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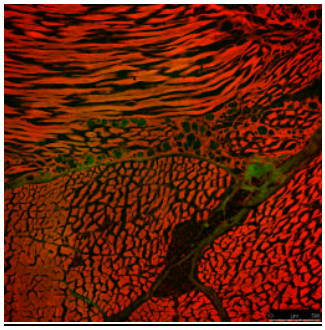
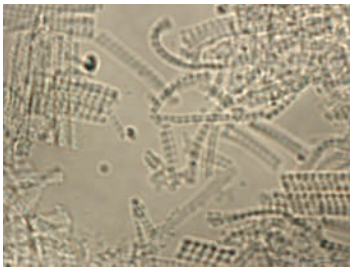
A food matrix approach to meat product development





Key external stakeholders:

Primary and secondary meat processors; Ingredients companies; retailers; Regulatory agencies: DAFM

Practical implications for stakeholders:

- Increasing consumer awareness of health issues associated with high dietary intake is driving the need for change in the products available to them. Therefore, the meat industry is examining the possibilities for meat products with reduced fat, salt and additives and assessing the potential for meat-based functional foods.
- Processed meat products represent complex systems that can be considered as a 'matrix' of interacting components. Processes and forces operating at the micro-scale impact on the macro-scale properties of the product.
- By improving our understanding of the impact of interactions between the food matrix and novel ingredients on technological and sensory performance, strategies were developed to optimise healthier versions of traditional meat products such as reduced fat and salt products and products including bioactive compounds and prebiotic fibres.

Main results:

- Comminuted product formulations (burgers, breakfast sausages, and frankfurters) with a wide range of salt and fat levels both above and below industry norms were assessed using consumer sensory panels and instrumental measurements. Several of the most preferred formulations represented a significant decrease in salt and fat content compared to typical retail counterparts (controls).
- Using response surface methodology, both comminuted and whole muscle products formulations containing functional ingredients, such as fibre, prebiotics, omega-3 fish oils and antioxidants were optimized and the most promising products were assessed by consumers.
- Detailed physico-chemical and ultra-structural analyses better elucidated the underlying forces governing overall product quality, the knowledge of which can be used in a more systematic scientific approach to new product development.
- Reducing fat and salt is possible without affecting consumers' perception of quality, while enhancing products with functional ingredients can also be achieved to further enhance their health profile.

Opportunity / Benefit:

Information and databases available to industry that can be used in future to predict the effects of alteration of various parameters on microstructure, molecular interactions and their relationship with product quality .

Collaborating Institutions:

University College Cork (UCC)

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1. Project background:

Most of the existing processes applied in the development of meat products, have been developed empirically by testing the effect of a limited number of ingredients/inclusion levels/processing conditions on product quality and yield, which is pragmatic but does little to develop an understanding of the physic-chemical processes that govern the final product. Implementation of a systematic scientific approach in the controlled and efficient development of future meat products requires a basic application of chemical, biochemical, physical and biological principles and consideration of the meat system as a matrix of interacting components. The overall objectives of this project were to:

- enhance understanding of the effect of the complex interactions between the components of commercially relevant meat matrices with each other and with added ingredients on the technological and sensory properties of meat products
- to further assess the interaction of ingredients with processing at the molecular and food matrix level
- to generate information on the applicability of the comminuted meat matrix as a delivery system for bioactives.

2. Questions addressed by the project:

- What is the effect of modifying salt and fat level and their interactions on consumer acceptance and technological performance of commercially relevant meat products?
- Can model systems provide insight on the physic-chemical and technological properties of intrinsic components of meat, such as myofibrillar and sarcoplasmic proteins?
- Is it possible to develop a healthier meat product without compromise on sensory or technological performance?
- Are meat products suitable as delivery vehicles for healthy and bioactive ingredients?
- Can ultra-structural visualisation techniques, nuclear magnetic resonance and differential scanning calorimetry help us gain understanding on the interactions among food components?
- What is the consumer view of nutraceutical-containing meat products?

