An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

Food Institutional Research Measure

Final Report

CyberBar: Smartfone delivered anti-tamper food traceability system based on direct on food Data Matrix (DM) printing and chain integrity sensors

DAFM Project Reference No: 11/FP/405

Start date: 01/03/2013

End Date: 30/04/2014

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Collaborating Research Institutions and Researchers: *N/A*

Please place *one* "x" below in the appropriate area on the research continuum where you feel this project fits

Basic/Fundamental ⟶ Applied ⟶ Pre Commercial

1	2	3	4	5	**X**	7

Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report;

Priority Area (s)	**Sustainable Food Production and Processing, Food for Health**

Key words: laser; data-matrix; traceability; anti-tamper.

1. Rationale for Undertaking the Research

Food traceability and supply chain integrity is a major area of interest both nationally and internationally. Furthermore, the ability of a traceability system to monitor the composition and the position of each lot in the production and supply chains represents a very powerful tool to improve the overall performance of the food supply chain (FSC). There is major concern amongst consumer, retailers and indigenous processors regarding the origin of food, its manipulation (e.g. re-labelling, re-packaging) for either legitimate (legal) commercial gain or, worse, sheer fraud. In particular, consumers need to be reassured regarding the origin, quality and safety of food.

Poultry meat is of particular concern: it is one of the most widely traded meat forms, internationally; and there is a major trade in the "substantial transformation" of poultry meat within Europe. While consumers/processors are concerned about "substantial transformation", it is legal, but it adds a huge level of concern to the citizen. In many cases where "substantial transformation" is occurring, high quality food producers are being put at a disadvantage vis-àvis the rest of the market (as the consumer cannot differentiate between genuine "home grown" Irish produce and imported "substantially transformed" product). The consumer has genuine nutrition and health fears regarding food, and becomes very concerned when a major food scare occurs. There are many notable national and international examples of this: the acrylamide adulteration of baby formula; the pork dioxin scare, BSE, Avian Influenza, etc.

The EU and national governments have invested billions of euros in research and development, and product withdrawal, relating to food safety; and yet there are major potential traceability gaps in the chain. This innovative system, CyberBar©, can fill these gaps, giving a higher level of integrity to product information, including Country of Origin, thus increasing stakeholder (consumer) satisfaction by:

(1) Attaching traceability information directly to the product itself (item level traceability) and not to a label attached to the product packaging – i.e. direct printing of DM codes onto the fillet;
(2) Using sensors to automatically monitor the conditions (product temperature and GPS location) during shipping or storage (at batch level)
(3) Processing and storing the information online and delivering the information via interorganisational enterprise systems (chain members) and web applications to the consumer.

2. Research Approach

Encrypted product information in the form of 2D barcodes was applied to chicken breasts. The resolution and longevity of the code after simple laser treatment were not satisfactory. To improve these important attributes, many techniques were explored. The use of additional food grade paste was deemed necessary in the process to produce a satisfactory branding of the chicken breast. This process, including the use of the formulated paste, has been filed for patent. The paste enhances and prolongs the effects of the laser etching until long after the product's shelf life and through the freezing process. The contrast is enhanced by the browning action of the paste in a lasered area and the opaque, comparatively bright colour of the surrounding paste unaffected by the laser. The colour combination that is achieved appears to be natural to chicken breasts, however, at a closer range, the contrast between the two colours is sufficient to be read by a barcode scanning app on a mobile phone.

There was engagement with marketing bodies in parallel with the technological developments. It was found that informing consumers of the benefits of this technology is crucial to its acceptance. Similarly, the approval of this marking technique for use as a meat health marking by the European Food Safety Authority would greatly improve the prospects of this technology as this would negate any need for an

ingredients list to be displayed on the packaging of the fresh meat product. We are working with the FSAI on an amendment application to allow for the use of this technology as a health marking method.

The cloud architecture incorporates the real time geo-location information as well as the time and temperature profile of the chicken breasts en-route to the retail location. A demonstration of the application process, the subsequent in-transit parameter logging and the interpretation of the encrypted information from the surface of the chicken breast product was given to the industry partners – Manor Farm.

3. Research Achievements/Results

Task 1: Direct on-food data matrix (DM) printing and chain integrity system

A viable DM printing protocol has been successfully identified and tested with the aid of Domino Ltd. and Codico Ltd. Food grade additives were explored to aid in DM preservation and integrity and resulted in the development of an innovative imprinting process that achieves high resolution prints(Figure 1).

