Final Report

AgriFood Workshop

21-22 January 2016

Contents

Acknowledgements

The FSA and STFC would like to thank the participants at this workshop, and Oxford Creativity for their time and input.

Summary

Introduction

The Agrifood workshop investigated technological solutions to challenges in agriculture and food production, divided into two streams.

- The **Broad Stream** considered challenges posed by all types of food.
- The **Meat Stream** focussed on the challenges posed in official controls in meat establishments.

The workshop brought together forty experts from disciplines such as astrophysics, food technology, veterinary science, data science, and microbiology. The purposes of the meeting were

- to identify challenges;
- to identify potential solutions; and;
- to recommend promising areas for further work.

The workshop was organised and funded by Science and Technology Facilities Council (STFC) and the Food Standards Agency (FSA) and held at STFC's Harwell Campus on the 21st and 22nd January 2016.

Summary of Meat Stream

The FSA faces particular challenges associated with official controls in meat establishments (also known as abattoirs or slaughterhouses). Many meat-borne pathogens are not detectable by the human eye, and therefore current meat inspection practises are not able to identify them. This problem is exacerbated by large numbers of animals being slaughtered, rapid line speeds, and small profit margins. To this end this stream addressed the following challenges.

Challenge 1: To make improvements in the speed of delivery of official controls, and the accuracy and value of data recording.

Challenge 2: To improve our ability to identify and quantify risks which are not currently detected as part of the delivery of official controls

Challenge 3: To reduce the need for manual handling of carcases or the need to make incisions, thus reducing cross contamination.

Barriers to producing safe meat through official controls

During the workshop, a comprehensive contextual assessment was undertaken of how the challenges related to the supply chain, underpinning legislation, the immediate food production environment and how meat inspection used to be, is now, and what may be important in the future.

A number of barriers to producing safe meat emerged, namely around;

- Emerging risks such as anti-microbial resistance (AMR), limited genetic variability of breeding stock and Hepatitis E need to be taken into account to 'future proof' improvements to inspection.
- Emerging technology has a significant role to play, such as smart sensing technology, mobile apps, rapid on/offline testing, automation and GM. These should therefore be a consideration in addressing these challenges.
- The regulations[1] - including deterrents, minimum legal requirements of Hazard Analysis Critical Control Point (HACCP), no ownership of standards nor official controls, outdated legislation and available regulatory resources.
- Food production systems including the globalisation of food trade, coordination of global food production, complexity of supply chain/network and its traceability challenges leading to less accountability, and the environmental impact of food production systems and sustainability.
- Diversity between meat establishments (e.g. family business, cooperatives, corporations, SME's) and how these may have their own leverages. The balance of profit margins between food businesses e.g. very low in meat processing but high in retailing.
- The tension between safe food and affordable food.
- Knowledge gaps included pathogen serotypes differ between primary production sites and processing sites and also biofilm formation and resistance to decontamination.

[1] For information on the relevant regulations, see https://www.food.gov.uk/enforcement/approved-premises-official-controls

Recommendations and next steps for Meat Stream

A network should be created involving scientists from multiple disciplines in both academia and industry. The solutions raised should be presented to industry for their views and reflections. The aim of this engagement would be to produce a shortlist of worked-up projects or research programmes. These solutions and underlying principles could potentially then (through the facilities of STFC) be incorporated into a theoretical 21st Century Abattoir model to assist potential benefits and identify those areas for further progression.

The vision is that once the theoretical model has been developed and the benefits have been realised, further scoping work can then commence on exploring the opportunity to put the model into practice through collaborative partnerships. A number of solutions emerged during the workshop that may present novel ways to address these complex challenges, and these can be found in **Appendix 1**

Summary of Broad Stream

The Broad Stream considered the wider challenges faced by the Agri-Food sector as a whole. The ideal outcome defined in the workshop was for consumers to have access to food that is ethically produced, safe, secure, and authentic. It should be of a high quality that provides high nutritional value and produces the minimum possible amount of waste from production through to post consumption.

The theme that was prevalent through most of the discussions was the need for global initiatives, such as monitoring and predicting climate change – this affects not just the farm but leads to better decision making throughout the supply chain from 'farm to fork'. The key areas highlighted in the supply chain were:

- scale, distance and complexity (food miles);
- automation; and
- harmonisation of technology.

Reducing the food miles and enhancing automation (ensuring compatibility between different systems) could result in improved safety and reduced waste thereby highlighting opportunities to re-invest back down the chain to improve nutrition and safety factors. The prominent areas that could enhance food production were:

- better use of historical data;
- better sensors;
- using satellite data more effectively; and
- use of analytics to better predict markets and hence understand the drivers of commodity prices (such as oil/wheat).

