



Code of Practice for Managing Acrylamide Formation in Foods

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1. INTRODUCTION

CONTEXT

1. Regulation (EC) No. 853/2004 of 29 April 2004 on the hygiene of foodstuffs establishes a set of obligations for food business operators (FBOs) to ensure a high level of consumer protection with regard to food safety. These include compliance with the general hygiene provisions, and the requirement to put in place, implement and maintain a permanent procedure or procedures based on the HACCP principles.
2. In addition the Regulation allows for specific criteria, requirements and targets and associated sampling and analysis methods to be laid down by the Commission through further measures. **Regulation XXX** establishes such obligations in relation to acrylamide in food. Under **Regulation XXX** it is mandatory for FBOs to apply the FoodDrinkEurope Code of Practice for Managing Acrylamide Formation in Foods as a means of targeting acrylamide levels that are as low as is reasonably achievable (ALARA).

PURPOSE, SCOPE AND DEFINITIONS

3. This Code of Practice lays down the general and sector-specific requirements for FBOs to manage acrylamide formation in the following foods:

PP: Products based on raw potatoes
PC: Sliced potato crisps
PF: French fries and other cut (deep fried) potato products
DB: Dough-based potato crisps, snacks and crackers
CB: Cereal-based products (common to all of the cereal-based categories)
FB: Fine bakery wares
BC: Breakfast cereals
CO: Coffee
CS: Coffee substitutes mainly containing cereals
CC: Coffee substitutes mainly containing chicory
BB: Baby biscuits and infant cereals
BJ: Baby jar foods (low-acid and prune-based foods)

4. The term 'shall' is used to indicate where it is the duty of the FBO to ensure that a mitigation measure has been assessed, implemented and documented. Where a mitigation measure is not implemented, a detailed explanation of why this is the case must be available and satisfactory justification provided (e.g. if alternative mitigation actions remove the need for the measure in question).
5. The term 'should' is used to indicate an expected or desirable mitigation measure or parameter that is to be given serious consideration by FBOs, and for which adequate explanation should be available if not applied for a particular process and/or product.

STRUCTURE

6. Section 2 provides background information on acrylamide. Section 3 lays down general mandatory requirements applicable for all categories. Section 4 lays down sector-specific mitigation measures for mandatory assessment by FBOs that have been proven to be effective in commercial applications.

FURTHER GUIDANCE

7. Based on the principles of this Code of Practice and the descriptions of mitigation measures per category, individual sectors have developed additional detailed guidance on best practices for their specific raw materials, processes and final product categories.
8. Depending on the category, it may be possible in some cases to define specific measurable targets or specifications. In others, the diversity of the category may mean that less specificity is possible. In certain other cases, measurable targets may not be defined owing to the absence of appropriate tools, even though sectors have adequately investigated or specified control measures to mitigate acrylamide for their category.

2. BACKGROUND

1. Acrylamide is formed in cooked starchy foods mainly by the reaction of the amino acid asparagine with reducing sugars such as glucose and fructose as part of the Maillard reaction.
2. Acrylamide formation primarily takes place under conditions of high temperature (usually in excess of 120°C) and low moisture. It is the combination of temperature and heating time to which the product is subjected that is pivotal to acrylamide formation, not the specific temperature *per se* or the specific cooking process (e.g. roasting, frying, baking).
3. Asparagine and sugars are necessary for plant growth and development and so their role in acrylamide formation cannot be considered in isolation. Furthermore, the Maillard reaction depends on these common food components to provide the characteristic flavour, colour and texture of a given product.
4. In light of the conclusions of the European Food Safety Authority's risk assessment on acrylamide in foodⁱ, the food industry should continue to reduce acrylamide in food products. The complete elimination of acrylamide from food is not possible. Therefore the principle objective shall be to reduce levels in food to as low as is reasonably achievable (ALARA).
5. Considerations when determining whether levels are ALARA may include:
 - potential impact on levels of acrylamide in the final product;
 - potential impact on the formation of other process contaminants and/or reduction in control of other hazards e.g. microbiological hazards;
 - feasibility of implementing the mitigation measure, e.g. legal compliance, commercial availability, occupational health hazards, timescales and costs associated with upgrading or replacing plant equipment;
 - impact on organoleptic properties, product characteristics and other quality-related aspects of the final product;
 - potential impact on product safety;
 - nutritional quality related to the use of certain ingredients in preference to others, e.g. use of whole grain cereals instead of refined cereals.
6. The food industry has developed, and is maintaining, a document (the FoodDrinkEurope 'Acrylamide Toolbox'ⁱⁱ) that contains descriptions of potential intervention steps, which may prevent or reduce formation of acrylamide in specific manufacturing processes and products. The Toolbox includes potential mitigation options that are at research or development stage as well as mitigation measures that have been proven to be effective at commercial plant level. Research and development in the areas of agronomy, industrial processing and final preparation are ongoing and new findings will continue to be included in the Toolbox.
7. The sector-specific mitigation measures laid down in Section 3 have been proven to be effective in commercial applications. Therefore this Section provides a more focussed list of measures that can be applied in consistency with Good Manufacturing Practices (GMP).

