EPSRC CENTRE FOR INNOVATIVE MANUFACTURING IN Food

Annual Report

2016/2017

UNIVERSITY OF BIRMINGHAM

Loughborough University

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

www.manufacturingfoodfutures.com

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Executive summary

The EPSRC Centre for Innovative Manufacturing in Food has just entered its fourth year of operation. This report provides an overview of the progress of the Centre and we are in the process of engaging with a number of challenges.

In the summer of 2016, we held our mid-term review with an external panel of experts to reflect on the Centre's progress and achievements thus far. The feedback we received was positive, but also gave us direction for future success. Firstly, we need to engage in Future Strategy, and secondly to expand the Centre's Impactful Delivery.

To tackle the areas of Future Strategy we have embarked on a technology roadmapping exercise, which in the next few months will be sense checked against industry drivers and long term needs. We believe that this will allow us to further develop our interactions with other academic groups and strengthen our industrial linkages, both within the UK and internationally.

Impactful Delivery is being explored down a number of avenues. We are in the midst of attempting to deliver a number of patented technologies to industry, working closely with R&D teams to embed the technology for application. The majority of the extra £6.4 million we have brought in is also industry linked – either through direct support or drawing down higher TRL Innovate UK funding; projects which are industry led.

Our Outreach Activities also provide 'delivery' opportunities. In March 2016 Loughborough University hosted our second conference 'Manufacturing Food Futures', at which we had 110 delegates, with a 50:50 mix of industry and academia. The third in the series will be held in the Great Hall, University of Birmingham at the end of March 2017.

We have also arranged two workshops on 'Additive Manufacturing' for the food industry. This area has been supported with a £3.5 million grant from EPSRC linking our Centre with the Centre for Innovative Manufacturing in Additive Manufacturing – 'Formulation for 3D printing: Creating a plug and play platform for a disruptive UK industry'.

Two workshops planned for this year are the 3rd UK Hydrocolloids Symposium 'Hydrocolloid Structures Determining Functionality', and one with BBSRC's NIBB FoodWasteNet on 'Food Waste Valorisation for the Food Industry'.

The Centre is going from strength to strength and we now have a steady state of 50 people involved with us and our project portfolio has also continued to grow. The progression of our projects has led to new follow-up research and many of our projects have also transitioned from initial scoping phase to longer term projects.

Our researchers and staff have taken up opportunities to develop their skills through multiple routes including secondments both nationally and internationally. We also have eight past members who have taken professional jobs in the industry or elsewhere. Particular thanks go to Dr Jennie Lord who was our Outreach Officer for 21 months, helping build the Centre in its formative stage.

About us

> **“Our vision for the EPSRC Centre for Innovative Manufacturing in Food is to meet the challenges of global food security through developing world-class technologies, tools and leaders, tailored to meet the needs of current challenges whilst redesigning resource-efficient and sustainable, nutritious foods of the future.”**

The food and drink industry is the largest manufacturing sector in the UK and the gross value added to the economy is £21.9 billion and accounts for almost 16% of total manufacturing turnover in the UK. This is an extremely valuable sector to the UK and is critical in shaping how food is produced and consumed, ultimately contributing greatly to the health and wellbeing of the population.

In December 2013, £5.6 million was awarded by the Engineering and Physical Sciences Research Council (EPSRC) to establish the EPSRC Centre for Innovative Manufacturing in Food to support over five years. The Centre addresses the challenges facing the global food system, from farm gate to the consumer and beyond.

The two Grand Challenges and six Research Themes focused at the Centre reflect the concerns of the sector and ensures the Centre conducts research that will enable the delivery of healthy, nutritious food through resilient and sustainable food supply chains.

We work closely with policy influencers, institutions and the food and drink sector to ensure that new science and innovation at the Centre remains relevant to the community.

The EPSRC Centre for Innovative Manufacturing in Food is a partnership between the University of Nottingham, the University of Birmingham and Loughborough University. The Centre Director and two Deputy Directors are assisted by the operations team of three and there are six academics involved in the grant. The team currently has eight research fellows and associates, four research assistants, 22 PhD’s and three teaching and technical support staff.

