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Development of healthier meats and meat products

Key external stakeholders:

Meat processors, retailers, ingredients companies, consumers

Practical implications for stakeholders:

The outcomes of the research from this project deliver know-how to the Irish meat industry on how to develop innovative, healthy, value-added meat products of high nutritional and sensory quality.
The knowledge generated will enable Irish meat processors to make significant inroads into the functional food market and increase Irish competitiveness in this area.

Main results:

- Lutein, Sesamol and Ellagic acid reduced lipid oxidation in raw and cooked beef and pork products
- These plant extracts had no adverse effects on the sensory properties of the meat products
- There were some beneficial effects on texture and sensory properties of some products

Opportunity / Benefit:

Irish meat processors can increase the desirability of their products to consumers by using natural plant extracts in place of synthetic additives. They could also create new markets by developing functional meat products using plant extracts. Teagasc can assist through advice, consultancy work and/or contract research on how to develop healthier meat products and/or functional meat products using plant derived ingredients

Collaborating Institutions:

UCC

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1. Project background:

Many consumers have genuine health and nutritional concerns, and these are often cited as the major factors influencing choice. This has manifested itself in increased demand for low fat and low calorie products, functional and fortified foods, probiotics and organic products. Although the meat industry has been affected by the perceived relationship between meat products and the incidence of obesity and cardiovascular disease it has been slow to respond with such products.

The health promoting properties of 'functional foods' has attracted considerable research interest in recent years. Functional foods are defined as 'foods by virtue of physiologically active components which benefit beyond basic nutrition and prevent disease or confer an improved state of health'. The dairy industry has embraced the functional food concept but the meat industry has been slow to follow.

The action of functional foods is based on the use of functional ingredients, including proteins, carbohydrates, fats and plant derived phytochemicals/nutraceuticals such as Rosemary, Oregano, Sage, Echinacea, Green Tea Extract, Green Coffee Antioxidant, Lutein, Sesamol and Ellagic acid. The incorporation of such nutraceuticals/plant extracts into meat products offers potential health benefits to consumers and considerable commercial economic potential to the food industry.

2. Questions addressed by the project:

- What is the bioactivity of phytochemicals and nutraceuticals to be employed as functional ingredients in meat products?
- How does the addition of Rosemary, Oregano, Sage, Echinacea, Green Tea Extract and Green Coffee Antioxidant affect the quality and safety of minced beef patties and cooked sliced beef?
- How does the addition of Lutein, Sesamol and Ellagic acid affect the quality and safety of minced beef patties and cooked sliced beef?
- What is the bioactivity of phytochemicals and nutraceuticals in beef products?
- How does the addition of Rosemary, Oregano, Sage, Echinacea, Green Tea Extract and Green Coffee Antioxidant affect the quality and safety of pork sausages, black puddings and cooked hams?
- Does the addition of Lutein, Sesamol and Ellagic acid affect the quality and safety of pork sausages?
- What is the bioactivity of phytochemicals and nutraceuticals in pork products?

3. The experimental studies:

- An in vitro cell model (human intestinal Caco-2 cells) was used to assess selected nutraceuticals and phytochemicals to determine their bioactivity and determine effective levels and their effects on DNA integrity, oxidant-induced DNA damage and oxidant-induced cell injury were studied to determine safe levels to use in meat products (UCC)
- Using effective but safe ranges (see above) dose response studies of the effects of plant extracts (Rosemary, Oregano, Sage, Echinacea, Green Coffee Antioxidant and Green Tea Extract (UCC) and Lutein, Sesamol and Ellagic acid (Teagasc) in model meat systems were carried out using 25% beef and pork muscle homogenates.. Microbial analysis was also carried out.
- Trials were then carried out in real beef (patties, mince and joints) and pork (patties, sausages black pudding and hams) products. The plant extracts were added at a range of levels and a range of quality parameters were measured. The bioactivity and safety of the plant extracts were determined in the raw and cooked products.

4. Main results:

- Rosemary (15 µg/ml), Oregano (60 µg/ml), Sage (60 µg/ml), Echinacea (250 µg/ml), Green Tea

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Extract (10 µg/ml), Green Coffee Antioxidant (10 µg/ml), Sesamol (600 µg/ml), Lutein (30 µg/ml) and Ellagic acid (10 µg/ml) did not induce DNA damage or cell injury. Sage and Lutein significantly increased cellular glutathione content whereas the other compounds had no effect.

