



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

Food Institutional Research Measure

Final Report

Meat4Vitality: Enhancement of texture, flavour and nutritional value of meat products for older adults

DAFM Project Reference No: 11/F/045

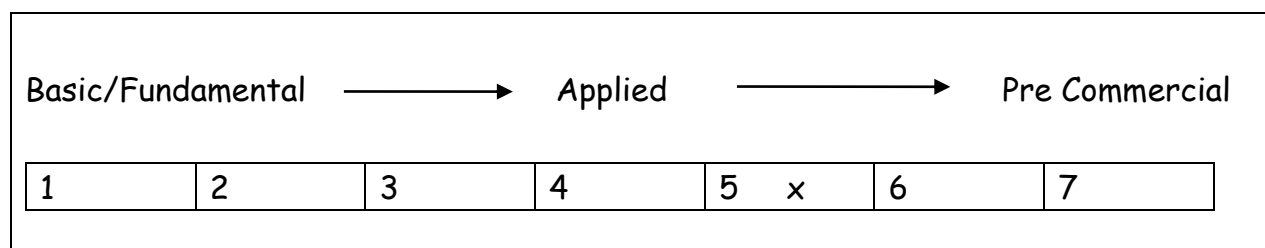
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Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report;

Priority Area (s)	Food for health Sustainable food production and processing
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Key words: healthy meats, older adults, protein, texture, sarcopenia

1. Rationale for Undertaking the Research

According to the World Health Organisation "In almost every country, the proportion of people aged over 60 years is growing faster than any other age group." Healthy ageing through maintaining vitality and quality of life is thus a grand challenge of growing international importance. It is well known that nutrition has an important role to play in promoting healthy ageing, however, caloric intake decreases 800 and 1200 kcal/day for women and men between the ages of 20 and 80 (Lichtenstein, Rasmussen et al. 2008) due to factors such as decreased appetite, poor dentition, impaired taste and smell and cognitive impairment. Such unintended weight loss in older adults can lead to impaired immunity, muscle wasting and cognitive function deficits (Zhu, Devine et al. 2010). According to the survey of health and ageing in retired in Europe (SHARE), less than 10 % of European men and women aged 80+ would rate their health as excellent, while more than forty percent would rate their health as fair to poor, with 25% of 70-79 year olds rating their health as fair to poor. The National Adult Nutrition Survey showed that meat is a staple food of older people in Ireland. Red meat is intrinsically a rich source of certain nutrients which are particularly important for healthy ageing. These include protein, for growth and repair, fatty acids such as CLA and PUFA for cognitive function, as well as vitamins and micronutrients e.g. iron, calcium, selenium and zinc (Hazell 1982; Kwak, Lee et al. 2010; Pannier, Ponnampalam et al. 2010). However, meat is a challenging food matrix, in terms of texture and this partly explains why intakes decrease in older adults. Reformed and comminuted meat products also offer potential as vehicles for fortification with added nutrients such as fibre, vitamins and minerals, but little work has been done in this area. Initial work in our laboratory (O8RDTAFRC671) indicates that bioactivity of functional ingredients is not affected by inclusion/processing in meat products. If meat products can be made more appealing to older adults by modifying their texture and flavour, while retaining or enhancing their nutritive value especially protein, certain vitamins and micronutrients, this could be a valuable step forward to improve the vitality and quality of life of a growing sector of the population.

2. Research Approach

The project included a review of the literature around the market for functional foods and subsequent prioritisation of products and nutritional gaps. Subsequent tasks focused on developing case studies in the area of texture optimisation, flavour enhancement, nutritional fortification of consumer acceptable meat products and development of packaging solutions for older consumers. Detailed case studies involving processing, formulation, technological and sensory analysis were completed. These model system tasks were complemented by detailed in vitro digestion and microstructure analysis to provide insight on the relationships between structure, processing and digestion. Finally, the sensory acceptability of optimised products to the target consumer group were assessed.