EPSRC CENTRE FOR INNOVATIVE MANUFACTURING IN Food

3 Universities

£5.6m of EPSRC funding

Our team

1 Centre Director
2 Deputy Directors

+

3 Operations team
6 Academics
8 Research associates/fellows
4 Research assistants
22 PhD's
3 Teaching and technical support
11 Advisory board members

Our impact

3 Annual conferences organised
2 Workshops delivered
80+ Presentations

+

8 patents

70 publications

26 Industrial collaborations
24 Academic collaborations

+

£6.4m Additional investments

Processing influences on food structure

Better understanding of the interplay between food components and processes is needed to sustainably engineer foods that are fit for purpose.

Intact oil bodies can be extracted from oleaginous seeds and the sustainable processing of oilseeds can yield added value ingredients for the food industry. Understanding how extraction conditions relate to the quality of the extracted oleosomes will allow us to explore the functionality of these naturally emulsified structures for food applications.

A fundamental understanding of the food microstructure, such as foams and emulsions, will enable the design of stable food structures using more sustainable processes. At the Centre, we are using novel techniques to examine foam microstructures, particularly to understand film drainage to improve foam storage. Emulsions are present in a large variety of food products, however many conventional processes require high levels of energy. Confined Impinging Jet Reactors (CIJR) is an innovative technology being developed at the Centre. An advantage of this processing technology is the reduced energy required to achieve emulsification. Membrane emulsification is another technique that is used to produce emulsions with a narrow droplet-size distribution. The Centre is investigating the use of a rotating membrane to produce highly mono-disperse stable emulsions using food-grade particles.

Meet
Vincenzo di Bari

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Dr Vincenzo di Bari is a Research Fellow at the University of Nottingham. He attained his PhD at the School of Chemical Engineering at the University of Birmingham in December 2015. Prior to his PhD he graduated from Italy with a BSc Hons and MSc in Food Science and Technology at the Faculty of Agriculture in Foggia, Italy.

When looking for post-doctoral research opportunities, the prospect of joining the EPSRC Centre for Innovative Manufacturing (CIM) in Food was attractive for its dynamic structure, i.e. partnership between three Universities, and by the 'Food System' approach. This approach offered a unique opportunity to work on new research challenges, which were relevant from a fundamental science as well as from an applied point of view.

As a member of the CIM in Food, my research has developed mainly around one of the six Research Themes identified as 'Upgrading of Materials', which aims at the recovery and valorisation of natural biomaterials as well as transformation of waste streams for food applications. Specifically the two main research topics I am focused on are: (1) the use of oleogels: a novel route for the replacements of saturated and trans-unsaturated fats to structure edible oils in foods; (2) aqueous recovery of natural lipid organelles i.e. 'oleosomes' or 'oil bodies', from oil rich seeds for food emulsions applications.

The oleogels project started to address one of the Developed World key challenges: the reduction of 'unhealthy' fats in food products. 'Rice bran wax' (RBW) was selected as 'oleogelator' as it is an abundant food grade waste product available worldwide. This project, developed together with Dr Bettina Wolf and Professor Tim Foster, started with studying the thermal and rheological fundamental properties of RBW oleogels in order to be able to understand behaviour and design the performance of these novel ingredients. The project has evolved to investigate the use of oleogels in baked food products. This has set new exciting challenges which include understanding the functional role of fats in batters and final products and new ways to achieve the same properties in the traditional products using our novel ingredients. In order to achieve a real impact on society, collaborative work with industrial partners of the Centre has already started which will eventually allow lab-scale knowledge to be applied on an industrial level.

The research project aiming at the 'upgrade of oleosomes' addresses the global challenge of utilising sustainable natural ingredients for food production. The concept of using oleosomes in foods was introduced at the University of Nottingham by Dr David Gray. Through our research we have gained a deep understanding of the role of processing conditions on the quality of the final extract. This has allowed us to develop a novel extraction method which can be tailored to produce oleosome extracts with the desired properties. Our work also benefits from national (Rothamsted Research Institute) and international (University of Wageningen) collaborations and also with industrial partners.