3. The experimental studies:

- Interaction between 1) purified intact myofibrils and 2) sarcoplasmic protein extracts from beef muscle with thermal processing and salt were studied to investigate gelation properties.
- Model systems representing a wide range of salt and fat levels for important comminuted products were established and assessed through technological andconsumer sensory analysis to identify where it was possible to reduce these ingredients below levels currently utilised in retail products.
- Once levels of salt and fat were optimised, putative bioactive ingredients were included in optimised formulations and assessed for sensory and technological performance and bioactive persistence through cooking was assessed.
- Functional and bioactive ingredients including rice starch and fructose were assessed in cooked ham products, both whole muscle and reformed.
- The freezing properties of brined muscle cuts were investigated and the potential of ultrasound to

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improve freezing time was assessed.
- Consumer surveys were carried out to identify consumer attitudes towards typical ingredients in meat products and nutraceutical-containing meat products.

4. Main results:

- Myosin and actin in extracted myofibrils differed in their thermal properties. For actin, there is a significant interaction effect between salt and thermal processing, whereas for myosin, the effects of salt and temperature are independent.
- Salt reduction in beef patties improved consumer sensory performance. The most consumer acceptable beef patty was that containing 40% fat with a salt level of 1%.
- For breakfast sausages, products containing 1.4% and 1.0% salt were significantly ($P<0.01$) more acceptable to consumers than higher salt levels. Producing a product within the limits of salt levels recommended by the FSAI is thus not only achievable but also can produce a superior product when rated by consumers.
- For frankfurters, lower fat levels (10% and 15%) with higher salt levels (2.5-3%) were significantly the most acceptable variants to consumers. Fat levels can be potentially reduced without significantly affecting overall acceptability, with a greater challenge for salt reduction.
- Optimisation of the sensory analysis of sausages containing a prebiotic dietary fibre (inulin) suggested that further reductions in fat can be achieved (>50% reduction) without affecting eating quality.
- Optimisation of burger formulation with a lower added-fat level (reduction of 7.8% compared to the control) substituted with commercial encapsulated fish oil was achieved with an acceptable desirability level in terms of technological performance. However, sensory analysis carried out on this optimised formulation showed that some flavour modification did occur.
- For whole muscle products, the application of power ultrasound had a positive effect on freezing properties (i.e. decreased the freezing time) of non-brined and brined round beef pieces compared to controls.
- Partial or total substitution of phosphates and dextrose with the inclusion of rice starch and/or fructo-oligosacharides is feasible in the manufacture of whole muscle hams; while it leads to a certain reduction in yield, a product of satisfactory quality (measured instrumentally and chemically) is obtained which may represent a healthier product compared with those currently available at retail.
- Consumer studies carried out on the whole muscle hams have indicated consumer preferences towards the removal of additives and support inclusions like dietary fibre as they could be further beneficial to their health.
- Retention of CoQ10 in fortified sausages and burgers was high after cooking (74-75%). Furthermore, results from *in vitro* digestibility assay showed a high rate of digestibility with up to 95% (sausages) remaining intact & reaching the absorption site in small intestine, indicating its potential as a functional ingredient.
- Reduced fat and salt, and CoQ10 fortified patties were more accepted by consumers compared to commercially available products and scored significantly higher for appearance. Reduced fat and salt, as well as the CoQ10 fortified, sausages were found to compare quite well to their commercial counterparts for overall acceptability, whereas commercial frankfurters were more favoured in comparison to reduced fat and CoQ10 fortified versions.
- Many of the respondents were willing to consume meat based functional food products but were not willing to pay more for them.
- Time domain NMR analysis gave a more detailed account of the binding properties between water and mixture components in sausages than empirically derived responses of cook loss and total expressible fluid. Three distinct peaks were identified that can be associated with water that is trapped, bound and free. Of these, trapped and free water were the most strongly correlated with moisture loss. Models for trapped and free water were significant and indicated samples with increasing inulin had higher trapped water and lower free water populations.
- The application of ultra-structural techniques was highly relevant and permitted visualisation of the physico-chemical changes underpinning the macro-scale technological and sensory parameters. For example, the reduction in fat in inulin enriched sausages was visualised by differential staining and confocal microscopy while the crystalline structure of the inulin molecule was visible using cryo-scanning electron microscopy.

