Use of the FoodDrinkEurope Toolbox in Acrylamide mitigation

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I. Background on acrylamide in food
II. Risk management issue
III. Explanation of the risk management concept of ALARA (As Low As Reasonably Achievable)
IV. Food industry “Toolbox”
V. Savoury snacks “Toolbox”
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I. **Background on acrylamide in food**

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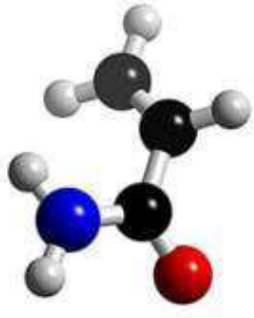
What is Acrylamide?



- An organic chemical compound used in a variety of industrial applications, including the production of plastics, the preparation of polyacrylamide gels used in laboratories, water treatment, soil treatment and cosmetics.

- **<u>Known neurotoxin and genotoxic carcinogen</u>**

- Maximum levels for acrylamide concerning food contact materials, water and grouting applications exist as indicators of improper use:
  - Limit of migration from materials in contact with food: Absent at Detection Limit: 10 µg/kg (EU)
  - Drinking water: Maximum limit 0.1 µg/litre (WHO)
  - 0.1% by weight for grouting applications (EU REACH)

Discovered in food in 2002

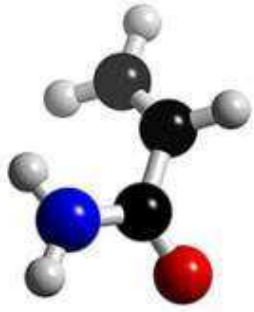
- Researchers in Sweden announce the discovery of acrylamide in common cooked food items, such as potato products, bread, coffee and cereal.

- Some cooked foods subsequently found to contain acrylamide at levels at up to 5 000 µg/kg.

- Will have been present in diets since man first started to cook.

SNACKEX 2013

How is it Formed?



- Forms naturally in starchy foods as a result of heating
- In both commercial and domestic, traditional and modern, cooking processes

- The Maillard / browning reaction during cooking has been confirmed as the major formation route, where:

Fructose/glucose + asparagine $\xrightarrow{\text{Heat}}$ acrylamide

- Amount of acrylamide formed depends on:
  - Available levels asparagine and reducing sugars (fructose, glucose, …)
  - Temperature and Cooking time (total thermal input)
  - Ultimate finished product moisture

Health concern?

- **Risk assessments** indicate a human health concern for acrylamide in food:
  - WHO/FAO JECFA in 2005 and 2010
  - USA FDA National Toxicology Program (NTP) report 2011 confirms tumour formation in animals - implications for human health still unclear
  - New EFSA risk assessment in progress (deadline 30 June 2015)

- **Epidemiology: still very unclear**
  - occupational exposure – two major studies do not support relationship
  - some limited evidence for cancer risk in specific sites
  - conflicting reports for some cancer types

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Active Regulatory Risk Management Issue

CODEX Alimentarius

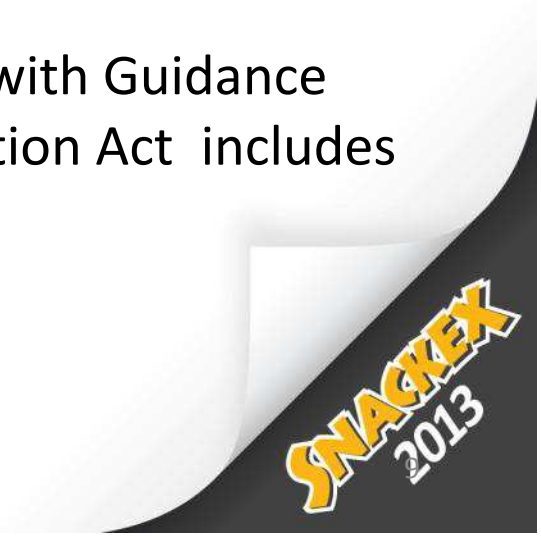
- Code of Practice for Reduction of Acrylamide in Food (CAC/RCP 67-2009)

  http://www.codexalimentarius.net/download/standards/11258/CXP_067e.pdf

- Plan to revisit Acrylamide after allowing time for the current Code of Practice to be taken up

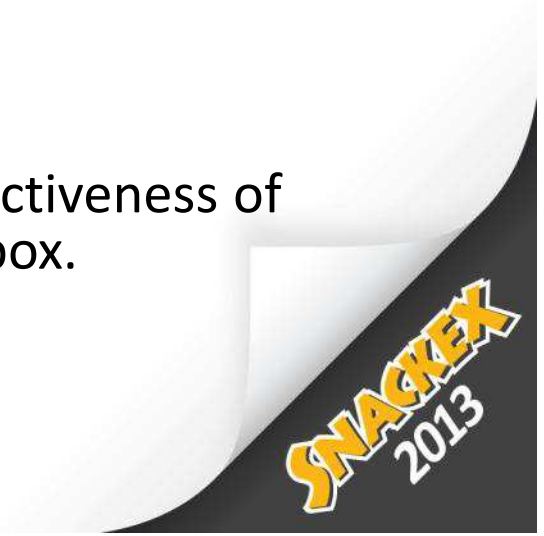
Ex-EU

- US FDA - In-market monitoring underway in 2011 with Guidance planned to be issued; new Food Safety Modernization Act includes Hazard Analysis plans for contaminants
- Asia Pacific - focused on Codex Code of Practice
- Latin America - focused on Codex Code of Practice



Commission Recommendation 2007/331/EC

- MS to monitor products at the market level or at production sites.
- Sets basic products, sample numbers and frequencies, and analytical requirements
- Specific information to be provided: starting material fresh potatoes or pre-fabricates, addition of other ingredients, flavours or additives.
- Reported once a year to EFSA.
- Results will be evaluated in order to assess the effectiveness of voluntary measures i.e. the FoodDrinkEurope Toolbox.
- Extended indefinitely by 2010/307/EU



Commission Recommendation of 10.1.2011 on investigations into the levels of acrylamide in food

- Sets “indicative values” based on EFSA monitoring 2007-2008

  Potato crisps – 1000 µg/kg

  Soft bread – 150 µg/kg

  Biscuits, crackers, wafers – 500 µg/kg

- Recommends Member States “...carry out further investigations into the production and processing methods used by food producers.. ”.

