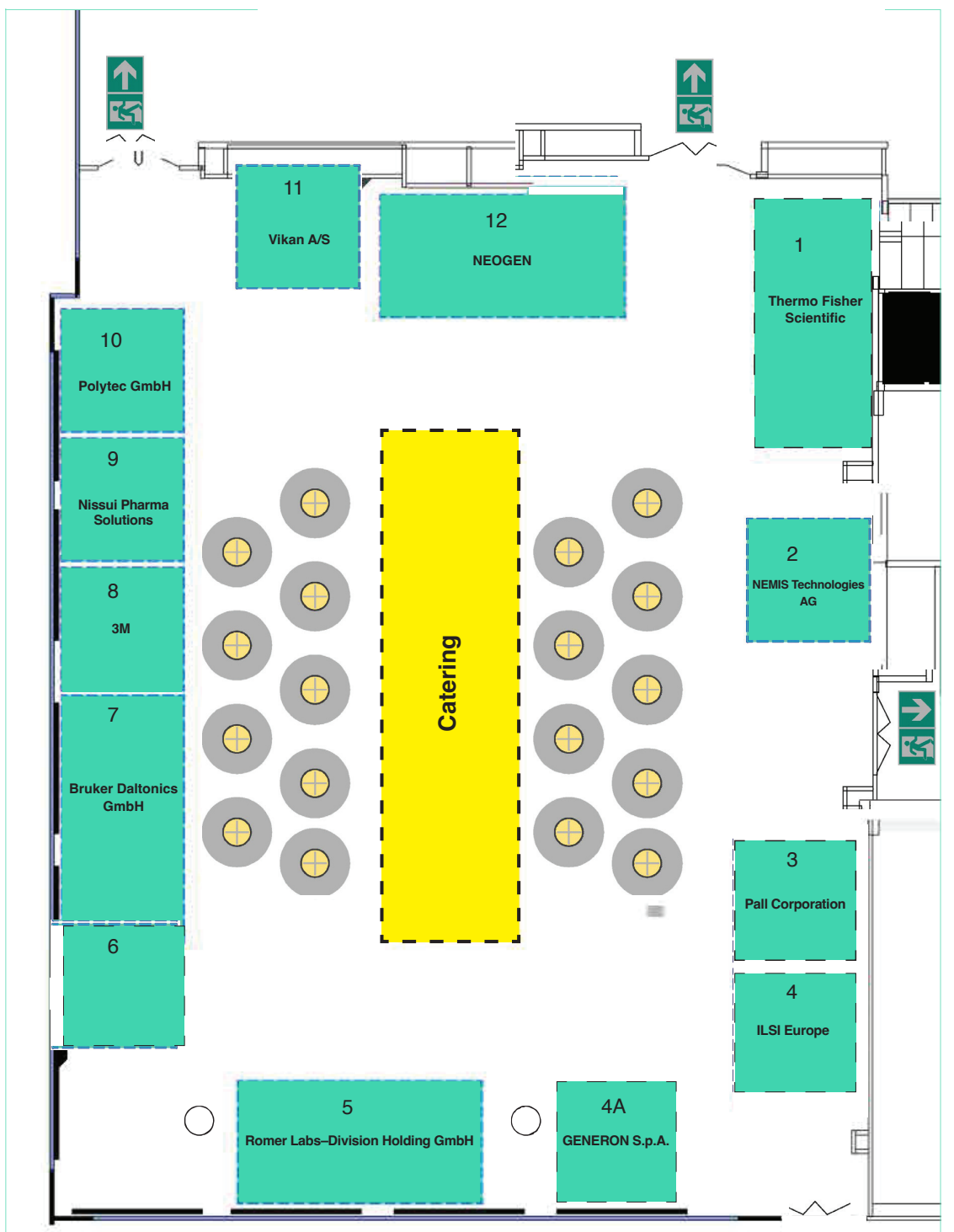
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**Thursday, 5 May 2022**

10.00 – 16.00

## EXHIBIT EVENTS

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 12.00 Lunch  
 15.00 Networking Coffee Break  
 17.00 Reception