3. GENERAL MANDATORY REQUIREMENTS

1. FBOs shall assess the suitability of all sector-specific mitigation measures listed in this Code of Practice in relation to their specific products and process facility conditions, and apply those measures that are effective and reasonable at appropriate stages of production, in order to reduce the levels of acrylamide in their products to levels which are 'As Low As Reasonably Achievable' (ALARA).
2. Owing to the diversity of individual products and manufacturing processes, not all mitigation measures will be effective and reasonable in every situation. The non-application of any sector-specific mitigation measures listed in this Code of Practice shall be duly justified by the FBO.
3. FBOs shall repeat the assessment at least annually or when raw materials, recipe and/or process conditions change substantially, or when new mitigation measures have been identified for the sector.
4. FBOs shall monitor levels of acrylamide in finished products at least annually in order to verify the effectiveness of the measures applied. EU Indicative Valuesⁱⁱⁱ per product category should be used as benchmarks for the purposes of monitoring. Where levels in a finished product consistently exceed the relevant Indicative Value, a review shall be carried out to confirm and document that all effective and reasonable mitigation measures are being appropriately applied.
5. FBOs shall continuously review mitigation measures used and adjust processes and controls as appropriate, taking into account all relevant factors, including the potential to increase other contaminants, microbiological stability and the acceptability of the final product to the consumer.
6. FBOs shall document and maintain suitable records to demonstrate:
 - how they have assessed the mitigation measures listed in this Code of Practice;
 - how they have applied the relevant mitigation measures listed in this Code of Practice;
 - how they justify the non-application of mitigation measures listed in this Code of Practice;
 - how they are monitoring the application of mitigation measures on a continuous basis.

Appendix 1 contains example assessment forms for use by FBOs to assess measures, identify those that are applicable and establish which measures are ineffective or unreasonable for their particular product and process. Alternative approaches may be used to document this assessment.

7. The mandatory requirements laid down in this Code of Practice are compatible with, and can be implemented through companies' Food Safety Management or HACCP Systems. Consequently, the mandatory requirements should be incorporated as relevant for the specific raw materials, product composition, processes and facilities. The mandatory requirements shall be implemented through pre-requisite programmes (PRP), other relevant programmes or control measures as appropriate.

4. SECTOR-SPECIFIC REQUIREMENTS FOR MANDATORY ASSESSMENT

PP - MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR PRODUCTS BASED ON RAW POTATOES

Selection of Suitable Potato Varieties

1. Manufacturers shall select potato varieties which are low in acrylamide precursors e.g. reducing sugars [fructose and glucose] and asparagine and ensure that these are suitable for the local conditions in which the potatoes will be cultivated, keeping in mind the intended final product.
[Note: 'The European Cultivated Potato Database'^{iv} provides information on the botanical, agronomic and quality characteristics for a range of currently available potato varieties. This and other similar national databases may be suitable starting points for manufacturers to help them to determine whether the varieties they have selected are suitable for the local growing conditions, the growing and storage periods and the intended finished product].
2. For stored potatoes manufacturers shall ensure that they have selected varieties which are suitable for the intended storage period and conditions, and that these are used within their optimal storage window.
3. Manufacturers shall establish a continuous programme to test new, promising varieties with lower acrylamide forming potential in cultivation, storage and processing trials.
4. Where potatoes are sourced via contract farming or 'spot market' procurement, manufacturers shall specify the potato variety in line with paragraphs 1 and 2 in this section.

Potato Storage and Release

5. Manufacturers shall agree appropriate storage practices with farmers/suppliers.
6. Where manufacturers operate their own storage facilities, they shall specify appropriate potato storage practices.
7. Storage environments shall be specified and controlled for temperature (at least above 6° C, with temperature specified for the potato variety stored), and humidity to minimise senescent sweetening.
8. Where legally permitted, sprouting shall be suppressed in long term stored potatoes using appropriate agents (e.g. Chlorpropham (CIPC)-based formulations) or permitted compounds (e.g. for organic products where CIPC is not permitted).
9. Potato lots shall be tested for reducing sugars at the time of harvest, and during storage.
10. Manufacturers shall agree transport specifications in terms of temperature and duration, especially if outside temperatures are significantly cooler than storage.

Monitoring and Verification

11. Manufacturers shall establish a continuous programme of analysis on acrylamide levels in finished product to confirm that controls and mitigation steps are effective. If manufacturers decide to use colour measurement only (being the most rapid method of evaluation) they should establish the statistical correlation between the finished fried colour and the acrylamide level.
12. Acrylamide testing shall be carried out by applying referenced analytical methods for acrylamide detection and quantification.

PC – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR SLICED POTATO CRISPS

Recipe and Process Design

1. Manufacturers shall establish potato acceptance/action/rejection specifications with their suppliers in terms of reducing sugars and also on the percentage of bruised, spotted or damaged potatoes of any kind.
2. Manufacturers shall establish a clear set of actions to be taken should a potato lot fail to meet the acceptance specifications
3. Prior to use potato lots shall be analysed against the established acceptance/action/rejection specifications, including for reducing sugars. The results and subsequent actions shall be documented.
4. For each product design, manufacturers shall specify target frying oil temperatures at the exit of the fryer.
5. The fryer exit temperature shall be as low as feasibly possible on a specific line and for the specific product, in line with expected quality and food safety standards, and taking into account relevant factors.
[Note: relevant factors include (non-exhaustive list): Fryer manufacturer, fryer type, potato variety, total solids, potato size, growing conditions, sugar content, seasonality and the target moisture content for the product].

Typically the fryer exit temperature should not be higher than 168°C.

Where the fryer exit temperature is specified higher than 168°C due to a specific product/design/technology, then the manufacturer shall provide additional verification data demonstrating that the level of acrylamide in the finished product meets the ALARA principle and at a minimum is lower than the current Indicative Value.

6. For each product design manufacturers shall specify the target moisture content post frying and the minimal acceptable moisture content, and maintain records to demonstrate controls.
7. The target moisture level shall be set as high as feasibly possible on a specific line and for a specific product, in line with expected quality and food safety standards, and taking into account relevant factors.
[Note: including (non-exhaustive list): potato variety, seasonality, tuber size, the accuracy of the analytical methodology/monitoring technology, and the fryer exit temperature].
8. The absolute minimum moisture content shall not be lower than 1.0%.