Working at the EPSRC CIM in Food has offered me many unique opportunities to face interdisciplinary challenges. I have really appreciated being part of such a diverse group and it is a great experience.

Designing resilient food supply chains

The food sector needs to take into consideration its environmental impact in manufacturing and must not continue producing at the expense of the environment.

An approach to reducing environmental impact is for manufacturers to consider the product design and process of manufacturing as a way of developing resilient supply chains. At the Centre we have generated a taxonomy that allows for resilience, whilst taking into account the shelf life and natural variability of materials and product. The Centre is partnering with industry to validate these measures for factory implementation.

Another way to address environmental impact is to categorise and examine the factors contributing to food waste from production to end-product use. These are some of the projects that are being explored at the Centre to aid the reduction and improved utilisation of food waste.

A significant cost to the food manufacturing sector is the large volumes of effluent generated. Our researchers have developed a non-invasive sensor which provides feedback on effluent to optimise treatment of water.

Meet **Patrick Webb**

Loughborough University

Dr Patrick Webb is a newly appointed Lecturer in Advanced Manufacturing in the School of Mechanical, Electrical and Manufacturing Industry at Loughborough University. Until recently he was a Research Associate with the Centre for Sustainable Manufacturing and Recycling Technology (SMART) at Loughborough, working in the EPSRC Centre for Innovative Manufacturing (CIM) in Food on water use efficiency in food manufacturing. Patrick is continuing his association with the CIM in his new role.

The target of the work I have been involved in for the Centre is gaining an in-depth understanding of water consumption and waste in food manufacturing, in order to develop appropriate tools and technologies to better manage this consumption in the future. In particular, the research assertion is that opportunity exists to significantly avoid or reduce water usage and effluent production by understanding water flows at the unit process level. By contrast current industry water management practices concentrate on supply side or end-of-pipe (effluent treatment) measures which do not address the fundamentals of why and whether existing volumes of water use are required. Our vision at the Centre is to combine instrumentation for non-invasive water monitoring, with modelling and software support for decision making regarding investment in water efficiency.

The results are expected to be applicable across manufacturing more widely. The research is timely because in the near future water will rival energy as a sustainability issue, with demand for freshwater exceeding local supply in more and more regions of the world. Water supply quality and reliability, and restrictions on effluent discharge contents and quantity, are already concerns for manufacturing industry in the UK and will become increasingly important.

One of the things I enjoy most about my job is talking to industrial collaborators, understanding their problems and point of view, and going into factories and seeing the ingenious technical and operational solutions that have been implemented. The food industry is new to me because my previous experience has been in other areas of manufacturing, and I have appreciated the opportunity to learn about specific industry concerns with hygiene, short shelf life and rapidly changing demand. I have also seen many food industry concerns common with my previous experience, such as traceability and quality assurance.

I have been able to bring to this research a combination of commercial and academic experience in innovation. My time at the Manufacturing Technology Centre gave me an insight that I value into many issues affecting academic –industrial relationships, such as differing time scales, drivers and reward mechanisms, and which I have tried to apply to my work for the CIM. I believe that these differing drivers can be negotiated successfully, that relationships of mutual respect can be constructed, and that these are mutually beneficial. For me the Centre for Innovative Manufacturing in Food provides an excellent example of how this can be done and I intend to continue my association with the Centre in my new role.

Meet **Jamie Stone**

Loughborough University

Jamie began his PhD at the University of Loughborough in late 2014. He is supervised by Professor Shahin Rahimifard at the Centre for Sustainable Manufacturing and Recycling Technologies. Prior to this, Jamie gained his BSc in Medical Microbiology and Virology from The University of Warwick (2010) and an MSc in Food Security also from The University of Warwick (2012). Jamie has experience in the field of sustainable development in a UK setting with Localise West Midlands (2012) and in an international development context with APT Action on Poverty (2013). His current research explores the different factors influencing the resilience of UK food supply chains and how they can be modified by different types of food supply chain actors to enhance resilience.

