Institution: Harper Adams University (HAU)		
Unit of Assessment: UoA6		
Title of case study: **Reducing fusarium mycotoxin contamination of food and feed**		
Period when the underpinning research was undertaken: 2001-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): **Professor Simon Edwards**	**Role(s) (e.g. job title):** **Professor of Plant Pathology**	**Period(s) employed by submitting HEI:** **1997-Current**
Period when the claimed impact occurred: 2013-2020		
Is this case study continued from a case study submitted in 2014? Yes		

1. Summary of the impact (indicative maximum 100 words)

Further studies since REF2014, on the impact of agronomic practices on the fusarium mycotoxin content of harvested cereals have resulted in a reduction in the exposure of these mycotoxins, improving the safety of the UK diet. This is demonstrated by a 53% reduction in the mean deoxynivalenol content and an 83% reduction in exceedances of legal limits in unprocessed wheat intended for human consumption in the UK, with an estimated annual benefit of £5.95m to UK farmers. Impacts have been extended into European Union policy by the updating of legislation on fusarium mycotoxins in human food and animal feed.

2. Underpinning research (indicative maximum 500 words)

European Commission legislation published to reduce exposure to fusarium mycotoxins

Mycotoxins are toxic metabolites produced by fungi that are harmful to humans at low concentrations. Fusarium pathogens of small grain cereals (wheat, barley and oats) produce a range of mycotoxins with deoxynivalenol (DON) being the one occurring most frequently and at highest concentrations. Other mycotoxins of concern are zearalenone, HT-2 and T-2. The primary source of DON in European diets is wheat-based products.

In 2001, the European Commission initiative "Collection of occurrence data on *Fusarium* toxins in food and assessment of dietary intake by the population of EU Member States" was established. The exposure to the mycotoxin, DON, was measured using the Total Daily Intake (TDI), which is the daily amount of a chemical that has been assessed safe for humans on a long-term basis. This pan-European study identified that exposure to the mycotoxin, DON, was generally below the TDI but in some age groups, the exposure was very close to the TDI, and, for high consumers, the TDI was exceeded.

Consequently, the European Commission (2006) published legislation to reduce the exposure of the European Union population to fusarium mycotoxins in order to protect public health.

Research development stages leading to monitoring and reducing mycotoxins

The research reported in the REF2014 case study started in 2001 as European legislation regarding fusarium mycotoxins was being drafted. The first research projects were conducted to determine whether fusarium mycotoxins were an issue in UK cereals and, if so, what agronomic practices could be modified to reduce the mycotoxins of importance[3.1, 3.2].

Results indicated that:

- on average 2.3% of samples exceeded the proposed DON legal limit for wheat intended for human consumption; and
- associated key agronomic factors included rotation, cultivation, cultivar choice and fungicide use.

The research underpinning this REF2021 case study was conducted to:

- increase the statistical strength of the models generated;
- identify new factors based on collection of additional agronomic data (eg cropping history and date of harvest)[3.3, 3.4];
- investigate particular agronomic practices under experimental conditions (eg harvest date and fungicide usage)[3.5]; and
- improve and validate the ability to predict mycotoxin risk[3.3].

The work for the REF2014 case study was conducted on wheat, barley and oats but this case study focusses on wheat as the primary source of fusarium mycotoxins in the UK diet. The final project in this case study, MyToolBox, was a Horizon 2020 project with extensive dissemination activities based around a web-based platform. This included a section on pre-harvest mitigation for which HAU was the Workpackage leader. MyToolBox developed a web-based platform, including resistant plant resources, management tools and technologies to effectively monitor and reduce the incidence of mycotoxin contaminants in crop production as well as in the food and feed supply chains[3.6]. This project enabled the dissemination of the information generated across Europe and beyond.

