Pathogen Surveillance in Agriculture, Food and the Environment (PATH-SAFE)

Webinar Series

PATH-SAFE & The Food Safety Research Network Showcase

18th May 2023



FOOD SAFETY RESEARCH NETWORK

Showcase Event with PATH-SAFE

May 2023



Biotechnology and Biological Sciences Research Council







Collaboratively making food safer from microbial risks



Guiding Principles: Innovation in the Food Safety Ecosystem

Identify 'problems worth solving by us' (ideas and opportunities to reduce microbial threats in food)

Broker partnerships within and across sectors (connect partners across food industry, government and academia)

Quickly get partners the resources they need (streamlined and fast application and review processes)

Keep momentum towards delivering impact (advice and potential for additional resources from the Network) Supports from the Network

(community creation, resource coordination, culture of innovation)

FOOD SAFFTY



What are the 'problems worth solving by us'?





REDUCED PLASTICS in PACKAGING



NEW PREFERENCES for PLANT-BASED FOODS

ALTERNATIVE PROTEINS



NEW FOOD REGULATIONS

Each those the area and drained) 113 can contain

ENERGY

93

10.01 00.00

Typical energy values per 1009: 342KUB1cal

INNOVATIVE INTERVENTIONS during PROCESSING



DYSBIOSIS to ONE HEALTH

Banerjee, S., van der Heijden, M.G.A. Soil microbiomes and one health. Nat Rev Microbiol21, 6–20 (2023). https://doi.org/10.1038/s41579-022-00779-w



PRIORITY 1 REDUCING THE MICROBIAL RISK OF KNOWN PATHOGENS

ASSESS chemical, biological, other interventions MEASURE with culture, molecular, genomics SHARE data for action now and in the future



PRIORITY 2 UNDERSTANDING THE RISK OF ALTERNATIVE PROTEINS AND NEW PLANT-BASED FOODS

INVESTIGATE microbes, shelf life in new foods DETERMINE risk in new production systems SHARE findings with industry and consumers



PRIORITY 3 APPLYING FOOD SAFETY KNOWLEDGE AND NEW TOOLS TO READY-TO-EAT FOODS

TEST microbes & interventions for this category UNDERSTAND why best practice not taken up DEVELOP training on validated interventions





Active Collaborative Projects









Larger Projects / Workshops



RISKS with **READY-TO-EAT** FOODS





University of Southampton



Unilever



BACTERIOPHAGE as an ANTIBIOTIC

KK

Innovate UK



20%

Department for Environment Food & Rural Affairs

IMPACTS of CLIMATE CHANGE on FOOD SAFETY

FOOD BUSINESS to BUSINESS SHARING of MICROBIOLOGY DATA

~ Indicators 😹 Templates 🔃 Alert 📿

0 41 Regin / Ballin, B. STIVARC + □ □ 07785.0 HIGHLY L788.0 CM11. R9 • □ □ CIII 6746K CANK BRC 0 1 AT? man was 1, 10, day, the COCC (1, 431,535) -1397,457

Ways to get involved...

Visit fsrn.quadram.ac.uk

or email

foodsafetynetwork@quadram.ac.uk





C 🔒 quadra	am.ac.uk/food-safety-research-network/					Ø
				People Vacancies	s f ¥ in	0
	Quadram		Our Science About Inde	ustry Events News 1	Get Involved Contact	
$\left[\right]$	Institute	0 1 40		$\langle 1 1 1 \rangle$	ୁର	~
Vn						
	Martin Calle					
	Food Cotoby			«A 11:17		
10	Food Safety	Research Ne	twork	N)[i!]	1)][[1
10	Food Safety	Research Ne	etwork	NH!	1 11 (1
	Food Safety	Research Ne	twork))[[1
	Food Safety If you are interested in finding out more able	Research Ne	etwork)][[1
	Food Safety If you are interested in finding out more able Food Safety Research Network Food Safety Research Network contact f	Research Ne	etwork))[[
	Food Safety If you are interested in finding out more able Food Safety Research Network Food Safety Research Network contact If Name *	Research Ne out the network please complete the form be ork	etwork		()) ((
	Food Safety If you are interested in finding out more abi Food Safety Research Network contact f Name *	Research Ne	etwork			
	Food Safety If you are interested in finding out more able Food Safety Research Network contact I Name * Email *	Research Ne	etwork			
	Food Safety Research Network contact f	Research Ne	etwork			
	Food Safety If you are interested in finding out more able Food Safety Research Network contact f Name * Email * Croanisation *	Research Ne	etwork			



