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

13F529 - Adding value to ready to eat crustacean products by improving their quality, safety and shelf life using enhanced conventional and novel processing methods.

Final Report

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

SUMMARY

The main objectives of the project were firstly a comparison of products manufactured by conventional, QUALCRUST “state-of-the-art” and overseas methods. Secondly, optimisation of quality/safety of Irish “entire” and “particulate” crustacean products by (i) manipulation of early processing stages (wprt formulation/cook-loss); (ii) identification of optimum heat processing conditions; (iii) identification of most appropriate packaging options. Thirdly, assessing microbial/chemical shelf-life of products. Finally, dissemination of outputs to relevant stakeholders.

In terms of Results and Impact Focus group of Qualcrust pilot scale, commercially available and overseas competitor crab products suggested the Qualcrust product had best sensory characteristics. Clean label ingredients, lactic and acetic acid (5%, w/v) increased shelf-life. Sodium caseinate and potato starch substantially increased crab meat yield. Standard pasteurisation (70°C for 2 min) eliminated L. monocytogenes but maximizing shelf-life required higher temperatures. Low oxygen barrier pouches reduced shelf-life vs. conventional films. HPP on claws improved meat detachment, increased yields and enhanced mass transfer. Microwave, Ohmic heating (OH) and alternative steam cooking methods (i.e., continuous, stepped, delta and high-low temperature) showed great potential for OH but no improvement on crab quality from alternative steam cooking. Ultrasound has potential to reduce total cadmium concentration by up to 23%. A model to evaluate packaging size vs. thermal profile of particulate white meat was developed/validated. Two models to predict heat penetration during second heat treatment were developed/validated. Ionizing irradiation inactivated main microorganisms showing great potential for whole/particulate crab processing. A new process for crab claws was developed following guidelines from Irish industrial partner. A focus group with industrial representatives regarding desired quality features in white ready-to-eat particulates sought by consumers was completed. Ultrasound improved cleaning/heat penetration during cooking while reducing heat impact on crab quality. Two Industry demonstrations, an end of project seminar, technical notes and an article in Irish skipper.

KEYWORDS

Crab, Enhanced Processing, Quality.

ACRONYM	Qualcrust
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COLLABORATORS, INSTITUTION	Dr Declan Bolton, Teagasc. Mr John Fagan, Bord Iascaigh Mhara.
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Section 1 - Research Approach & Results

Start Date

01 March 2014

End Date

31 December 2018

Research Programme

Food Institutional Research Measure

TRL Scale

TRL 4: Technology validated in lab

NRPE Priority area

Food for Health

Total DAFM Award

€594,742.00

Total Project Expenditure

€558,256.07

Rationale for undertaking the Research

At the time the initial project proposal was submitted, more than two thirds of crab landed in Ireland was exported within the EU, though there was increasing demand from outside the EU (particularly from China) for this product. 2011 figures showed 42% exported fresh, 58% frozen and only 1% prepared. Thus, great potential exists to add value to this product. In-port crab processing involves procedures in existence for generations. Considerable scope for process optimisation (and quality enhancement) exists at 3 stages:

1. Initial processing (e.g., minimising cook-loss through clean-label-ingredient incorporation and novel methods for cook-loss-exudate removal during boiling, potential eliminating post-cook-washing and subsequent pasteurisation)
2. Heat processing (optimising conditions to ensure microbiologically safe products while reducing heat-induced negative impact on quality)
3. Packaging

The project set out to optimise the above stages and focused on (a) entire unfrozen-crab and (b) a particulate-crab foodstuff. The effectiveness of optimisation of the 3 stages was assessed to ascertain the gains over current and aspirational products. The main outcomes will be optimised readily adoptable manufacturing protocols which will maximise the quality of Irish exported crab and an improvement in the industry/science interface.

A series of 13 technical notes were prepared for the Irish Industry. An article was printed in the Irish Skipper. Probably the most exciting and interesting dissemination from the project were the demonstration sessions attended by Irish Industry and hosted by BIM at their sites in Clonakilty and Killybegs. Representatives from virtually the entire crab processing sector attended both of these events.

