



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

15F610 - Novel clean label strategies for the nutritional and sensory optimisation of reduced salt and fat processed meat products

Final Report

This project was funded under the Department of
Agriculture, Food and the Marine Competitive Funding
Programme.

SUMMARY

NATRIOPT optimised processed meats through the reduction and or replacement of salt and fat using novel ingredients as replacers (eg. edible seaweeds). Potential therapeutic benefits of seaweed consumption have been reported in the management of body weight, obesity and cardiovascular diseases thus offsetting negative effects of salt and fat. Also, heterogeneity of distribution of salt content (eg, two batters/layers with different salt contents in processed products enhances sensory perception of salt flavour intensity. Additionally inclusions of aromas that suggest saltiness and fat/creaminess can offset the sensory disadvantages of salt- and fat-reduced products and is termed Odour-induced saltiness enhancement (OISE). These were explored along with the effects of matrix changes on flavour chemistry systems utilising advanced GC (Gas Chromatography) techniques. Salt and fat reduction has a major impact on flavour perception due to changes in the ratios of polar and non-polar flavour molecules. This data, captured from state of the art GC techniques as well as sensory and consumer data were mined using chemometrics to obtain a deeper understanding of the inherent flavour chemistry systems involved in salt and fat reduction/replacement in processed meats.

KEYWORDS

Salt; Fat; Reduction

ACRONYM

NAPRIPOOT

PROJECT COORDINATOR, INSTITUTION

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Cork.

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COLLABORATORS, INSTITUTION

Prof Joe Kerry, University College Cork.
Dr Ruth Hamill & Dr Kieran Kilcawley,
Teagasc.

PUBLICATION DATE

November 2022.

Section 1 - Research Approach & Results

Start Date

01 August 2017

End Date

28 February 2022

Research Programme

Food Institutional Research Measure

TRL Scale

TRL 3: Experimental Proof of Concept

NRPE Priority area

Connected Health & Independent Living

Total DAFM Award

€871,795.60

Total Project Expenditure

€834,851.92

Rationale for undertaking the Research

Processed meat consumption increases the risk of attracting chronic diseases such as obesity, cancer and stroke. These products comprise one of the major sources of sodium. In Ireland and the UK the daily sodium adult intake is approximately three times the recommended daily allowance. Also, high saturated fat levels present a greater risk of obesity, type 2 diabetes and cardiovascular disease. The aim of this project was to utilise novel ingredients (edible seaweeds) as salt and fat replacers which also confer therapeutic benefits in the management of body weight and obesity.

In effect these materials substituted the sensory properties removed by salt and fat as well as adding a potential therapeutic benefit. The majority of studies assessing the short-term effects of seaweed derived alginate consumption indicate that alginate may increase satiety, reduce energy intake and support weight reduction. The present project also identified how heterogeneity of distribution of salt content in processed products enhances sensory perception of salt flavour intensity. This has been termed increased taste sensory contrast. Strategies explored included preparation of burgers with alternative salt contents followed by crude mixing. Taste-aroma interactions were also utilized to boost saltiness. Inclusions of aromas that suggest saltiness and fat/creaminess can offset the sensory disadvantages of salt and fat-reduced products. Odour-induced saltiness enhancement (OISE). This phenomenon was explored in developing low salt and fat processed meat products.

Methodology

The aim of this project was to utilise novel ingredients (edible seaweeds) as salt and fat replacers which also confer therapeutic benefits in the management of body weight and obesity. In effect these materials substitute for the sensory properties removed by salt and fat reduction as well as adding a therapeutic benefit. Additionally, a novel consumer and sensory-driven product optimisation strategy was demonstrated by which products can be made healthier through the reduction of negative ingredients like salt and fat without compromising cost, safety

and of course consumer satisfaction. There is also considerable evidence that heterogeneity of distribution of salt content in processed products enhances sensory perception of salt flavour intensity. This has been termed increased taste sensory contrast. Strategies explored included preparation of meat layers with alternative salt contents. Creating products with heterogeneity in the stimulus has been shown to enhance the perception of sensory trait intensity. Location of a high stimulus concentration on the outer parts of the product can enhance perception of taste. The present project demonstrated that increased intensity of saltiness was perceived when higher salt was located within internal burger layers. Taste-aroma interactions were also utilized to boost saltiness. Inclusions of aromas that suggest saltiness and fat/creaminess can offset the sensory disadvantages of salt- and fat-reduced products. This Odour-induced saltiness enhancement (OISE) was explored in developing low salt and fat processed meat products. For Hedonic analysis consumers chose reduced-salt OISE pork sausages unless a strong odour induced salt enhancer was used (bacon), whereas, in heterogenous salt distributed burger samples, the consumers identified salt perception where NaCl was predominant in the internal layers.