The overall objectives of this project were:

1. To review the market for functional foods in the elderly focusing on key issues including market size, consumer segments and health requirements.
2. To develop optimised processing strategies to develop fresh or marinated meat products with texture profiles appropriate for older consumers, while preserving their intrinsic nutritional value
3. To enhance the flavour attributes of processed meat products using clean label and healthy ingredients to enhance their chemosensory acceptability to older consumers
4. To use novel processing, such as PiVac, in conjunction with clean label ingredients and specific nutrients to develop novel fortified comminuted and reformed products specifically targeted at nutritional deficits common in older people
5. To develop ready-to heat products with intrinsic and packaging characteristics optimised for older people
6. To enhance understanding of the influence of processing, formulation and packaging on microstructure, nutrient bioaccessibility and acceptability to older adults in case study products
7. To provide blueprints for meat processors to streamline the development of new meat products highly acceptable to older consumers.

3. Research Achievements/Results

- Important attributes of meat products were enhanced with a view to addressing the needs of older consumers.
- The sensory capability of young, middle-aged and elderly Irish assessors to identify beef steaks of varying texture varied significantly and poor identification of tenderness classification was found in the 71-85 age cohort groupings
- The Meat4Vitality project developed targeted meat products for the growing cohort of over-65s.
- A variety of proteinaceous plant-based ingredients increased the protein content of beef patty formulations.
- Rice protein addition enhanced protein content in beef patties, while lentil flour did not increase protein but it imparted a softer texture.
- Optimisation of patty composition was possible and allowed protein-enriched beef patties deliver approximately 30g protein in small portion size (75g), as favoured by older people
- Optimised patties were analysed with a trained sensory panel and demonstrated satisfactory sensory characteristics with a stronger beef aroma and increased tenderness profile
- Restructured steaks were successfully developed using the PiVac wrapping technology
- Restructured products with plant proteins were less susceptible to digestion than controls
- Fruit-derived proteolytic enzymes were successful in tenderizing tougher cuts of beef

- Cuts marinated in fruit acids, such as malic acid had a more favourable shear force and sensory tenderness profile
- The texture of optimised marinated products was more acceptable to older adults than controls
- Sous vide was a promising technique to add value to lower value cuts and is highly relevant to older consumers
- Acceptability of novel products to the target market was demonstrated using consumer panels of over-65s in UCC and AFBI
- For corned beef and sausage products, assessors of varying age groups had differing preferences for certain NaCl levels and salt replacers
- Sausage formulation choice was found to be driven by texture for the younger age cohort, flavour for the middle age cohort and visual aspects from the oldest age cohort
- Consumer panels also showed that within the over-65 cohort, sensory acuity was stratified with age

4. Impact of the Research

Meat has extensive intrinsic nutritional benefits, and also serves as a suitable vehicle for fortification. Older adults also accept meat products readily as traditional food products. However, consumption tends to decline, as we get older while the need for certain nutrients, including protein, increases, leading to malnutrition, and other health risks. As part of this project, new scientific information was generated on the technological, sensory including consumer, and nutritional aspects of innovative meat product templates developed taking cognisance of the nutritional requirements and preferences of older adults.

This project was showcased at several Teagasc Gateways events and a specific focused workshop entitled "Healthy Ageing: Opportunities for NPD" held at Teagasc Ashtown on Nov 29, 2017. Fifteen peer-reviewed publications have emerged to date and aspects of the work were highlighted in poster and oral presentations at international conferences such as invited speaker at the International Congress of Meat Science and the World Congress of Food Science and Technology. The project outputs were featured as part of the Teagasc Impacts 2017 publication. Two PhD theses were submitted as a result of the work done in this project.