Feedback mechanisms (both technological and data driven) throughout this process could enhance production. For instance, the detection of pathogen data during the processing phase could be fed back to the farms to improve the quality of the produce.

It was also recognised that behavioural change of consumers is an important factor in addressing some of the challenges faced by the agri-food sector. There are a number of mechanisms for encouraging this. One example is that supermarkets are often seen as the

drivers behind some aspects of consumer behaviour. To encourage footfall they have to display full shelves and a wide range of products. This itself leads to waste (such as out-of-date surplus produce). Incentives could be offered (or technology implemented) so that consumers would be encouraged to pre-order. This would then negate the need for overly full supermarket shelves and help in reducing waste.

Recommendations and next steps for Broad Stream

Routes to enable such aspirations were identified at global, regional, and personal levels. At the global level there is currently insufficient market intelligence as different regions are working under separate conditions and legislation. A move towards a unified food monitoring system incorporating all models with open and shared data was recommended. This would be supplemented at a regional level with tracking, forecasting systems, pro-active management (supported by legislation) and active feedback systems.

The above model would be supported at the personal level through feedback mechanisms where individuals in the supply chain could make informed decisions to enhance their part of the process

Such a model would facilitate the education of consumers allowing them to make better choices that are safe and healthy using information/data that is both reliable as well as trustworthy. Such openness is a means to move towards generating embedded trust throughout the food journey and further demonstrate ethics within the industry. Potential projects are described in **Appendix 2.**

Conclusions

The workshop showed that STFC working with the FSA and others were able to identify technology and expertise that could be applied to the area of food production. Also the workshop identified that there were opportunities for communities to work together to address both current issues in supply chains and to look at building a more resilient food processing chain not just for now but also for the future.

The workshop report and this summary document form a good base, which will both inform organisational policy and enable decisions to be made when identifying future opportunities in this area.

The workshop has already been helpful in the development of thinking and subsequent STFC funding call for the STFC Food Network+.

Acronyms and Abbreviations

AMR	Antimicrobial Resistance
B2B	Business to Business
BRC	British Retail Consortium (food safety standard)
EU	European Union
FBO	Food Business Operator
FCI	Food Chain Information
FSA	Food Standards Agency
FSC	Food Security Center
GAP	Good Agricultural Practice
GMO	Genetically Modified Organism
GMP	Good Manufacturing Practice
GRP	Good Regulatory Practice
HACCP	Hazard Analysis Critical Control Point
HPC	High Performance Computing
HPP	High Pressure Processing
HSE	Health and Safety Executive
ISO	International Standards Organisation
JIT	Just In Time
KPI	Key Performance Indicator
MI	Meat Inspector
MRI	Magnetic Resonance Imaging
OV	Official Vet
PHE	Public Health England
PM	Post-Mortem
RTE	Ready to Eat
QR	Quick Response (code)
SALSA	Safe and Local Supplier Approval
STFC	Science and Technology Facilities Council
TB	Tuberculosis
TRIZ	The Theory of Inventive Problem Solving
UAV	Unmanned Aerial Vehicle

Appendix 1: Solutions for Meat Stream

A number of solutions emerged during the workshop that may present novel ways to address the complex challenges presented. The solutions in the appendix are broadly categorised under the following headings;

- Materials – these are all the reagents used in the production of the product.
- Methods – these described the processes deployed to produce the product
- Manpower – the people involved in the production/planning of product
- Machinery – this describes the equipment/tools and machinery utilised in the production/planning of product.
- Metachange –generate substantial or radical change of circumstance

Solution description	**Solution category(s)**					**Benefits of the solution**
	Materials	**Methods**	**Manpower**	**Machinery**	**Metachange**	
Smart packaging with anti-microbial properties	■					Indicates when shelf life expires, or product gets to an excessivelyhigh temperature, detection of pathogens, inhibition of microbial growth.
Remove/detect pathogens on farm		■				Detection of pathogens during primary production, purpose is to prevent plant contamination rather than remedial action in meat plant.
Public education			■			Consumer training/education – deployed in a number of ways through social media e.g. QR code on packaging
Pooled sampling to reduce cost		■				Generate/facilitate structure to assist FBO's in pooling sampling to benefit from economies of scale. This could reduce costs, allow sharing of data between all parties and increase assurance. Ability to triangulate results also possible.
Directed imaging of pathogens		■		■		Imaging pathogens in real life – permits 100% inspection and provides good indication of real world contamination levels and locations, e.g. with UV, bacteriophages/yeast