Methodology

- Thermoresistometry to obtain microbial inactivation kinetic data (i.e., D and Z values).
- Immersion Cooking (with or without ultrasound) in a Gyson KS MK2 535 bath.
- Irradiation in a 10-MeV circular electron accelerator.
- High pressure processing in a Hyperbaric HPP system.
- Heat penetration curves using thermocouples.
- Cook water turbidity by spectrophotometry at 515 nm.
- Salt by silver nitrate titration and moisture by oven drying.
- Cadmium by ICP-MS.
- Water holding capacity by centrifugation.
- Colour by tristimulus colorimetry
- Microbial food safety/shelf-life studies: Established using culture-based and molecular (16S rRNA sequence) methods. The latter required DNA extraction using a QIAGEN D Neasy DNA extraction kit while multiple copies of the V3-V4 variable region of the bacterial 16S rRNA genes were generated using universal primers. PCR products were sequenced using an Illumina MiSeq platform and the Illumina reads filtered on the basis of quality and length with prinse. Paired-end reads with a minimum overlap of 20bp were joined using Fastq-join. Sequences were clustered together with a 97% identity using a closed reference usearch v7.0 algorithm to obtain their Operative Taxonomic Unit (OTUs), with chimeric OTUs removed against the gold database. The taxonomic assignment of these OTUs was obtained against the Ribosomal database project. Alpha and Beta-diversity was determined using QIIME and additional analysis were performed with the R package phyloseq. The statistical analysis of the data was analyzed by PERMANOVA for beta-diversity analysis.
- In the thermal inactivation and related studies, crabs were cooked in a commercial retort or water-bath while the meat was characterised in terms of pH using a surface electrode, available water (aw) using a water activity meter while the water holding capacity was determined as per the centrifugal method.

Project Results

- Crab Total-Viable-Counts (TVC) and Total-Enteric-Counts (TEC) ranged from approximately 2 to 5 log10 and 1.7 to 2.0 log10 CFU/g/cm2 , respectively. The carapace samples were most heavily contaminated with heterotrophic marine bacteria (HMB), lactic acid bacteria (LAB), Pseudomonas spp. hydrogen sulphide producing bacteria (HSPB), Clostridium spp. and Listeria spp. counts of 4.9, 2.9, 3.7, 3.6, 4.4 and 2.2 log10 CFU/g, respectively. This site also had the highest diversity of bacteria. Overall Proteobacteria dominated in crab samples, with a lower abundance of Firmicutes, Actinobacteria and Bacteriodetes. This data suggests the carapace should be included in all future sampling.
- Pasteurisation at 70°C for 2 min was sufficient to eliminate L. monocytogenes suggesting mild pasteurisation is sufficient to assure the safety of crab meat. However, significantly ($P< 0.05$) lower bacteria counts were obtained throughout storage when the crabs were cooked at 90°C for 10 min and packed in the convention high barrier (O2 permeability rate of < 20 cm3/m3) film as compared to pasteurisation at 70°C for 2 min and packaging in a medium barrier (O2 permeability rate of < 60 cm3/m3) cook-in-the-bag pouch suggesting the former should be used to maximise shelf-life.
- Acetic and lactic acid (5%, v/v) increased the microbial shelf-life of raw crab meat from 5 to 11 and 8 days, respectively while other ingredients such as citric acid (5%, v/v) and sodium chloride (5%, w/v) had no effect. Incorporating sodium caseinate, potato starch and/or ascorbic acid during soaking increased the yield by approximately 3-4%. It was included that these treatments/ingredients could increase shelf-life and yield.
- Bacillus weihenstephanesis/Kokuria atrinae were the most heat resistant spore/vegetative cell respectively.

- High-Pressure-Processing (HPP) increases NaCl uptake, reduces microbial contamination and optimises meat extraction. US assists early processing stages enhances cleaning and heat penetration/rate and reduces cadmium content of edible crab. Ohmic and microwave heating gave more uniform heating. Mathematical models were designed to predict heat penetration in entire “large” crustaceans.
- Electron-beam-radiation and US are promising technologies for pasteurising particulate carb and were very effective for inactivating spores in crab. Ultrasonically assisted heating with hot filled packaging produced sensorially acceptable and microbiologically safe product with >30 days shelf-life.
- Crabs cooked conventionally had a microbial shelf-life of 45-50 days. Ready-to-eat white crab meat, treated at mild temperatures +/- US had a shelf-life of 11-12 days.
- Dissemination outcomes were achieved in scientific publications, PhD theses successfully defended (3x), article in a trade review journal, technical notes, conference publications and presentations, industry workshops and a final dissemination workshop and a video/presentation on the UCD component of the project for an industry day.
- Focus groups and new product development produced products industry would aspire to which were showcased in dissemination activities.
- Many technical innovations with commercial potential were developed and shared with industry. The Crab processing sector is technically savvy but was hesitant to engage with the project at a formal level. This sector has not had access to public good research of this nature prior to Qualcrust and are somewhat suspicious of it and fear revealing knowledge of their current practices to their competitors.