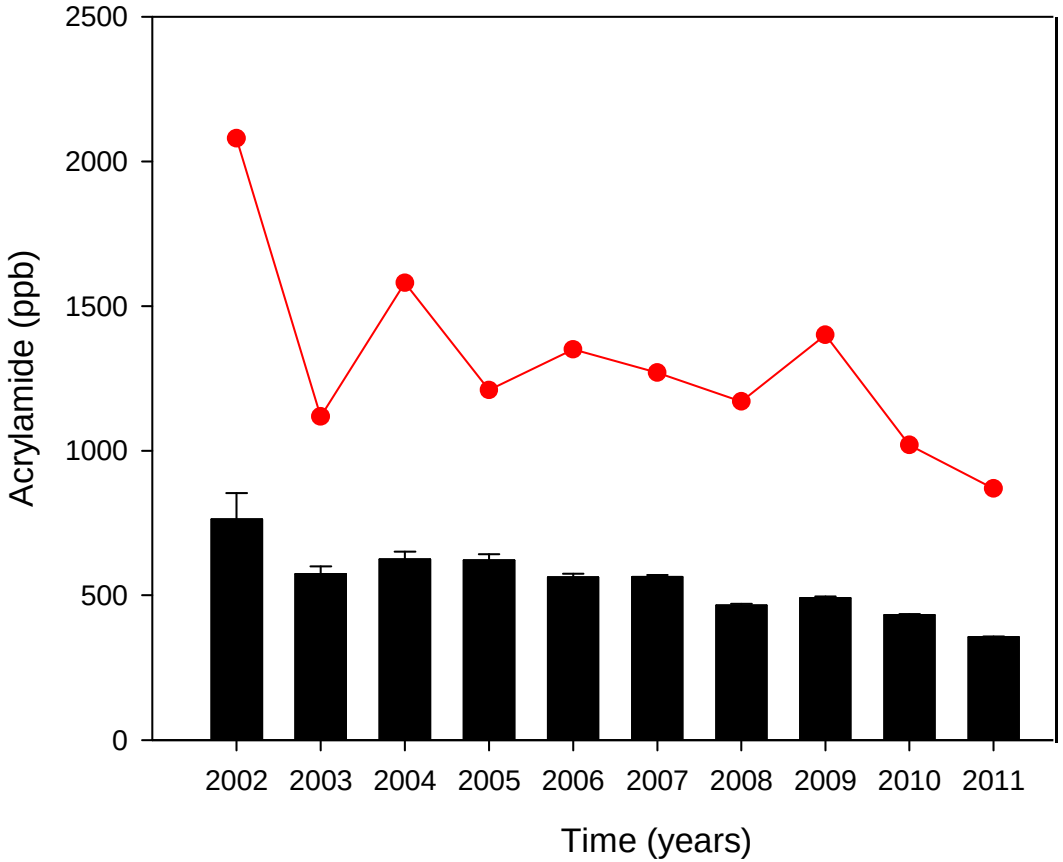
- Levels currently under review - no changes proposed for potato crisps

Annual EFSA Reports

- October 2012 report - Total 1 481 samples potato crisps
  - 2007 Max detected 4 180 µg/kg (Mean 551 µg/kg)
  - 2008 Max detected 4 382 µg/kg (Mean 580 µg/kg)
  - 2009 Max detected 4 804 µg/kg (Mean 639 µg/kg)
  - 2010 Max detected 4 533 µg/kg (Mean 675 µg/kg)

- October 2012 report - Total 243 samples non-potato savoury snacks
  - 2007 Max detected 2 110 µg/kg (Mean 275 µg/kg)
  - 2008 Max detected 2 120 µg/kg (Mean 238 µg/kg)
  - 2009 Max detected 621 µg/kg (Mean 208 µg/kg)
  - 2010 Max detected 1 910 µg/kg (Mean 192 µg/kg)

ESA Data: Overall trend



Mean acrylamide levels with standard errors (black) and trend in 95% (Q95) (red) quantile over years

- **General trend:** Overall decrease in the Mean from 763 (± 91.1) ppb in 2002 to 358 (± 2.5) ppb in 2011; a reduction of 53%.

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“ALARA”

- **The risk management concept of “As Low As Reasonably Achievable” (ALARA)** simply means that a Food Business Operator should take appropriate measures to reduce the presence of a given contaminant in a final product to a minimum
- **Efforts to achieving “ALARA” management should take account of**
  - Feasibility and effectiveness of proposed controls
  - Potential risks from other contaminants through new / changed conditions e.g. reduced microbial controls at lower thermal input, production of other by-products
  - Organoleptic properties and quality of the final product
- **To ensure continuing compliance with “ALARA” risk management**
  - Monitor the effectiveness of the implemented measures
  - Review them as necessary

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Sharing Knowledge / Informing Industry

Similar Technologies
Similar processes and equipment e.g. extruding breakfast cereals similar to extruding a savoury snack

Similar Ingredients
Similar raw materials from same supply chain e.g. potato and cereal flours

The following trade associations are committed to sharing knowledge and informing industry partners about AA mitigation:

