

Project number: 6592

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Food & the Marine

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The Microbiology and shelf-life of cod (*Gadus morhua*) and salmon (*Salmo salar*)



Key external stakeholders:

Seafood Processors & Bord Iascaigh Mhara (BIM)

Practical implications for stakeholders:

Based on the data generated in this study fish processors should invest in vacuum packaging technologies to maximise shelf-life.

Main results:

- A range of different bacteria are involved in the spoilage of fish.
- Fish are at the end of shelf-life when the bacterial count reached 100,000 to 1,000,000 bacteria per square centimetre or per square gram.
- Treatment with organic acids, essential oils or reducing the storage temperature of the fish to -2°C did not prolong the shelf-life but vacuum packaging, especially using a high barrier film, enhanced shelf-life.

Opportunity / Benefit:

Fish processors should work with Teagasc on different strategies to enhance shelf-life, thereby improving the freshness of fish available to domestic consumers and developing increased export opportunities to geographically distant markets.

Collaborating Institutions:

University College Dublin

Teagasc project team: Dr. Declan Bolton (PI)
Mr. Conor Smyth
Mr. Colin Fogarty

External collaborators: Prof. Paul Whyte, Prof. Nigel Brunton and Prof. James Lyng
(University College Dublin)

1. Project background:

As salmon and cod are two of the most valuable products in the seafood industry, it is essential to maintain a product of excellent quality. However it is also necessary to improve the product where possible. It is generally agreed that a 24-hour extension in shelf-life could significantly impact on profitability, sustainability and reduce food waste.

This project explores the possibility of improving analytical methods (sensory, microbiological and chemical) to assess freshness in seafood and to investigate the antimicrobial potential of a range of natural ingredients both alone and in combination with packaging (modified atmosphere and vacuum skin pack) and chilled storage temperatures to extend the shelf life of cod and salmon.

2. Questions addressed by the project:

The questions to be answered by this study included;

1. What bacteria grow on cod and salmon during chilled storage?
2. What makes up the microbiota present in the GI tract of Atlantic salmon?
3. What is the relationship between sensory and microbiological end-point of shelf-life?
4. Does sub-zero (-2°C) storage prolong the shelf-life of cod?
5. Could organic acid or essential oil treatments enhance the shelf-life of fish stored on ice or vacuum packaged?
6. Does vacuum packaging in a high barrier film enhance the shelf-life of cod or salmon?

3. The experimental studies:

Fresh cod and salmon were obtained from a local fishmonger and subject to a range of different experiments designed to establish which bacteria are responsible for spoilage and which treatments should be used to enhance the shelf-life. The treatments tested included storage at sub-zero temperatures (-2 °C), treatment with 5% citric acid, lactic acid, capric acid, 12% tri-sodium phosphate, 1% citral, carvacrol, thymol and eugenol and vacuum packaging in higher barrier films (O₂ permeability of ≤2 cm³/m² d bar). All bacteria testing was undertaken using International Standard Organisation (ISO) or other peer reviewed methods and sensory analysis was also undertaken based on the quality index method (QIM).

4. Main results:

- After 10 days storage at 2°C, the concentrations of bacteria ranged from approximately 100 to 10,000,000 cells per cm² or per gram. At the point of sensory spoilage (8 days), the total bacteria count ranged from approximately 100,000 to

1,000,000 cells per cm⁻² or per gram.

- Using Miseq Illumina high throughput sequencing, spoilage bacteria were found throughout the gastrointestinal tract of salmon.
- Sub-zero (-2°C) storage of vacuum skin packed cod did not reduce bacterial growth or extend the shelf-life.
- Overall, treatment with organic acids or essential oils did not result in lower bacteria counts during storage and did not prolong the shelf-life of cod or salmon stored on ice or vacuum packaged.
- Vacuum packaging had either a minimal impact or doubled the shelf-life, with the high barrier film achieving an increased shelf-life of up to 3 days longer than the low barrier packaging materials.

5. Opportunity/Benefit:

This research provides data on the microbial shelf-life of cod including the impact of sub-zero storage. Fish processors could enhance the shelf-life of cod and salmon using vacuum packaging technologies.

6. Dissemination:

A workshop was held in the 'Training and Conference Centre' located at Teagasc Food Research Centre in Ashtown, Dublin 15 on Thursday 26th July, 2018.

Main publications:

Fogarty, C., Whyte, P., Brunton, N., Lyng, J., Smyth, C., Fagan, J. and Bolton, D. J. (2018). The microbiology of farmed Atlantic salmon (*Salmo salar*) stored on ice for 10 days. *Food Microbiology* 77: 38-42.