Section 2 - Research Outputs

Summary of Project Findings

- The project created a critical mass of crustacean processing expertise in RPO's and developed links with key processors in the sector. Successful Industry engagement events were held.
- Products developed (e.g., Crab Cakes, Crab Aranchini, Crab Mousse and Crab Bouillon) could be easily commercially manufactured.
- Products currently available e.g., RTE white meat (from claws), should be reviewed in terms of heat treatments to avoid overheating/quality decrease.
- Process induced weight losses of 10% are common but sodium caseinate or potato starch increase yield without adversely affecting shelf-life.
- Crab processors could consider HPP processing to enhance ingredient migration.
- Ultrasound application during cooking can reduce the Cd content of crab.
- For whole crabs, mathematical models developed can optimize conventional heating conditions, maintaining final product quality.
- Alternative heating methods (e.g. ultrasound, ohmic heating or microwaves), proved very useful in reducing treatment times without altering the product quality.
- Regarding particulate crab products, HPP proved a very efficient technology to improve the meat extraction yield, which could reduce economical losses. Moreover, radiation and MTS proved to be very efficient for the pasteurization of these products, inactivating even the most resistant bacterial spores in crab meat.
- Milder processing conditions and/or a lower barrier bags will adversely affect shelf-life.
- Conventional heat treatments (high time/temperature process) can negatively affect most nutritional/quality aspects evaluated.
- The knowledge of crab microflora generated in the project could be used for designing more efficient thermal treatments, ensuring final product quality.
- Thermal inactivation studies provided needed data for L. monocytogenes in crab meat.
- Shelf-life studies demonstrated that minimal changes in thermal treatments, packaging, storage conditions, etc, can greatly affect final product quality and shelf-life.
- The project has advanced knowledge on many aspects of crab processing and has used every means at its disposal to disseminate this knowledge to the scientific community and the crab processing industry.

Summary of Staff Outputs

Research Output	Male	Female	Total Number
PhD Students	2	1	3
Post Doctorates	1	1	2

Summary of Academic Outputs

Research Outputs	Total Number	Details
Publications in Peer Reviewed Scientific Journals	11	1. Aoife McDermott, Paul Whyte, Nigel Brunton, James Lyng, John Fagan and Declan Bolton (2018). The effect of organic acid and sodium chloride dips on the shelf-life of refrigerated Irish brown crab (Cancer pagurus) meat. LWT , doi: 10.1016/j.lwt.2018.08.039.

