Final Project Summary

Effect of sulphur fertilisation on the acrylamide-forming potential of wheat

Project number	217-0001	**Final Project Report**	PR525
Start date	July 2013	**End date**	October 2013
HGCA funding	£7,978	**Total cost**	£7,978

What was the challenge/demand for the work?

Wheat products are major contributors to dietary intake of acrylamide, a processing contaminant that forms from asparagine (an amino acid) and sugars during baking. Acrylamide is considered to be ‘probably cancer-causing’ by the International Agency for Research on Cancer, and also affects the nervous system and fertility at high doses. The FAO/WHO Expert Committee on Food Additives has recommended that dietary exposure should be reduced and the European Food Safety Authority issued ‘indicative’ levels for acrylamide in food in early 2011.

The food industry has learnt much about how acrylamide forms and devised many methods to reduce the presence of acrylamide in foods by changing their cooking and processing conditions. However, these methods are only applicable in some products, and the food industry also remains vulnerable to fluctuations in the acrylamide-forming potential of its raw materials, including wheat grain, so is pressing its supply chain to do more to address the problem. The development of best agronomic practice to keep wheat’s acrylamide-forming potential as low as reasonably achievable is therefore extremely important.

The amount of acrylamide that forms when wheat flour is baked is determined by the concentration of asparagine, and asparagine accumulates to very high levels if wheat is grown under conditions of sulphur deficiency. This makes sulphur availability the most important factor affecting the acrylamide-forming potential of wheat grain. The aim of this project was to provide data on acrylamide formation in flour from grain samples produced from six field trials in which different levels of sulphur had been applied, so that advice could be provided on the optimum levels of sulphur application to keep the potential for acrylamide formation to a minimum.

How did the project address this?

Fine, wholemeal flour was available from grain produced in field trials of four different varieties of winter wheat, grown at three different locations over three harvest years (Table 1). In each trial, sulphur (S) had been applied at five different levels as potassium sulphate (46 % SO_3; 54 % K_2O) in the early spring at similar timing to the first nitrogen application. The five S levels were 0, 12.5, 25, 50 and 75 kg SO_3 per hectare (corresponding to 0, 5, 10, 20 and 30 kg S per hectare). N and P fertilisers were applied at rates recommended in the Fertiliser Manual (RB209).

Asparagine concentrations were measured by the analytical technique of gas chromatography and mass spectrometry (also known as GC-MS). Acrylamide formation was induced by heating flour for 20 minutes at 170 °C and measured by a similar technique of liquid chromatography and tandem mass spectrometry (LC-MS/MS). The results were analysed statistically.

Table 1. Details of field trials that provided flour for the study

Year	Site	Soil texture	Variety
2009/10	Brockhampton (Herefordshire)	Sandy loam	Alchemy
2010/11	Brockhampton (Herefordshire)	Sandy loam	Panorama
2009/10	Frostenden (Suffolk)	Sandy loam/loamy sand	Viscount
2011/12	Frostenden (Suffolk)	Sandy loam/loamy sand	Viscount
2010/11	Woburn (Bedfordshire	Sandy loam	Oakley
2011/12	Woburn (Bedfordshire)	Sandy loam	Oakley

What outputs has the project delivered?

The results showed a clear and statistically significant effect of sulphur (S) application in reducing the acrylamide-forming potential of wheat in five of the six trials (Figure 1). The exception was a trial at Woburn, Bedfordshire in 2011/12; a year in which heavy rainfall in spring and early summer, followed by a dry mid to late summer, may have affected the outcome of the experiment. The overall means for acrylamide formation in flour for the different levels of SO_3 application over all of the site, variety and year combinations are presented graphically in Figure 2 and show the optimum level of SO_3 application to be 50 kg/ha (20 kg S/ha).

The Fertiliser Manual recommends the application of 25 – 50 kg/ha SO_3 for wheat, with the higher end of this range thought to be necessary for high yields and to ensure protein quality of bread-making varieties. For reducing acrylamide formation, overall the benefit of applying 50 kg/ha of SO_3 compared with 25 kg/ha was modest. However, at Woburn in 2010/11 with variety Oakley, applying 50 kg SO_3/ha instead of 25 kg SO_3/ha reduced acrylamide formation by 40 %, while at Brockhampton in the same year with variety Panorama it reduced acrylamide formation by 44 %. Given the necessity of preventing free asparagine accumulation in all conditions, without the benefit of hindsight, it is therefore recommended that sulphur-containing fertiliser be applied at a rate of 50 kg SO_3/ha (20 kg S/ha). This rate of sulphur application will keep acrylamide-forming potential as low as reasonably achievable, and should be used regardless of yield and other quality issues.