Having modified traditional products to suit the needs of older adults, and communicated the results of detailed quality and acceptability analyses on the developed products to meat processors, and by providing review of consumer, social, nutritional challenges associated with elder nutrition where meat can play a role, the project outputs have had impact among a wide range of stakeholders, including food processors, packaging companies, nutritionists and dietitians, policymakers as well as the scientific community. These are detailed below, while the outputs from the project also led to new funding applications as well as funded projects.

4(a) Summary of Research Outcomes

(i) Collaborative links developed during this research

The team has developed new collaborative linkages with TUD Human Nutrition and Dietetics and the Agri-Food Biosciences Institute, Northern Ireland. Within Teagasc, cross-centre and cross-functional links were strengthened.

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

- The improved texture, sensory properties and functional benefits of novel meat products developed in case studies in this project will improve consumer appeal in a growing consumer segment (older adults) and could increase in European market share for meat processing companies.

(iii) Outcomes with economic potential

- Knowledge of specific opportunities in meat product development targeting the requirements of older adults has been communicated to, and will have economic potential for meat processors in new product development.
- Results of consumer trials with older adults demonstrate the acceptance of developed innovative products.
- Insights into packaging issues and challenges faced by older adults with difficult-to-open packaging have been communicated to industry and will provide a basis to improve packaging of product offerings by meat processors and thereby increase market share.

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

- Enhanced consumption of meat with its intrinsic nutritional benefits will contribute towards improved nutritional status indicators in older adults.
- Availability of flavoursome and wholesome fortified meat products will provide greater choice to older adults enhancing nutritional status, vitality and quality of life.
- Enhanced knowledge of the structure-function relationship in meat products using microscopy, in vitro gut models and nutritional profiling is of benefit to dietitians, industry and the international scientific community.

4(b) Summary of Research Outputs

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

1. Botinestean, C, Hossain, M, Mullen, AM, Kerry, JP, Hamill, RM (2021). The influence of the interaction of sous-vide cooking time and papain concentration on tenderness and technological characteristics of meat products. *Meat Science* 177(6), 108491
2. Botinestean, C, Hossain, M, Mullen, AM, Auty, MAE, Kerry, JP, Hamill, RM (2019) Optimization of textural and technological parameters using response surface methodology (RSM) for the development of beef products for older consumers. *Journal of Texture Studies*, July 2019, <https://doi.org/10.1111/jtxs.12467>
3. Baugreet, S, Kerry, J.P., Allen, P., Gallagher, E, Hamill, R. M. (2018). Physicochemical Characteristics of Protein-Enriched Restructured Beef Steaks with Phosphates, Transglutaminase, and Elasticised Package Forming. *Journal of Food Quality*, 2018, 2, 1-11.
4. Sephora Baugreet, Carolina Gomez, Mark A.E. Auty, Joseph P. Kerry, Ruth M. Hamill, André Brodkorb (2019). In vitro digestion of protein-enriched restructured beef steaks with pea protein isolate, rice protein and lentil flour following sous vide processing. *Innovative Food Science and Emerging Technologies*, 54, June 2019, p. 152-161.
5. Paula Conroy, Maurice G. O'Sullivan, Ruth M. Hamill, Joe P. Kerry (2019). Sensory optimisation of salt-reduced corned beef for different consumer segments. *Meat Science*, Volume 154, August 2019, Pages 1-10
6. Baugreet, Sephora; Kerry, Joseph P.; Brodkorb, André; Gomez, Carolina; Auty, Mark; Allen, Paul; Hamill, Ruth M (2018). Optimisation of plant protein and transglutaminase content in novel beef restructured steaks for older adults by central composite design. *Meat Science*, 137, p. 265-274 <https://doi.org/10.1016/j.meatsci.2018.03.024>
7. Conroy, P, O'Sullivan, MG, Hamill, RM, Kerry JP (2018). Impact on the physical and sensory properties of salt-and fat-reduced traditional Irish breakfast sausages on various age cohorts acceptance. *Meat Science*, <https://doi.org/10.1016/j.meatsci.2018.04.037>
8. Botinestean, C, Gomez, C, Nian, YQ, Auty, MA, Kerry, JP, Hamill, RM (2017). Possibilities for developing texture-modified beef steaks suitable for older consumers using fruit-derived proteolytic enzymes. *Journal of Texture Studies*, DOI: 10.1111/jtxs.12305
9. Baugreet, S, Hamill, RM, Allen, P, Kerry, JP (2017). Application of novel PiVac technology for the development of fortified restructured beef steaks targeted at older consumers. *Journal of Food Processing and Preservation*, 2017, e13498.