Figure 1: Instantly readable laser etched DM on chicken surface following application of formulated food grade paste following 7 days of refrigerated storage.

Shelf life testing was carried out on the DM imprinting on chicken breasts to demonstrate that the longevity of the DM outlasts the shelf life of the chicken. Further long-life tests found that the DM retains both integrity and resolution for a minimum of 12 months under freezer conditions (Figure 2).

Figure 2: Photograph of long-life testing under freezer conditions. The 2D barcode was confirmed readable after 2 months of freezing.

A series of meetings with the industry partner marketing department highlighted the requirement for consumer education in acceptance of this product identification system. Cook-out test of the final etched products results in chalky taste of the cooked paste, while the associated chicken meat retained its normal

sensory attributes. Issues of taste and appearance were the main concerns for establishment of consumer acceptance.

Task 2: Smart RFID system combining geo-location and temperature monitoring of the batch.
An environmental sensing unit was developed and tested for suitability. This process involved an initial de-risking of the technology from a wireless protocol perspective. This initially required the testing of each individual sensor in terms of functionality (at moderate conditions and in extremes) and also responsiveness to determine a suitable sensor matrix. Once each sensing unit had passed baseline testing in isolation – each individual sensing unit was integrated onto electronic PCB where a further testing schedule – similar to above – was carried out. This was to ensure sensor performance did not diminish when integrated into the system. Each of the environmental sensing units was then integrated into test trucks and transmitted information to a web gateway (Figure 3) which was responsible for GPS stamping each transmitted data package before they were transmitted to cloud based web portal.

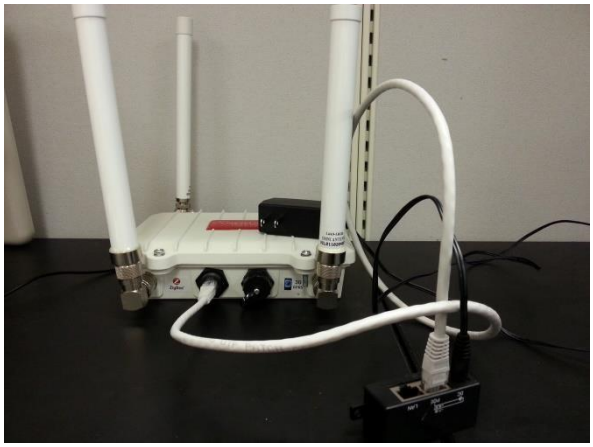

Figure 3: Environmental sensing unit for product data capture (un-housed).

Task 3: Cloud / Smartphone Architecture Development
Fully functional Cloud infrastructure was created that was suitable to the data streams involved in poultry FSC management system. Figure 4 illustrates an interactive web portal with which the user has the option to "touch and view" each truck and view the vital statistics during transportation

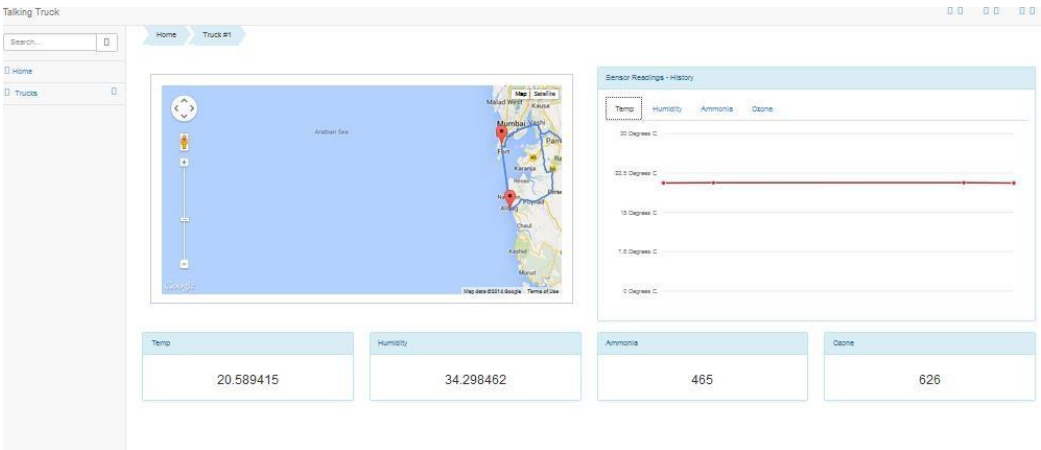

Figure 4: Interactive web interface for viewing statistics of each truck

A consumer friendly smartphone android application was developed (Figure 5), incorporating a 2D barcode reader allowing for the scanning of the codes imprinted onto the chicken fillets. This interface

allows for the communication of information to the consumer from the earlier stages of the chain of custody. It also allows for the collection of customer data for use in marketing/promotional exercises.