**Thursday, 5 May 2022**

10.00 Networking Coffee Break  
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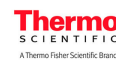
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[www.empiricalfoods.com](http://www.empiricalfoods.com)

Food Directorate, Health Canada  
[www.hc-sc.gc.ca](http://www.hc-sc.gc.ca)

Food Enterprise Solutions  
[www.foodsolutions.global](http://www.foodsolutions.global)

Food Microbiological Laboratories, Inc.  
[www.foodmicrolabs.com](http://www.foodmicrolabs.com)

Food Research Institute, University  
of Wisconsin–Madison  
[www.fri.wisc.edu](http://www.fri.wisc.edu)

FREMONTA Corp.  
[www.fremonta.com](http://www.fremonta.com)

HiMedia Laboratories Pvt. Ltd.  
[www.himedialabs.com](http://www.himedialabs.com)

IDEXX Laboratories, Inc.  
[www.idexx.com](http://www.idexx.com)

IEH Laboratories & Consulting Group  
[www.iehinc.com](http://www.iehinc.com)

The Industrial Fumigant Company, LLC  
[www.indfumco.com](http://www.indfumco.com)

Institute for Food Safety and Health  
[www.ifsh.iit.edu](http://www.ifsh.iit.edu)

International Dairy Foods Association  
[www.idfa.org](http://www.idfa.org)

International Fresh Produce Association  
[www.freshproduce.com](http://www.freshproduce.com)

Intertek Alchemy  
[www.alchemysystems.com](http://www.alchemysystems.com)

The Kroger Co.  
[www.kroger.com](http://www.kroger.com)

Lumaco  
[www.lumaco.com](http://www.lumaco.com)

Mastronardi Produce Limited  
[www.sunsetgrown.com](http://www.sunsetgrown.com)

Matrix Sciences  
[www.matrixsciences.com](http://www.matrixsciences.com)

Michelson Laboratories, Inc.  
[www.michelsonlab.com](http://www.michelsonlab.com)

Michigan State University Online  
Food Safety Programs  
[www.foodsafety.msu.edu](http://www.foodsafety.msu.edu)

Micro Essential Laboratory, Inc.  
[www.microessentiallab.com](http://www.microessentiallab.com)

Micro-Smedt  
[www.micro-smedt.be](http://www.micro-smedt.be)

Microbiologics, Inc.  
[www.microbiologics.com](http://www.microbiologics.com)

Midland Scientific, Inc.  
[www.midlandsci.com](http://www.midlandsci.com)

Mondelēz International  
[www.mondelezinternational.com](http://www.mondelezinternational.com)

Nasco Whirl-Pak Division  
[www.whirl-pak.com](http://www.whirl-pak.com)

NSF International  
[www.nsf.org](http://www.nsf.org)

NSI Lab Solutions  
[www.nsilabsolutions.com](http://www.nsilabsolutions.com)

Orkin Commercial Services  
[www.orkin.com](http://www.orkin.com)

Overhill Farms, Inc.  
[www.overhillfarms.com](http://www.overhillfarms.com)

Polyskope Labs  
[www.polyskopelabs.com](http://www.polyskopelabs.com)

Post Consumer Brands  
[www.postconsumerbrands.com](http://www.postconsumerbrands.com)

The Procter & Gamble Company  
[www.pgpro.com](http://www.pgpro.com)

Publix Super Markets, Inc.  
[www.publix.com](http://www.publix.com)

Puremed Canada Inc.  
[www.puremed.ca](http://www.puremed.ca)

Q Laboratories  
[www qlaboratories.com](http://www qlaboratories.com)

Quaker Maid Meats  
[www.quakermaidmeats.com](http://www.quakermaidmeats.com)

QualiTru Sampling Systems  
[www.qualitru.com](http://www.qualitru.com)

QUANTEM Food Safety Laboratories, LLC  
[www.quantemfood.com](http://www.quantemfood.com)

R & F Products  
[www.rf-products.net](http://www.rf-products.net)