Submit



Developing and delivering phage-based technologies in the UK

PATH-SAFE & FSRN Showcase

18th May 2023

Dr Francesca Hodges Phage Innovation Network Lead Knowledge Transfer Manager – Emerging Technologies & 10 francesca.hodges@iuk.ktn-uk.org





Innovate UK Group



What is a bacteriophage?



- A bacteriophage (phage) is a virus that infects and kills bacteria
- Phages are natural predators of bacteria
- Phages are abundant in the environment
- The discovery of phages predates that of antibiotics
- Phages have been used effectively in various countries around the world for a century
- They are a viable aid for improving the longevity of antibiotics
- They have potential as sustainable and organic biocontrol agents



How do phages work?



How can we use phages?



Phage Innovation Network – intended impacts

- Unite key stakeholders within the phage community and from other supporting areas
- Understand emerging innovations in the development of phage-based technologies (PBT)
- Improve cross sector access to phage-based technologies
- Create a business community around innovations in phage research for sector growth and economic benefit in the UK
- Change perceptions of anti-infectives and their role in society











FSRN support

Workshop event (March 16th, 2023):

- Outline the state-of-the-art of phage research and development in the UK
- Define the capacity for sector growth and development and the steps needed to initiate and sustain this
- Refine outputs from the Phage Innovation Network needed to support the community
- Cross-sector knowledge exchange to inform best approaches for addressing barriers to development and implementation of PBTs

UK Phage Innovation Showcase (May 16th, 2023):

- Showcase translational research in the development of PBTs in the UK
- Highlight key successes within the phage community
- Explore common challenges present across sectors in the development and implementation of PBTs and
- Discuss how the phage community can work together to realise the full potential of PBTs



Key actions

- Formulation and publication of a national strategy regarding support of development and use of PBTs in the UK this should include approaches for responsible communication about PBTs to the public.
- Establishment of on-shore GMP manufacturing to support cross sector development and use of PBTs.
- Establishment of key infrastructure, in addition to manufacturing capability, to support the sustained use of PBTs e.g., national phage biobank.
- Develop and make publicly available regulatory roadmaps that provide clarity and guidance on the appropriate regulatory approach for different applications of PBTs.
- Development of collaborative cross council funding calls providing longer term support for translational projects focussing on building interdisciplinary partnerships between academic groups, and with industry to bring novel, non-traditional antimicrobial products to the market.
- Support of economic cost-benefit analyses of the use of PBTs in different sectors.



Thank you!

Dr Francesca Hodges Phage Innovation Network Lead Knowledge Transfer Manager – Emerging Technologies & Industries francesca.hodges@iuk.ktn-uk.org









Profiling microbial communities in *Acheta domesticus* production systems

Dr Edward Fox – Department of Applied Sciences, Northumbria University





Introduction

Acheta domesticus production
Insect Food & Feed UK



• UK Edible Insect Association:

Professional Trade Association supporting UK industry.

~10 edible insect farming operations across the UK.

Acheta domesticus farmed in the UK.





Insect Food & Feed UK



 Highly nutritious food source, rich in protein, fat, vitamins, minerals, fibre and polyphenols. - Aiello et al, 2021.