Ensuring that the world is supplied with enough food to meet its needs and that this food is accessible in a form that matches people's diverse lifestyles and cultures, and is produced in a way that does not exhaust the natural systems upon which production depends is arguably one of the most important challenges facing society today. Addressing such a challenge cannot be achieved by academia alone and certainly not via research that focuses individual topics such as agriculture, food science, logistics and policy as isolated areas. Holistic centres that collaborate with other research centres, industry and policy makers are vital and this is what attracted me to the EPSRC Centre for Innovative Manufacturing in Food. My research aligns with one of the Centre's grand challenges "Sustainable Food Supply and Manufacture" and explores the resilience of UK food supply chains. It is a key link in helping to close the gap between how novel food ingredients and production processes investigated elsewhere within the Centre can be sourced, and delivered to where they are needed in the most sustainable and disruption resistant method possible.

My project investigates how the increasingly popular topic of resilience in supply chains can be translated to the food industry. Work so far has focused on synthesising inconsistent definitions of resilience in academia and industry into a concise and unified taxonomy of key vulnerabilities and mitigating capabilities that allow for resilience. These taxonomies are currently being empirically validated by a wide range of stakeholders across UK food supply chains and developed into a theoretical model for building adaptive resilience. This model will form the basis for simulation of resilience strategies in the face of volatility projected in association with major future stressors such as climate change and population growth.

Alongside my PhD, I also take an active interest in science outreach and feel strongly that as scientists, we have a responsibility to make our research accessible and useable to wider society. One of the areas I am very heavily interested in is addressing the shortage of young people pursuing careers in Science, Technology, Engineering and Maths (STEM). I have been actively involved in engaging young people (for example, at the annual Your Green Futures School workshops in Solihull), using my own research, and the work of others within the Centre, to highlight the wide range of career routes and huge importance of science and engineering. I am also keen to use the cutting edge research being undertaken at the Centre to engage with and influence policy makers. To this effect, I have attended a number of professional development training workshops on the matter and have had the opportunity to put this to good use in a recent submission of an enquiry proposal to the House of Commons Science and Technology Committee. Such opportunities, actively encouraged and supported by the Centre, are excellent for career development and highlights the importance the Centre places on early career researcher development.

Improving the flexibility of food manufacturing

The changing consumer behaviours and development of new business operating models is indicating that more adaptable manufacturing is required in the future.

At the Centre, we are exploring the feasibility of food production in relation to distribution chains and food materials and manufacturing processes for distributed manufacturing. This enables production of food to be closer to the point of use. Consumers can finish a product quickly before consuming to the same quality that would have otherwise been completed by the manufacturer. Through distributed manufacturing, the food waste generated is also reduced with extended product shelf life and increased storage stability.

Researchers at the Centre are developing a set of metrics to highlight areas where distributed and localised manufacturing may provide economic, environmental and social benefits.

To improve the shelf life of perishables, a project being explored at the Centre specifically focuses on tomato structure. Cell wall remodeling normally occurs during the process of tomato fruit softening and by modifying cell wall genes expression during ripening the texture and therefore shelf life of the fruit may be altered.

Other projects have focused on formulation and processing techniques that are relevant to the food sector. The team is developing new food formulations that can be dried for prolonged shelf life and rehydrated when required to achieve desirable organoleptic properties.

Meet
Gladness-Marry Manecka

UNIVERSITY OF BIRMINGHAM

Gladness started her PhD at the University of Birmingham in March 2015. She is supervised by Dr Thomas Mills and Professor Ian Norton at the School of Chemical Engineering in the Microstructure Group. Before her graduate research, Gladness graduated with a Master in Material Science specialised in bio functional polymers from the University of East Paris Creteil, France. Her current research explores producing oil-in-water emulsions specially formulated to be reconstituted after they have been dried.

During my Master's degree I took classes on chemistry and engineering of formulation that sparked my interest. The possibility to create and modulate such systems was very interesting to me. I knew from then that I wanted to work on the improvement of such structures. Transitioning from a chemistry background to a chemical engineering project, makes me see the work of a researcher from a different angle.