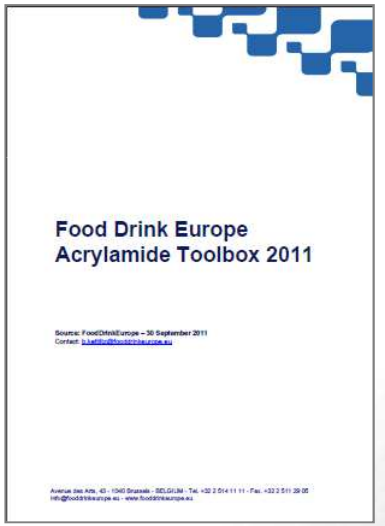
FoodDrinkEurope, European Snacks Association (ESA), Association of Chocolate, Biscuit and Confectionary Industries of the EU (CAOBISCO), International Association of Plant Bakeries (AIBI), European Potato Processors' Association (EUPPA), European Cereal Breakfast Association (CEEREAL) .

Acrylamide “Toolbox”

- Lists the status of potential Acrylamide mitigation tools in a range of food categories http://ec.europa.eu/food/food/chemicalsafety/contaminants/acrylamide_en.htm

- First published 2005, revised 2008 and latest revision published September 2011 (further revision in 2013)

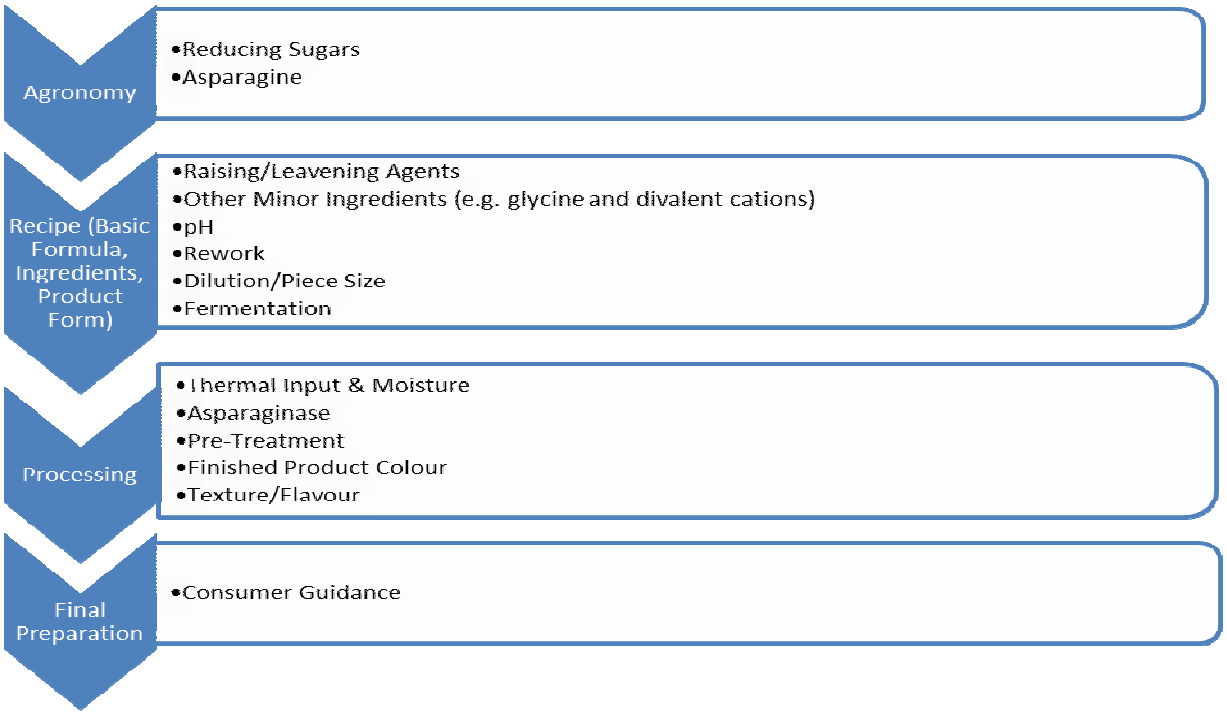
- Forms basis for CODEX Code of Practice for the Reduction of Acrylamide in Foods (CAC/RCP 67-2009)

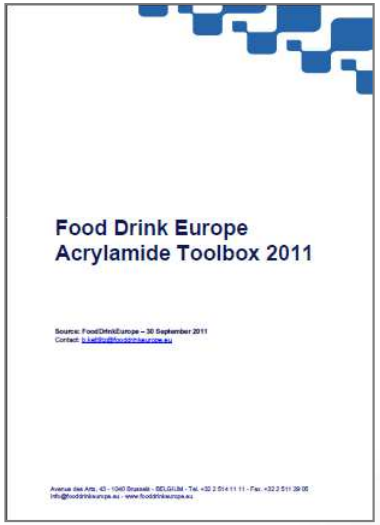


Webinars: https://www.fdf.org.uk/keyissues.aspx?issue=646

Acrylamide “Toolbox”

- The “Toolbox” is arranged in sections according to where different mitigation tools can be applied, with comments and examples

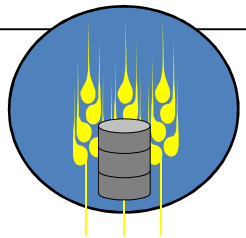


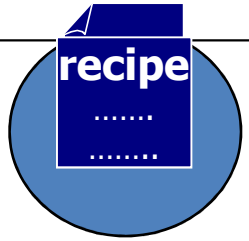


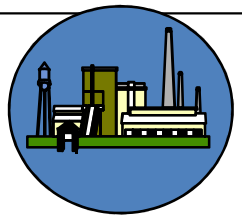
- Each tool is classified according to its stage / status of development - Laboratory , Pilot or Industrial Scale