Project Results

NATRIOPT optimised processed meats, burgers and sausages, through the reduction and or replacement of salt and fat using novel ingredients as replacers (e.g. edible red and brown seaweeds). Additionally, the project has demonstrated that heterogeneity of distribution of salt content (e.g., two batters or meat layers with different salt contents unevenly mixed) in processed products enhances sensory perception of salt flavour intensity. Also, the project found that inclusions of aromas that suggest saltiness can offset the sensory disadvantages of salt- and fat-reduced products and is termed Odour-induced saltiness enhancement (OISE). In heterogenous salt distributed burger samples, the consumers identified salt perception where NaCl was predominant in the internal layers. Potentially this could be used to reduce salt in processed meats by concentrating salt at specific locations. NATRIOPT demonstrated that product matrix changes can be measured by flavour chemistry systems utilising advanced GC (Gas Chromatography) techniques which yield a greater understanding of sensory mechanisms. Salt and fat reduction has a major impact on flavour perception due to changes in the ratios of polar and non-polar flavour molecules. This data, captured from state of the art GC techniques as well as sensory and consumer data was mined using chemometrics. Thus this deep understanding of the inherent flavour chemistry systems involved in salt and fat reduction/replacement combined with affective (hedonic) sensory data allowed the development of optimised products from both a nutritional and sensory perspective.

Section 2 - Research Outputs

Summary of Project Findings

Production of a flash profiling (Optimised Descriptive Profiling) protocol with Finalised multivariate data analytical methodology is a product development strategy whereby variants can be optimised rapidly through consumer driven approaches. Also, in parallel, nutritional optimisation can be achieved. This is a major goal for the process food sector, one which I have discussed recently with the industry through a workshop (Rapid2020-Dawn Farm Foods).

Additionally new gas chromatography(GC) methodologies have been developed over the course of this project that add to the current cannon of existing methods.

Sensory-accepted sausage formulations using brown seaweeds sea spaghetti and Irish wakame were 10% fat, 0.5% salt and 15% fat, 1% salt, respectively. The shelf-life (TVC) of aerobically packaged low-fat, low-salt, seaweed-formulated sausages was reduced by seven days when compared to the control. MAP (80% O₂/ 20% CO₂) and vacuum packaging extended the shelf-life of equivalent formulated sausages.

For red seaweeds, dulse (PP) at 10% fat 0.5% salt and nori at 10% fat 1% salt were the most acceptable formulations from a sensory point of view. This data is commercially useful to producers for optimisation of similar commercial products. The sensory results indicated that salt enhancement can be achieved through heterogeneity of salt distribution in beef burgers. Salt added to external layers of the burger patties was far less perceived when compared to salt added to internal layers of the treatment. Therefore, a well-constructed salt distribution may allow significant salt reduction in the same time maintaining the overall salt intensity of the sample. Also the project found that inclusions of aromas that suggest saltiness can offset the sensory disadvantages of salt- and fat-reduced products and is termed Odour-induced saltiness enhancement (OISE). For Hedonic analysis consumers chose reduced-salt OISE pork sausages unless a strong odour induced salt enhancer was used (bacon).