Reading Thermal  
[www.readingthermal.com](http://www.readingthermal.com)

Recall InfoLink  
[www.recallinfolink.com](http://www.recallinfolink.com)

Rentokil  
[www.rentokil.com/us](http://www.rentokil.com/us)

Restaurant Brands International  
[www.rbi.com](http://www.rbi.com)

Retail Business Services, an Ahold  
Delhaize USA Company  
[www.retailbusinessservices.com](http://www.retailbusinessservices.com)

Rochester Midland Corporation  
[www.rochestermidland.com](http://www.rochestermidland.com)

Romer Labs, Inc.  
[www.romerlabs.com](http://www.romerlabs.com)

Sensitech Inc.  
[www.sensitech.com](http://www.sensitech.com)

Seward Laboratory Systems Inc.  
[www.seward.co.uk](http://www.seward.co.uk)

Shamrock Foods Company  
[www.shamrockfoods.com](http://www.shamrockfoods.com)

Steamerics, Inc.  
[www.steamerics.com](http://www.steamerics.com)

Steritech  
[www.steritech.com](http://www.steritech.com)

Testo Solutions USA, Inc.  
[www.testo.com/solutions](http://www.testo.com/solutions)

Texas Roadhouse, Inc.  
[www.texasroadhouse.com](http://www.texasroadhouse.com)

Truly Nolen International for Pest Control K.S.A.  
[www.trulynolen.com](http://www.trulynolen.com)

Upside Foods  
[www.upsidefoods.com](http://www.upsidefoods.com)

Vikan A/S  
[www.vikan.com](http://www.vikan.com)

Vitsab International AB  
[www.vitsab.com](http://www.vitsab.com)

Wegmans Food Markets, Inc.  
[www.wegmans.com](http://www.wegmans.com)

# PAST EUROPEAN STUDENT TRAVEL SCHOLARSHIP RECIPIENTS

2014 – Erika Georget  
2015 – Emily Jackson  
2016 – Amanda Demeter  
2017 – Christian Hertwig

2018 – Katrien Begyn and Giannis Koukkidis  
2019 – Maria Gkerekou and Yifan Zhang  
2020 – Alessia Delbrück and Hannah Pye  
2021 – None presented

# STUDENT AWARD COMPETITION RECIPIENTS

2009 **Overall:** Peter Rossmannith  
**Posters:** Antje Frohling and Mary Pia Cuervo  
2010 **Technical:** Rocio Morales-Rayas  
**Posters:** Orla Condell and Shane Cooney  
2011 **Technical:** Srianant Wanassen  
**Poster:** Era Taludhar  
2012 **Technical:** Srianant Wanassen  
**Poster:** Srianant Wanassen  
2013 **Technical:** Kai Reineke  
**Poster:** Brenda Magajna  
2014 **Technical:** Sungyul Yoo  
**Posters:** Cristina Rodriguez and Renáta Kugler

2015 **Technical:** Bernhard Merget  
**Poster:** Hend Al Gahmi  
2016 **Posters:** Cristina Rodriguez and Ifigeneia Makariti  
2017 **Technical:** Marcia Boura  
**Poster:** Ifigeneia Makariti  
2018 **Technical:** Lena Fritsch  
**Poster:** Aurelien Maillet  
2019 **Technical:** Krishna S. Gelda  
**Poster:** Beatriz Nunes Silva  
2020 Meeting Cancelled  
2021 **Technical:** Alessia Delbrück  
**Poster:** Xingchen Zhao

# PAST LOCATIONS

2005 Prague, Czech Republic  
2006 Barcelona, Spain  
2007 Rome, Italy  
2008 Lisbon, Portugal  
2009 Berlin, Germany  
2010 Dublin, Ireland  
2011 Ede, The Netherlands  
2012 Warsaw, Poland  
2013 Marseille, France

2014 Budapest, Hungary  
2015 Cardiff, Wales  
2016 Athens, Greece  
2017 Brussels, Belgium  
2018 Stockholm, Sweden  
2019 Nantes, France  
2020 Meeting Cancelled  
2021 Virtual Meeting



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