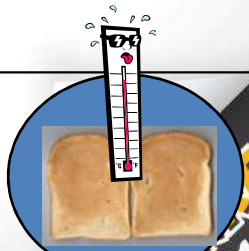
One-page pamphlets

Pre-Requisite Considerations	Raw Materials	Recipe Design	Process Design	Finished Product Attributes
	• Only use suitable (low sugar) potato varieties. • Store environment controlled for temperature (> 6° C) and humidity. • Sprouting suppressed in stored potatoes using CIPC. • In-coming potatoes checked at plant.	• Some pre-processed ingredients may already contain high levels of acrylamide which could impact upon levels in the final product. • Thicker cut crisps may result in increased acrylamide levels as they require higher thermal input to create the end product. • Use of some ingredients may, in addition to flavour, compensate for lighter coloured crisps by providing additional colour	• Optimised and strictly defined cooking conditions (management of oil / temperature / dwell time) to produce a product with a golden yellow colour. • In-line feedback of cooking dependent on moisture content. • In-line post fryer colour / defects rejection. • Washing potato slices in warm / hot water to remove excess sugars. • Adequate peeling: Reducing sugars can be higher in the peel layer of some varieties.	• Off-line testing for colour. (Target light golden colour)









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Raw Materials: Potato Variety and Supply Tools

Agronomics

- Fertility impact on AA
- Variety screening, development and optimisation
- Introduction of sugar stable varieties (Right Variety Right place Right Time)

Harvest Techniques

- Optimised time of harvesting
- Chemical maturity analysis (vine kill and storage data)

Storage Conditions

- Variety specific storage optimisation
- Defect and Bruise free handling
- Storage ventilation and temperature optimisation
- Storage facility survey
- Crop storage monitoring

Transportation

- Transportation Optimisation - test from farm to plant (mode, air temp, duration, plant unloading techniques)
- Inventory optimisation

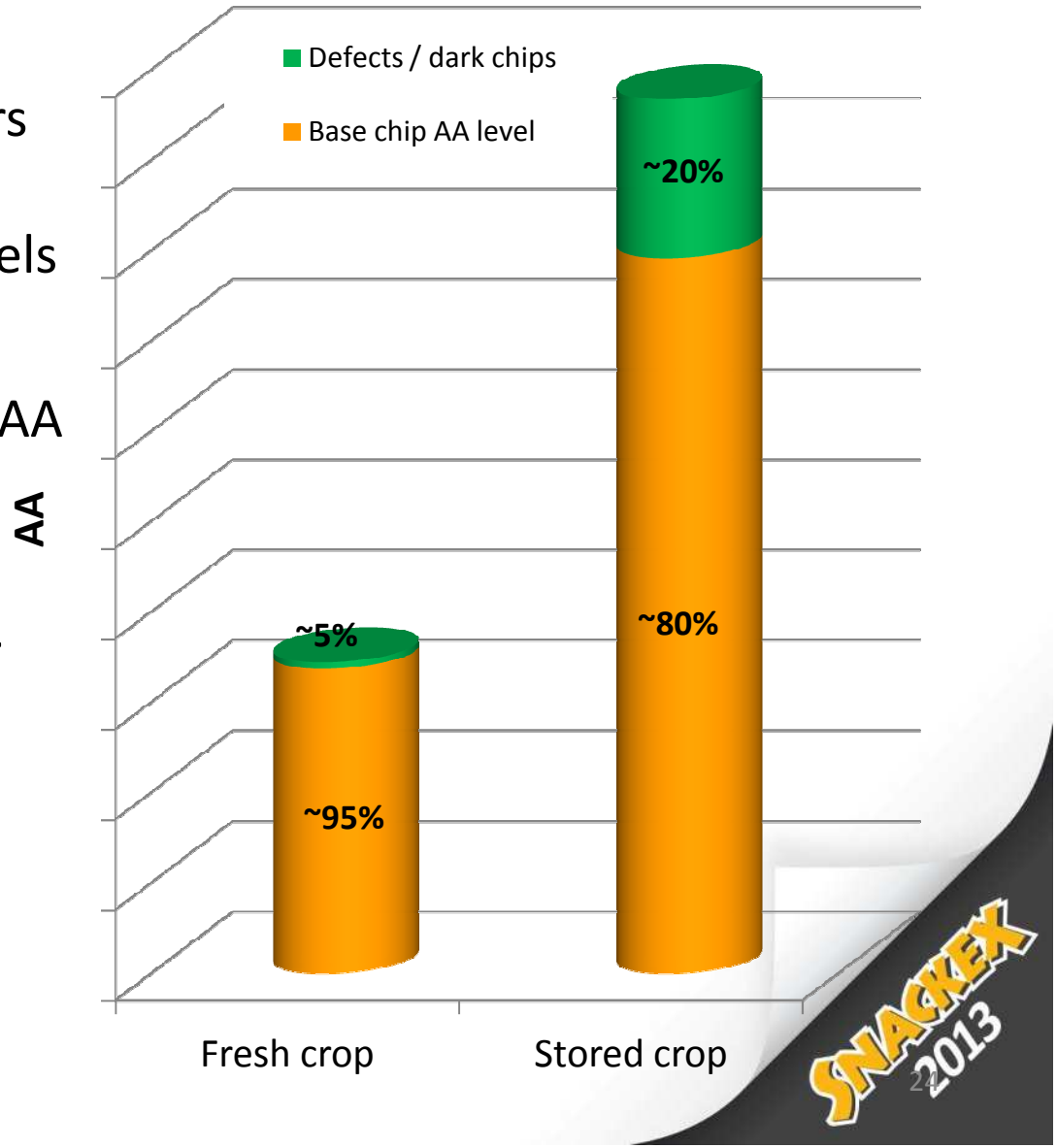
Plant Handling

Raw Materials: Recommendations for Storage Good Practice

- Avoid using potatoes stored below 6°C
- Transport from farm to factory at temp. > 6°C for long storage.
- Use of sprout suppressants following Good Agricultural Practice.
- Reconditioning at higher temp. (e.g. ambient) over a period of a few weeks
- Lot selection based on reducing sugars content.

