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Innovative processing to preserve positive health effects in pelagic fish products

Key external stakeholders:

Seafood processors, policy makers, prepared consumer foods sector

Practical implications for stakeholders:

Increased awareness of the diet's importance for overall health has led to an increase in the demand for products with enhanced healthiness which have good sensorial properties. Pelagic fish is rich in omega-3 lipids (EPA and DHA) which has documented beneficial effect against coronary heart diseases, easily digestible proteins and vitamins (E and D). Therefore pelagic fish is a valuable food resource in a healthy diet. However, during processing high temperatures, exposure to air and prooxidative components (like heme), may lead to loss or destruction of the valuable healthy components i.e. oxidation of omega-3 fatty acids and proteins. During raw material storage, microbial contamination can lead to the formation of histamine. Therefore, optimal processing technologies to turn healthy pelagic fish raw material into healthy and safe pre-prepared food products are needed. This project developed a comprehensive toolbox to optimise existing and novel technologies for developing healthy, high quality, safe and sustainable pelagic fish based products.

Main results:

1. A range of thermal and non-thermal technologies were employed for pelagic fish and fish products.
2. Superchilling was found to double the shelf-life of mackerel fillet compared to chilled storage. Both microbiological spoilage, amount of biogenic amines, and freshness index showed that fish had acceptable quality up to 14 days, but only 7 days for chilled storage.
3. Smoking, a traditional method for fish processing was studied in combination with high pressure processing. It was shown that treatments of 300MPa or 500MPa for five minutes could extend the shelf life of mackerel, as a significant reduction of Total Viable Counts (TVC) and H_2S-producing bacteria (below detection limit) was observed in mackerel fillets, immediately after treatment.
4. Combination of high pressure processing with hot smoking in mild conditions induced an improvement in colour characteristics, along with textural properties. The combination of HPP and smoking has been demonstrated to enhance the quality attributes of mackerel, contributing to the maintenance of its nutritional value, and is a promising treatment to extend the shelf life of mackerel.

Opportunity / Benefit:

- Demonstration of novel non-thermal technologies for improving the sustainability of fish and fish products.
- Technological interventions for improved shelf life and further developments in the area of novel processing technologies applied to the seafood sector.

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Collaborating Institutions:

Teagasc project team: Prof Brijesh K Tiwari (PI)
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External collaborators: Dr. Turid Rustad (NTNU) and 10 European Researchers

1. Project background:

ProHealth was brought together to combine the expertise of different European research and academic groups, including also three industrial collaborators on the advisory board. The project partners were geographically well balanced, with three partners representing northern Europe (Norway, Ireland), one partner representing Eastern Europe (Poland) and one partner representing southern Europe (Italy). All participating partners have long experience in processing of food for better quality and safety, but with complementary experience as described below. All participating countries have pelagic fisheries where better and more efficient utilisation of the catch for human consumption is needed. The combination of the research knowledge and experience from handling and processing of pelagic raw materials will enable technology transfer both to the pelagic fish industry but also to the consortium supporting the optimization of technological solutions for improved processing of fish. The project results have the potential to contribute to strengthening the European market for fish products, thus securing employment and improving the profitability of the pelagic industry. The multi-disciplinary and multinational consortium has access to wide academic, industrial and stakeholder networks, and based on that has the capacity to spread the knowledge from the project outcomes.

Better utilization of pelagic fish to make healthy products that are affordable for the majority of consumers in different countries will contribute to meeting the increasing demand for food, as well as having a positive effect on the health of the population. The new product prototypes for ready-to--eat/ready to cook fish can create new business opportunities for industry aiming at developing high- value products from pelagic fish.

2. Questions addressed by the project:

- How can novel processing technologies be employed for enhancing shelf life of pelagic fish products?

The aim of the project is to develop a comprehensive toolbox of optimized existing and novel technologies for developing healthy, high quality, safe and sustainable fish products from pelagic fish species.

3. The experimental studies:

Pelagic fish products were processed using a range of novel non-thermal technologies, including high pressure processing, plasma technologies, supechilling with an aim to enhance the shelf life and improved health benefits whilst maintaining consumer acceptability. Variation in functional properties and quality and safety in pelagic fish (Atlantic herring, Baltic herring and Atlantic Mackerel) were investigated along with the effect of novel plasma technologies and packaging solutions on fish quality and safety.

4. Main results:

- Development of novel processing technologies for enhancing shelf life of fish products.
- High pressure treatments of 300MPa or 500MPa for five minutes could extend the shelf life of mackerel, as a significant reduction of Total Viable Counts (TVC) and H_2S-producing bacteria (below detection limit) was observed in mackerel fillets, immediately after treatment.
- Plasma activated water can be employed for improving microbial safety of fish fillets.
- Changes in quality characteristics were observed in relation to protease activity and protein oxidation in chilled, superchilled and frozen mackerel fillets during storage.
- Sous vide treated pelagic fish had an improved shelf life and it was shown that adding antioxidants is important for preserving the valuable lipids

5. Opportunity/Benefit:

- State-of-the art novel cold plasma technologies, high pressure processing and combination of conventional and novel technologies for pelagic fish products were developed.
- Smoking of fish in combination with high pressure processing was demonstrated to be effective to enhance shelf life.
- Plasma activated water using cold plasma technologies can be employed for washing of pelagic fish

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for enhance microbial safety and shelf life.
- Packaging strategies for fish products for improved shelf life and quality were developed.
- Development of a comprehensive technology toolbox for a range of fish products.