Summary of Staff Outputs

Research Output	Male	Female	Total Number
PhD Students	0	2	2
Post Doctorates	3	2	5

Summary of Academic Outputs

Research Outputs	Total Number	Details
Publications in Peer Reviewed Scientific Journals	8	<ol style="list-style-type: none">Mohammed, H. O., O'Grady, M. N., O'Sullivan, M. G., Hamill, R. M., Kilcawley, K. N., & Kerry, J. P. (2021). An Assessment of Selected Nutritional, Bioactive, Thermal and Technological Properties of Brown and Red Irish Seaweed Species. <i>Foods</i>, 10(11), 2784.Mohammed, H.O., O'Grady, M.N., O'Sullivan, M.G., Hamill, R.M., Kilcawley, K.N. and Kerry, J.P., 2022. Acceptable Inclusion Levels for Selected Brown and Red

- Irish Seaweed Species in Pork Sausages. *Foods*, 11(10), p.1522.
3. Garicano-Vilar, E., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2019). Review: Volatile compounds of six species of edible seaweed. *Algal Research*, 45, 101740.
 4. Garicano-Vilar, E., Ouyang, H., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2019). Effect of salt and fat reduction and its replacement with 1% edible seaweeds on the chemical, sensory and volatile component profile of reformulated frankfurters. *Meat Science*, 161, 108001.
 5. Garicano-Vilar, E., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N (2020). A Chemometric approach to characterise the aroma of 8 selected brown and red edible seaweeds/extracts. *Journal of the Science of Food and Agricultural*, 101, 3, 1228-1238.
<https://doi.org/10.1002/jsfa.10735>
 6. Garicano-Vilar, E., O'Grady, M.N., Mannion, D.T., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N. (2020). Optimization of a high-capacity sorptive extraction gas chromatography-mass spectrometry method for untargeted volatile profiling and for the quantification of targeted lipid oxidation compounds in raw beef patties. *Meat Science*, Accepted.
 7. Garicano-Vilar, E., O'Sullivan, M.G., Kerry, J.P., Kilcawley, K.N (2022). Analysis of volatile compounds in beef and pork by means of different sample preparation techniques for gas-chromatography. A review. *Journal Separation Science*, 5:482–512.
 8. Tyuftin, A. A., Mohammed, H., Kerry, J. P., O'Sullivan, M. G., Hamill, R. and Kilcawley, K. (2021) 'Microscopy-assisted digital photography as an economical analytical tool for assessment of food particles and their distribution through the use of the ImageJ program', *Advances in Nutrition and Food Science*, 2021(2), pp. 1-10. doi: 10.37722/ANAFS.2021202

Peer
Reviewed
Conference
Papers

11

1. Elena Garicano-Vilar, Maurice G O'Sullivan, Joseph P Kerry, Kieran N Kilcawley. Development of a high-capacity sorptive extraction (HiSorb) gas chromatography mass spectrometry method for the identification of volatiles associated with lipid oxidation in raw beef. IFSTI December 2020 46th Annual Food Science and Technology Conference.
 2. Garicano-Vilar, E., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N. (2020). OPTIMIZATION OF A HIGH-CAPACITY SORPTIVE EXTRACTION (HI-SORB) METHOD COUPLED TO GAS CHROMATROGRAPHY-MASS
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SPECTROMETRY FOR THE DETERMINATION OF LIPID OXIDATION VOLATILE COMPOUNDS IN BEEF MEAT. 66th International Congress of Meat Science and Technology and 73rd Reciprocal Meat Conference (ICoMST/RMC 2020)