		2. Aoife McDermott, Paul Whyte, Nigel Brunton, James Lyng, John Fagan and Declan Bolton (2018). Thermal inactivation of Listeria monocytogenes in Irish brown crab (Cancer pagurus) meat. Journal of Food Protection, 81, 12, 2003-2006. 3. Aoife McDermott, Paul Whyte, Nigel Brunton, James Lyng, John Fagan and Declan Bolton (2018). Increasing the yield of Irish Brown Crab (Cancer pagurus) during processing without adversely affecting shelf-life. FOODs 2018, 7, 99; doi:10.3390/foods7070099, available at file:///C:/Users/Declan.Bolton/Downloads/foods-07-00099.pdf 4. Lian, F., Måge, I., Lorentzen, G., Siikavuopio, S., Øverbø, K., Vang, B., & Lindberg, D. (2018). Exploring the effect of inhibitors, cooking and freezing on melanosis in snow crab (Chionoecetes opilio) clusters. Food Control, 92, 255–266. 5. Lorentzen, G., Lian, F., & Siikavuopio, S. I. (2019). Quality parameters of processed clusters of red king crab (Paralithodes camtschaticus) – Effects of live holding at 5 and 10 °C up to 92 days without feeding. Food Control, 95, 142–149. 6. Condón-Abanto, S., Arroyo, C., Álvarez, I., Brunton, N., Whyte, P., & Lyng, J. G. (2018). An assessment of the application of ultrasound in the processing of ready-to-eat whole brown crab (Cancer pagurus). Ultrasonics Sonochemistry, 40, Part A, 497-504. 7. Condón-Abanto, S., Arroyo, C., Álvarez, I., Condón, S., & Lyng, J. G. (2016). Application of ultrasound in combination with heat and pressure for the inactivation of spore forming bacteria isolated from edible crab (Cancer pagurus). International Journal of Food Microbiology, 223, 9-16. 8. Condón-Abanto, S., Pedrós-Garrido, S., Cebrián, G., Raso, J., Condón, S., Lyng, J. G., & Álvarez, I. (2018). Crab-meat-isolated psychrophilic spore forming bacteria inactivation by electron beam ionizing radiation. Food Microbiology, 76, 374-381. 9. Condón-Abanto, S., Raso, J., Arroyo, C., Lyng, J.G., Condón, S. and Álvarez, I. (2018). Evaluation of the potential of ultrasound technology combined with mild temperatures to reduce cadmium content of edible crab (Cancer pagurus). Ultrasonics Sonochemistry, 48, 550-554. 10. Condón-Abanto, S., et al. "Quality-based thermokinetic optimization of ready-to-eat whole edible crab (Cancer pagurus) pasteurisation treatments." Food and Bioprocess Technology 12 (2019): 436-446. 11. Lian, Federico, et al. "High-Pressure processing for the production of added-value claw meat from edible crab (Cancer pagurus)." Foods 10.5 (2021): 955.
Peer Reviewed Conference Papers	18	1. McDermott, A., P. Whyte, N. Brunton, J. Lyng and D.J. Bolton (2016) Establishing thermal resistance profiles of Listeria monocytogenes isolated from Irish seafood products. Poster presentation at the FOOD MICRO International Conference, University College Dublin, 19th to 22nd July 2016, Abstract book, page 439.

2. Aoife McDermott, Paul Whyte, Nigel Brunton, James Lyng and Declan Bolton (2016). Establishing thermal resistance profiles of Listeria monocytogenes isolated from Irish seafood product. Poster presentation at the 46th West European Fish Technologists Association (WEFTA) Conference, Split, Croatia, 12th to 14th October 2016.
3. Aoife McDermott, Paul Whyte, Nigel Brunton, James Lyng and Declan Bolton (2016). Establishing thermal resistance profiles of Listeria monocytogenes isolated from Irish seafood product. Poster presentation, at the IUFoST International Conference, RDS Dublin, 21st to 25th August, 2016, Abstract Book, page 1101.
4. Aoife McDermott, James Lyng, Nigel Brunton, Paul Whyte, John Fagan and Declan Bolton (2017). Thermal inactivation of Listeria monocytogenes in crab meat. Oral presentation at the 47th West European Fish Technologists Association Conference, Aviva Stadium, Dublin, 9th to 12th October 2017, Conference Book, page 81.
5. Aoife McDermott, James Lyng, Nigel Brunton, Paul Whyte, John Fagan and Declan Bolton (2017). The use of sodium caseinate and potato starch to increase the yield of Irish brown crab (Cancer pagurus). Poster presentation at the 47th West European Fish Technologists Association Conference, Aviva Stadium, Dublin, 9th to 12th October 2017, Conference Book, page 116.
6. Condón-Abanto, S., Lian, F., Arroyo, C., Brunton, N., Whyte, P. and Lyng, J.G. Poster presentation: Efecto de la pasteurización del buey de mar (Cancer Pagurus) en el seno de un campo ultrasónico. SEM 2014. Zaragoza, Spain. (ISBN:978-84-941181-7-3).
7. Condón-Abanto, S., Lian, F., Arroyo, C., Brunton, N., Whyte, P. and Lyng, J.G. Poster presentation: Predicción de la vida útil de buey de mar (Cancer Pagurus) pasterizado a 75 °C según las normas recomendadas por la FDA. SEM 2014. Zaragoza, Spain. (ISBN:978-84941181-7-3).
8. Condón-Abanto, S., Lian, F., Arroyo, C., Brunton, N., Whyte, P. and Lyng, J.G. Poster presentation: Effect of cooking assisted by ultrasound on the Irish edible crab. IFT15 annual meeting. July 2015. Chicago IL, USA.
9. Condón-Abanto, S., Sanz, J., Condón, S., Lyng, J.G., Raso, J., Álvarez, I. Poster presentation: High temperature-short time treatments in crab claws meat assisted by Pulsed Electric Fields. 2nd Worlds congress on electroporation and Pulsed Electric Fields in Biology, Medicine, Food and Environmental technologies. September 2017. Norfolk (VA), USA.
10. Condón-Abanto, S., Arroyo, C., Álvarez, I., Raso, J. and Lyng, J.G. Poster presentation: Assessment of the potential of ionizing radiation to inactivate bacterial spores present in brown crab (Cancer pagurus). 47th conference of the West European Fish Technologists' Association (47th WEFTA). October 2017. Dublin, Ireland.

