Project number: 6430 & 6488[1]
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ReValueProtein: Exploration of Irish meat processing streams for Recovery of high Value Protein based ingredients for food and non-food uses

Key *external* stakeholders:

- Irish meat producers and processors; food companies; food ingredients (functional ingredients and protein enrichment); feed companies; sports nutrition; and nutraceuticals.
- Bio-based materials companies, e.g. bio-based plastics, bioactive compound carriers, biomedical materials (for cell growth).

Practical implications for stakeholders:

- Meat co-products are rich sources of valuable protein with nutritional as well as functional properties, which can be further explored for applications in food formulations, for cleaner label ingredients, to improve the nutritional profile of protein enriched products and to generate bioactive peptides.
- Opportunities have been demonstrated for further valorisation of blood proteins identified through enhanced separation of plasma proteins, generation of bio-plastics from lower value protein fraction.
- Technology innovation to use blood proteins to generate insoluble, transparent bio-based film with improved barrier properties: a technology which holds potential for other protein-based films.
- Comprehensive raw materials & extracts characterisation and processing technology evaluation to support revalorisation of meat co-products into higher value food, non-food, biomedical applications.

Main results:

- Co-products from the meat processing industry are a rich and underexplored source of proteins possessing valuable techno-functional properties; as well as being suitable for the generation of bio plastic, bioactive peptides and materials for biomedical applications.
- Research capacity has been established to extract (lab and pilot scale), characterise and evaluate animal (non-dairy) protein sources for techno-functional & bioactives applications, bio-plastic generation etc. for food and non-food uses.

[1] Also includes updates from project no. 6488: Targeting meat primary and secondary processing streams for the development of protein-rich products with techno-functional properties or rich in healthy low molecular weight molecules

Opportunity / Benefit:

- Meat co-products from the meat processing industry are a rich and underexplored source of proteins possessing valuable techno-functional properties; as well as being suitable for the generation of bio-based plastics, bioactive hydrolysates and peptides. A number of these meat co-products commanded low (less than €1/kg), neutral or negative (disposal costs) values. Given the scale of production significant opportunities exist for meat processors, bio-plastic, ingredient and nutritional product manufacturers and for bio-medical applications.

Collaborating institutes: UCC, NUIG, UCD, Shannon ABC/IT Tralee

Teagasc project team: Dr. Anne Maria Mullen, Dr. Carlos Alvarez, Dr. Liana Drummond, Dr. Maeve Henchion, Dr. Maria Hayes, Dr. Dilip Rai

1. Project background:

Meat production inevitably generates co-products and side streams whose value is generally lower than that of meat. Simultaneously, more sustainable practices and an adherence to the principles of a circular bio-economy approach have become increasingly necessary. Establishing steps to maximize ultilisation of natural resources and to minimise food waste at every stage of the processing chain is critical with a view to identifying opportunities to reduce, recycle or revalorise. ReValueProtein assessed a variety of processing technologies of relevance for the recovery of functional proteins from meat processing co-products. A number of these meat co-products currently command low (less than €1/kg), neutral or negative (disposal costs) values. With figures from CSO indicating around 1.8 million bovine and over 3.5 million porcine slaughtered in Ireland in 2019, combined with the knowledge that co-products account for as much as 48-55% of the live weight depending on species.

2. Questions addressed by the project:

- What are the alternative, higher value, approaches to commercializing beef and pork co-products based on their protein content and functionality?
- How feasible is it to convert these products into protein rich extracts with applications in bio-plastics, as food ingredients and as sources of peptides or materials of relevance in a biomedical context?

3. Main results:

- An invention (IDF Teagasc Ref IDF2017546) was developed for a new method of generating a bio-plastic from haemoglobin which results in a transparent and insoluble film. The cellular (red blood cell) fraction is the one which remains after plasma recovery and is rich in haemoglobin. Bioactive compounds (antimicrobials) were successfully incorporated into the film and tested against selected micro-organisms. The same bio-based film was also tested by our partners in NUIG as scaffold in cell growing assays with positive preliminary results.
- A novel method employing cell crenation has been developed which leads to improved animal blood separation process giving rise to higher quality, low haemoglobin, content plasma.
- A validated mathematical model was developed to predict protein extraction and recovery yields from bovine and porcine lungs under different processing conditions (time, pH, temperature and solvent ratio) and was applied to generate lung protein for techno-functional tests.
- Protein rich powder was generated from lung tissue using optimized conditions and which possessed functional properties of interest for food product formulations. Behaviour in a meat system was tested by incorporating into beef burger patties and 10% inclusion levels had no

negative effects on texture or cook loss compared to control product.

