Project number: 6601
Funding source: Department of Agriculture, Food and The Marine
Date: June, 2020
Project dates: Apr 2014 – Mar 2019

Reducing Mycotoxin levels in plant derived foods and beverages

Key external stakeholders:

- Regulatory agencies: DAFM and FSAI.
- Cereal millers, feed manufacturers and processors.
- Analytical testing laboratories.

Practical implications for stakeholders:

The project produced a comprehensive method that has been developed for the analysis of multiple mycotoxin residues in oats and beer. Also, a number of methods for decontaminating artificially infected wheat grains prior to storage for 6 weeks were evaluated.

Main points

- Mycotoxin residues can contaminate cereals in the filed or during storage.
- Mycotoxin levels in cereals can be reduced through processing and correct storage of cereals.
- Therefore, continued surveillance of mycotoxin residues by industry and regulatory laboratories is required along the farm to fork chain.
- The safety of Irish cereal products has been improved on this project through the application of more comprehensive tests and decontaminations strategies.

Main results:

Analytical methods were developed to measure ≥ 40 mycotoxin residues in cereals and beverages. The application of the methodology to the analysis of mycotoxins in different oat samples showed the importance of monitoring a wider range of mycotoxins in food, other than the regulated compounds, as many different mycotoxin can occur in the final product. The evaluated decontamination procedures included physical (high hydrostatic pressure, ultrasound, vacuum packaging and microwaves with and without sodium hypochlorite), chemical (hydrogen peroxide, sodium hypochlorite, acetic acid, sorbate, propionate, quaternary ammonium compounds, and cold plasma), and microbiological (lactic acid bacteria) treatments. The most efficient decontamination method was vacuum packaging, allowing a total fungal inhibition combined with no noteworthy grain and bread quality deterioration.

Opportunity / Benefit:

The methods developed for mycotoxin residues in oats and beverages are very important for monitoring the compliance of Irish and imported food with EU regulatory limits. The evaluation of methodologies for mitigating the presence of mycotoxins revealed that the traditional approaches (i.e. vacuum packaging) are still superior and cost-effective in comparison with the novel technologies (such as plasma and ultrasound).

Collaborating Institutions:

UCC
QUB

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External collaborators: Elke Arendt, University College Cork

1. Project background:

Fungal contamination is problematic in a wide range of food products. Fungal growth, leading to spoilage, is the main cause of product and concomitant economic losses. Furthermore, fungal mycotoxin production can cause serious public health hazards in foods. The objectives of this project were to; (i) reduce mould contamination and growth; (ii) detoxify contaminated grains; (iii) prevent mycotoxin absorption from cereal-derived foods and beverages, for a sustainable bio-based Irish economy. A range of methods were evaluated to reduce fungal growth and subsequent mycotoxin production. The impact of fungal contamination at a raw-material level was evaluated using naturally-contaminated/fungal-challenged grains, with barley and wheat model systems. The impact of fungal contamination on grains (grain storage) and selected foods quality (malt and bread) will be analysed. Special emphasis was placed on mycotoxin analyses. A range of physical (high-pressure, thermal), chemical (H_2O_2, NaOCl, quaternary salts, electrolysed water) and biological (anti-fungal lactic acid bacteria) methods were applied to reduce fungal growth and detoxify mycotoxins. Effective treatments were applied to achieve the most efficient, economically and technologically viable reductions in fungal growth and mycotoxin levels. The impact of these treatments on food and beverage processability and product quality was then assessed.

2. Questions addressed by the project:

- Qs1: Can improved analytical methods be developed to detect mycotoxin residues in cereals and beer?
- Qs2: What is the situation in relation to mycotoxin contamination of Irish grown cereals?
- Qs3: What are the most effective methodologies for reducing the levels of mycotoxin contamination in wheat grains?

3. The experimental studies:

The project was coordinated by the Teagasc Food Research Centre (TFRCA), Ashtown, Dublin. TFRCA were responsible for the development and validation of analytical methods for the measurement of mycotoxin residues using LC-MS/MS. Besides the toxins currently regulated, the method included a range of analytes of emerging toxicological interest. The Researchers in the Teagasc Crops Research Division, Oak Park, Carlow, Ireland were responsible for providing oat samples used to carry out the investigation. The oat samples collected for mycotoxins analysis were tested using the method developed at TFRCA. Two standards operating procedures (SOPs) for oats and beer methods were produced by Teagasc. Researchers based in the School of Food and Nutritional Sciences, National University of Ireland, University College Cork, College Road, Cork, Co., Cork, Ireland were responsible for assessing decontamination treatments. As part of this task, high hydrostatic pressure, ultrasound, vacuum packaging, microwaves, hydrogen peroxide, sodium hypochlorite, acetic acid, sorbate, propionate, quaternary ammonium compounds, cold plasma, lactic acid bacteria, were evaluated on artificially infected wheat grains prior to storage for 6 weeks. The research activities on the project were disseminated through e-Newsletters, workshops, seminars, national conferences, international conferences and peer reviewed publications.