9. Manufacturers shall use in-line colour sorting for potato crisps post frying.

Monitoring and Verification

10. Manufacturers shall establish an ongoing monitoring programme of analysis for acrylamide levels in products to confirm that GMP controls are effective.
[Note: ESA supports the continuation of EU Indicative Valuesⁱⁱⁱ as a benchmark for manufacturers to help them understand how their product compares to established statistical values and as a basis for understanding how they might improve and lower mean and maximum levels in their products].
11. Acrylamide testing shall be carried out by applying approved analytical methods for acrylamide detection and quantification.

Further Guidance

12. Further detailed guidance for FBOs is available in the ESA (European Snack Association) Code of Practice for managing acrylamide formation during the production of sliced potato crisps.

PF – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR FRENCH FRIES AND OTHER CUT (DEEP FRIED) POTATO PRODUCTS

Recipe and Process Design

1. Manufacturers shall establish potato acceptance/ rejection specifications with clear criteria for lot acceptance, for reducing sugars and also based on the percentage of bruised, spotted, green or damaged potatoes of any kind.

Manufacturers shall be able to demonstrate decision criteria for exceptionally accepting lots exceeding the raw product specification, including the specification of corrective actions to ensure that products - after final preparation - meet the Indicative Value for the product category.

2. Potato lots shall be tested for reducing sugars prior to use. This can be done by fry testing (using colours as an indicator of potential high reducing sugar content): indicative fry testing 20-25 centre strips, which are fried to evaluate frying colours of the potato strips against the raw colour specification using a valid USDA/ Munsell colour chart or calibrated “company-specific charts for small operators”. Alternatively the overall finished frying colour can be measured by specific equipment (e.g. Agtron).
3. Manufacturers shall remove immature tubers having a low specific gravity (low underwater weight) and high reducing sugar levels. Removal is typically done by passing tubers through a salt brine, and/or similar systems which make immature tubers float. Alternatively, problem lots can be washed externally to sort out bad tubers.
4. Manufacturers shall remove slivers as much as possible right after cutting to avoid burned pieces in the final cooked product.
5. Manufacturers shall blanch potato strips to remove some of the reducing sugars from the outside of the strips, resulting in lower levels of acrylamide in the final cooked product. Blanching regimes need to be adapted to the specific quality attributes of the incoming raw material lots and to consistently stay within specification limits for finished product colour.

6. Manufacturers shall prevent (enzymatic) discolouration and after cooking darkening. This is typically done by applying disodium diphosphate (E450), which also lowers the pH of the washing water and as a consequence inhibits the Maillard browning reaction.
7. Manufacturers shall control the colour of the final product by strategic addition of dextrose (= glucose) after blanching, if needed, to consistently stay within specification limits. Controlled addition of dextrose after blanching results in lower acrylamide levels in the final cooked product, at the same colour (Agtron), as observed in unblanched products with only accumulated natural reducing sugars. The combination of both supports an even (light) golden yellow frying colour in the final prepared potato products, with lower acrylamide levels, when cooked to the same end colour compared to products that have not been blanched and had no dextrose added.

Monitoring and Verification

8. Manufacturers shall establish a continuous product-testing program to verify the finished frying colour of product directly coming from the production line. Product samples shall be cooked using recommended cooking times and temperatures, as defined in the product specifications. The production process shall be adapted (e.g. limiting dextrose dosage, increase blanching time) when the result of the product colour testing is outside product specifications' limits.

Final Preparation

9. Manufacturers shall indicate recommended cooking methods (time, temperature, quantity, specified for oven/ deep fryer/ pan) on packaging and/or via other communication channels made available for end users. Recommended cooking methods shall be in agreement with customer specifications and requirements for professional end users and must be validated per product type to ensure products have optimal sensory quality at the lightest acceptable colour, per cooking method specified (e.g. fryer, oven). For consumers the recommended cooking instructions shall be clearly displayed on all product packaging.
10. Manufacturers shall recommend to professional end users that they should have tools available for the operators (e.g. chefs) to ensure good cooking methods and also provide calibrated equipment (e.g. timers, frying curves, colour grading charts (e.g. USDA/Munsell) and at minimum, clear pictures with targeted final prepared product colours.
11. Manufacturers shall refer end users to the golden frying recipe provided on the website www.goodfries.eu, In particular the following points should be noted:
 - Keep the temperature between 160 and 175°C when frying, and 180-220°C when using an oven (use the lower temperature when fan switched on);
 - Cook until a golden yellow colour; end users can use fry colour charts for reference, if no other tools are available, for a quick assessment of finished fried/ baked product based on their colour.
 - Do not overcook (always avoid frying/ baking until the product colour gets brown / too dark), turn oven products after 10 minutes or halfway through the total cooking time;
 - Strictly follow the recommended cooking instructions, as provided by the manufacturer;
 - When preparing smaller quantities than indicated on pack, reduce the cooking time, to avoid excessive browning of the product;
 - For optimal product quality do not overfill the frying basket; fill your basket up to the halfway mark to avoid excessive oil uptake by extended frying times.

Further Guidance

12. In addition, further detailed guidance for FBOs is available in the EuPPA (European Potato Processors Association) Code of Practice on managing acrylamide formation in French fries and other cut (deep fried) potato products.

DB – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR DOUGH-BASED POTATO CRISPS, SNACKS AND CRACKERS

Raw Materials

1. For each product design manufacturers shall specify target values for reducing sugars in their dehydrated potato ingredients with their suppliers. These targets shall be documented.
2. The target value for reducing sugars shall be set as low as feasibly possible, taking into account all relevant factors in the design and production of the finished product.
[Note: Relevant factors include the amount of potato ingredients in the product recipe, further possible mitigation measures, further processing of the dough, seasonality, and the target moisture content for the product].