 Advantages in sustainable production versus other animal proteins:

- Lower associated greenhouse gas emissions.
- Greater feed and water conversion efficiency.
- Lower land use requirement.

Growing UK (global) food industry.



Why this project?





Project Rationale

"Understanding of the microbial dynamics during insect rearing is limited, and is an important knowledge gap that needs to be filled" - Garofalo et al, 2019.

- Provide science to help underpin confidence in UK insect production food safety.
- ✓ Inform industry best practice.
- ✓ Support industry growth.







ACTIVITY 1:

Benchmarking the microbial community in *Acheta domesticus* production systems

- Feed > Rearing > Product.
- Insect + Processing environment.





ACTIVITY 2:

Challenge trial with pathogens

- Pathogen interactions in the production system:
 - Insect colonisation, impact, and persistence through system.





ACTIVITY 3: Dissemination

Industry workshop.





Thank you



PathSafe Presentation 18th May 2023 Kelly Shields – Fresh Produce Consortium

What is the Issue?

- Microbial contamination in fresh produce, both for nationally and internationally, are increasing in prevalence and occurring in consecutive years.
- Recent cases have been identified in imported produce (enoki mushrooms) and UK grown produce (lettuce) and have flagged on the FSA FILG signals. Pathogens of concern are STEC and Listeria Mono.





Table 5.1.6c. Foodborne outbreaks by food vehicle investigated and reported to national public health surveillance per year, 2015 to 2020 in the UK^[footnote 29]

Food vehicle	2015	2016	2017	2018	2019	2020	Total
Poultry meat and poultry meat products	12	7	6	5	4	4	38
Composite or mixed foods	6	6	4	5	11	0	32
Other mixed meat/poultry/products	7	5	2	4	2	1	21
Eggs and egg products	3	5	2	2	6	1	19
Beef/bovine meat and products	3	4	2	4	2	2	17
Crustaceans/shellfish/molluscs	1	1	2	6	3	3	16
Fruits and vegetables	0	3	3	3	0	3	12
Dairy	0	1	3	1	1	4	10
Pork meat and products	3	0	2	2	2	0	9
Lamb meat and products	2	0	1	3	2	0	8
Finfish and products	1	0	0	2	0	1	4
Herbs/spices/cereal products/nuts and seeds	0	0	1	1	1	1	4
Potable water	1	0	0	0	0	0	1
Unknown ^[footnote 30]	14	17	10	11	23	10	85
Total	53	49	38	49	57	30	276

Fresh produce in







Who would have thought eating healthily could be so risky?!





Fresh Produce Outlets and End Users

65% of market share **Multiple retailers / FMCG** – require suppliers to have BRC / Red Tractor / GlobalGAP / 3rd party certification (plus additional specific food safety audits). Enhanced compliance / brand reputation and generally good traceability systems

35% of market share

<2% of

market

share

Wholesale / food service – suppliers may often be required to have certification to RT, BRC, GlobalGAP. Larger businesses will have higher compliance requirements, smaller ones may trade in cash / traceability less managed

Micro business / farmers markets – may purchase direct from grower or from wholesale. May require suppliers to have certification but controls are more likely to be a mix of spot purchase / long standing suppliers.



What factors contribute to micro contamination of fresh produce?



What are areas for focus and improvement?





Potential Opportunities with FSRN Funding



GROWER TRAINING

WHOLESALE DUE DILIGENCE VERTICAL FARMING GUIDANCE



Grower Training – what is there and what is missing?