4. Main results:

Tests were developed and validated to measure ≥ 40 mycotoxin residues in cereals and beverages. The developed methods were fully validated according to Commission Regulation 2006/401/EC, Commission Decision 2002/657/EC and SANTE/11813/2017. The methods are superior to existing published methods because of the range of analytes covered and automation of a key step in the sample preparation procedure. The method was applied to research samples generated by research studies carried out by Teagasc, UCC and DAFM. A number of methods for decontaminating artificially infected wheat grains prior to storage were evaluated based on fungal bio-mass and accumulation of 13 mycotoxins. Also, the impact on the grain quality was assessed through comprehensive flour analysis. The most efficient and cost-effective decontamination method was vacuum packaging, allowing a total fungal inhibition combined with no noteworthy grain and bread quality deterioration.

5. Opportunity/Benefit:

Two new sensitive and accurate tests were developed, which allow the combined analysis of 40 or more mycotoxin residues in oats and beverages. The research carried out during the development of this method has produced many key findings that improve the analysis of these residues, such as inclusion of analytes of

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increasing toxicological interest (emerging mycotoxins and plant-modified metabolites) and automation of sample preparation for a higher sample throughput. This method is very important for monitoring compliance with EU regulatory limits and providing new knowledge on the occurrence of these residues in food. Also, mycotoxin analysis identified the a number of emerging toxins, suggesting further monitoring and toxicological assessment of these compounds by legislation bodies. The evaluation of new effective treatments for mycotoxin reduction has shown that vacuum packaging is still a superior method compared to modern approaches based on novel technologies, allowing a total fungal inhibition combined with no noteworthy grain and bread quality deterioration.

6. Dissemination:

Peyer L.C., de Kruijf, M., O'Mahony, J., DeColli, L., Danaher, M., Zarnkow, M., Jacob, F. and Arendt, E.K. (2016). Application of Lactobacillus brevis R2Δ as an antifungal culture to improve safety and quality of malt and beer. Proceedings of 18th World Congress of Food Science and Technology, Dublin, Ireland, August 2016.

Lorenzo De Colli, Martin Danaher and Chris Elliott. Poster title:"Development of a multi-residue method for the analysis of mycotoxins, including masked mycotoxins, in cereal-based food by UHPLC-MS/MS". IUFoST World Congress of Food Science and Technology, 21st – 25th August 2016 (Dublin).

Martin Danaher. Mycotoxins analysis in flour. Presented at Training Workshop Creating value in wheat and gluten-free based bakery production chain, 14 – 15 May 2015, UCC, Cork.

Lorenzo De Colli. Oral Presentation title:"Development of a multi-residue method for the analysis of mycotoxins, including masked mycotoxins, in cereal-based food by UHPLC-MS/MS". Postgraduate Symposium at Queen's University Belfast, June 2015.

Lorenzo De Colli. Oral Presentation title:"Development of a multi-residue method for the analysis of mycotoxins, including masked mycotoxins, in cereal-based food by UHPLC-MS/MS". Food Safety Department Seminar, Teagasc Ashtown Food Research Centre, September 2015.

Lorenzo De Colli, Martin Danaher and Chris Elliott. Poster title:"Development of a multi-residue method for the analysis of mycotoxins, including masked mycotoxins, in cereal-based food by UHPLC-MS/MS". 44th Annual Food Research Conference in Teagasc Moorepark, 14th December 2015.

Lorenzo De Colli, Poster title: "Mycotoxin presence in Irish oats: a preliminary investigation focusing on T-2, HT-2 and T2G". Ashtown International Advisory Board, June 2016.

Main publications:

Schmidt, M., Horstmann, S., DeColli, L., Danaher, M., Speer, K., Zannini, E., Arendt, E.K., Impact of fungal contamination of wheat on grain quality criteria. Journal of Cereal Science 69 (2016) 95 - 103.

De Colli, L., Elliott, C., Finnan, J., Grant, J., Arendt., McCormick, S.P., Danaher, M. Determination of 42 Mycotoxins in Oats using a mechnaically assisted QuEChERS sample preparation and UHPLC-MS/MS detection. J. Chromatography B. (in press 2020).

7. Compiled by:

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