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Acrylamide in Food: Why is it there? Is it a problem? What can be done?



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11 June 2013




LIVSMEDELSVERKET
NATIONAL FOOD ADMINISTRATION

24 April 2002
Swedish National Food Administration
and University of Stockholm

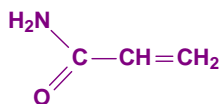
Reported acrylamide in fried and baked
foods at levels up to 3000 ppb

Published on website

Tareke, et al., *J. Agric. Food Chem.*, 2002, 50: 4998-5006.



What is Acrylamide and Why Worry?



Acrylamide (2-propenamide)

- Industrial chemical used in production of polymers
- Known to be a neurotoxin
- W.H.O. classify as "probable human carcinogen"
- Carcinogenic in animals at high doses
- Found in cereal and potato products at levels up to 5 ppm

Food Products containing High Concentrations of Acrylamide

Food product	µg/kg (ppb)
potato, French-fried	200 – 12,000
potato chips, crisps	170 – 3,700
potato, puffs, deep-fried	1,270
potato, boiled	nd
biscuits, crackers	nd – 3,200
snacks, other than potato	nd – 1,915
gingerbread	90 – 1,660
cereals, breakfast	nd – 1,346
crispbread	800 – 1,200

M. Friedman, *J. Agric Food Chem.* 2003, 51: 4504-4526

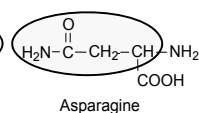
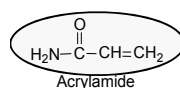
Toxicology of Acrylamide

- Carcinogen in laboratory animals
 - above 2 mg/kg body wt/day
 - has been shown to form DNA adducts
- Neurological damage
 - in animals
 - in humans exposed to high levels through industrial exposure
- Carcinogen in humans?
 - Not proven
 - can form haemoglobin adducts (via glycidamide) but no DNA adducts reported
- W.H.O. classify as "Probable human carcinogen"

Origin of Acrylamide in Fried and Baked Food



- Requires high temperature cooking conditions
- Maillard reaction** involving **asparagine** and sugars is the major route

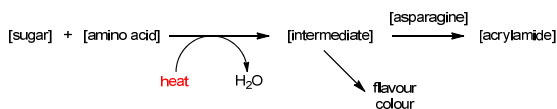


Asparagine in Plant Foods

	Free Asparagine (mmol/kg)	Asparagine (% total amino acids)
Potato flakes	27	38%
Rye flour	4.8	26%
Wheat flour	1.3	16%

- Asparagine is essential in plants, providing source of nitrogen for protein synthesis
- Seeds and tubers contain high levels of free asparagine as nitrogen store for plant during early growth

Some strategies for reducing acrylamide in cooked foods



- Modify time/temperature of cooking
- Remove precursors (sugar & asparagine)
- Modify reaction with antioxidants and other reagents
- All these could also affect flavour and colour

Asparaginase

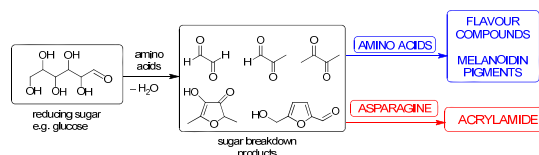
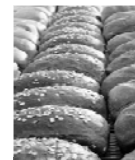
- Naturally-occurring enzyme which converts asparagine to aspartic acid
- Can be used in foods to lower level of asparagine prior to cooking
- Two products are now commercially available
- Applicable to food products which involve dough process (biscuits, bread, crispbread)
- Not easily applied to potato products such as crisps and fries and not applicable to home or restaurant cooking.

The Maillard Reaction in Foods

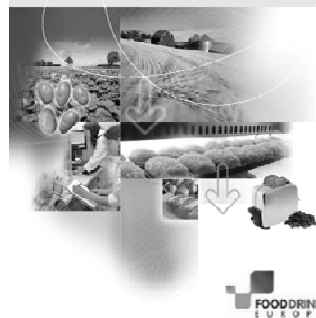


Reaction between Amino Acids and Reducing Sugars

- Produces aromas in heated foods
- Responsible for colour formation (non-enzymic browning)



Food Drink Europe Acrylamide Toolbox 2011



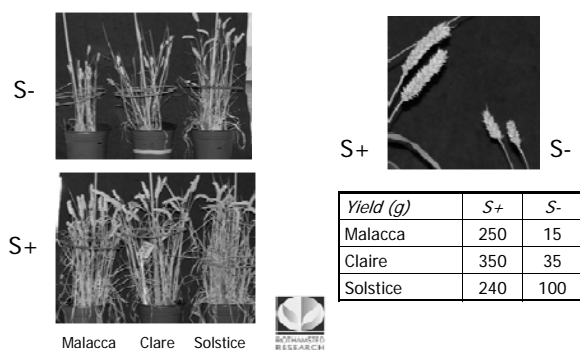
The "Toolbox" is the result of several years of industry cooperation in the food industry to understand acrylamide formation and potential intervention steps.