Typically target values for reducing sugars should not exceed 1.5%.

Where the target value is higher than 1.5% the manufacturer shall provide additional verification data demonstrating that the level of acrylamide in the finished product meets the ALARA principle and at a minimum is lower than the current Indicative Value.

Recipe and Process Design

3. Dehydrated potato ingredients shall be analysed prior to use to confirm that reducing sugar comply with the established target values.
[Note: Analysis can be carried out by the manufacturer or by the supplier].
4. Manufacturers shall establish a clear set of actions to be taken should dehydrated potato ingredients fail to meet the specified target values. The results and subsequent actions shall be documented.
5. For each product design manufacturers shall review whether it is possible to utilise the partial replacement of potato ingredients with ingredients with lower acrylamide forming potential, taking into account the requirements of the specific product and its production methods.
6. In wet dough-based systems, for each product design manufacturers shall review whether it is possible to use the following substances, taking into account the requirements of the specific end product, and its production methods:
 - Asparaginase
 - Acids or their salts (to reduce the pH of the dough)
 - Calcium salts

[Note: These substances may not be synergistic in their mitigation effect i.e. specifically applies to asparaginase and lowering pH].

Manufacturers shall document and maintain records relating to the application of these GMP, including the justifications for decisions should a manufacturer choose not to apply a specific GMP (in line with the ALARA principles).

7. Where dough-based potato crisps, snacks or crackers are fried, for each product design manufacturers shall specify target frying oil temperatures at the exit of the fryer and maintain records to demonstrate controls.
8. The fryer exit temperature shall be as low as feasibly possible on a specific line and for the specific product, in line with expected quality and food safety standards and taking into account relevant factors.
[Note: Relevant factors include the fryer manufacturer, fryer type, sugar content and the target moisture content for the product].

Typically the fryer exit temperature should not be higher than 175°C. Where the target temperature is higher than 175°C, the manufacturer shall provide additional verification data demonstrating that the level of acrylamide in the finished product meets the ALARA principle and at a minimum is lower than the current Indicative Value.

[Note: Most pellet products are fried at temperatures higher than 175°C because of their very short frying time and the temperatures needed to achieve the required expansion and texture of these products].

9. Where dough-based potato crisps, snacks or crackers are baked, for each product design manufacturers shall specify the baking temperature at the exit of the baking oven and maintain records to demonstrate controls.
10. The temperature at the exit of the baking oven/drying process shall be as low as feasibly possible on a specific line and for the specific product, in line with expected quality and food safety standards, and taking into account relevant factors.
[Note: Relevant factors include the machinery type, reducing sugar content and the target moisture content for the product].

Typically the temperature at the end of the baking/drying process should not be higher than 175°C. Where the temperature is higher than 175°C, the manufacturer shall provide additional verification data demonstrating that the level of acrylamide in the finished product meets the ALARA principle and at a minimum is lower than the current Indicative Value.

11. For each product design manufacturers shall specify the target moisture content post frying or baking and the minimal acceptable moisture content, and maintain records to demonstrate controls.
12. The target moisture level shall be set as high as feasibly possible on a specific line and for a specific product, in line with expected quality and food safety standards, and taking into account relevant factors.
[Note: Relevant factors include the accuracy of the analytical methodology/monitoring technology, and the fryer exit/baking/drying temperature].
13. The absolute minimum moisture content shall not be lower than 1.0%.

Monitoring and Verification

14. Manufacturers shall establish an ongoing monitoring programme of analysis for acrylamide levels in products to confirm that GMP controls are effective.
[Note: ESA supports the continuation of EU Indicative Valuesⁱⁱⁱ as a benchmark for manufacturers to help them understand how their product compares to established statistical values and as basis for understanding how they might improve and lower mean and maximum levels in their products].
15. Acrylamide testing shall be carried out by applying approved analytical methods for acrylamide detection and quantification.

Further Guidance

16. Further detailed guidance for FBOs is available in the ESA (European Snack Association) Code of Practice for managing acrylamide formation during the production of dough-based potato crisps, snacks and crackers.

CP - MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR CEREAL-BASED PRODUCTS

1. Free asparagine rather than reducing sugars is the key determinant of acrylamide formation in cereal products. The level of free asparagine in the cereal tends to correlate positively with acrylamide formation in cereal products. Free asparagine can vary widely within and between individual varieties of grains and is also dependent on specific growing conditions. Sourcing specific low asparagine cereal varieties is not yet possible because the environmental effect on free asparagine levels is much greater than the varietal effect.
2. Free asparagine levels in cereals can become elevated during plant development when the plant is grown under stressed conditions, particularly in sulphur-deprived soils. The sector-specific associations of the FBOs for fine bakery wares, breakfast cereals, cereal-based coffee substitutes and for baby biscuits, infant cereals and baby jar foods (low-acid and prune-based foods) shall encourage the associations representing primary cereal producers to establish a guidance document on maintaining balanced sulphur levels through cereal cultivation.

Late application of nitrogen may increase the free asparagine and total free amino acid concentration in wheat and other cereals, causing a concomitant increase in acrylamide-forming potential. Nitrogen fertilizer is required to maintain the yield and quality of the crop, but excessive application should be avoided.

The sector-specific associations of the FBOs for fine bakery wares, breakfast cereals, cereal-based coffee substitutes and for baby biscuits, infant cereals and baby jar foods (low-acid and prune-based foods) shall encourage the associations representing the primary cereal producers to establish a guidance document on the potential formation of asparagine through late and excessive application of nitrogen.