Base Sugar Levels are large contributor to AA

- Storage impact on base sugars can be large and lead to significantly increased AA levels
- Defects contribute to overall AA levels in potato crisps
- Defects that are high in sugar are the primary concern
- Defects vary by size, quantity and intensity



Optimal Potato Supply
Ultimate solution, long timeline

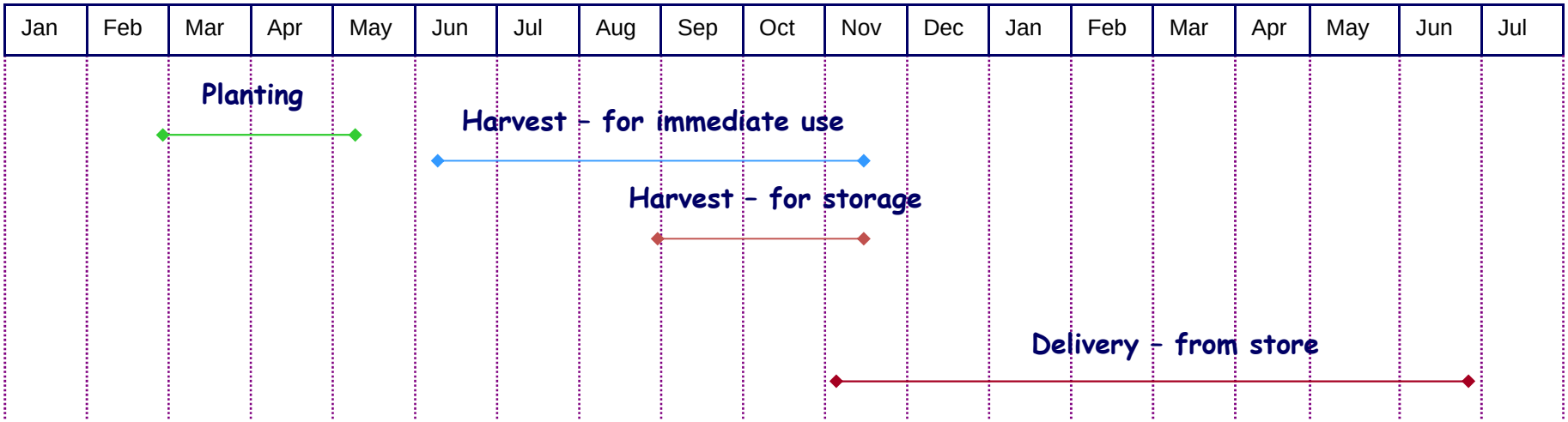
Future opportunities include:

- Breeding new potato varieties with lower reducing sugar content and/or less cold sweetening effect.

- Understanding agronomy impact

- BBSRC sponsored LINK project – started April 2009, duration 3-years
  - Identification of genotypes and varieties of potato that have low levels of the key acrylamide precursors, free asparagine, other amino acids and sugars
  - Establish optimum levels of soil sulphur (S) and N without exacerbating acrylamide risk with excessive S and N fertiliser