10. Baugreet, S., Kerry, J. P., Botinestean, C., Allen, P., & Hamill, R. M. (2017). Optimisation of protein-fortified beef patties targeted to the needs of older adults: a mixture design approach. *Meat Science*, Volume 134, December 2017, Pages 111-118
11. Conroy, P, O'Sullivan, MG, Hamill, RM, Kerry, JP (2017). Sensory capability of young, middle-aged and elderly Irish assessors to identify beef steaks of varying texture. *Meat Science*, Volume 132, October 2017, Pages 125-130, 020
12. Baugreet, S, Hamill, R.M., Kerry, J.P., McCarthy, S.N. (2017). Mitigating nutrition and health deficiencies in older adults - a role for food innovation? *Journal of Food Science*, 2017 Apr;82 (4):848-855.
13. Baugreet, S., Kerry, J. P., Botinestean, C., Allen, P., & Hamill, R. M. (2016). Development of novel fortified beef patties with added functional protein ingredients for the elderly. *Meat Science*, 122, 40-47.
14. Botinestean, C., Keenan, D. F., Kerry, J. P., & Hamill, R. M. (2016). The effect of thermal treatments including sous-vide, blast freezing and their combinations on beef tenderness of *M. semitendinosus* steaks targeted at elderly consumers. *Lwt-Food Science and Technology*, 74, 154-159.
15. Hamill, R. M. & Botinestean, C. (2015). Meat: Structure. *Encyclopedia of food and health* (pp. 701-710) doi:10.1016/B978-0-12-384947-2.00451-7

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

1. Salt reduction and potassium replacement perception of traditional corned beef in different age (18-85) cohorts. P. M. Conroy, R. M. HAMILL, J. P. Kerry and M. G. O'Sullivan. *International Congress of Meat Science and Technology 2017*.
2. Texture optimisation of novel restructured beef steaks suitable for elderly people using clean label plant proteins and pivalic acid. S. Baugreet, J. P. Kerry, P. Allen and R. M. Hamill. *International Congress of Meat Science and Technology 2017*.
3. Enhancing the texture attributes in meat products using food grade acids to increase the appeal for older consumers. C. Botinestean, A. M. Mullen, M. Hossain, J. P. Kerry, R. M. Hamill. *International Congress of Meat Science and Technology 2017*.
4. The effects of using fruit fibres and rice starch on the technological and textural parameters of a beef product. C. Botinestean, A. M. Mullen, J. P. Kerry, R. M. Hamill. *International Congress of Meat Science and Technology 2017*.