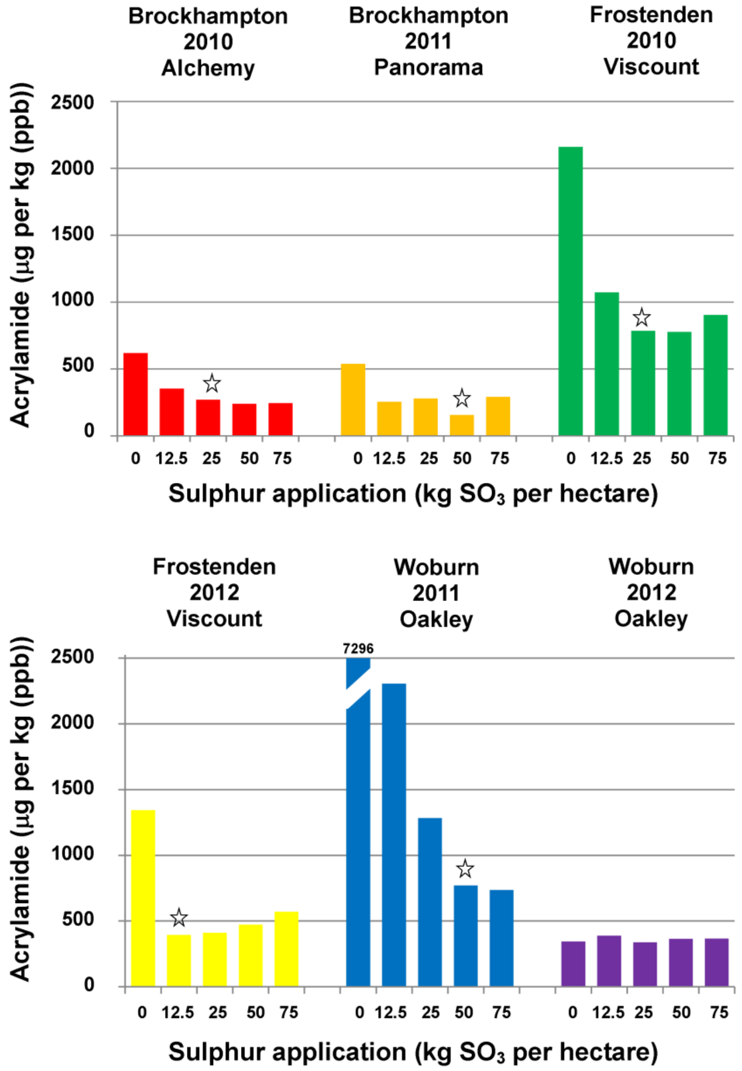

Figure 1. Acrylamide formed in wholemeal flour heated for 20 minutes at 170 °C. The flour was prepared from grain samples of four varieties of wheat (Alchemy, Viscount, Oakley and Panorama) produced at three different sites (Brockhampton, Frostenden and Woburn) over three years (2009/10, 2010/11 and 2011/12) with five different levels of sulphur application, as indicated. The star symbol indicates the lowest amount of sulphur application that gave a significant reduction in acrylamide formation compared with the 0 kg SO_3 sample, with no further significant reduction with higher SO_3 application.

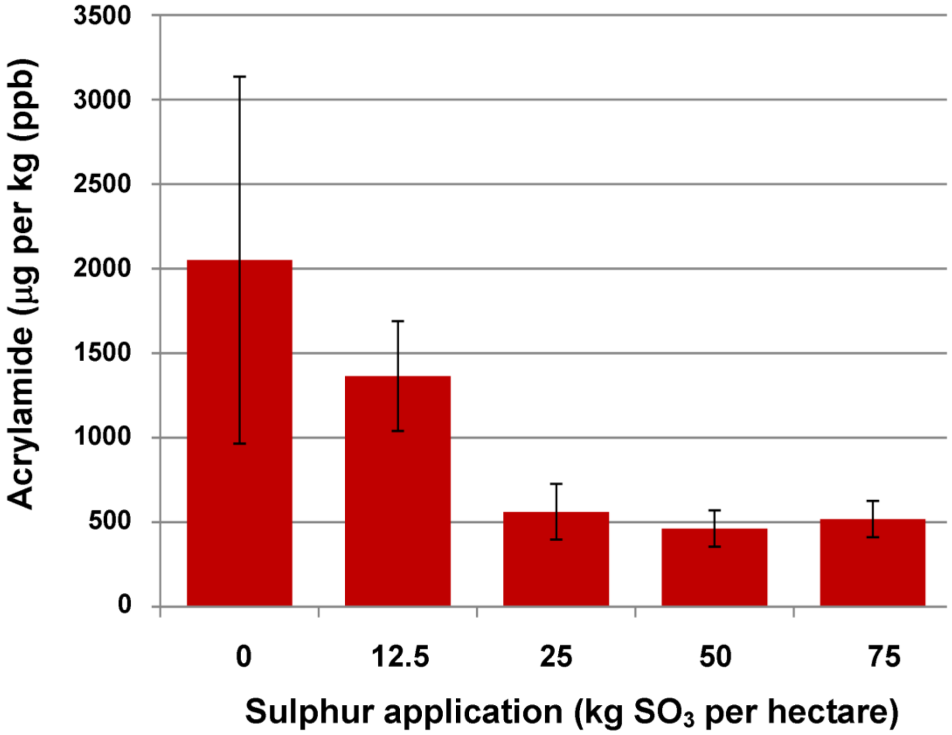

Figure 2. Acrylamide formation averaged for all combinations of variety, site and year, with standard errors, for five levels of applied S (SO_3).

Who will benefit from this project and why?
Farmers will be able to demonstrate to their food industry users that they are adopting methods to reduce the potential for acrylamide formation in wheat products, backed up by scientific research. If the advice is followed, food processors will not have to deal with consignments of wheat grain that have unusually high levels of asparagine because the wheat has not been supplied with adequate amounts of sulphur, making it easier for them to comply with current indicative levels for acrylamide and the evolving regulatory situation. Keeping the acrylamide-forming potential of wheat as low as is reasonably achievable will make it less likely that the regulatory situation will be tightened up, and reduce the incentive for food processors to substitute wheat with other raw materials in products where that might be possible.

If the challenge has not been specifically met, state why and how this could be overcome
Not applicable

Lead partner	Nigel Halford, Rothamsted Research
Scientific partners	
Industry partners	PepsiCo International Ltd
Government sponsor	