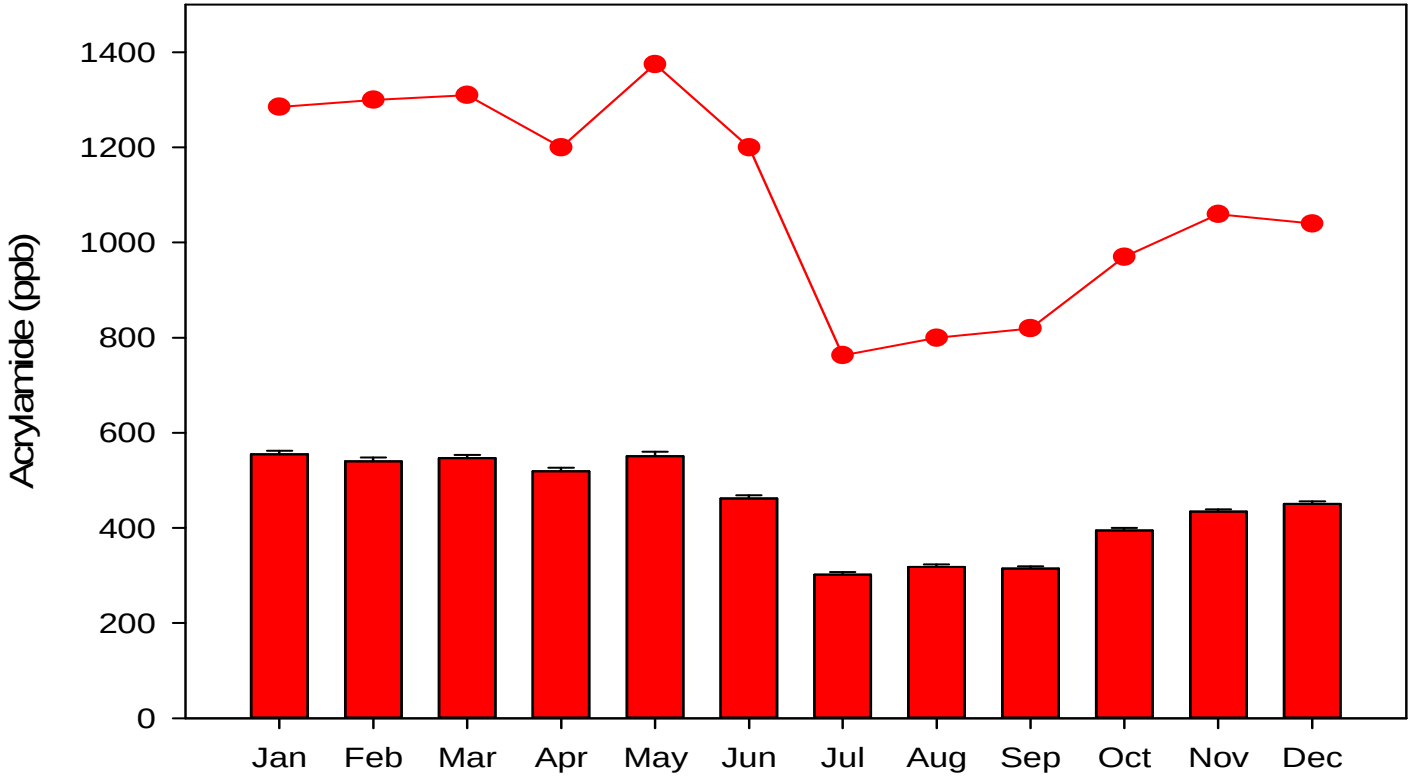
Potato supply calendar



- No single potato variety can provide all year round supply.
- Potatoes are made available for all year round consumption by using fresh crop immediately post-harvest, and for the rest of the year by using stored potatoes.
- As a result there are different varieties used throughout the year.
- Exact dates vary depending on country, variety and weather (e.g. drought conditions or excessive wet weather during harvesting season).

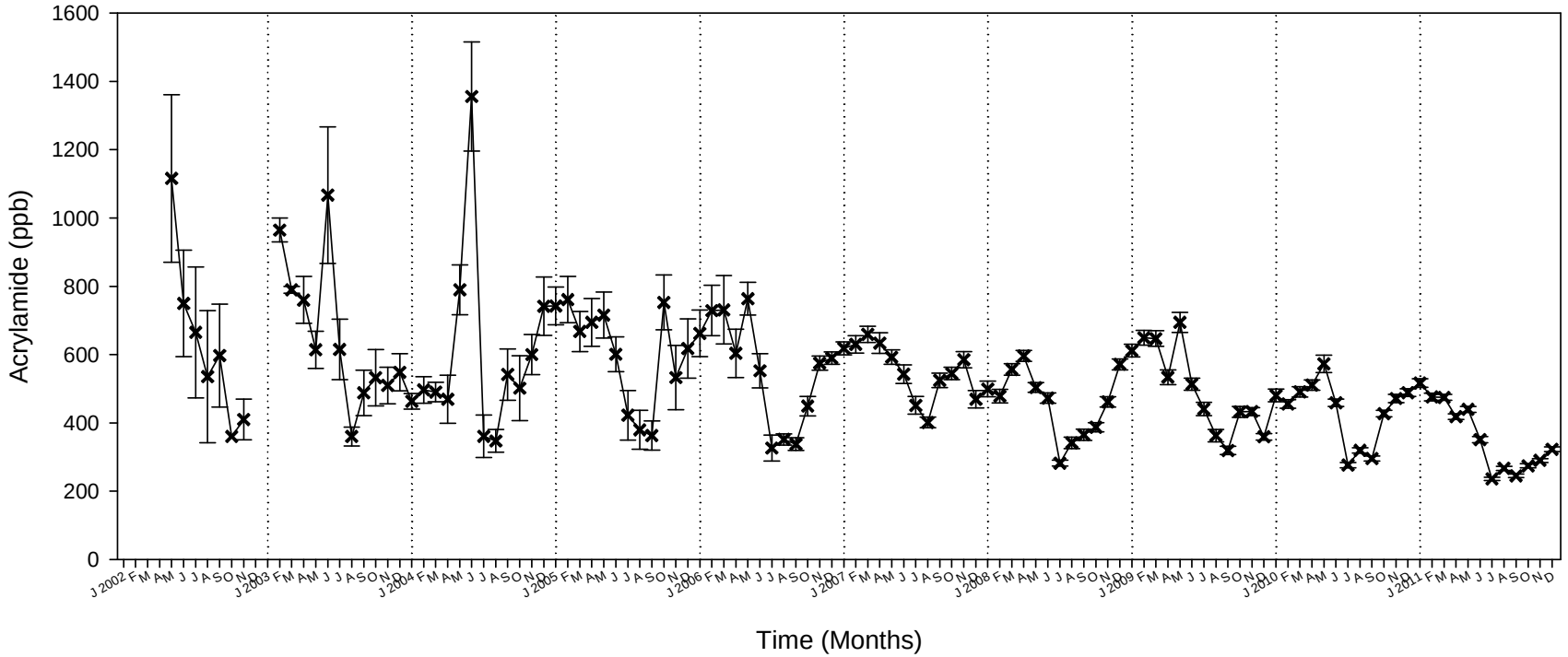
The impact of seasonality

- The data shows that acrylamide is at its lowest in July when new season potatoes start to be used in production. The level remains low in August and September before increasing from October until January, then remaining relatively high until the cycle starts again in July.
- Crisps produced in the first six months of the calendar year have higher acrylamide levels than those in the later half because of the need to use potatoes from long-term storage.



Mean acrylamide levels (sum all data) with standard errors (red bars) and trend in 95% (Q95) (red line) quantile

The impact of seasonality



Mean acrylamide levels over time (2002-2011) with standard errors; plotted monthly

The data shows variance arising from seasonality over the years, and highlights the extent to which manufacturers are reliant upon a good potato harvest to help control mean levels.