Over the last few years, dry emulsion systems have generated increasing interest. These dry emulsion systems have increased shelf life and lower industrial costs. To produce re-dispersible oil-in-water dry emulsions, the emulsifier has to be chosen wisely since it is the main mechanical protection of the oil droplet during drying but also becomes the outer layer of the resulting powder. The aim of my project is to produce re-dispersible dry emulsions. The main focus of this study is to understand how the emulsifier of these type of emulsions should be chosen so it can protect the structure during the drying process whilst optimising the reconstitution after rehydration.

Working within the EPSRC Centre for Innovative Manufacturing in Food has provided valuable opportunities to interact with colleagues, both in the industry and academia. I have been very fortunate to be part of the Centre's inspiring research community and have a great support system to share and exchange research ideas.

Additive manufacturing with edible materials

Additive manufacturing of food can offer the food and drink industry a number of competitive advantages including: Customisation, Structures with visual appeal, On-demand production, Utilisation of novel materials and Geometric complexity.

The Centre is exploring different methods of using edible materials for additive manufacturing. Our researchers are exploring Fused Deposition Modelling (FDM) to process food grade biopolymers to create edible filaments. The properties of particular food grade materials are being explored to ascertain whether they are suitable as a printing medium. In addition, the research is exploring how different materials react throughout the printing process and if their properties are affected after the process.

Other research at the Centre has focused on using natural materials relevant to the food industry and Binder Jetting to create 3D printed materials with feature sizes of less than 100 µm. This produces structures with unique and interesting topographies.

Meet
Dr Aditya Nayak

UNIVERSITY OF BIRMINGHAM

Dr Aditya Nayak is a research associate and a Marie Skłodowska-Curie Fellow currently under the mentorship of Professor Ian Norton at the University of Birmingham. Prior to joining the EPSRC Centre for Innovative Manufacturing in Food, Aditya obtained his BSc and PhD in Biochemistry from Kuvempu University, India. Later, he joined Sejong University in South Korea as a Postdoctoral Scientist, where he secured funding from the Korean National Research Foundation (KNRF) as Principal investigator. In addition he was also a co-investigator in two more projects funded by the Ministry of Food and Drug Safety (Korea) and the Nongshim Food Company (Korea).

The objective of my current Marie Curie Fellowship project entitled "Ayurvedic Bioactive Compounds Stabilized Pickering Double Emulsions- Fabrication and *in vitro* Evaluation" is to use the nanonization technology to engineer the particle characteristics, such as size, morphology and polymorphism, of ayurvedic bioactives to optimize their Pickering ability. In the next phase of the project, I would like to use the ayurvedic bioactive stabilized emulsions to develop food product prototypes to study their suitability to use in the industrially processed food products. This work is conducted in collaboration with Unilever.

Recently, I was awarded the Universitas 21 Staff Fellowship and Career Development Fund. These fellowships are awarded to staff members who transfer new knowledge and skills within the network of 21 Universities. My aim is to build upon my earlier independent work to become an independent research leader in my own right. I aspire to be a pioneer in the development of novel and innovative technologies to engineer particles for food and pharmaceutical applications.

Being part of the EPSRC Centre for Innovative manufacturing in Food has provided unique opportunities and I have received invaluable support towards my research and aspirations. The Centre has connected me with peers from many different research disciplines. In addition, this has enabled me to learn more about the challenges and needs of other research fields and how I can contribute to address those challenges by using my knowledge and expertise.

Exploring natural ingredients and designing products to improve health and wellbeing

Combining a need to reduce food waste and to impact on a 'Circular Economy' for the food system, strategies are required to provide sustainable solutions in getting more out of what nature provides.

The Centre aims to challenge traditional food production by finding more efficient and effective uses of ingredients and food materials. To align with changing consumer lifestyles, the Centre is exploring ways to meet demands to produce novel products for healthier diets using natural ingredients. Research at the Centre examines alternative sources to achieve traditional structures.

Some of our projects have been exploring food grade materials, such as protein-pectin complexes, bees wax and lignin-rich particles, derived from food waste, to form stable emulsions.

Projects utilising insect and plant-based proteins have proven to be sustainable, nutritious filler ingredients, to provide added functionality to food microstructure.