6. Dissemination:

Main publications:

- Albertos, I., Martín-Diana, A. B., Cullen, P. J., Tiwari, B. K., Ojha, S. K., Bourke, P., Álvarez, C., & Rico, D. (2017). Effects of dielectric barrier discharge (DBD) generated plasma on microbial reduction and quality parameters of fresh mackerel (Scomber scombrus) fillets. Innovative Food Science & Emerging Technologies, 44, 11. 7-122.
- Albertos, I., Martin-Diana, A. B., Cullen, P. J., Tiwari, B. K., Ojha, S. K., Bourke, P., & D. Rico. Shelf-life extension of herring (Clupea harengus) using in-package atmospheric plasma technology. Innovative Food Science & Emerging Technologies. (Accepted) https://doi.org/10.1016/j.ifset.2017.09.010
- de Alba, M., Pérez-Andrés, J.M., Harrison, S.M., Brunton, N.P., Burgess, C.M., & Tiwari, B.K. (2019). High pressure processing on microbial inactivation, quality parameters and nutritional quality indices of mackerel fillets. Innovative Food Science and Emerging Technologies 55, 80–87.
- Zhao, Y-M., de Alba, M., Sun, D-W., & Tiwari, B.K. (2019). Principles and recent applications of novel non-thermal processing technologies for the fish industry—a review. Critical Reviews in Food Science and Nutrition,59 (5), 728-742.
- Pérez-Andrés, J.M.; de Alba, M.; Harrison, S.M.; Brunton, N.P.; Cullen, P.J. and Tiwari, B.K. 2020. Effects of cold atmospheric plasma on mackerel lipid and protein oxidation during storage. LWT-Food Sci. Technol. 118: https://doi.org/10.1016/j.lwt.2019.108697
- Kulawik, P., Álvarez, C., Cullen, P. J., Aznar-Roca, R., Mullen, A. M., & Tiwari, B. (2018). The effect of non-thermal plasma on the lipid oxidation and microbiological quality of sushi. Innovative Food Science & Emerging Technologies, 45, 412-417.
- Kulawik, P., & Tiwari, B. (2018). Recent advancements in the application of non-thermal plasma technology for the seafood industry. Critical reviews in food science and nutrition, 1-12.
- Cropotova, J., Mozuraityte R., Standal I.B., Ojha, S. Rustad T. Tiwari, B.K. (2020). Influence of high-pressure processing on quality attributes of haddock and mackerel minces during frozen storage, and fishcakes prepared thereof, Innov. Food Sci. & Emerging Technol. 59, January 2020, 102236
- Pérez-Andrés, J.M., de Alba, M., Harrison, S.M., Brunton, N.P., Cullen, P.J., Tiwari, B.K. (2019). Effects of cold atmospheric plasma on mackerel lipid and protein oxidation during storage. LWT-Food Science and Technology (In Press).
- Pérez-Andrés, J.M.; Charoux, C.; Cullen, P.J. and Tiwari, B.K. 2018. Chemical modifications of lipids and proteins by nonthermal food processing technologies. J Agr. Food Chem. 66:5041-5054
- Zhao, Y. M.; Ojha, S.; Burgess, C. M.; Sun, D. W.; Tiwari, B. K., Influence of various fish constituents on inactivation efficacy of plasma-activated water. International Journal of Food Science & Technology 2020, 55, (6), 2630-2641.
- Zhao, Y. M.; Ojha, S.; Burgess, C. M.; Sun, D. W.; Tiwari, B. K., Inactivation efficacy and mechanisms of plasma activated water on bacteria in planktonic state. Journal of Applied Microbiology 2020.
- Zhao, Y. M.; Ojha, S.; Burgess, C. M.; Sun, D. W.; Tiwari, B. K., Inactivation efficacy of plasma-activated water: influence of plasma treatment time, exposure time and bacterial species. International Journal of Food Science & Technology 2020.
- Zhao, Y. M.; Patange, A.; Sun, D. W.; Tiwari, B., Plasma-activated water: Physicochemical properties, microbial inactivation mechanisms, factors influencing antimicrobial effectiveness, and applications in the food industry. Comprehensive Reviews in Food Science and Food Safety 2020.

Popular publications:

Tiwari, B. (2016). Fishing for opportunities: Irish food magazine

De Alba M, Burgess C.M. & Tiwari, B.K. (2017). High pressure processing technology for smoked fish.

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