Recipe design

- Co-ingredients: pre-processed cereals, processed sugars such as molasses, or certain processed spices/flavourings may add to Acrylamide levels

- Dilution of ingredients: e.g. partial replacement of potato components

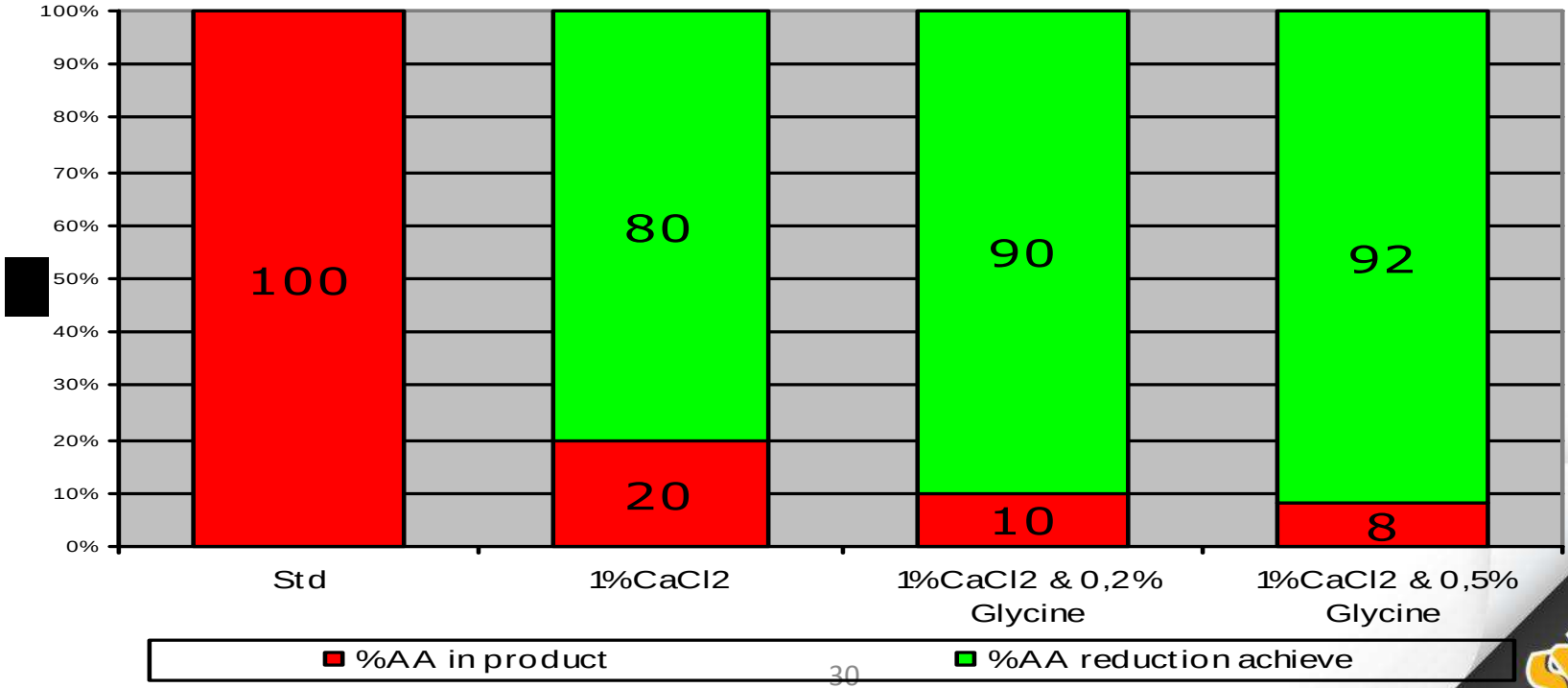
- Thicker crisps requires longer frying time to reach the required moisture content - potentially increasing AA content.

- pH: citric or ascorbic acid synergistic benefits with calcium salts (lab/pilot scale)

- Amino acids: compete with asparaginase (lab/pilot scale)

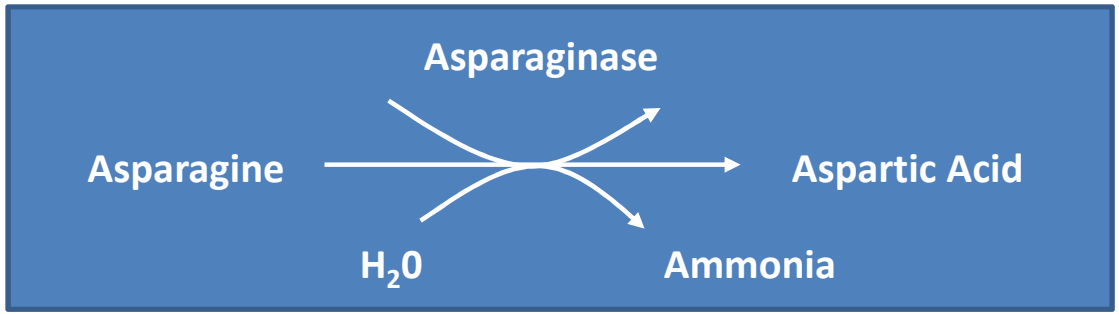
Use of Calcium Salts and Amino Acids in Pellet Snacks

- Use of amino acids and calcium salts has proved promising at Lab scale
- Now moving to implementation of calcium salts on potato-based pellet snacks
  - Glycine and calcium chloride were added at various levels to the dry mix of ingredients prior to pellet formation
  - Products were then cooked and compared to standard recipe for percentage reduction.