3. Fungal pathogen infection causes a significant increase in free asparagine concentration in cereal grain. The sector-specific associations of the FBOs for fine bakery wares, breakfast cereals, cereal-based coffee substitutes and for baby biscuits, infant cereals and baby jar foods (low-acid and prune-based foods) shall encourage the associations representing the primary cereal producers to establish a guidance document to encourage farmers to apply best practices on crop protection measures to prevent fungal infection.

FB – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR FINE BAKERY WARES

1. The definition of Fine Bakery Wares covers a range of different products¹. Acrylamide formation is determined by heat (time/temperature) input in combination with low final moisture content of typically less than 4-5 %, the presence of precursors of the acrylamide reaction in recipe ingredients, and added ingredients which may have the potential to influence the reaction conditions. Accordingly the mitigation measures are only relevant a specific part of the full range of Fine Bakery Wares. Specifically, the application of mitigation measures shall therefore be assessed for the following foods and similar products:² cookies, biscuits, rusks, cereal bars, scones, cornets, wafers, crumpets and gingerbread, as well as unsweetened products such as crackers, crisp breads and bread substitutes. In this category a cracker is a dry biscuit (a baked product based on cereal flour), e.g. soda crackers, rye crispbreads and matzot. The same mitigation measures also apply to products using whole grains/cereals. Products with higher moisture levels (such as cakes, muffins and soft waffles) are not susceptible to developing significant levels of acrylamide formation and therefore are not included in the scope of this Code of Practice.
2. These mitigation measures shall be assessed for application as such or in combination or as alternatives. The outcome of the assessment shall be documented as evidence to cover details of the assessment and the justification for the decisions taken on application of the measure.

Recipe and Product Design

FBOs shall establish and maintain product recipe specifications on the basis of general quality requirements and in particular in consideration of the following mitigation measures:

3. For relevant products, manufacturers shall consider reducing or replacing (fully or partially) ammonium bicarbonate with alternative raising agents such as sodium bicarbonate and acidulants, sodium bicarbonate and disodium diphosphates with organic acids or potassium variants thereof. Considerations should include that changes may result in organoleptic (taste, appearance, texture etc.) or nutritional changes (increased sodium content) that influence product identity and consumers acceptance.
4. For relevant products and where the product design allows, manufacturers shall consider replacing fructose or fructose-containing ingredients (e.g. syrups, honey) with glucose or non-reducing sugars (e.g. sucrose), particularly in recipes containing ammonium bicarbonate. Considerations should include that replacing fructose or other reducing sugars may result in a modified product identity due to loss of flavour and colour formation.
5. Manufacturers shall consider using asparaginase to reduce asparagine and mitigate the potential for acrylamide formation. In general, the use of asparaginase is proven to be one of the most efficient tools to reduce acrylamide levels and if used at low dosage rates has no negative impact on the organoleptic properties of the final product. For consideration, the efficacy of asparaginase is dependent on recipe, ingredients, moisture content and process (temperature, pH, time, distribution in dough) and therefore differs from product to product. In

¹ According to part E of Annex II of the Regulation (EC) No 1333/2008 on Food Additives: "This category covers sweet, salty and savoury products, including prepared doughs for their preparation, such as cookies, cakes, muffins, doughnuts, biscuits, rusks, cereal bars, pastries, pies, scones, cornets, wafers, crumpets, pancakes, gingerbread, éclairs, croissants, as well as unsweetened products such as crackers, crisp breads and bread substitutes. In this category a cracker is a dry biscuit (baked product based on cereal flour), e.g. soda crackers, rye crisps, matzot": http://ec.europa.eu/food/safety/docs/fs-improv-guidance_1333-2008_descr_annex2_en.pdf

² This reflects the categories for which Indicative Values have been set: "Biscuits and wafers, crackers, crispbread, ginger bread, products similar to the other products in this category."

particular, experience shows that there is limited or no effect in recipes with high fat content, low moisture or high pH value.

6. Where a product characteristic allows, manufacturers shall consider a partial replacement of wheat flour with alternative grain flour such as rice. For consideration, any change will have an impact on the baking and organoleptic properties. Different types of grains have shown different levels of asparagine (typical asparagine levels: rye > oats > wheat > maize > rice).
7. Manufacturers shall consider the impact of co-ingredients that may have the potential to raise acrylamide levels in the final product (e.g. use almonds roasted at lower rather than higher temperatures and dried fruits as potential fructose source). Manufacturers shall have a change control procedure in place to ensure that a change in products sourced from suppliers does not result in inadvertently increased acrylamide levels. Manufacturers shall ensure that suppliers of heat treated ingredients which are susceptible to acrylamide formation provide an ingredient acrylamide risk assessment and implement the appropriate mitigation measures.
8. Manufacturers shall consider the addition of organic acids/adjustment of pH in combination with other recommendations. Decreasing the pH will influence the Maillard reaction in the direction of decreased acrylamide formation. For considerations this option is limited by resulting organoleptic changes (less browning, modification of taste).

Processing

FBOs shall establish and maintain product manufacturing and finished product specifications on the basis of general quality requirements and in particular in consideration of the following mitigation measures:

9. Manufacturers shall control thermal input by optimising baking temperature, temperature profile and time. As guidance, thermal input as result of temperature and time is essential rather than temperature alone to control product characteristics and acrylamide formation. For consideration, solutions may vary depending on the particular product and capabilities of existing processing equipment.
10. Manufacturers shall consider increasing the moisture specification for the final product if feasible for the particular product and process in line with achieving quality (incl. physical properties), shelf life and food safety standards.
11. Manufacturers shall consider baking to a lighter colour endpoint in the final product if feasible to achieve the required quality, shelf life and food safety standards.
12. For new product development, manufacturers shall consider piece size/surface area to volume ratio during product design, as small product size potentially leads to higher acrylamide levels (heat impact).
13. Manufacturers shall adjust product and process design to account for ingredients that could be heat treated several times and as a result raise acrylamide levels in final products (e.g. pre-processed cereal pieces, nuts, seeds, dried fruits, etc.). The use of small quantities of rework is common practice today if within the specified range for colour formation. Although it is known that in general avoiding rework is reported to have no significant benefit in reducing acrylamide levels, manufacturer shall not use burnt products as rework.
14. For product pre-mixes that are to be baked at home or in catering establishments, clear on-pack preparation instructions shall be provided to lead to levels below the Indicative Values.