3. Garicano-Vilar, E., Ouyang, H., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2020). Chemometric analysis of volatile flavour sensory characteristics of reduced salt reformulated frankfurters containing 1% w/w edible seaweeds. 9th European Conference on Sensory and Consumer research (EuroSense 2020).
 4. Garicano-Vilar, E., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2019). Volatile component and odour profiles of three brown and two red edible species of seaweeds and a brown seaweed extract. 48th Annual Food Science and Technology Conference hosted by University of limerick and IFSTI, 16th December, 2019.
 5. Mohammed, H.O., O'Grady, M.N., Kilcawley, K.N., Hamill, R.N., Kerry, J.P and O'Sullivan, M.G. (2019). Effects of red seaweed species on physicochemical and sensory properties of low-salt, low-fat sausages. The 48th Annual Food Science and Technology Conference hosted by University of limerick and IFSTI, 16th December, 2019.
 6. Mohammed, H.O., O'Grady, M.N., Kilcawley, K.N., Hamill, R.N., Kerry, J.P and O'Sullivan, M.G. Acceptable inclusion levels for selected red and brown Irish seaweed species in pork sausages (2019). 65th International Congress of Meat Science and Technology, Berlin, Germany. 4-9 August 2019.
 7. Garicano-Vilar, E., Ouyang, H., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2018). Effect of salt and fat replacement by seaweed on the sensory and volatile component profile of frankfurters. The 47th Annual Food Science and Technology Conference hosted by University College Cork and IFSTI, 6-7th December, 2018.
 8. Mohammed, H.O., Ouyang, H., O'Grady, M.N., Kilcawley, K.N., Hamill, R. M., O'Sullivan, M.G. and Kerry, J.P. (2018). Brown and red seaweed species as potential salt and fat replacers in frankfurters The 47th Annual Food Science and Technology Conference hosted by University College Cork and IFSTI, 6-7th December, 2018.
 9. Mohammed, H.O., Ouyang, H., O'Grady, M.N., Kilcawley, K.N., Hamill, R. M., O'Sullivan, M.G. and Kerry, J.P. (2018). Characterisation of the nutritional and bioactive properties of brown and red Irish seaweeds for potential use as functional ingredients in processed meat products. The 47th Annual Food Science and Technology Conference hosted by University College Cork and IFSTI, 6-7th December, 2018.
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10. Bolger, Z., O'Sullivan, M.G. Kerry, J.P., Burke, A., Fitzpatrick, R. and Hamill, R. (2018). Effect of 3D printing on the eating quality of beef patties. The 47th Annual Food Science and Technology Conference hosted by University College Cork and IFSTI, 6-7th December 2018.'
11. Elena Garicano-Vilar, Maurice G O'Sullivan, Joseph P Kerry, Kieran N Kilcawley. Irish Mass Spectrometry Society Conference 2021 – Poster Presentation - Development of a high-capacity sorptive extraction (Hi-Sorb) gas chromatography mass spectrometry method for the quantification of volatiles associated with lipid oxidation in raw beef. Irish Mass Spectrometry Society Conference. May 11th and 12th 2021.

Training
Courses

23

Elena Garicano-Vilar,

- PhD Masterclass, 14-16 Feb 2018, Dublin (Talbot hotel), 5 ECTS, AFGDP.
- Advanced Writing and Presentation Skills, 21-22 Mar 2018, Teagasc Moorepark, 0 ECTS, TPDDP.
- Anthias GC Course, 18-22 Jun 2018, Teagasc Moorepark, 5 ECTS, Royal Society of Chemists.
- 2018 Walsh Fellowships Induction, 18-19 Dec 2018, Newpark Hotel, Kilkenny, 0 ECTS, Teagasc.
- Sensory workshop, 11-Mar-19, Limerick Institute Technology, 0 ECTS, Sensory Food Network Ireland.
- Statistics for Agri-Food Researchers, 5-7/05/2020, University College Cork, 247FSB, 5 ECTS, Organizer: UCC.
- Project Management for Agri Food Researchers, 18-20/03/2020, University College Cork, 5 ECTS, UCC.
- PhD Writing Essentials, 22/04/2020, Teagasc Oak Park, Teagasc Walsh Scholarships Programme.
- Sensory workshop, 11/03/2019, Limerick Institute Technology, 0 ECTS, Sensory Food Network Ireland.
- Web of Science, Endnote and Publishing with High-Impact, 01/04/2019, Teagasc Ashtown, 0 ECTS, Teagasc Library Service.
- R course (part I – introduction), 23-24/04/2019, Teagasc Moorepark, 0 ECTS, Jim Grant.
- R course (part II – multivariate analysis), 12/06/2019, Teagasc Moorepark, 0 ECTS, Jim Grant.
- Essential Statistics in R, 14-15 & 18/09/2020, Microsoft Teams (online), 0 ECTS, Walsh Scholarship Programme.
- Poster Do's and Don'ts, 30/04/2020, Microsoft Teams (online), 0 ECTS, Maynooth University.
- PhD Writing Essentials, 20/04/2020, Zoom and Professional Writing Academy classroom (online), 0 ECTS, Walsh Scholarship Programme.