Solution description	Solution category(s) Materials Methods Manpower Machinery Metachange					Benefits of the solution
Raman spectroscopy						Develop this technical for live data feed – benefits as directly above.
Bacteriophage or yeast imaging						Develop bacteriophage or yeast technology, that binds to bacteria or produces stain that can be detected (ideally visually)
Smart spray/wash						Smart and inactive spray, makes pathogens visible to naked eye or electronic eye/nose.
MRI/CT/Scatter X-ray tech/Ultrasound						Rather than incision, scan animal – utilised on farm prior to loading.
Non-contact tool to detect abnormal colour and shape (e.g. optical coherent tomography)						Tools that visually detect abnormities in colour or shape and notifies operator for further investigation.
Eliminate all manual handling, use of knives, visual detection default method						Reduces risk of cross contamination by the operator, inexpensive solution.
Robotics/automation						Explore robotic automatic to reduce the need for handling; to permit more robust treatments without harming the operator e.g. reduced humidity.
Laser knives/self-sterilising knife						Cutting with lasers wouldn't require sterilisation
Animal self-referral						Can an animal inform us they are contaminated? Could big data e.g. feeding, weight, colour, behaviour, sound,

Solution description	Solution category(s) Materials Methods Manpower Machinery Metachange					Benefits of the solution
						herd/flock history, be used as a proxy?
E-nose						Deploy E-nose to detect volatile compounds of key pathogens, auto reject mechanism attached to sniffer.
Smart helmet camera						Develop smart helmets to rapidly scan and assess carcass – through UV light.
Smart feed						Develop smart feeds which change colour on defecation to indicate contamination/levels of contamination (intensity of colour).
Smart water feed						Develop smart water feeds which change colour on defecation to indicate contamination/levels of contamination (intensity of colour).
Invert poultry carcasses						By hanging from head instead of the feet, cross contamination of the bird during intestine removal could be reduced.
De-stress holding pen by lowering temperature, darker room and more space.						Evidence demonstrates that these changes have a significant impact on contamination levels in proceeding process steps.
Add antimicrobial to scalding water						Reduces microbiological load during scalding process
UV imaging for gross contamination as well as quality inspection						Combines quality and food safety requirements into single optic system.

Solution description	Solution category(s) Materials Methods Manpower Machinery Metachange					Benefits of the solution
Introduce biocide step in poultry production.		■		■	■	Current regulations do not permit, but this could prevent contamination
Smart labels	■					Label changes colour when shelf life exceeded or falls out of chill chain. Consumer educational tool.
Eliminate water use from slaughter house process (poultry only).					■	Water identified as key vector for cross contamination i.e. scalding tank, washing and aerosols. Utilise other means to achieve finished product – *examples follow below*
Methods to reduce water in poultry processing						
Steam scalding		■		■	■	Reduced water consumption, but may cook product and part sterilise.
Wax to remove feathers		■		■	■	No water used
Electrocute to remove feathers	■				■	Dry feathers are valuable by-product, could be kept dry and sold. Therefore electrocute or heat to open follicles then blast air to loosen feathers.
Induce moulting with hormone in feed, with short half-life.	■				■	No water used in scalding
Retain feathers, cut limbs off and skin		■			■	Reduces load of contamination but also value of product.

Appendix 2: Potential projects identified by the broad stream

Technology Sector	Theme Highlighted at Workshop	Comments	Potential Projects/Programmes
Strategic	Resistance	STFC has already conducted studies into AMR (Anti-Microbial Resistance).	A lightweight assessment could be conducted into the way forward
	Formulation	Feedstocks and associated products for livestock	Investigation into the details of the challenges in this area
	Aquaculture technology requirements	This could be another workshop	Investigation into the details of the challenges in this area and a plot of 'Who's who' in the UK
	Farmer engagement	This could be a Global Food Security Cross Council Programme project.	STFC/FSA to discuss with Global Food Security Programme Co-ordination Group
Other Tech	Nanotechnology	R&D as part of other technology programmes.	Investigation into where in the food system does miniaturisation give an advantage? What opportunities are there for nanomaterials?
	Consumers moving towards optimum diet leading to a requirement for decision support	Aspects of this are already in discussion that the Food Innovation Network. What can STFC contribute to this? Possibly HPC or modelling	STFC/FSA to discuss with the Food Innovation Network

Appendix 3: Workshop methodology

The workshop utilised the Theory of Inventive Problem Solving (TRIZ), and was facilitated by TRIZ experts from Oxford Creativity. TRIZ is a systematic and structured approach to understanding and solving problems which enables clear thinking and the generation of innovative ideas. It is particularly powerful for getting teams to work well together, for both understanding problems effectively, and generating ideas of how to solve them. For further details on how this methodology was utilised to generate the solutions, please contact Fraeya.Whiffin@foodstandards.gsi.gov.uk