5. Using the response surface methodology to facilitate the optimization of texture-modified injected meat products targeted at elderly consumers. C. Botinestean, A. M. Mullen, J. P. Kerry, R. M. Hamill. International Congress of Meat Science and Technology 2017.
6. Sensory differences between young, middle aged and elderly assessors for beef steak of varying texture. P. M. Conroy, M. G. O'Sullivan, R. M. Hamill and J. P. Kerry. International Congress of Meat Science and Technology 2016
7. Botinestean C., Kerry J. P., Hamill R.M. The effect of mechanical treatments on the tenderness of M. semitendinosus beef steaks targeted at elderly consumers, IUFoST, 18th World Congress of Food Science and Technology, 21st-25th of August, Dublin, Ireland, 2016.
8. Salt levels in traditional breakfast sausages developed for the elderly and the effects on physiochemical and sensory properties. P. M. Conroy, M. G. O'Sullivan, R.M Hamill and J. P. Kerry. International Congress of Meat Science and Technology 2016.
9. Botinestean C., Kerry J. P., Hamill R.M. The effect of fruit-derived proteolytic enzymes on tenderness of beef steaks targeted at elderly consumers, IUFoST, 18th World Congress of Food Science and Technology, 21st-25th of August, Dublin, Ireland, 2016.
10. Botinestean C., Keenan D.F., Kerry J. P., Hamill R.M. The effect of sous-vide and freezing thermal treatments on tenderness of beef M. semitendinosus steaks targeted at elderly consumers. The 29th EFFoST International Conference, 10th-12th of November, Athens, Greece, 2015
11. Baugreet S., Kerry J.P., Botinestean C., Hamill R.M. Assessing the potential to enhance dietary protein intake in elderly consumers through fortification of beef patties. The 29th EFFoST International Conference, 10th-12th November Athens, Greece, 2015
12. Baugreet S., Kerry J.P., Botinestean C., Hamill R.M. Development of fortified beef patties with enhanced protein content suitable for elderly consumers, 61st International Congress of Meat Science and Technology, 23th-28th August, Clermont-Ferrand, France, 2015

(iii) National Report

(iv) Workshops/seminars at which results were presented

1. "Healthy Ageing: Opportunities for NPD"
2. Teagasc Meat@Gateways, Ashtown, Dublin 15, May 2014
3. Teagasc Gateways events from 2014-2018

(v) Intellectual Property applications/licences/patents

(vi) Other

5. Scientists trained by Project

Total Number of PhD theses: 2

1. Dr. Sephora Baugreet (2018). Optimisation of quality and nutritional value of reformed/restructured meat products for older adults developed using plant proteins. University College Cork.
2. Dr. Paula Conroy (2018). Development, assessment and optimisation of meat systems for the aging consumer through processing and packaging modification. University College Cork.

Total Number of Masters theses: 0

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (Person Years)
Teagasc	7	1.75
UCC	1	0.10
Agri-Food Bioscience Centre	2	0.17
Total	9	2.02

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (months) Person years
Post Doctorates	1	3
Contract Researchers		
PhD Students	2	6
Masters Students		
Temporary researcher	1	1
Other (unpaid visiting)		
Total	4	10

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended
-	-

9. Project Expenditure

Total expenditure of the project:	€471,151.66
Total Award by DAFM:	€491,237.38
Other sources of funding including benefit in kind and/or cash contribution(specify):	
Teagasc Walsh Scholarship :	€88,000

Breakdown of Total Expenditure

Category	Teagasc TAFRC	Teagasc TMFRC	UCC	Total
Contract staff	138,319.71	30,452.87		168,772.58
Temporary staff				
Post doctorates			14,617.24	14,617.24
Post graduates			67,095.00	67,095.00
Consumables	37,461.61	350.56	21,738.08	59,550.25
Travel and subsistence	11,773.70	1,116.30	11,201.68	24,091.68
Sub total	187,555.02	31,919.73	114,652.00	334,126.75
Durable equipment				
Other	17,555.46		21,107.22	38,662.68
Overheads	54,391.31	9,575.92	34,395.00	98,362.23
Total	259,501.79	41,495.65	170,154.22	471,151.66

10. Leveraging

A Teagasc Walsh Scholarship was leveraged for this project. The project led to additional project proposals and funded projects including NATRIOPT (15F610): Novel clean label strategies for the nutritional and sensory optimisation of reduced salt and fat processed meat products. The outputs also directly led to the team's involvement in the major DAFM Programme, i.e. UPROTEIN (2019PROG702): Unlocking protein resource opportunities to evolve Ireland's nutrition.

11. Future Strategies

The results of the research have provided a strong basis for future scientific research and are also under consideration for industry collaborative projects. The outputs are regularly communicated to industry.