Biotechnology and Biological Sciences Research Council

Improved food safety through policy change

BBSRC-funded research has informed international food safety law for the food contaminant acrylamide. Researchers at Rothamsted Research, an Institute strategically funded by BBSRC, studied ways to reduce acrylamide formation in food. Their advice has been adopted by the European Commission to regulate agronomy and food manufacturing practices.

The Food Standards Agency recommends aiming for a golden colour when frying, baking, roasting or toasting to reduce acrylamide formation in high-risk foods.

Acrylamide is a food contaminant classed as a probable human carcinogen. It forms when foods such as potatoes, beans and cereals are cooked at high temperatures over 120°C[1], specifically when they are baked, fried, roasted or toasted. The contaminant was discovered in 2002 and was found to form during the Maillard reaction, the same reaction that gives these foods their flavour, colour and smell. Longer cooking times and higher temperatures can lead to greater acrylamide production.

"Acrylamide is not present in the crop, but it forms during cooking and processing. It forms from free (non-protein) asparagine and sugars, which are naturally present in grains, tubers, beans and other crops," explains principal investigator Professor Nigel Halford.

The amino acid asparagine and sugars are acrylamide precursors, with a direct link between their levels in raw ingredients and the amount of acrylamide in the cooked products. Asparagine concentration determines how much acrylamide forms in wheat products, whereas in potatoes it is determined by sugar levels.

In 2005, Halford was awarded a BBSRC Responsive Mode grant, supported by the Food Standards Agency, sparking an ongoing in collaboration with Professor Donald Mottram and Dr Steve Elmore at the University of Reading. The team studied how to reduce acrylamide formation in potato- and cereal-based foods. In this and later projects they studied varietal differences, growing practices and acrylamide precursors, and found that sulphur depletion, disease and excess nitrogen all cause higher asparagine levels in wheat grain. This led to the European Commission introducing new regulations to ensure wheat is grown with good disease control, enough sulphur, and without too much nitrogen.

"It's really important that food businesses are provided with a crop raw material with less potential for acrylamide formation. That would mean they could comply with regulations without making changes to their processes, which would be very expensive," says Halford. "If we can get asparagine down, specifically, then food businesses may be able to comply with acrylamide regulations while retaining the quality of their product."

Halford went on to study how to produce low acrylamide risk potatoes by looking at genetic and varietal differences, and the effects of growing and storage conditions on sugar content. The Defra Sustainable Arable Link project, funded by BBSRC[2], had several industry partners including Kettle Foods Ltd, PepsiCo and Tesco. They found that storage conditions have a big impact on sugar formation, and that using the right potato variety for a product is vital. As a result, in 2018 the European Commission revised its rules on potato storage to reduce sugar accumulation in potatoes. The findings were also used by crisp and French fry manufacturers to adapt their processes and reduce acrylamide formation in their products.

IMPACT SUMMARY

Food safety advice from BBSRC-funded research has informed international laws on acrylamide. Acrylamide is a probable carcinogen which forms in foods made from potatoes, cereals and beans (including coffee) when they are cooked at temperatures over 120°C.

Professor Nigel Halford and Dr Tanya Curtis at Rothamsted Research, an Institute strategically funded by BBSRC, used a series of BBSRC grants to study acrylamide formation. The research involved industry collaborations including with Kellogg's, Nestlé and Tesco, and informed the European Commission's regulations for benchmark levels of acrylamide and practices for reducing acrylamide formation.

A BBSRC Follow-on Fund Pathfinder award supported the establishment of start-up company Curtis Analytics Ltd in 2017, enabling Curtis' transition to company Director. The company now employs seven people and provides an asparagine testing service for food manufacturers to ensure their products meet food safety standards.

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From PhD student to company director

Dr Tanya Curtis started researching acrylamide in 2006, on a HGCA[‡]/BBSRC -funded studentship with Professor Nigel Halford at Rothamsted Research and Professor Donald Mottram at the University of Reading. She continued in Halford's team as a postdoctoral researcher on his BBSRC LINK project studying the acrylamide-forming potential of wheat.

BBSRC Pathfinder funding helped Curtis establish start-up company Curtis Analytics in 2017 to help food manufacturers reduce acrylamide in their products.

Curtis has also set up a second company, Ryeharvest, to manufacture edible film for cereal bars, and is hoping to start another based on her asparagine instant testing technology.

"I really believe that more scientists should go into business. I think that will speed up the development of better products and services," says Curtis. "Without BBSRC I don't think I would have achieved any of this. It's been vital for the existence of Curtis Analytics."

[‡]Home-Grown Cereals Authority, now AHDB

A further LINK grant[3], with partners including Kellogg's, Weetabix and Nestlé, supported genetic studies into reducing wheat's acrylamide-forming potential. The project revealed useful information on the genetic and environmental factors that influence asparagine accumulation, and about how asparagine levels vary between wheat varieties. This is being used by industry partners to control acrylamide formation in their products, and by wheat breeders to identify lines of wheat which show promise for breeding low-asparagine varieties.

Halford and postdoctoral researcher Dr Tanya Curtis realised that providing an asparagine testing service could help food manufacturers ensure their products meet food safety standards. They engaged a technology management consultancy using a BBSRC Follow-on Funding Pathfinder award[4], who confirmed the viability of the business model. Start-up company Curtis Analytics[5] was established in 2017 with Dr Curtis as director. "If I hadn't done the work with BBSRC, I don't think I would have achieved the level of expertise I have with acrylamide and asparagine analysis, and I wouldn't have had the links with industry to set up the business," she says.

The company now employs seven people and measures acrylamide in finished products, and asparagine and sugars in raw ingredients to determine their acrylamide-forming potential. "After testing, we continue working with our clients, looking at their ingredients and where asparagine is found, so we can advise them where the problem is and how they can mitigate it," says Curtis.

"One company has reduced asparagine levels by about 80%, and another has reached negligible levels of asparagine." The test takes just a few days, but Curtis is also working on a portable Asparagine testing device, which will allow rapid 'at-the-gate' asparagine testing so that manufacturers can decide whether a wheat crop is suitable for their products.

Halford and his colleagues are continuing to work on genetic and agronomic techniques to produce wheat grain with lower asparagine levels using two BBSRC-funded studentships[6,7], In one of the studentships, project partners Mondelez will produce baked goods to ensure product quality can be maintained when using low-asparagine wheat flour. Curtis Analytics are still working closely with Rothamsted Research, including analysing gene edited wheat lines. Halford hopes to test these lines in the field experimentally, under controlled conditions. "We appear to have lines with ultra-low asparagine levels, which is really exciting," says Halford. "There is a long way to go but potentially they could lead to wheat products with lower acrylamide levels and therefore improved food safety. I think it's really important that the public understand that biotechnology can be about consumer benefits and, in this case, food safety."

Curtis Analytics Ltd, established by Dr Tanya Curtis with help from BBSRC Pathfinder funding, helps food manufacturers reduce acrylamide in their products. Image: Curtis Analytics

REFERENCES

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