		11. Condon-Abanto, S., Tovar, F., Arroyo, C., Whyte, P., Brunton, N., Álvarez, I. and Lyng, J.G. Poster presentation: Use of alternative heating technologies in the production of ready to eat crab claws. 31st EFFoST international conference. November 2017. Sitges, Spain 12. Condón-Abanto, S., Lian, F., Arroyo, C., Brunton, N., Whyte, P. and Lyng, J.G. Oral presentation: Application of ultrasound during the heat processing of Irish Brown crab. 43rd Annual Food Research Conference, IFSTI. December 2014. Dublin, Ireland. 13. Condón-Abanto, S., Lian, F., Arroyo, C., Whyte, P., Brunton, N. and Lyng, J.G. Oral presentation: Heat resistance of the most isolated spore-forming bacteria in ready-to-eat brown crab meat. Trans-Atlantic Fisheries Technology Conference, TAFT. October 2015. Nantes, France. 14. Condón-Abanto, S., Arroyo, C., Alvarez, I., Condón, S., Brunton, N. and Lyng, J.G. Oral presentation: Cleaning effect of the application of ultrasound during cooking of edible crab (Cancer pagurus). IUFoST (World Congress of Food Science and Technology). August 2016, Dublin, Ireland. 15. Condon-Abanto, S., Lian, F., Arroyo, C., Whyte, P., Brunton, N. and Lyng, J.G. Oral presentation: Effect of storage temperature on shelf life and microbiological profiles of ready-to-eat whole brown crab. 46th conference of the West European Fish Technologists' Association (46th WEFTA). October 2016. Split, Croatia. 16. Condón-Abanto, S., Arroyo, C., Álvarez, I., Raso, J., Brunton, N. and Lyng, J.G. Oral presentation: Optimization of the second pasteurization step in ready-to-eat whole brown crab (Cancer pagurus). 47th conference of the West European Fish Technologists' Association (47th WEFTA). October 2017. Dublin, Ireland. 17. Lian, F., De Conto, E., Fagan, J. D., Whyte, P., Lyng, J. G., & Brunton, N. P. (2017). An assessment of the application of high-pressure processing for the production of ready-to-eat meat of edible crab (Cancer pagurus). Oral presentation, 47th Conference of the West European Fish Technologists' Association (WEFTA 2017). Dublin, Ireland, 10–12th October 2017. 18. Lian, F., Lyng, J. G., & Brunton, N. P. (2017). Application of the checkall-that-apply (CATA) sensory method to identify drivers of liking in ready-to-eat meat of edible crab (Cancer pagurus). Poster presentation, 47th Conference of the West European Fish Technologists' Association (WEFTA 2017). Dublin, Ireland, 10–12th October 2017.
PhD Theses	3	1. Adding value to ready-to-eat crustacean products by improving quality, safety and shelf life using conventional and novel processing methods (PhD, Aoife McDermott, UCD, 5th December 2018). 2. Process optimization for "entire" and "particulate" crustaceans using novel technologies (PhD Santiago Condón-Abanto, UCD, 14th June 2019).

3. Adding value to European commercial crab species - Quality aspects of particulate crab meat products as influenced by conventional and novel processing methods technologies (PhD Federico Lian, UCD, 05th December 2019).