- The presence of sage, oregano or rosemary in the growth media protected DNA, to varying degrees, against H_2O_2. Sage was the only plant extract to protect against H_2O_2-induced cell injury.
- In beef muscle homogenates, oxymyoglobin oxidation and lipid oxidation decreased with increasing plant extract concentration in the order: Green Tea Extract > Sage > Rosemary > Green Coffee Antioxidant ≈ Oregano > Echinacea. Levels of lipid oxidation in pork muscle homogenates were lower than those in beef muscle homogenates. In pork muscle homogenates, lipid oxidation decreased with increasing plant extract concentration.
- In beef and pork muscle homogenates, lipid oxidation decreased with the addition of each plant extract and in the order: sesamol > ellagic acid > lutein. Ellagic acid decreased oxymyoglobin oxidation while sesamol increased oxymyoglobin oxidation in beef and pork muscle homogenates.
- Rosemary (300, 600 µg/g), Oregano (600, 1200 µg/g), Sage (600, 1200 µg/g), Echinacea (2000, 4000 µg/g) Green Coffee Antioxidant (600, 1200 µg/g) and Green Tea Extract (90, 180 µg/g) did not affect the surface colour of minced beef patties stored aerobically (up to 4 days) or in MAP (up to 12 days) but both levels of each plant extract reduced lipid oxidation.
- Sensory parameters of cooked patties, containing the higher level of each plant extract, stored aerobically (day 0 and day 3) and in MAP (day 2 and day 12) were unaffected.
- Addition of 534 µg/g Rosemary, 1069 µg/g Oregano, 715 µg/g Sage, 3032 µg/g Echinacea, 928 µg/g Green Coffee Antioxidant and 131 µg/g Green Tea Extract to beef topsides reduced lipid oxidation in sliced beef stored aerobically, in MAP or in vacuum packs. Sensory properties were not affected.
- Lutein (100, 200 µg/g) and Ellagic acid (300 and 600 µg/g) did not affect colour, however, Sesamol (250 and 500 µg/g) reduced the redness and increased oxymyoglobin oxidation. Lutein, Sesamol and Ellagic acid reduced lipid oxidation in raw beef patties stored aerobically and in MAP.
- Ellagic acid and Sesamol had no effect on TPA parameters of cooked beef patties on days 1 and 8 of storage, but Lutein increased gumminess and reduced the springiness on day 1. Lutein, Sesamol and Ellagic acid did not affect the sensorial properties of cooked minced beef patties.
- Lutein and Sesamol reduced lipid oxidation in cooked sliced beef stored aerobically and in MAP. Colour was unaffected by Lutein and Sesamol. Lutein and Sesamol increased sliced beef tenderness and reduced hardness, gumminess, chewiness and springiness.
- In raw minced beef patties, Lutein and Ellagic acid did not affect colour, however, Sesamol reduced redness and increased oxymyoglobin oxidation, resulting in more metmyoglobin formation. Lutein, Sesamol and Ellagic acid reduced lipid oxidation in raw beef patties stored aerobically and in MAP.
- In cooked beef patties Ellagic acid and Sesamol had no effect on any texture parameters on days 1 and 8 of storage. However, Lutein increased gumminess and reduced springiness on day 1. Sesamol increased hardness on day 8. Lutein, Sesamol and Ellagic acid did not affect the sensorial properties of cooked minced beef patties.
- In cooked sliced beef, cook loss and microbial status were unaffected by Lutein and Sesamol injection. Lutein and sesamol reduced lipid oxidation under aerobic and MAP storage and antioxidant potency followed the order: sesamol > lutein > control. Surface colour was unaffected by Lutein and Sesamol. Lutein and Sesamol increased sliced beef sensory tenderness and reduced hardness, gumminess, chewiness and springiness and also reduced Warner-Bratzler shear force values.
- The bioactivity tests for cooked beef products showed no major effects for any of the plant extracts.
- In general the surface colour of raw pork sausages was unaffected by plant extracts. Oxidation was unaffected by plant extracts. All plant extracts reduced lipid oxidation in raw pork sausages stored in MAP (80% O_2:20% CO_2) with Rosemary, Sage and Green Tea Extract being the most effective.
- The plant extracts had no effects on any processing, shelf life or sensory parameters of cooked pork sausages and black puddings.
- In cooked hams lipid oxidation, cook loss, water holding capacity, texture, sliceability and sensory parameters were not affected by Rosemary or Green Tea Extract.
- Lutein and Sesamol decreased redness of raw pork patties stored aerobically. Ellagic acid increased the redness of pork patties stored aerobically and in MAP. Lutein, Sesamol and Ellagic acid reduced lipid oxidation in raw pork patties stored aerobically in the order: Sesamol ≈ Ellagic acid > Lutein.
- Sesamol and Ellagic acid but not Lutein reduced lipid oxidation in cooked pork patties stored aerobically, for up to 8 days, and in MAP for up to 12 days at 4°C. Lutein and Ellagic acid did not affect instrumental textural characteristics whereas Sesamol reduced hardness, springiness and chewiness while increasing cohesiveness. Sensory parameters were unaffected.
- Sesamol and Ellagic acid reduced lipid oxidation in raw pork sausages stored aerobically and in