Process Design: Asparaginase

- Asparaginase enzyme converts Asparagine in the presence of water to Ammonia and Aspartic Acid.



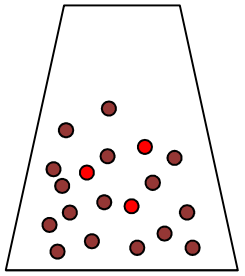
Asparaginase works for some formulated products

- Key factors affecting reaction

Contact Time

Temperature

pH



Barriers to Diffusion

- Asparaginase is very effective at reducing ASN
  - But, by products can cause off flavours in finished product

- Enzyme can be denatured in process, so need to monitor process inputs
  - Dosing rate vs. Recipe
  - Residence time & temperature

Asparaginase works for some formulated products

Enzyme works for…	Reason
Dough Based Products – e.g. Pretzels, Biscuits & ground Masa Products	Enzyme has ready access to ASN with appropriate contact time & temperature
Partial pre-treatment of potato granule based products	Enzyme can have ready access to ASN with appropriate contact time & temperature in granule manufacturing process
Enzyme Does Not Work For…	**Reason**
Sliced PC	Enzyme can not penetrate the intact cell structure of slices
Full treatment of Potato Flake Products	High ASN = High Ammonia and Aspartic Acid (Off flavor)

Process design

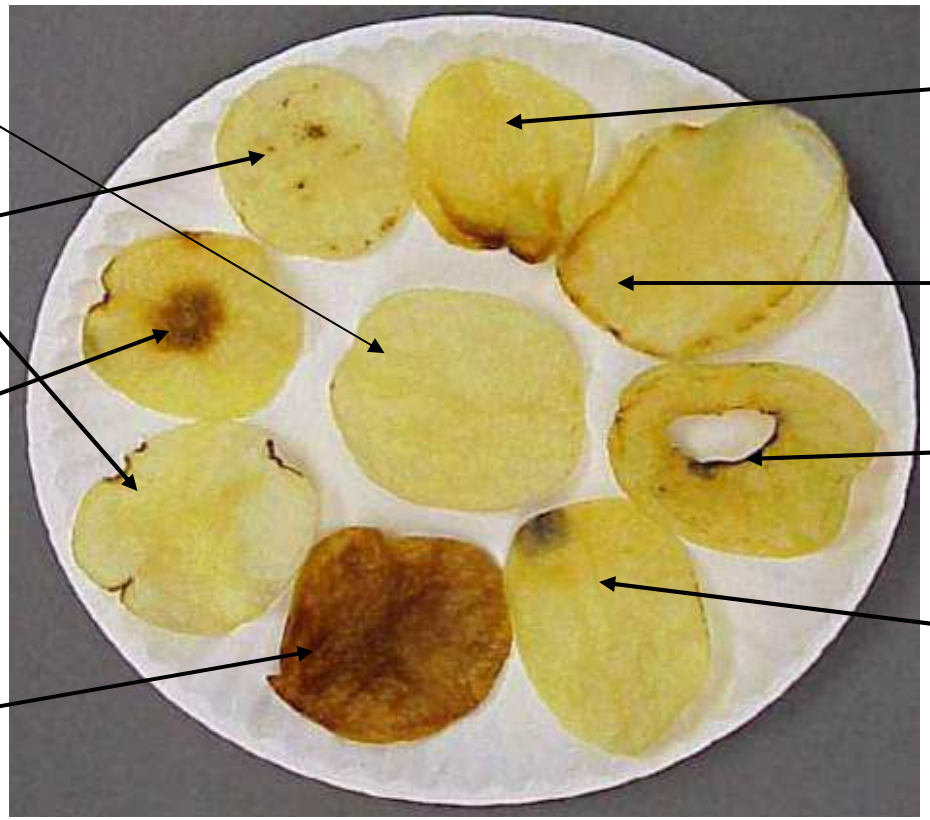
- Removing Defects
- Blanching:
  - ➢light blanch for high sugar potatoes may be considered
  - ➢longer blanch gives negative flavor / texture and higher oil uptake
- Higher moisture content in finished product / Reducing Fryer Temperature
- Vacuum frying alternate thermal input (low throughput)
- Adequate peeling: Reducing sugars can be higher in the peel layer of some varieties

Finished Product Colour

- Optical sorting – Elimination of dark coloured crisps
- Removal of ‘fines’ from frying oil
- Use of ingredients to compensate for lighter coloured potato crisps by providing additional colour.

Controlling Colour Related Defects

- Potato and process defects can be managed through a combination of careful variety selection, agronomy, optimised storage and handling.



Acrylamide Reduction in Savoury Snacks

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Potential Acrylamide Reduction Tools

Tools that have had some negative impacts

Idea Evaluated	Perspective
Blanching	• Light blanch for high sugar potatoes may be considered • Higher blanch gives negative flavor / texture and higher oil uptake
Acid Treatment	• Reduces AA however → Negative flavor impact
pH Treatment (Basic)	• Reduces AA however → Negative flavor impact
Enzymes	• Ineffective, intra cellular contact not possible
Disrupting cell membrane	• Reduces AA however →Changes to product nutritionals; Wasn't repeatable

Tools that HAVE worked

Managing In-Coming Potatoes for Reducing Sugar Content
Higher Finished Product Moisture
Reducing Fryer Temperature
Removing Defects
Asparaginase

ESA Commitments

- **Investment in agronomic and plant breeding R&D will help address some of the seasonal and varietal issues, but breeding of successful varieties will take several years to develop and to generate sufficient volumes for commercial production.**

- **Continued action to reduce acrylamide levels through existing and emerging mitigation strategies.**

- **Further awareness-raising actions and best practice sharing/implementation across the sector.**