UNCERTIFICATED PRODUCE SPECIFIC FOOD SAFETY TRAINING COURSES

Techni-K	UK	Food Safety & GMP for Manufacturing Raw Produce				
		Food Safety and GMP for Manufacturing of Raw Produce - Techni-K				
Fresh Produce Training & Development	UK	FPTD-Training-Courses-2022.pdf (freshproducetraining.com)				
Evergreen Training	UK	Raw Fresh Produce Food Hygiene and Safety in Manufacturing Level 2 - Evergreen Training				
CERTIFICATED PRODUC	CE SPEC	FIC FOOD SAFETY TRAINING COURSES				
CERTIFICATED PRODUC Level 2 Food Safety for Fresh Produce Field Workers	CE SPEC	FIC FOOD SAFETY TRAINING COURSES CIEH E-learning course - £32.40 (inc VAT) - launched in May 2023 Chartered Institute of Environmental Health Product information (cieh.org)				

- No Level 3 or 4 fresh produce safety training provision for decision makers in business to determine risk. There is no specific criteria within legislation / industry accreditation schemes.
- Food safety embedded into further / higher education provision?
- Science based food safety tools and decision making assistance is limited and not embedded in training

What does good look like?



What is the Produce Safety Alliance (PSA)?

The Produce Safety Alliance was established to help prepare fresh produce growers to meet the regulatory requirements included in the United States Food and Drug Administration's Food Safety Modernization Act (FSMA) Produce Safety Rule. The PSA is supported through a cooperative agreement funded by the USDA and the FDA.

Why is the PSA Important?

The PSA provides fundamental, science-based, on-farm food safety knowledge to fresh fruit and vegetable farmers, packers, regulatory personnel and others interested in the safety of fresh produce. This includes assessing produce safety risks, implementing Good Agricultural Practices, and how to meet regulatory demands associated with the FSMA Produce Safety Rule, as well as meet buyer requirements for food safety.



Key Details about the PSA Grower Training Curriculum

Through a four year nationwide development process, including ten Working Committees and eight grower focus groups, a seven module curriculum was developed. The curriculum includes content covering Good Agricultural Practices, co-management, and the new FSMA Produce Safety Rule requirements.

Initial Quadram funding has been provided to attend this course for research: content is advanced / science based content and tools/ 30 hours / Level 3 min / aimed at business owner / supervisors – could FSRN funding be used to scope the possibility to adopt this approach for levels 1- 4?



Wholesale Markets – the 'Unseen Middle'

Understanding wholesale due diligence



An analysis of the wholesale supply landscape would be essential to understand the current due diligence capabilities and adherence to legislative requirements could be a starting point for FSRN funding.



Follow on work could be a tailored approach to devising appropriate and proportionate standardised measures to mitigate the risk or microbial (and chemical / allergen) contamination of fresh produce sourced through the wholesale sector



This may be in the form of a SFBB type approach (provision of diarised reporting tools) and / or tailored training provision to raise awareness in this often overlooked sector.



Developing food safety standards for vertical farming

• This is an emerging production system with significant investment but

What is the key · area of vertical . farming focus?

- Vertical farming is out of scope for Red Tractor / BRC / organic standards and specific inherent food safety and microbial risks are not covered.
- Focus is on production system / energy / water / lighting capability food safety experts may not be on the payroll.
- Creation of good hygienic practice guidance, such as those created by FPC for sprouted seeds, could be an area of development for the FSRN funding.







FPC Next Steps



FURTHER ENGAGEMENT WITH QUADRAM / FSA RESILIENCE TEAM TO ASCERTAIN KEY PRIORITY ENGAGEMENT WITH ACADEMIC PARTNERS TO ESTABLISH FUNDING PARTNERSHIP SET SCOPE FOR THE KEY PRIORITY AND ENGAGE WITH INDUSTRY PARTNERS TO ENSURE THAT ALL STAKEHOLDERS ARE CONSULTED IN PROJECT COMPLETION IDENTIFY FURTHER FUNDING STREAMS THAT MAY SUPPORT THE CHOSEN PROJECT

ENGAGE on GENOMICS
THINK DIFFERENTLY
ACT on FINDINGS

and the second sec

+

EPIDEMIOLOGIC INSIGHTS

TARGETED INTERVENTIONS

Disinfection Regimens

Novel Antimicrobials

Hygiene Best Practices

Factory Design

Innovative Materials

Respond to Risk Level

Shift the Microbiota?