- A number of co-products were identified from ham processing: exudates from pork muscle prior to pumping, cook loss or cook out formed during the cooking processing and waste brine.
  - Exudate and ham trimmings showed most potential for revalorization. In particular the exudate displayed good water binding, oil binding and gelation properties. Both co-products had previously been treated as a waste product and on foot of this analysis have been valorised back into the food chain.
  - Protein recovery from brine solution has been optimised by means of pH shift and recovery was around 75% of total protein, with over 90% of salt removal. A desalting method was developed for used for the waste brine which allowed over 90% of the salt to be removed. Proteins recovered from brine solutions by acid precipitation had lower water and oil holding capacity, when compared with proteins extracted by dialysis; however solubility and gelling properties were not significantly altered
- Glue water offered a potential value chain as a wastewater stream from edible fat rendering. Ultrafiltration was proven effective in the treatment of wastewater from edible fat rendering leading to the recovery of proteins and 'cleaner' waste water going to the water treatment centre.
- Electro-dialysis and novel membrane technologies have been assessed for enhanced protein recovery from 'cook out' and glue water. A desalting method for glue water was developed based on the gelling properties of the proteins present.
- Proteins recovered from exudates, stick water and brine solutions were tested in real food systems (Irish style breakfast sausage) at two levels of inclusion (10% and 20% replacement of meat protein). Results show the 10% inclusion level exhibited minimal interference with quality.
- The impact of process technologies including non-thermal process technologies (US, PEF) were explored for relevance to protein extraction and protein functionality.
- Bioactivity, cytotoxicity and bioavailability data obtained (in partnership with UCC) suggests that bovine blood and lung tissues may be a rich source of novel hydrolysates with different bioactivities. Results also suggest that these hydrolysates exhibit good bioavailability. Further study of these hydrolysates could lead to incorporation into commercial products or use as functional food ingredients.

- Food grade enzymes were screened for effectiveness in producing antioxidant and antimicrobial peptides from porcine lung and red blood cells. The most efficient processing conditions were selected for scaling up to larger volumes.

- Scale-up of selected co-product production streams was successfully completed. Pilot-scale membrane filtration was carried out, guided by initial lab based trials, for recovery of fractions high in antioxidant activity. Ultrafiltration resulted in the anticipated enrichment of the proteins. The initial scale up trials focused on both porcine lung (10L) and porcine blood with blood selected for the final larger scale (50L) processing. Resulting fractions displayed a range of antioxidant activity and show potential antimicrobial activity.

- Consumer attitudes to this approach have been evaluated. An online consumer survey exploring Irish consumers' attitudes to incorporating protein extracted from beef offal into food was conducted. Insights from the research, coupled with consideration of related consumer behaviour theory and literature highlights the importance of a collective approach by a range of stakeholders and that "interventions" should focus as much on reducing consumption barriers (e.g. re taste and texture) as well as increasing consumption incentives (e.g. demonstrating sustainability credentials). For example converting offal to a protein powder/ingredient can reduce the aversion factor associated with the raw material.

4. Opportunity/Benefit:

Important information has been generated on the opportunities for higher value, innovative applications for meat co-products based on protein yield and functionality. Scalability of selected product lines demonstrated. Innovation developed of relevant to bio-plastic production. Applications for a wide variety of sectors demonstrated: ingredients/food, nutrition, biomedical, bio-plastics.

- **Dissemination:**

Outputs have been discussed with a diversity of stakeholders encompassing meat processors (including MTI), ingredient companies, blood processors, pet-food manufacturers, bio-plastics, biomedical etc. They received project details through Gateways events, workshops, demonstration activities, one-to-one meetings and conference calls. Relevant findings from all tasks have fed into activity on MTI (Meat Technology Ireland) in particular in informing the identification of suitable market opportunities for the Irish meat industry. Through invited keynote speeches and other oral presentations information was disseminated globally across the EU and in Australia. A number of proposals were submitted for funding at national and EU level based on outcomes. A strong focus on peer-reviewed publications (n=30 from Teagasc in journals with impact factor up to 24) and many book chapters have ensured wide dissemination to the scientific community.

Selected publications:

Mullen, A.M., Álvarez, C., Zeugolis, D.I., Henchion, M.,O'Neill, E., and Drummond, L. (2017) Alternative uses for co-products: Harnessing the potential of valuable compounds from meat processing chains. Meat Science 132: 90-98.

Álvarez, C., Drummond, L., Mullen, A.M. (2018). Expanding the industrial applications of a meat co-product: Generation of low-haemoglobin content plasma by means of red cells crenation. Journal of Cleaner Production 185, 805-813.

Lynch,S.A., Mullen, A.M., O'Neill, E.E., and Álvarez Garcia, C. (2017). Harnessing the Potential of Blood Proteins as Functional Ingredients: A Review of the State of the Art in Blood Processing. Comprehensive Reviews in Food Science and Food Safety. Published online: 09/02/2017 DOI: 10.1111/1541-4337.12254. Impact factor 7.03

Lynch,S.A., Álvarez, C., O'Neill, E.E., Keenan, D.F. and Mullen, A.M. (2017). Optimization of Protein Recovery from Bovine Lung by pH Shift Process Using Response Surface Methodology. Journal of the Science of Food and Agriculture, 98(5):1951-1960 DOI: 10.1002/jsfa.8678.

5. Compiled by:

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