This work was funded by:

HGCA/FSA (2001-2005; £301K) Investigation of Fusarium mycotoxins in UK wheat production
HGCA (2007-2009; £113K) Improved risk assessment to minimise fusarium mycotoxins in harvested wheat grain
AHDB (2009-2012; £98K) Improved Modelling of Fusarium to Aid Mycotoxin Prediction in UK Wheat
HAU/Bayer CropSciences PhD Studentship (2011-2013; £51K) Impact of post-anthesis rainfall, fungicide and harvesting time on the concentration of deoxynivalenol and zearalenone in wheat
EU Horizon 2020 (2016-2020; £225K) Safe Food and Feed through an Integrated ToolBox for Mycotoxin Management (MyToolBox: Grant No 678012)

3. References to the research (indicative maximum of six references)

3.1 **EDWARDS SG**. 2006. Investigation of Fusarium mycotoxins in UK wheat production. AHDB Project Report No. 413. Available from: https://ahdb.org.uk/investigation-of-fusarium-mycotoxins-in-uk-wheat-production

3.2 **EDWARDS SG**. 2009. Fusarium mycotoxin content of UK organic and conventional wheat. Food Additives and Contaminants 26(4): 496-506. DOI: 10.1080/02652030802530679.

3.3 **EDWARDS SG**, JENNING P and PIETRAVALLE S. 2016. Improved Modelling of Fusarium to Aid Mycotoxin Prediction in UK Wheat. AHDB Project Report No. 566. Available from: https://ahdb.org.uk/improved-modelling-of-fusarium-to-aid-mycotoxin-prediction-in-uk-wheat

3.4 **EDWARDS SG** & JENNINGS P. 2018. Impact of agronomic factors on fusarium mycotoxins in harvested wheat. Food Additives & Contaminants 35: 2443-2454. DOI: 10.1080/19440049.2018.1543954.

3.5 KHARBIKAR LL, DICKIN ET & **EDWARDS SG**. 2015. Impact of post-anthesis rainfall, fungicide and harvesting time on the concentration of deoxynivalenol and zearalenone in wheat. Food Additives & Contaminants, 32: 2075-2085. DOI: 10.1080/19440049.2015.1084652.

3.6 KRSKA R, DE NIJS M, MCNERNEY O, PICHLER M, GILBERT J, **EDWARDS SG**, SUMAN M, MAGAN N, ROSSI V, VAN DER FELS-KLERX HJ, BAGI F, POSCHMAIER B, SULYOK M, BERTHILLER F, and VAN EGMOND HP. 2016. Safe food and feed through an integrated toolbox for mycotoxin management: the MyToolBox approach. World Mycotoxin Journal 9: 487-495. DOI: 10.3920/WMJ2016.2136.

The quality of the research can be judged by the journals where the work has been published. Both journals have an international profile in food science and have impact factors more than two. The six publications have been cited a total 220 times (January 2021).

4. Details of the impact (indicative maximum 750 words)

Background legislative requirements on maximum fusarium mycotoxin limits

Legislation setting maximum limits for fusarium mycotoxins has important key requirements:

1) need for Member States to generate their own national Codes of Good Agricultural Practice (GAP)
2) Member States and interested parties to communicate the results of investigations undertaken including occurrence data and progress with regard to the application of prevention measures avoiding mycotoxin contamination.
3) fusarium mycotoxin levels in cereals intended for human consumption should be as low as achievable by following GAP
4) setting maximum limits for cereals and cereal products intended for human consumption

REF2014 identified key agronomic factors and generated UK industry code of practice

Information generated from long-term observational studies (2001-2012) of mycotoxins in UK wheat by HAU identified key agronomic factors that impact on fusarium mycotoxins in small grain cereals. Based on data from these studies, HAU was commissioned by the Food Standards Agency (FSA) to generate the UK Code of GAP to reduce fusarium mycotoxins[5.1]. This document is required by EU legislation for each Member State and was disseminated to all UK cereal growers (ca. 40,000 farmers) by the FSA. The document clearly identifies the relative risk of different agronomic practices using a traffic light system of high- low risk.

Impacts REF2021

Industry guidelines on fusarium mycotoxins and risk assessment scheme

HAU collaborated with the Agriculture and Horticulture Development Board (AHDB) to generate Guidelines on fusarium mycotoxins[5.2] and the Fusarium risk assessment scheme[5.3]. Risk assessment was based on data generated in the Project Report 2.1 and modified and validated as part of Project Report 2.3 above. Historical data on access to these documents in previous years is not available but in the 2019/2020 growing season the AHDB webpage holding these documents was accessed 7023 times and the guidelines and risk assessment 4343 and 985 times respectively[5.4].

UK wheat quality assurance scheme adopted the risk assessment

The risk assessment was adopted by the Red Tractor assurance scheme (ca. 100% of UK wheat sold to mills is assured) and became a requirement of the grain passport[5.5] (this is a quality assurance/traceability document for ca. 172,000 consignments of assured wheat sold for human consumption in the UK each year).