Do we have a predominant pathogen or strain?

Are there other microbes supporting the pathogens?

How are pathogens surviving disinfection measures?

Can we track how pathogens are spreading?

What are the health risks of the observed pathogen?

Pathogen Surveillance in Agriculture, Food and the Environment (PATH-SAFE)

<u>Aim:</u>

To pilot a **better national surveillance system** for the monitoring and tracking of foodborne disease (**FBD**) and antimicrobial resistance (**AMR**) in the **agri-food system**.





Department for Environment Food & Rural Affairs UK Health Security Agency Directorate

Veterinary Medicines Directorate





PATH-SAFE WS1a Data Platform Development

Prof. David Aanensen, Oxford University, PATH-SAFE Data Fellow





WS1a - Consortium Approach

- Bring together proven technical and scientific expertise
- Build consensus framework for species analytic and bioinformatic delivery across public health agencies
- Deliver an intuitive end point for genomic output for decision making
- Robust hosting on proven technology for PATH-SAFE CLIMB-BIGDATA
- Exemplify for *Salmonella* and build route for extension / expansion to other pathogens



ntre for **Genomic**

hogen Surveillance

WS1a - Overview



Centre for Genomic Pathogen Surveillance

Reprint Pridemiology Services



https://www.climb.ac.uk/



- Scalable cloud hosting and containerised analytic pipelines management
- Base platform utilised for COG-UK
- Decentralised sequencing centralised analytics decentralised delivery

Digital Epidemiology Services

• Web upload/authentication and ID generation







https://enterobase.warwick.ac.uk/



- Years of experience hosting and providing research interface for multiple pathogens (Salmonella, Escherichia/Shigella etc.)
- Will undertake assembly pipeline comparisons to inform decision making and sign-off by PATH-SAFE governance
- Genomic data where possible from WS1a will feed into Enterobase for community







https://pubmlst.org/

- Providing gold-standard typing (MLST/cgMLST) for the research and public health communities for multiple pathogens
- Ensuring maximal utility of APIs to deliver typing and where possible enhanced usage of data for the research community
- Additional retrospective sequencing and analysis of Campylobacter is being undertaken across the UK in order to gather baseline data



Pathogenwatch

Centre for Genomic Pathogen Surveillance

https://pathogen.watch/



A global platform for genomic surveillance.

- Fast predictions of resistant genotypes and clustering.
- Real-time analytics and genomic epidemiology. •
- Facilitates processing, clustering and exploration of whole genome • assemblies.
- Easily integrates with Epicollect.





Digital Epidemiology Services






AMR Catalogues Typing Clustering Additional..

Population Monitoring



Clustering





Digital Epidemiology Services

PATH-SAFE WS1 Advisory Groups

- Antimicrobial Resistance : Chair: Prof Kat Holt
- Technical Advisory Group : Chair: Dr Tim Dallman
- FBD Data Standards: Chair: Prof. Tom Connor
- International Interactions: Chair: Dr Matthew Gilmour

PATH-SAFE White Paper on best practice for genomic surveillance



PATH-SAFE WS3a

Horizon scanning and technology readiness level study, with in-field testing of rapid diagnostic technology 18th May 2023

> Catherine Harrison Barbara Agstner

Pathsafe - Workstream 3a Technology Readiness Level (TRL) study



WS3a - Scope

Horizon scanning and technology readiness level study, with in-field testing of rapid diagnostic technology



Target pathogens:

Norovirus, Campylobacter, Salmonella, Listeria, Clostridium, Indicator organisms



Sample matrixes:

Water, Meat, Shellfish, Dairy, Swabs, Animal feed, Fish, Fresh produce, RTE (Ready to Eat products)

OVERVIEW OF Literature review



- Broad scope which returned 28,142 papers
- 8,489 eliminated due to duplication
- 16,485 eliminated due to lack of relevance or no additional content.
- 3,168 papers collated into categories of technologies for full review.