Intellectual Property

None to report

Summary of other Project Outputs

Project Outputs	Details	Total No.
New Processes	A series of 13 Technical notes were prepared as part of the output of this project. These technical notes were in a format suitable for dissemination to Industry. 1. Technical Note No: 01 Title Pilot scale manufacturing protocols for entire (ready-to-eat) edible crab 2. Technical Note No: 02 Title: Pilot scale manufacturing protocols for particulate meat products (ready-to-eat) from edible crab 3. Technical Note No: 03 Focus group comparison among brown crab “particulate” products 4. Technical Note No: 04 Title: Improving the yield and shelf life of entire crustaceans through chemical (reformulation) solutions 5. Technical Note No: 05 The potential for ultrasound to assist early processing stages (diffusion and cleaning) 6. Technical Note No: 06 Title: High-pressure processing for the production of added-value claw meat from edible crab 7. Technical Note No: 07 Ultrasonically assisted physical removal of cook loss exudate from entire crustaceans 8. Technical Note No: 08 Assessment of the potential of ultrasound to reduce the cadmium content of Irish edible crab 9. Technical Note No: 9 Whole crabs processing: Ultrasonically assisted vs. Conventional heating. Effect on the microbial, sensorial and physicochemical shelf-life. 10. Technical Note No: 10 Comparison of the sensory quality of crustacean products under different processing stages. 11. Technical Note No: 11 Title: Identification of spoilage and pathogenic organisms in Irish Brown Crab 12. Technical Note No: 12 Assessment of alternative technologies for the inactivation of the main spoilage and pathogenic microorganisms present in Irish edible crab 13. Technical Note No: 13 Title: Microbial and chemical shelf-life of white meat extracted from mildly cooked edible crab claws	13

Potential Impact related to Policy, Practice and Other Impacts

Impact	Details
Industry	The project involved Industrial Liaison with the Irish Crab processing sector both one on one meetings and larger dissemination events at BIM facilities and an final project seminar at Teagasc Ashtown. Despite our best efforts, the lack of significant industry engagement in terms of steering the direction of the project was unexpected and meant the project received little guidance from industry in terms of overseas state of the art products that they would aspire to. While this was most disappointing, we did receive good guidance from BIM staff (John Fagan in particular). Despite this extraordinary lack of Industry engagement, the project coordinator hopes that the alternative strategy adopted by the team more than compensates for this as a significant amount of information on new crab based products has been developed. The products which have been developed (e.g. Crab Cakes, Crab Aranchini, Crab Mousse and Crab Bouillon) represent alternative ready to eat added value products that could be easily manufactured by industry. Products of this kind are currently not on the market and the developed products represents blueprints for ready uptake by industry. Apart from the new developed products, those currently available in the market, such as white meat (from claws), should be reviewed in terms of the heat treatments that are applied. It is suggested that the industry should optimize the time/temperature ratios applied to their products in order to avoid overheating treatments, and therefore, the decrease in the quality parameters of the final product. Furthermore significant investigations into alternative novel processes were performed (ultrasound, High Pressure Processing and Food Irradiation). Ultrasound and High pressure processing could easily be implemented in Irish Industry (particularly ultrasound and while Food Irradiation is not permitted in Ireland it is permitted in other European countries.
Industry	Novel processes developed using technologies such as ultrasound, high pressure processing and food irradiation could be used by the irish and european crab processing industry to improve product quality, enhance product yield and improve product safety and shelf life respectively. The knowledge generated could be used by the seafood processors to develop crab meat products with enhanced food safety and longer shelf-life. Post cook yield could also be increased resulting in increased sales value per crab.
Industry	A series of 13 technical notes (as outlined above).

Dissemination Activities

Activity	Details
Workshops at which results were presented	With the assistance of BIM, three very successful industry engagement days were held in period 4. The first was held in Clonakilty in the BIM Seafood Development Centre on 25th July 2017 and the second in Killybegs on 27th July 2017 and a third, smaller event was also held in UCD on 24th October 2017. At each of these sessions, the project team was introduced, and an overview of results was presented. The newly developed methods to add value to ready to eat crustacean products by improving their quality, safety and shelf life using enhanced conventional and novel processing methods were described. This included • Optimisation of cooking of whole and particulate crab products including: o Heat process validation. o Identification of microorganisms present in crab. o Novel single step cooking/cooling methods that can be adopted by industry. • Impact of High Pressure Processing on crab products. • Consumer liking (Sensory evaluation) of crab products. • Some examples of new products that have been developed. • Shelf life evaluation. • Demonstration of Ultrasonically assisted crab cooking was also performed. • The work that remains to be done on the project was also be described. A copy of the presentation from those events was provided in 'PPR4 - Appendix 2a Industry Engagement – Presentation' with pictures from the events captured in 'PPR4 – Appendix 2b Industry Engagement – Photos'. Arising from these events, UCD along with Pat Molloy (Connemara Seafood) and Frank Brannigan (Brennan & Company) have planned on site trials at Connemara Seafood premises.
Seminars at which results were presented	An end of project seminar was held in Teagasc Ashtown on Thursday 26th July 2018. Adding value and new market opportunities for the Seafood Sector. Researchers involved in Qualcrust all presented their findings in a series of presentations. J.G. Lyng, S. Condon, F. Lian, A. McDermot, D. Bolton, N. Brunton, C. Arroyo, P. Whyte, J. Fagan and P. O'Leary UCD Institute of Food and Health - Industry Day (10th June 2019) This involved a video prepared in advance https://youtu.be/GPHiBBrHb7Q and on the day, a fireside chat presentation with John Fagan (BIM) and James Lyng (UCD) outlining the work conducted at UCD as part of this project.