The Centre is currently investigating potential replacements of undesirable solid fats in food products, such as cakes and pastries. Research projects are exploring the functionalities of a range of food hydrocolloids towards the design of healthier foods.

There is a considerable interest in improved delivery and controlled release of actives including tastants, minerals, vitamins, and probiotics. Our researchers are exploring processes to effectively deliver key nutrients for triggered release in the gastrointestinal tract. To improve delivery of such sensitive components, researchers are assessing the processing parameters of specific drying methods and their effects on the integrity of the encapsulated nutrient. In addition, biopolymer complexes have been examined and have demonstrated promising encapsulating potentials.

Meet
Holly Cuthill

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Holly started her PhD at The University of Nottingham in August 2016 after completing her BSc degree in Food Science and Nutrition. She is supervised by Dr Bettina Wolf and Dr Joanne Gould at the University of Nottingham and Dr Evelien Beuling from Mondelez International who is her industry sponsor.

My PhD project builds on the work of Dr Joanne Gould, who is one of the Postdoctoral Researchers at the EPSRC Centre for Innovative Manufacturing (CIM).

Coffee waste is generated through multiple routes including industrial processing and at the consumer level. This waste stream is lignin-rich and has been demonstrated to be suitable for creating functional food ingredients with emulsifying ability. The main focus of my PhD is to design lignin-based food particle ingredients with controlled interfacial properties. To date I have developed a method to relocate and extract the lignin from spent coffee and other biomass. I have gained understanding of different analysis techniques and utilised both expertise at the University and also at Mondelez International. The next stage of my research will be to complete the characterisation of the extracted lignin and the formation of lignin microparticles.

Being involved as a researcher in the Centre has already offered multiple opportunities to showcase my initial research and for me to receive valuable feedback. In March 2017, I will be my attending my second Centre conference. Last year I was lucky enough to attend and learn about the wide range of research. I expanded on this when attending Food Matters Live last November where I was also able to discuss the early stages of my research.

Having sponsorship from Mondelez International and being associated with the CIM has already demonstrated to be highly valuable for my development and I look forward to more opportunities the Centre will bring.

Case studies

Case study

Upgrading food waste for emulsion stabilisation

Pickering particles are particles that are adsorbed at the oil/water interface to stabilise emulsions. They can be used to replace artificial surfactants and offer stability and prolonged shelf-life. However, most of these Pickering particles require chemical modification and are often restricted in food application. Our previous work has demonstrated that natural Pickering particles, which are suitable for food application, have surface active properties in part due to lignin.

Based on this finding, research was conducted to utilise the hydrophobic nature of lignin to design Pickering particles to stabilise food emulsions and foams. Ground coffee waste was selected due to the natural presence of lignin in cell wall material, the current acceptance of coffee in food and beverages and the generation of large quantities of coffee waste globally. In Europe alone, manufacturing instant coffee produces approximately 300,000 tonnes of spent coffee waste annually, in addition to, 550,000 tonnes of ground coffee waste a year from UK coffee shops and households.

Our researchers have demonstrated that waste coffee particles can act as Pickering particles for oil-in-water emulsions and water-in-oil emulsions. The emulsions were stable over a wide range of pH, shear and temperature conditions. This research has established that lignin-rich food waste can be upgraded to functional food ingredients which are capable of stabilising emulsions.

This work has led to follow-on funding for two PhD projects investigating alternative thermal processing and extraction protocols to create a range of natural lignin-rich particles for food formulations.


AMG

Case Study

Sustainable management of food waste

Reducing food waste is one of the Sustainable Development Goals set by the United Nations. As much as a third of all food produced for human consumption is never eaten. This has significant environmental, social and economic ramifications. It is important to take a holistic approach to understanding food waste rather than considering different aspects in isolation. The Centre has developed a systematic methodology to categorise types of food waste. Used in conjunction with the food waste hierarchy, the Food Waste Management Decision Tree (FWMDT) is then able to identify the best approach to waste management.

This methodology was tested at two large UK food and drink manufacturers: Molson Coors and Quorn Foods. For each business, the detailed breakdown of the types of food waste generated provided far better results than general itemisation.