Toolbox is freely available to all food producers to provide means of reducing acrylamide in food.

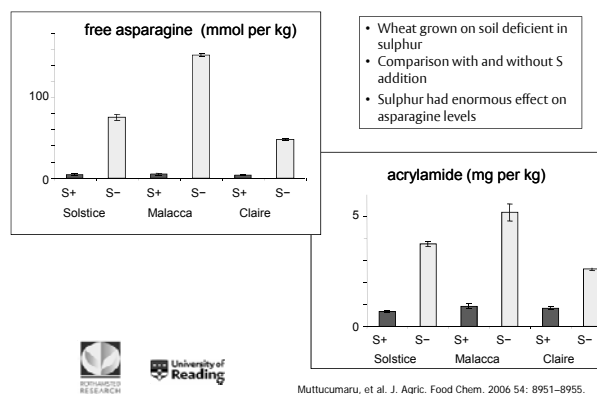
How can we change raw material composition?

- Plant nutrition
 - sulphur and nitrogen fertilisation can affect free asparagine levels
- Genetics
 - varieties containing low amounts of asparagine
 - less acrylamide, yet full flavour and colour
 - varieties of potatoes which are less susceptible to cold-sweetening (sugars from starch during cold storage)
 - Acrylamide-forming potential reduced in stored potatoes

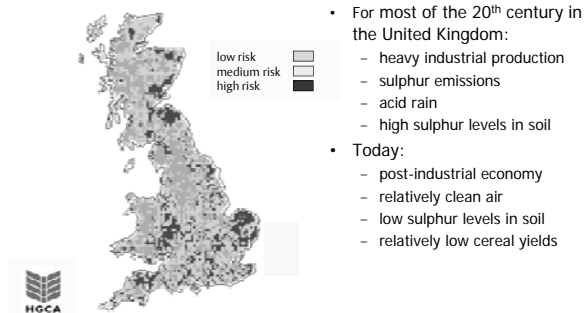
Yields for wheat grown with and without sulphate fertiliser



Acrylamide and asparagine in wheat

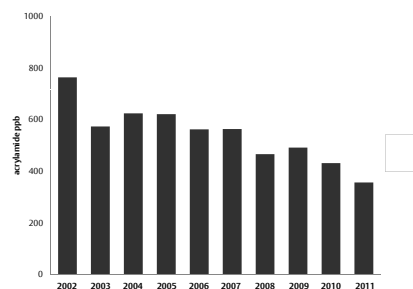


Sulphur deficiency risk in UK cereals



Acrylamide found in commercial potato crisps 2002 - 2011

Data obtained from over 45,000 samples analysed since acrylamide first discovered in food



Summary

- Acrylamide is the biggest issue in Food Science for many decades
- The Maillard reaction is the route to acrylamide in cooked foods
- The same reaction is responsible for desirable flavour and colour in these cooked foods
- Many of the approaches to reducing acrylamide affect the whole Maillard reaction
- Food industry has collaborated in an unprecedented way to mitigate the problem.
- Key question is "how to reduce acrylamide without adversely affecting flavour and colour?"
- Agronomy and plant breeding offer some longer term solutions

Some references

- Food Standards Agency
http://food.gov.uk/policy-advice/acrylamide_branch/
- Food Drink Europe Acrylamide Toolbox
http://ec.europa.eu/food/food/chemicalsafety/contaminants/ciaa_acrylamide_toolbox_09.pdf
- Mottram D S, Wedzicha B L and Dodson A T (2002), Acrylamide is formed in the Maillard reaction, *Nature*, **419**, 448-449.
- Mucci L A and Wilson K A (2008), Acrylamide intake through diet and human cancer risk, *Journal of Agricultural and Food Chemistry*, **56**, 6013-6019.
- Friedman M and Levin C E (2008), Review of methods for the reduction of dietary content and toxicity of acrylamide, *Journal of Agricultural and Food Chemistry*, **56**, 6113-6140.