- An Introduction to Research Integrity, Ethics and Open Science, any time before 07/07/2020, Canvas (online), 5 ECTS, UCC.
- Leadership for the Agri-Food Researcher, 19/03/2021 to 16/04/2021, Online, 5 ECTS, University College Cork.
- Project Management for Agri-Food Researchers, 19/02/2021 to 12/03/2021, Online, 5 ECTS, University College Cork.
- Analysis and interpretation of experimental data with mathematical and statistical tools, 25/01/2021 to 15/02/2021, Online, 5 ECTS, University College Cork.
- Scientific training for enhanced postgraduate studies – Communication skills, 20-21/01/2021; 25/03/2021; 7-8/04/2021, Credits: 5 ECTS, University College Cork.

Halimah Mohammed:

- FS3004 - Sensory Analysis, Flavour and Colour
- PE6001- Analysis and Interpretation of Experimental Data with
- Mathematical and Statistical Tools
- FS6626- Career Management Skills for the Food Sector

PhD Theses	2	<ol style="list-style-type: none"> 1. Halimah Mohammed to complete PhD thesis in Spring 2023 THE USE OF EDIBLE RED AND BROWN IRISH SEAWEED SPECIES FOR THE DEVELOPMENT OF CONSUMER-ACCEPTED, LOW-FAT, LOW-SALT PROCESSED MEAT PRODUCT (SAUSAGES) 2. Elena Garicano-Vilar to complete PhD thesis in Spring 2023 Quantification of volatile compounds (oxidative and olfactory) in meat products and impact of seaweed addition on the sensory and volatile profiles of processed meat products.
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Other	1	<p>Oral presentation Halimah O. Mohammed, Maurice G. O’Sullivan, Joseph P. Kerry. Reduction of salt and fat in processed meats (sausages) using edible seaweed species. Oral presentation at Food and Nutritional Sciences (UCC) Internal Conference; 2019 Dec 13; Cork, Ireland.</p>
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Intellectual Property

Not-applicable. All data that was generated was and will be disseminated in the public domain.

Summary of other Project Outputs

Project Outputs	Details	Total No.
New Processes	<ul style="list-style-type: none">Garicano-Vilar, E., O'Grady, M.N., Mannion, D.T., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N. (2020). Optimization of a high-capacity sorptive extraction gas chromatography-mass spectrometry method for untargeted volatile profiling and for the quantification of targeted lipid oxidation compounds in raw beef patties. Meat Science, Accepted.Also the project found that inclusions of aromas that suggest saltiness can offset the sensory disadvantages of salt- and fat-reduced products and is termed Odour-induced saltiness enhancement (OISE). For Hedonic analysis consumers chose reduced-salt OISE pork sausages unless a strong odour induced salt enhancer was used (bacon).The sensory results indicated that salt enhancement can be achieved through heterogeneity of salt distribution in beef burgers. Salt added to external layers of the burger patties was far less perceived when compared to salt added to internal layers of the treatment. Therefore, a well-constructed salt distribution may allow significant salt reduction in the same time maintaining the overall salt intensity of the sample	3

Potential Impact related to Policy, Practice and Other Impacts

Impact	Details
Industry	Natriopt demonstrates a consumer-driven protocol by which industry can nutritionally optimise their products with respect to reducing negative ingredients, like, salt fat sugar etc. This also has the added societal benefit of also making populations healthier. Also, as above salt heterogeneity and odour-induced saltiness enhancement (OISE) demonstrate strategies by which salt can be reduced while maintaining intensity.

Dissemination Activities

Activity	Details
Workshops at which results were presented	RAPID2020 Industry WORKSHOP. Companies; Dawn Farm Foods; International Meat Ingredients; DawnMeats Research Advances in Protein Innovation Development. 20th August 2020. AN INNOVATION EVENT: RESHAPING OUR FUTURE. Speaker/Presenter Dr. Maurice O'Sullivan; Focus on Reformulation for Health and Wellness: Impact on Consumer Acceptance.