At Molson Coors, by using FWMDT, two types of waste were identified to be upgradable: waste beer and filter waste. By managing the waste streams in alternative ways, more value could potentially be obtained. Similarly, analysis of the waste generated at Quorn Foods also showed that one type of waste was upgradable. Food product returns are currently sent to anaerobic digestion. FWMDT has highlighted that by identifying sub-types of food product returns, some of the food waste could be redistributed for human consumption.

This new methodology can be adapted to individual businesses to improve waste management. It will help to utilise food waste far more effectively.

Case Study

Drying and rehydrating for distributed manufacturing

There are increasing demands for food manufacturers to deliver quality products free-from preservatives to consumers. Drying is used extensively in the food industry to prolong the product shelf life by inhibiting the growth of microorganisms and their enzyme activity without the use of preservatives. Some of the most commonly used drying techniques are oven drying and freeze drying. However, these methods can often have detrimental effects on the texture and rehydration capacity of the dried food. This is particularly apparent in fruit and vegetables, which have a high moisture content. The other major drawbacks are the very long processing times and high energy costs.

Osmotic dehydration could be an effective pre-treatment for these drying processes. Foodstuffs are dehydrated by immersing them in a hypertonic solution where moisture diffuses from the food towards the solution.

We have shown that by using an osmotic dehydration pre-treatment, drying times of strawberries for both oven and freeze drying can be greatly reduced. The mechanical and structural properties of the strawberries were also better retained.

From an industrial point of view this could lead to a reduction in cost and improvement in the quality of the product.

Activities at the Centre

Delivering impact and engaging with the food industry and academia

As a national Centre, we continue to build and strengthen our links within the UK to ensure that our strategic objectivities are complementary to research activities undertaken at other institutes.

The EPSRC Centre for Innovative Manufacturing in Food is delivering impact through multiple avenues. The Centre leads innovative food research programmes and we are working collaboratively with other national and international research communities to deliver translatable innovative research for industry applications. We are now at a stage of progressing patented technologies developed at the Centre to be adapted for industry applications.

The Centre's research is generating substantial interest from the sector and the commercial impact and relevance of our research is demonstrated through the high level of industry sponsorship, some of which have also been supported by funding streams including Innovate UK and BBSRC. Overall, collaborations with our members has generated an additional £6.4 million to the EPCRC Centre for Innovative Manufacturing in Food.

Our research has been disseminated to national and international audiences at the following conferences and Workshops:

APRIL TO MAY
2016

7 – 8 April	'Agri-food Opportunities in Additive Manufacturing'- a pre-competitive workshop for the food industry, Nottingham, UK
10 - 13 April	16th Food Colloids Conference, Wageningen, The Netherlands
12 April	2nd Edition of the 3D Food Printing Conference, Venlo, The Netherlands
15 April	Institute of Physics: Physics in Food Manufacturing Summit, London, UK
19 - 21 April	PARTEC International Congress on Particle Technology, Nuremberg, Germany
20 April	IFST Spring Conference 'Food Sustainability: Waste not, want not'
16 -20 May	13th International Hydrocolloids Conference, Guelph, Ontario, Canada
17 - 18 May	Edie Live, Birmingham, UK

JULY TO AUGUST 2016

5 July	Food and Drink IT Summit, Birmingham, UK
7 - 8 July	EPSRC Centre for Industrial Sustainability Conference
20 - 22 July	10th CIRP Conference on Intelligent Computation in Manufacturing Engineering, Ischia, Italy
21 - 25 August	IUFoST 18th World Congress of Food and Science and Technology, Dublin, Ireland

SEPTEMBER TO OCTOBER 2016

1 September	East Midlands University Association Conference, Loughborough, UK
7 - 9 September	RSC/SCI Colloids Group Meeting: Particles at Interfaces, Leeds, UK
11 - 14 September	7th European Conference on Sensory and Consumer Research, Dijon, France
September	The Royal Society of Chemistry East Midlands Division. Guest lecturer presenting: 'Designing food's structure for functionality'.
3 - 5 October	14th Global Conference on Sustainable Manufacturing, Stellenbosch, South Africa
19 - 21 October	Food Factory 8th International Conference
25 October	Engineering and Physical Sciences Research Conference, Birmingham, UK
26 - 28 October	2nd Congress Food Structure Design, Antalya, Turkey
31 October	Influence and Impact Annual Research Conference, Loughborough, UK