Knowledge Transfer Activities

Identify knowledge outputs generated during this project.	Knowledge for industry: This project generated knowledge for the seafood sector to enhance the safety, shelf-life and commercial value of Irish brown crab. Knowledge for regulatory: The knowledge on pathogen decreases and the effectiveness of current pasteurisation validates current policy in terms of land-spreading digestate and the time-temperature conditions required for pasteurisation. Academic knowledge: Novel insights and data were generated on the microbiology of Irish brown crab (including bacterial contamination in different parts of the crab) and, to the best of our knowledge, this is the first project to investigate the microbiome of these crustaceans
Identify any knowledge transfer activities executed within the project.	The knowledge generated above was transferred directly to our industry and regulatory stakeholders through ongoing communications, a final report and the project workshop. Knowledge was also shared with academia and food safety regulatory seminars, conferences and other events mentioned above. The knowledge presented in posters was discussed with interested parties at dedicated sessions while oral presentations affording an opportunity for discussion and feedback.
List any impacts resulting from the knowledge transferred during the project.	No metrics are available which quantify impacts from knowledge transferred during the project

Section 3 - Leveraging, Future Strategies & Reference

Leveraging Metrics

None to report.

Future Strategies

There may be a possibility to have a targeted project with one of the industry partners in an SFI centre proposal at some point in the future.

Project Publications

Publications in Peer Reviewed Scientific Journals:

1. Aoife McDermott, Paul Whyte, Nigel Brunton, James Lyng, John Fagan and Declan Bolton (2018). The effect of organic acid and sodium chloride dips on the shelf-life of refrigerated Irish brown crab (Cancer pagurus) meat. LWT , doi: 10.1016/j.lwt.2018.08.039.
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1. Technical Note No: 01 Title Pilot scale manufacturing protocols for entire (ready-to-eat) edible crab.
2. Technical Note No: 02 Title: Pilot scale manufacturing protocols for particulate meat products (ready-to-eat) from edible crab.
3. Technical Note No: 03 Focus group comparison among brown crab “particulate” products.
4. Technical Note No: 04 Title: Improving the yield and shelf life of entire crustaceans through chemical (reformulation) solutions.
5. Technical Note No: 05 The potential for ultrasound to assist early processing stages (diffusion and cleaning).
6. Technical Note No: 06 Title: High-pressure processing for the production of added-value claw meat from edible crab.
7. Technical Note No: 07 Ultrasonically assisted physical removal of cook loss exudate from entire crustaceans.
8. Technical Note No: 08 Assessment of the potential of ultrasound to reduce the cadmium content of Irish edible crab.
9. Technical Note No: 9 Whole crabs processing: Ultrasonically assisted vs. Conventional heating. Effect on the microbial, sensorial and physicochemical shelf-life.
10. Technical Note No: 10 Comparison of the sensory quality of crustacean products under different processing stages.
11. Technical Note No: 11 Title: Identification of spoilage and pathogenic organisms in Irish Brown Crab.
12. Technical Note No: 12 Assessment of alternative technologies for the inactivation of the main spoilage and pathogenic microorganisms present in Irish edible crab.
13. Technical Note No: 13 Title: Microbial and chemical shelf-life of white meat extracted from mildly cooked edible crab claws.

- In addition, a copy of an Article from the Irish Skipper which was prepared and published as part of this project (February 2019).