Generated financial benefits to UK farmers

Financial benefits of this research have been estimated by AHDB[5.4] as saving £2M per annum in premium for growers of milling wheat and UKFM[5.5] consider the reduction in DON levels represents a potential retention of £5.59M of value to UK farmers each year.

Conducted extensive dissemination activities, in UK, Europe and throughout the world

Extensive dissemination activities were conducted from 2013-2019 that included numerous presentations to cereal growers, agronomists and processors, and AHDB events and publications[5.4]. Dissemination was also conducted beyond the UK with presentations at the European Commission Mycotoxin Forums and International events (European Fusarium Seminar, World Mycotoxin Forum, Nordic Baltic Fusarium Seminar) and the dissemination activities of MyToolBox. The MyToolBox website was accessed >1 million times by stakeholders from 178 countries during the 4 year duration of the project (98% non-UK)[5.6].

Contributed to updating of EU legislation and assessment of global mycotoxin exposure

All mycotoxin occurrence data generated in these studies has been submitted to the European Food Safety Authority (EFSA) database (18,288 data submissions) to allow use within EFSA risk assessments of fusarium mycotoxins (DON, zearalenone, HT-2 and T-2 toxin) within the European Union. Presentation of data to the European Commission Working Group on Agricultural Contaminants on the relative importance of meteorological and agronomic factors has directly impacted on the elaboration and ongoing updating of EU legislation on fusarium mycotoxins in food and feed[5.7].

Occurrence data has also been submitted to the WHO GEMS - Food Contamination Monitoring and Assessment Programme where global occurrence data is used in assessment of the exposure to mycotoxins across the world. For example, HT-2 and T-2 toxin data were used to assess the global population exposure to these toxins at the 90th Joint FAO/WHO Expert Committee on Food Additives[5.8].

Reduction in UK consumer exposure to fusarium mycotoxins since code of practice introduced

A comparison of UK mycotoxin levels in wheat samples collected between 2001-2005 with samples collected by industry between 2016-2020 allowed an assessment of the UK consumer exposure to this mycotoxin before and after the generation and dissemination of Good Agricultural Practice to reduce fusarium mycotoxins. The average number of wheat samples exceeding the legal limit of 1,250ppb has decreased from 2.3% to 0.4%. (83% reduction)[5.9]. This has resulted in a reduction in both the chronic and acute exposure of the UK population to Fusarium mycotoxins with a corresponding reduction in risk of associated health impacts.

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Anon* 2007 The UK Code of Good Agricultural Practice to Reduce Fusarium Mycotoxins in Cereals. Food Standards Agency. Available from: https://www.food.gov.uk/sites/default/files/media/document/fusariumcop.pdf

5.2 Anon* 2016 Guidelines to minimise the risk of fusarium mycotoxins in cereals. AHDB. Available from: http://projectblue.blob.core.windows.net/media/Default/Imported%20Publication%20Docs/Guidelines%20to%20minimise%20the%20risk%20of%20fusarium%20mycotoxins%20in%20cereals.pdf

5.3 Anon* 2018 Risk assessment for fusarium mycotoxins in wheat. AHDB. Available from: https://projectblue.blob.core.windows.net/media/Default/Imported%20Publication%20Docs/Risk%20assessment%20for%20fusarium%20mycotoxins%20in%20wheat.pdf

5.4 Bhandari D 2021Testimony supplied by the Agriculture and Horticulture Development Board

5.5 Anon 2018 Passport poster guidance. AIC. Available from: https://www.agindustries.org.uk/sectors/grain-and-oilseed/resources/grain-passport.html

5.6 Pichler M 2021 Testimony supplied by the International Association for Cereal Science and Technology

5.7 Verstraete F 2021 Testimony supplied by European Commission DG Sante

5.8 Anon* 2020 Summary report of the Ninetieth Meeting of JECFA. Available from: https://www.who.int/foodsafety/publications/jecfa-summary/en/

5.9 Brennan J 2021 Testimony supplied by UK Flour Mills

*Professor Simon Edwards was sole author of 4.1, provided all data and was a co-author of 4.2 and 4.3 and was lead author for the HT2 and T2 section of 4.8.