Results Technology Review (1)

Technology	References per pathogen						
	Norovirus	Campylo- bacter	Clostridium	Listeria	Salmonella	E. coli	TOTAL
Polymerase chain reaction (PCR)	1	1	3	1	11	7	190
LAMP/Loop mediated Isothermal amplification	1	5	1	9	33	31	314
Other isothermal amplification methods	5	0	1	12	23	17	455
Lateral flow tests	0	1	1	6	11	11	185
Biosensor	11	5	2	14	27	45	677
Nanomaterials	8	3	3	9	49	41	610
Microfluidics device	1	1	0	5	28	19	290
Paper-based analytical device (PAD)	0	1	1	1	8	11	158
Lab-on-a-Chip device	0	0	0	1	4	1	64

Results Technology Review (2)

Technology	References per pathogen						
	Norovirus	Campylo- bacter	Clostridium	Listeria	Salmonella	E. coli	TOTAL
ELISA	0	0	0	0	1	1	18
Crude extraction method	2	5	5	3	21	22	129
Aptamers	5	2	1	8	24	24	168
CRISPR (Clustered regularly interspaced short palindromic repeats)	2	2	0	4	11	10	163
ATP bioluminescence	0	0	0	1	1	6	14
HCR/Hybridisation chain reaction	0	1	0	1	1	2	43
Electrochemical impedance spectroscopy	1	0	0	1	4	11	60
Surface plasmon resonance	2	0	1	0	1	4	79
Vibrational spectroscopy	2	1	1	3	6	13	196
Mass spectrometry	0	0	0	0	0	2	17
Chemiluminescent assays	0	1	1	3	2	4	48
Nanopore sequencing	0	1	0	0	0	1	26
Hydrogel	0	0	0	2	3	5	30
Remote sensing	0	0	0	0	0	1	33

Summary of four on-site testing technologies

	LFD	LAMP	Nanopore sequencing	Biosensor
Cost per sample (£)	2.5-20	10-30	50-200	1-2????
Time to result	5-30 minutes	20-60 minutes	8-10 hours	5-30 minutes
Sensitivity compared to qPCR	70-80%	85-100%	Less than qPCR (not quantified)	Uncertain (10 ² to 10 ³ CFU mL ⁻¹)
Specificity compared to qPCR	90%	100%	N/A	Unknown
Sample throughput	1	1-14 (variable)	Up to 96	1
Complexity of use	Simple	Moderate	Complex	Simple



OVERVIEW OF End-user study



- Conducted focus groups and interviews with strategic and operational end-users
- Gathered opinion on:
 - Scope of the project
 - Kind of settings that might be feasible (e.g. rudimentary lab)
 - Drivers that have led to the adoption of new diagnostic technologies
 - What are decision priorities for adoption? Cost, timeline, information obtained, diagnostic performance, ease of use?
 - What evidence is needed to adopt an alternative diagnostic technology?
 - What prevented the adoption of a new diagnostic technology in the past?

Given the scope of this project (pathogens/matrix), are there any organisations or processes you feel are best / worst suited for adopting portable detection technologies? Feasible settings?



Pathsafe - Workstream 3a Technology Readiness Level (TRL) study



THANK YOU FOR YOUR TIME







PATH-SAFE: Creating connections



Thank you for listening!

PATH-SAFE Programme

- Email: <u>PATHSAFE@food.gov.uk</u>
- Webpage: <u>PATH-SAFE</u>
- Newsletter and webinar series: Contact us to sign up to our mailing list

Food Safety Research Network

- Webpage: <u>https://quadram.ac.uk/food-safety-</u> research-network/
- Email: foodsafetynetwork@quadram.ac.uk

Slides and recording will be shared on the PATH-SAFE webpage in due course.