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MAP in the order: Sesamol > Ellagic acid > Lutein. Sesamol increased the water holding capacity.

- Sesamol and Ellagic acid reduced lipid oxidation in cooked pork sausages stored aerobically and in MAP in the order: Sesamol > Ellagic acid > Lutein. Minor decreases in cook losses occurred as a result of plant extract addition. Lutein and Ellagic acid reduced hardness on days 2 and day 12 of storage. Ellagic acid also reduced chewiness and gumminess on day 2 of storage. Lutein, Sesamol and Ellagic acid had no effect sensory parameters of cooked pork sausages.
- The surface colour and lipid oxidation in cooked ham slices was unaffected by Lutein and Sesamol.
- In cooked pork sausage and cooked pork mince, Sage, Oregano or Green Tea Extract containing pork sausage did not decrease cell viability at any of the concentrations employed and in some cases actually increased cell viability.
- There was evidence in cooked pork sausage and cooked pork mince that at some concentrations the plant extracts afforded some protection against H_2O_2-induced DNA damage.

5. Opportunity/Benefit:

Teagasc can provide the industry with advice, consultancy work and/or contract research on how to develop healthier meat products and/or functional meat products using plant derived ingredients. The research findings generated in this project may serve to restore consumer confidence regarding meat consumption especially among 'health conscious' consumers. These results demonstrate to consumers the possibly of eating meat products fortified with health promoting plant extracts without negatively influencing the sensory properties of the meat.

6. Dissemination:

Main publications:

Daly, T., Ryan, E., Aherne, S.A., O'Grady, M.N., Hayes, J., Allen, P., Kerry, J.P., O'Brien, N.M. (2010) 'Bioactivity of ellagic acid-, lutein- or sesamol-enriched meat patties assessed using an *in vitro* digestion and Caco-2 cell model system' *Food Research International* 43: 753-760.

Ryan, E., Aherne, S.A., O'Grady, M.N., McGovern, L., Kerry, J.P., O'Brien, N.M. (2009) 'Bioactivity of herb-enriched beef patties' *Journal of Medicinal Food* 12: 893-901.

Aherne, S.A., Kerry, J.P., O'Brien. N.M. (2007) 'Effects of plant extracts on antioxidant status and oxidant-induced stress in Caco-2 cells' *British Journal of Nutrition* 97: 321-328.

Hayes, J.E., Stepanyan, V., Allen, P., O'Grady, M.N., Kerry, J.P. (2010) 'Effect of lutein, sesamol, ellagic acid and olive leaf extract on the quality and shelf-life stability of packaged raw minced beef patties' *Meat Science* 84: 613-620.

Hayes, J.E., Stepanyan, V., Allen, P., O'Grady, M.N., Kerry, J.P. (2010) 'Evaluation of the effects of selected plant-derived nutraceuticals on the quality and shelf-life stability of raw and cooked pork sausages' *LWT – Food Science and Technology* 44(1): 164–172.

Hayes, J.E., Stepanyan, V., Allen, P., O'Grady, M.N., O'Brien, N.M., Kerry, J.P. (2009) 'The effect of lutein, sesamol, ellagic acid and olive leaf extract on lipid oxidation and oxymyoglobin oxidation in bovine and porcine muscle model systems' *Meat Science* 83: 201-208.

Hayes, J.E., Stepanyan, V., O'Grady, M.N., Allen, P., Kerry, J.P. (2009) 'Evaluation of the effects of selected phytochemicals on quality indices and sensorial properties of raw and cooked pork stored in different packaging systems' *Meat Science* 85: 289-296.

Hayes, J., Allen, P., Brunton, N.P., O'Grady, M.N. and Kerry, J.P. (2011) 'Phenolic composition and in vitro antioxicant capacity of four commercial phytochemical products: Olive leaf extract (Olea europaea L.), lutein, sesamol and ellagic acid' Food Chemistry 126: 948 – 955.

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