Monitoring and Verification

15. Finished products and heat-treated raw materials shall be tested on a risk assessment basis for acrylamide to verify that the mitigation measures are effective in keeping acrylamide levels to ALARA.
16. Products, which have been analysed as part of the monitoring to exceed the EU Indicative Valuesⁱⁱⁱ shall be subject to a review to confirm and document that all effective and reasonable mitigation measures are appropriately applied.
17. Acrylamide testing must be carried out by an ISO 17025 accredited laboratory/method.

Further Guidance

18. In addition, further detailed guidance for FBOs is available in the CAOBISCO (Chocolate, Biscuits & Confectionery of Europe) Code of Practice on managing acrylamide formation in fine bakery wares.

BC – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR BREAKFAST CEREALS

Description of the Product and Process

1. Breakfast cereals cover a broad spectrum of different products with a variety of raw materials, recipes and processes. Due to this heterogeneity there is no single solution available to manage acrylamide and not all measures are applicable for all types of breakfast cereals. Accordingly, the mitigation measures in the Code of Practice need to be tested for applicability for specific products.
2. The manufacturing processes for breakfast cereals vary by product type, but involve some of the following stages:
 - a. Grain preparation, e.g. cleaning, conditioning, rolling or cutting
 - b. Cooking, e.g. boiling, steam cooking or extrusion cooking
 - c. Shape forming, e.g. granulating, flaking, puffing, shredding, layering and crimping
 - d. Baking or toasting
 - e. Finishing, e.g. coating (followed by an additional drying stage) and/or blending
3. Cooking, drying, baking and toasting processes can expose the product to significant thermal treatment and it is usually in these steps that most acrylamide is formed. These heat-treatment stages also make a major contribution to the desirable taste, flavour, texture and colour with a strong impact on quality and consumer acceptance. They are also often the HACCP critical control points (CCPs) that render the product microbiologically safe and stable.
4. The choice of cereal often defines the character and identity of the product and, in practice, the options to replace one cereal with another in the recipe are very limited, while still maintaining desirable product characteristics and food safety considerations.
5. Many breakfast materials are made with wholegrain cereals and some with cereal bran. Besides a desired product characteristic, these ingredients provide important nutritional and health benefits (e.g. high fibre, whole grain, cholesterol reduction and moderated glycaemic response).

6. The product design as specified during product development determines the resulting acrylamide level to a large extent. Accordingly, it is key:
 - a. To assess the mitigation measures during the product development phase and when changing the design/ manufacturing specifications of a product (as part of a formal change management process).
 - b. To ensure that processing conditions during manufacturing are within the specified ranges.

Major reasons for fluctuations in acrylamide levels in final products are the natural variability of the precursors in raw materials and also the process variations.

Agronomy when the Supply Chain is within the Food Manufacturer's Control

7. Breakfast cereal manufacturers should keep abreast of progress on the research to breed new, low-asparagine varieties^v of wheat e.g. through CEEREAL (European trade association for breakfast cereal manufacturers).

Recipe

FBOs shall establish and maintain product recipe specifications on the basis of general quality requirements and in particular in consideration of the following mitigation measures:

8. Products based on maize and rice tend to have less acrylamide than those made with wheat, rye, oats and barley, therefore these grains shall be considered in new product developments pHACCP (pre-HACCP).
9. Reducing sugars (e.g. fructose and glucose) and ingredients containing reducing sugars (e.g. honey) are sometimes added for organoleptic reasons and process functionalities (binding clusters for cluster formation). If added prior to heat-treatment stages they can act as precursors to acrylamide formation. In this case, controls over addition rates shall be established and implemented at point of addition.
10. The acrylamide contribution from heat-treated dry-added ingredients (e.g. roasted/toasted nuts and oven dried fruits) to the total acrylamide value shall be assessed in the pHACCP, and alternative ingredients considered if the contribution is likely to bring the finished product above the current Indicative Values as per Commission Recommendation 2013/647/EU.ⁱⁱⁱ For ingredients over 200 ppb acrylamide, the assessment shall include:
 - a. a register of ingredients over 200 ppb acrylamide
 - b. verification steps, e.g. audits of suppliers pHACCP and/or analyses
 - c. consideration of acrylamide risks in suppliers' pHACCP (by the supplier)
 - d. a change control procedure to ensure that no changes are made that inadvertently increase acrylamide levels (by the supplier)
11. When the cereal is in a flour dough format and the process enables a sufficient time, temperature and moisture content for asparaginase to reduce asparagine levels significantly, manufacturers shall review the effectiveness of using asparaginase, providing there is no negative effect on flavour or risk of residual enzyme activity. However, the majority of breakfast cereals are typically based on intact or semi-intact grain, and the incorporation of enzymes such as asparaginase is not effective in these cases because the enzyme cannot penetrate the grain.