Seminars at
which results
were presented

Poster Presentations

- Elena Garicano-Vilar, Maurice G O'Sullivan, Joseph P Kerry, Kieran N Kilcawley. Development of a high-capacity sorptive extraction (Hi-Sorb) gas chromatography-mass spectrometry method for the identification of volatiles associated with lipid oxidation in raw beef. IFSTI December 2020 46th Annual Food Science and Technology Conference.
- Garicano-Vilar, E., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N. (2020). OPTIMIZATION OF A HIGH-CAPACITY SORPTIVE EXTRACTION (HI-SORB) METHOD COUPLED TO GAS CHROMATROGRAPHY-MASS SPECTROMETRY FOR THE DETERMINATION OF LIPID OXIDATION VOLATILE COMPOUNDS IN BEEF MEAT. 66th International Congress of Meat Science and Technology and 73rd Reciprocal Meat Conference (ICoMST/RMC 2020)
- Garicano-Vilar, E., Ouyang, H., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2020). Chemometric analysis of volatile flavour sensory characteristics of reduced salt reformulated frankfurters containing 1% w/w edible seaweeds. 9th European Conference on Sensory and Consumer research (EuroSense 2020).
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- Mohammed, H.O., O'Grady, M.N., Kilcawley, K.N., Hamill, R.N., Kerry, J.P and O'Sullivan, M.G. Acceptable inclusion levels for selected red and brown Irish seaweed species in pork sausages (2019). 65th International Congress of Meat Science and Technology, Berlin, Germany. 4-9 August 2019
- Garicano-Vilar, E., Ouyang, H., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2018). Effect of salt and fat replacement by seaweed on the sensory and volatile component profile of frankfurters. The 47th Annual Food Science and Technology Conference hosted by University College Cork and IFSTI, 6-7th December, 2018.
- Mohammed, H.O., Ouyang, H., O'Grady, M.N., Kilcawley, K.N., Hamill, R. M., O'Sullivan, M.G. and Kerry, J.P. (2018). Brown and red seaweed species as potential salt and fat replacers in frankfurters The 47th Annual Food Science and Technology Conference hosted by University College Cork and IFSTI, 6-7th December, 2018.
- Mohammed, H.O., Ouyang, H., O'Grady, M.N., Kilcawley, K.N., Hamill, R. M., O'Sullivan, M.G. and Kerry, J.P. (2018). Characterisation of the nutritional and bioactive properties of brown and red Irish seaweeds for potential use as functional ingredients in processed meat products. The 47th Annual Food Science and Technology Conference hosted by University College Cork and IFSTI, 6-7th December, 2018.

Oral Presentations

- Halimah O. Mohammed, Maurice G. O'Sullivan, Joseph P. Kerry. Reduction of salt and fat in processed meats (sausages) using edible seaweed species. Oral presentation at Food and Nutritional Sciences (UCC) Internal Conference; 2019 Dec 13; Cork, Ireland.
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Knowledge Transfer Activities

Identify knowledge outputs generated during this project.	Natriopt demonstrates a consumer-driven protocol by which industry can nutritionally optimise their products with respect to reducing negative ingredients, like, salt fat sugar etc. This also has the added societal benefit of also making populations healthier. Also, as above salt heterogeneity and odour-induced saltiness enhancement (OISE) demonstrate strategies by which salt can be reduced while maintaining intensity.
Identify any knowledge transfer activities executed within the project.	RAPID2020 Industry WORKSHOP. Companies; Dawn Farm Foods; International Meat Ingredients; DawnMeats Research Advances in Protein Innovation Development. 20th August 2020. AN INNOVATION EVENT: RESHAPING OUR FUTURE. Speaker/Presenter Dr. Maurice O'Sullivan; Focus on Reformulation for Health and Wellness: Impact on Consumer Acceptance.
Identify any knowledge transfer activities executed within the project.	Results were disseminated to Dawn Farm Foods, International Meat Ingredients and Dawn Meats. The impact is that these companies are now aware of a sensory-driven protocol to make their products healthier, while still maintaining safety.