NOVEMBER TO FEBRUARY 2016/17

15 November	Sustainable Food and Beverage Manufacturing, Birmingham, UK
28 - 30 November	30th EFFoST International Conference, Vienna, Austria
7 December	Local Nexus Network for Redistributed Manufacturing, Oxford, UK
9 January 2017	Topical Research Meeting on Physics in Food Manufacturing, Sheffield Hallam University. Delivering a talk on: The role of the EPSRC CIM in Food in delivering next generation technologies to meet the future needs of the Food Industry, Sheffield, UK
23 -26 January	Workshop on Innovations in Aerated Food Processing for Sustainability, Health and Life funded by the Newton-Ungku Omar Fund, Campden-BRI, Gloucestershire, UK
February	Interface and Food and Drink Federation Scotland - Food & Drink Reformulation for Health, Edinburgh, UK

Reaching out as a National Centre

APRIL
2016

The Centre is a proud advocate for disseminating knowledge though different activities. The team have participated in events designed for policy makers, industry and the wider public. Here are some examples of our activities:

Discovery Communities Live

Our team at the Centre attended the 'Waste Less Save More' workshop. The event connected companies and other groups tackling food waste and identifying how food waste can be reduced.

JULY 2016

Marks and Spencer Innovation Day

In July, the Centre was invited by Marks and Spencer to present some of the research conducted at the Centre. The event was part of a brainstorming session to highlight new areas of technology.

Sutton Trust Summer School

A team of EPSRC Centre staff and students ran an interactive workshop titled 'Creating Food Microstructures'. The session demonstrated typical processes used to create different microstructures in foods and how these affect the final product. The aim of running a session as part of the summer school was to inspire students to consider studying food science and the potential opportunities of the sector.

SEPTEMBER 2016

Year 11 Pathways to STEM

In September 2016, a team of research students and staff from the Centre took part in an event to inspire and encourage students to consider their future and the variety of STEM subjects. During the event at Nottingham, the team held various interactive demonstrations and discussions with the students.

NOVEMBER TO JANUARY 2016/17

Teaching Food Science and Engineering in Cooking Master School

In November 2016, the Centre contributed to a three-day training course on food science and engineering which took place in Tione di Trento (TN) Italy. Our researcher, delivered a course on common ingredients from a scientific perspective to the Cooking Master School students.

Food Matters Live

In November 2016, the EPSRC Centre showcased its research at Food Matters Live which took place at ExCel London. During the three-day event, our researcher shared and exchanged ideas with some of the 15,000 attendees of the event.

IFSTAL Symposium: Technology – a sliver bullet for the food system?

In January 2017, the Centre was invited to IFSTAL's first public symposium to deliver a presentation to academics, students, and professionals.

Our team

DIRECTORS

Professor Tim Foster, Centre Director University of Nottingham

Professor Ian Norton, Deputy Director University of Birmingham

Professor Shahin Rahimifard, Deputy Director Loughborough University

ACADEMICS

Dr David Gray, University of Nottingham

Dr Bettina Wolf, University of Nottingham

Dr Tom Mills, University of Birmingham

Dr Patrick Webb, Loughborough University

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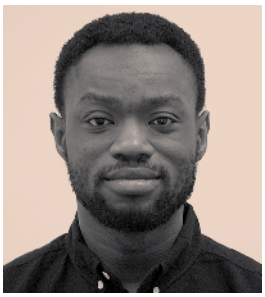

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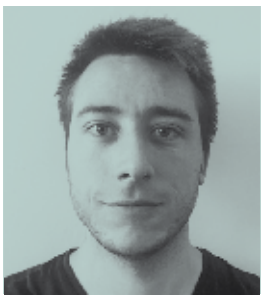

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