Processing

FBOs shall establish and maintain product manufacturing and finished product specifications on the basis of general quality requirements and in particular in consideration of the following mitigation measures:

12. Manufacturers shall identify the key critical heat-treatment step(s) in the process that generate(s) the most acrylamide in order to focus their acrylamide reduction/control efforts most effectively. This shall be achieved via a risk assessment. It is important to measure the moisture content as well, and express acrylamide concentration on a dry mass basis to eliminate the confounding effect of moisture changes.
13. Do not over-bake or over-toast. In general, higher heating temperatures and longer heating times generate higher acrylamide levels. Manufacturers shall identify an effective combination of temperature and/or heating times to minimise acrylamide formation without unacceptably compromising the taste, texture, colour, safety and stability (shelf-life) of the product.
14. Heating temperatures, times and feed-rates must be controlled in order to achieve typical minimal moisture contents (see below) after the final heat-treatment steps to help avoid the generation of acrylamide spikes.

Typical Minimum Moisture Content (g/100g)

Typical Minimum Moisture Contents are: [Baking / Toasting Equipment]: [per Cooking Platform]

- *Toasted products: 1 g/100 g for extruded products, 1 g/100 g for batch cooked products, 2 g/100 g for steam rolled products*
 - *Direct expanded products: 0,8 g/100 g for extruded products*
 - *Baked products: 2 g/100 g for continuously cooked products*
 - *Filled products: 2 g/100 g for extruded products*
 - *Other drying: 1 g/100 g for batch cooked products, 0,8 g/100 g for gun puffed products*
15. Reworking product back through the process has the potential to generate higher acrylamide levels through repeated exposure to the heat-treatments steps. Manufacturers shall assess the impact of rework on acrylamide levels and, if significant, focus on reducing or eliminating rework.
 16. Manufacturers shall have procedures in place (e.g. temperature controls / monitoring) to prevent the incidence of burnt product, as this may give rise to consumer dissatisfaction and acrylamide spikes.

Monitoring and Verification

17. Finished products and heat-treated raw materials shall be tested on a risk assessment basis for acrylamide to verify that the mitigation measures are effective in keeping acrylamide levels to ALARA.
18. Products, which have been analysed as part of the monitoring to exceed the EU Indicative Valuesⁱⁱⁱ shall be subject to a review to confirm and document that all effective and reasonable mitigation measures are appropriately applied.
19. Acrylamide testing must be carried out by an ISO17025 accredited laboratory/method.
20. A CoP Implementation Assessment must be completed for each product or product group for each manufacturing process.

Further Guidance

21. In addition, further detailed guidance for FBOs is available in the CEEREAL Code of Practice on managing acrylamide formation in breakfast cereals.

CO – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR COFFEE

Description of the Product and Process

1. Organoleptic properties of coffee are finely tuned by a careful selection of green coffee beans, blending, roasting conditions and processing technologies. Flavour and aroma are crucial to the identity of the products and subsequently consumer acceptance.
2. The European coffee industry has investigated the chain from green coffee to the coffee beverage for the factors affecting the acrylamide level. As in other food products, acrylamide in coffee forms from sugars and amino acids (predominantly asparagine) in the Maillard reaction. However, the content of acrylamide in coffee reaches a peak early in the roasting process, reflecting occurrence of both formation and destruction of acrylamide during roasting. Levels of acrylamide in the fully roasted product are a small fraction of the peak reached earlier. Within the sensorial range accepted by consumers, only relatively small reductions of acrylamide levels appear achievable. No single applicable measure for substantially reducing acrylamide levels in coffee is currently available.

Agronomy

3. Reducing sugars and moisture in raw material (green coffee) do not show a correlation with acrylamide in the finished product.
4. Although asparagine levels in the raw material (green coffee) vary between different botanical species and origins, there is a poor correlation between the level of free asparagine in the raw material and final acrylamide content in the finished product.

Recipe

5. On average, products based on Robusta beans tend to have slightly higher acrylamide levels than those made with Arabica beans. Therefore, within given sensorial limitations, blend composition shall be considered in product design and new product developments, when appropriate.

Processing

6. Manufacturers shall identify the critical roast conditions to favour optimal acrylamide conversion reactions within the target flavour profile.
7. Control of roast conditions shall be incorporated into a Pre-requisite Programme as part of Good Manufacturing Practice.
8. Results from laboratory/pilot trials performed by the European coffee industry in collaboration with enzyme suppliers indicate that applying asparaginase is not a universal option. In some coffee types enzyme treatment may have opportunities. Factors influencing the efficiency of the usage of asparaginase are explained in the sector guidance.

Monitoring and Verification

9. Acrylamide levels in finished products shall be monitored to verify that the control of the design and processing steps measures are effective in keeping acrylamide levels to ALARA. Acrylamide testing shall be carried out by application of an officially published standard method appropriate for coffee analysis (e.g. ISO 18862, EN 16618 or DIN 10785).

10. Products, which have been analysed as part of the monitoring to consistently exceed the EU Indicative Valuesⁱⁱⁱ shall be subject to a review to confirm and document that all effective and reasonable mitigation measures are appropriately applied. In such cases, manufacturers shall review the product design according to the Code of Practice options.
11. Manufacturers shall ensure that adaptations to the product design are in line with the ALARA principle.

Further Guidance

12. In addition, further detailed guidance for FBOs is available in the ECF (European Coffee Federation) Code of Practice on managing acrylamide formation in coffee.