Smyth, C., Brunton, N. P., Fogarty, C. and Bolton, D.J. (2018). The effect of organic acid, trisodium phosphate and essential oil component immersion treatments on the microbiology of cod (*Gadus morhua*) during chilled storage. *FOODS*, 7, 200; doi:10.3390/foods7120200 (published online).

Popular publications:

Smyth, C., Brunton, N., Lyng, J., Whyte, P and Bolton D.J. (2016) Assessing the quality of raw cod (*gadus morhua*) using microbiological, sensory and chemical indicators. Poster presentation at the 25th International ICFMH | FoodMicro Conference, University College Dublin, 19th to 22nd July 2016, Abstract book, page 446.

Fogarty, C., Whyte, P., Lyng, J., Brunton, N. and Bolton, D. J. (2016) Shelf-life extension of fresh salmon (*salmo salar*) using organic acids and phenolic compounds present in essential oils. Poster presentation at the 25th International ICFMH | FoodMicro Conference, University College Dublin, 19th to 22nd July 2016, Abstract book, page 447.

Fogarty, C., Whyte, P., and Bolton, D. (2016). Assessing the quality of raw salmon (*Salmo salar*) using microbiological, sensory and chemical indicators. Poster presentation at the 18th International Union of Food Science and Technology (IUFoST) Conference, held at the Royal Dublin Society (RDS), Ballsbridge, Dublin, 21st and 25th August 2016.

Smyth, C., Brunton, N. and Bolton, D. (2016). Studies on shelf-life extension of cod (*Gadus morhua*) using clean label ingredients. Poster presentation at the 18th International Union of Food Science and Technology (IUFoST) Conference, held at the Royal Dublin Society (RDS), Ballsbridge, Dublin, 21st to 25th August 2016.

Smyth, C., Brunton, N., Lyng, J., Whyte, P. and Bolton D.J. (2016). Assessing the quality of raw cod (*Gadus morhua*) using microbiological, sensory and chemical indicators. Poster presentation at the 46th West European Fish Technologists' Association (WEFTA) conference, held at the Hotel "Park", Split, Croatia., 12th to 14th October 2016

Fogarty, C., Whyte, P., Lyng, J., Brunton, N. and Bolton, D. J. (2016). Shelf-life extension of fresh salmon (*salmo salar*) using organic acids and phenolic compounds present in essential oils. Poster presentation at the 46th West European Fish Technologists' Association (WEFTA) conference, held at the Hotel "Park", Split, Croatia., 12th to 14th October 2016

Fogarty, C., Whyte, P., Lyng, J., Brunton, N. and Bolton, D. J. (2017). Effect of the combination of clean label ingredients and packaging conditions on the shelf-life of meat. Poster presentation at the 63rd International Congress of Meat Science and Technology, Rochestown Park Hotel, Cork, 13th to 18th August, 2017. Abstract Book, page 908.

Smyth, C., Brunton, N., Lyng, J., Whyte, P. and Bolton D.J. (2017). Effect of the combination of clean label ingredients and packaging conditions on the shelf-life and microbiology of meat. Poster presentation at the 63rd International Congress of Meat Science and Technology, Rochestown Park Hotel, Cork, 13th to 18th August, 2017. Abstract Book, page 912.

Fogarty, C., Smyth, C., Whyte, P., Lyng, J., Brunton, N. and Bolton, D. J. (2017). Using natural ingredients and packaging technologies to enhance the shelf-life of cod and salmon. Oral presentation at the 47th West European Fish Technologists Association Conference, Aviva Stadium, Lansdowne Rd, Dublin, 9th to 12th October 2017, Conference Book, page 59.

Fogarty, C., Whyte, P., and Bolton, D. (2017). Assessing the quality of raw salmon (*Salmo salar*) using microbiological, sensory and chemical indicators. Poster presentation at the 47th West European Fish Technologists' Association (WEFTA) conference, Aviva Stadium, Lansdowne Rd, Dublin, 9th and 12th October 2017.

Smyth, C., Brunton, N. and Bolton, D. (2017). Assessing the quality of raw cod (*Gadus morhua*) using microbiological, sensory and chemical indicators. Poster presentation at the 47th West European Fish Technologists' Association (WEFTA) conference, Aviva Stadium, Lansdowne Rd, Dublin, 9th to 12th October 2017.

7. Compiled by: Dr. Declan J. Bolton