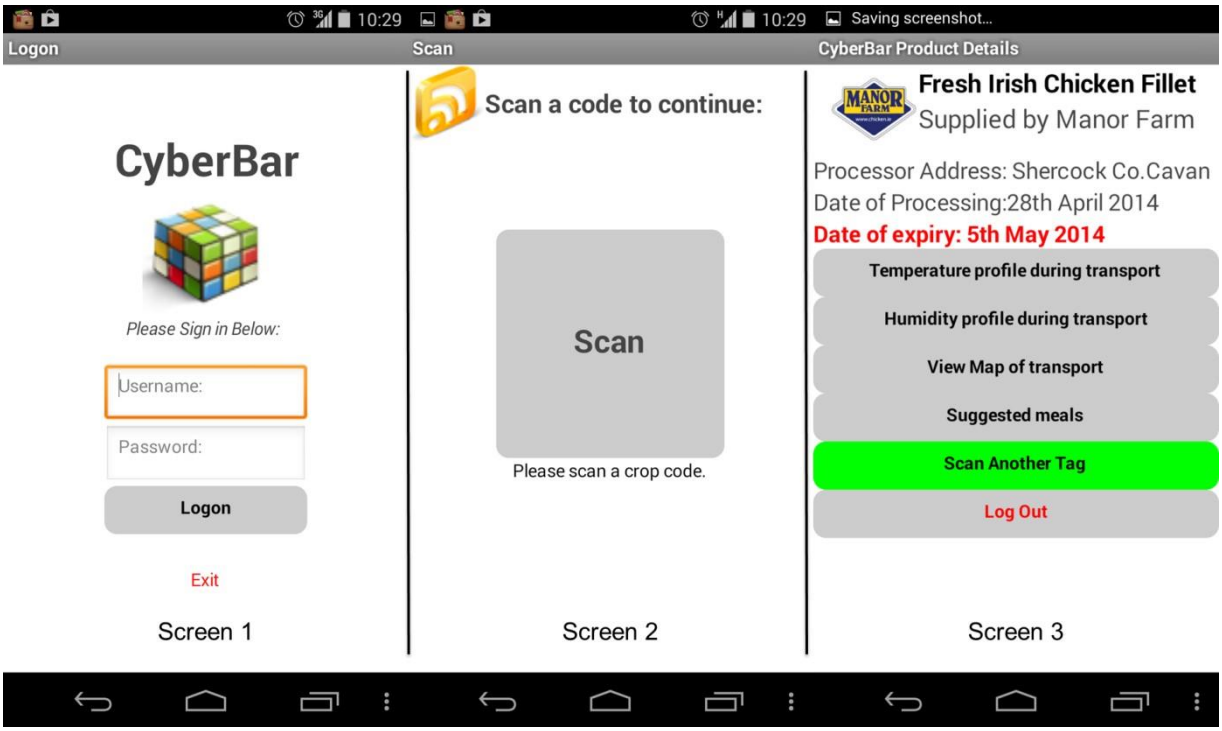

Figure 5: Screenshots of fully functional android application.

Task 4: CyberBar System Integration

The deliverables of tasks 1, 2 and 3 were merged and presented on 30th April 2014 in a full system demonstration given to our industry partner on the process from imprinting the chicken breasts to reading the codes (as a consumer) and obtaining product information via the smartphone application.