Section 3 - Leveraging, Future Strategies & Reference

Leveraging Metrics

None

Future Strategies

The Engineering and Physical Sciences Research Council in the UK (EPSRC) and Science Foundation Ireland (SFI) have entered an agreement to welcome, encourage and support research applications that cut across national boundaries involving collaborative teams led by researchers from the UK and Ireland. The project involves several areas of research including food colloids, structure design, mucoadhesion, mucopenetration, sodium binding and sensory perception. Professor Vitaliy is a well-known respected researcher from the University of Reading in the area of pharmaceuticals and has worked on mucoadhesive biopolymers. Dr. Maurice O'Sullivan is a sensory scientist and senior lecturer in food science working in the School of Food and Nutritional Sciences, University College Cork, Ireland with a long history and published books and journal articles in sensory science and salt/fat reduction. Also, the formative work from Natriopt was a foundation for inclusion on this project. It is based on the fact that proteins and polysaccharides can interact with sodium salt and the mucosal membrane on the tongue and either improve or delay the salt release, a phenomenon known as Mucoadhesion. EPSRC and SFI will contribute a max of 500,000 Euros each (million Euros in total).

Project Publications

List publications numerically.

Journal Publications (8).

1. Mohammed, H. O., O'Grady, M. N., O'Sullivan, M. G., Hamill, R. M., Kilcawley, K. N., & Kerry, J. P. (2021). An Assessment of Selected Nutritional, Bioactive, Thermal and Technological Properties of Brown and Red Irish Seaweed Species. *Foods*, 10(11), 2784.
2. Mohammed, H.O., O'Grady, M.N., O'Sullivan, M.G., Hamill, R.M., Kilcawley, K.N. and Kerry, J.P., 2022. Acceptable Inclusion Levels for Selected Brown and Red Irish Seaweed Species in Pork Sausages. *Foods*, 11(10), p.1522.
3. Garicano-Vilar, E., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2019). Review: Volatile compounds of six species of edible seaweed. *Algal Research*, 45, 101740.
4. Garicano-Vilar, E., Ouyang, H., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2019). Effect of salt and fat reduction and its replacement with 1% edible seaweeds on the chemical, sensory and volatile component profile of reformulated frankfurters. *Meat Science*, 161, 108001.
5. Garicano-Vilar, E., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N. (2020). A Chemometric approach to characterise the aroma of selected brown and red edible seaweeds/extracts. *Journal of the Science of Food and Agricultural*, 101, 3, 12281238. <https://doi.org/10.1002/jsfa.10735>
6. Garicano-Vilar, E., O'Grady, M.N., Mannion, D.T., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N. (2020). Optimization of a high-capacity sorptive extraction gas chromatography-mass spectrometry method for untargeted volatile profiling and for the quantification of targeted lipid oxidation compounds in raw beef patties. *Meat Science*, Accepted.
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8. Tyuftin, A. A., Mohammed, H., Kerry, J. P., O'Sullivan, M. G., Hamill, R. and Kilcawley, K. (2021) 'Microscopy-assisted digital photography as an economical analytical tool for assessment of food particles and their

Conference Publications (11).

1. Elena Garicano-Vilar, Maurice G O'Sullivan, Joseph P Kerry, Kieran N Kilcawley. Development of a high-capacity sorptive extraction (Hi-Sorb) gas chromatography mass spectrometry method for the identification of volatiles associated with lipid oxidation in raw beef. IFSTI December 2020 46th Annual Food Science and Technology Conference.
2. Garicano-Vilar, E., O'Sullivan, M.G., Kerry, J.P. and Kilcawley, K.N. (2020). OPTIMIZATION OF A HIGH-CAPACITY SORPTIVE EXTRACTION (HI-SORB) METHOD COUPLED TO GAS CHROMATROGRAPHY-MASS SPECTROMETRY FOR THE DETERMINATION OF LIPID OXIDATION VOLATILE COMPOUNDS IN BEEF MEAT. 66th International Congress of Meat Science and Technology and 73rd Reciprocal Meat Conference (ICoMST/RMC 2020).
3. Garicano-Vilar, E., Ouyang, H., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2020). Chemometric analysis of volatile flavour sensory characteristics of reduced salt reformulated frankfurters containing 1% w/w edible seaweeds. 9th European Conference on Sensory and Consumer research (EuroSense 2020).
4. Garicano-Vilar, E., O'Sullivan, M.G., O'Grady, M.N., Kerry, J.P. and Kilcawley, K.N. (2019). Volatile component and odour profiles of three brown and two red edible species of seaweeds and a brown seaweed extract. 48th Annual Food Science and Technology Conference hosted by University of limerick and IFSTI, 16th December, 2019.
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