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5. Opportunity/Benefit:

A series of large datasets have been generated from more than ten experimental trials on a variety of model systems, and prototype case study products of comminuted, whole muscle and reformed products have been explored in detail. A large number of novel additives, many technologically functional, the majority of which are clean label, several of which are potentially bioactive, have been included in prototype products and comprehensively investigated so that their impact on techno-functional and sensory parameters of the selected products has been established. Furthermore, a number of processing interventions have been explored and novel processing interventions have been tested. Main findings have been published in peer-review journals. However, the data held in our databases is a further source of information of practical utility for the Irish meat processing industry. Datasets from Teagasc and UCC have now been compiled and are stored in a single database in digital format at Teagasc. For example, companies may wish to use these datasets to explore in greater detail the attributes of a specific prototype product and its interaction with ingredients and processing. Finally, we have clearly demonstrated the benefits of optimisation through response surface methodology and this can be applied in future research partnerships with industry e.g. to investigate a new ingredient/ functional additive.

6. Dissemination:

This project was showcased at several Teagasc Gateways events and highlighted in the national press. Several peer-reviewed publications have emerged to date and aspects of the work were highlighted at international conferences such as the International Congress of Meat Science.

Main publications:

1. Keenan, D. F., Auty, M. A. E., Doran, L., Kerry, J.P., Hamill, R. M. (2014). Investigating the influence of inulin as a fat substitute in comminuted products using rheology, calorimetric and microscopy techniques. Food Structure, 01: 2014.
2. Keenan, D. F., V. C. Resconi, J. P. Kerry and R. M. Hamill (2014). Modelling the influence of inulin as a fat substitute in comminuted meat products on their physico-chemical characteristics and eating quality using a mixture design approach. Meat Science 96(3): 1384-1394.
3. Tobin, B. D., M. G. O'Sullivan, R. Hamill and J. P. Kerry (2014). Effect of cooking and in vitro digestion on the stability of co-enzyme Q10 in processed meat products. Food Chemistry 150: 187-192.
4. Tobin, B. D., M. G. O'Sullivan, R. Hamill and J. P. Kerry (2014). European consumer attitudes on the associated health benefits of neutraceutical-containing processed meats using Co-enzyme Q10 as a sample functional ingredient. Meat Science 97(2): 207-213.
5. Resconi, V. C., Keenan, D. F., Gough, S., Doran, L., Allen, P., Kerry, J. P., and Hamill, R. M. (2013). Starch and fibre in whole-muscle cooked ham: yield microstructure and sensory discrimination. Proceedings: 59th International Congress of Meat Science and Technology (ICoMST) 0-37, Izmir, Turkey, August 2013
6. Tobin, B.D., O'Sullivan, M. G., Hamill, R.M. and J. P. Kerry (2013). The impact of salt and fat level variation on the physiochemical properties and sensory quality of pork breakfast sausages. Meat Science, 93, 2, February 2013, 145-152
7. Tobin, B.D., O'Sullivan, M. G., Hamill, R.M. and J. P. Kerry (2012). Effect of varying salt and fat levels on the sensory and physiochemical quality of frankfurters. Meat Science, 92, 4, pp. 659-666
8. Tobin, B.D., O'Sullivan, MG, Hamill, R.M., Kerry JP (2012). Effect of varying salt and fat levels on the sensory quality of beef patties. Meat Science, 91, 4, pp. 460-465.
9. McArdle, R, Hamill, RM and Kerry, JP (2011). Utilisation of hydrocolloids in processed meat systems. In: Processed meats: improving safety, nutrition and quality, p. 243-269. Edited by JP Kerry and JF Kerry, Woodhead Publishing.

7. Compiled by: Dr. Ruth Hamill and Dr. Derek Keenan

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