4. Impact of the Research

4(a) Summary of Research Outcomes

(i) Collaborative links developed during this research

PPR No.	PPR Start Date (dd/mm/yy)	PPR End Date (dd/mm/yy)	Link with new RPO (Collaborating/ Informal/ Leave Blank)	Nature of Link (eg. Use of facilities, use of staff, Use of samples)	Name of RPO
1	01/03/2013	30/04/2014	Collaborating	Collaboration on new proposals	Marine Institute, Ireland

2	01/03/2013	30/04/2014	Informal	Knowledge transfer	Redbrook Ingredients, Ireland
3	01/03/2013	30/04/2014	Collaborating	Use of facilities	Codico, Ireland
4	01/03/2013	30/04/2014	Collaborating	Use of facilities	Domino, Germany
5	01/03/2013	30/04/2014	Informal	Collaboration on new proposals	LaserFoods, Spain
6	01/03/2013	30/04/2014	Informal	Knowledge transfer	FSAI, Ireland
7	01/03/2013	30/04/2014	Collaborating	Software development of application	IMAR, IT Tralee

(ii) Outcomes where new products, technologies and processes were developed and/or adopted

A new process for etching codes directly onto the surface of whole meat cuts was developed. This process is currently being evaluated by Manor Farm for potential incorporation into processing line.

(iii) Outcomes with economic potential

There is a large economic potential with the developing of a novel processing for coding whole meat cuts safely. This process has the potential to create a secure, verifiable, tamper-proof method of identifying and tracking wholesale and individual meat cuts. If proven successful and marketed to the major food producers then the process can become a global identification standard.

(iv) Outcomes with national/ policy/social/environmental potential

The improved traceability of meat cuts will have potential to improve national policy and enhance Ireland's green image.

The whole system has the potential to create a niche market of carbon conscious consumers who want to buy verified, local produce.

4 (b) Summary of Research Outputs

(i) Peer-reviewed publications, International Journal/Book chapters.

Cushen, M. and Cummins, E. Novel Packaging of Meat (2015) Emerging Technologies in Meat Processing Editors: E.Cummins and J Lyng. Wiley Blackwell, Chichester UK

(ii) Popular non-scientific publications and abstracts including those presented at conferences

McCarthy, U., Brennan, L., Corkery, G., Ward, S. RFIDJournal Live 2013, Orlando Florida April 30 to May 2. Track: Visibility / Traceability. "Using RFID to Establish a Secure Chain of Custody in the Meat Industry"

Cushen, M., Brennan, L., McCarthy, U., Corkery, G., Ward, S. CyberBar-Smartphone Ready Food Traceability and Consumer Communication. Fourth International Conference on Food Studies 20-21 October 2014 Monash University Prato Centre, Prato, Italy

Cushen, M., Brennan, L., McCarthy, U., Corkery, G., Ward, S. CyberBar-Smartphone Ready Food Traceability and Consumer Communication. SIEF 20th International Ethnological Food Research Conference 3-6 September 2014 University of Lodz, Lodz, Poland

(iii) National Report

N/A

(iv) Workshops/seminars at which results were presented

N/A

(v) Intellectual Property applications/licences/patents

US Patent Application No. 62/067,497
Patent is currently provisionally filed awaiting full specification.

(vi) Other

N/A

5. Scientists trained by Project

Total Number of PhD theses: 0

Total Number of Masters theses: 0

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	contribution (person years)
UCD	1	0.1
Total	**1**	**0.1**

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (person years)
Post Doctorates/Contract Researchers	2	0.66
PhD students		
Masters students		
Temporary researchers	2	0.2
Other		
Total	**4**	**0.86**

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended
N/A	

9. Project Expenditure

Total expenditure of the project:	€ 92,181.13
Total Award by DAFM:	€ 98,749
Other sources of funding including benefit in kind and/or cash contribution(specify):	€ 0

Breakdown of Total Expenditure

Category	UCD	Name Institution 2	Name Institution 3	Name Institution 4	Total
Contract staff	38,981.52				
Temporary staff	0				
Post doctorates	0				
Post graduates	0				
Consumables	2,020.36				
Travel and subsistence	9,252.63				
Sub total	50,254.51				
Durable equipment					
Other	26,850.27				
Overheads	15,076.35				
Total	**92,181.13**				

10. Leveraging

Summarise any additional resources'/funding leveraged by this award from other sources e.g. Additional Staff, National/EU funding secured, EI Commercialisation Fund, etc.

N/A

11. Future Strategies

Currently, the project is continuing with food paste trials to improve the patent specification and meet requirement set by FSAI. Once trials are complete, we plan on engaging in talks with a number of OEM laser manufactures to develop a full pilot production line with Manor Farm. Timelines for this process is expected to be 6 -12 months.