CS – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR COFFEE SUBSTITUTES MAINLY CONTAINING CEREALS

Description of the Product and Process

1. The main process for coffee substitutes mainly containing cereals can be described as below:
 - a. roasting and grinding to obtain ground roasted cereal
 - b. extraction (with water), concentration and drying to obtain instant (soluble) cereal products
 - c. blending for coffee substitutes containing other ingredients
2. Organoleptic properties of coffee substitutes mainly containing cereal (e.g. barley, malted barley, rye or wheat) depend on roasting conditions, processing technologies and recipe. The resulting flavor and aroma are essential to the identity of the products.
3. Formation mechanisms of acrylamide in roasted cereals have been partly identified and some factors are still under consideration. Above 150°C, the acrylamide content decreases with continued roasting, with final concentration being dependent on the target degree of roast. Colour is an important indicator of roasting degree and directly related to the organoleptic properties of the product. Roasted cereal products tend to have relatively lower amounts of acrylamide than coffee or other substitutes because of the lower content of precursors and longer roasting time that allows comparably more acrylamide to degrade.
4. At present, most of the tools usable at an industrial scale to reduce acrylamide levels have an impact on the organoleptic quality of roasted products. Within the sensorial range accepted by consumers, only a relatively small reduction in acrylamide levels appears achievable for a 100% cereal product. No single measure for substantially reducing acrylamide in roasted cereal products is currently available.

Recipe

5. In general, products based on maize and rice tend to have less acrylamide than those made with wheat, rye, oats, or barley, therefore these grains shall be considered in new product developments, when appropriate.
6. Reducing sugars (e.g. fructose and glucose) and ingredients containing reducing sugars (e.g. honey) if added prior to high temperature processing stages can act as precursors to acrylamide formation. In such cases appropriate controls over addition rates shall be established and implemented.

7. In the framework of substitutes not made exclusively from cereal and especially for new products, the possibility of the addition of other ingredients after high temperature processing shall be assessed by manufacturers.

Processing

8. The applicability of asparaginase enzyme treatment of the cereal grain prior to roasting is limited because roasted cereal products are based on the intact grain. In general terms, exposing intact cereal grain to asparaginase does not appear to measurably reduce acrylamide levels in the finished product.
9. Manufacturers shall identify the critical roast conditions to favour optimal acrylamide conversion reactions within the target flavour profile.
10. Control of roast conditions shall be incorporated into a Pre-requisite Program (PRP) as part of Good Manufacturing Practice (GMP).

Monitoring and Verification

11. Acrylamide levels in finished products shall be monitored to verify that the control of the design and processing steps measures are effective in keeping acrylamide levels to ALARA. Acrylamide testing shall be carried out by application of a standard method appropriate for cereal analysis (e.g. EN 16618). Fast methods (e.g. colour) can also be used during the process to monitor process parameters.
12. Products, which have been analysed as part of the monitoring and consistently exceed the EU Indicative Valuesⁱⁱⁱ shall be subject to a review to confirm and document that all effective and reasonable mitigation measures are appropriately applied. In such cases, manufacturers shall review the product design according to the Code of Practice options.
13. Manufacturers shall ensure that adaptations to the product design are in line with the ALARA principle.

Further Guidance

14. In addition, further detailed guidance for FBOs is available in the Code of Practice on managing acrylamide formation in coffee substitutes mainly containing cereals

CC – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR COFFEE SUBSTITUTES MAINLY CONTAINING CHICORY

Description of the Product and Process

1. The main process for coffee substitutes mainly containing chicory can be described as below:
 - a. washing, cutting & drying the chicory roots
 - b. roasting and grinding to obtain ground roasted chicory
 - c. extraction (with water) and concentration or spray drying to obtain chicory extracts
 - d. blending for coffee substitutes containing others ingredients
2. Formation mechanisms for acrylamide in chicory have been partially identified and some factors are still under consideration. The main acrylamide precursors in chicory are asparagine and reducing sugars, especially fructose, originating mainly from inulin hydrolysis during roasting. Studies at pilot scale show that asparagine content of dried chicory is moderately but

significantly correlated to the formation of acrylamide, but no relationship has been observed between reducing sugar levels and acrylamide formation during roasting.

3. The organoleptic properties of coffee substitutes mainly containing chicory depend on roasting conditions, processing technologies and recipe. The resulting flavour and aroma are essential to the identity of the products and subsequently consumer acceptance. At present, most of the tools usable at an industrial level to reduce acrylamide levels have a repercussion on the organoleptic quality of roasted products and their name. Only relatively small reductions in acrylamide levels appear achievable for 100% chicory products.

Agronomy

4. Asparagine levels in raw material may vary between different cultivars and years (weather conditions) with a significant correlation between free asparagine level in raw material and final acrylamide content in finished product. Reducing nitrogen supply lowers asparagine content in the root but the impact on crop yields (chicory crop as well as the next crop) is to be taken into account. FBOs shall inform their suppliers that cultivars and nitrogen supply may impact acrylamide formation.

Recipe

5. In the framework of substitutes not made exclusively from chicory (less than 100% and $\geq 50\%$) and especially for new products, the possibility of the addition of other ingredients shall be assessed by manufacturers (e.g. chicory fibers, roasted cereals), as these have been shown to be effective tools at the commercial level.

Processing

6. Manufacturers shall identify the critical roast conditions (duration and temperature) to favour optimal acrylamide conversion reactions within the target flavour profile. Conclusions shall be documented.
7. Control of roast conditions shall be incorporated into the manufacturer's food safety management system.
8. The process does not allow an efficient asparaginase enzyme treatment of the chicory roots.

Monitoring and Verification

9. Acrylamide levels in finished products shall be monitored to verify that the control of the design and processing steps measures are effective in keeping acrylamide levels to ALARA. Acrylamide testing shall be carried out by application of a standard method appropriate for chicory analysis (e.g., EN 16618). Fast methods (e.g. colour) can also be used during the process to monitor process parameters.
10. Manufacturers shall carry out investigations into the production and processing methods in cases where the level of acrylamide in coffee substitutes exceeds the acrylamide Indicative Value set for the respective food category.
11. Manufacturers shall ensure that adaptations to the product design are in line with the ALARA principle.

Further Guidance

12. In addition, further detailed guidance for FBOs is available in the SCF (le Syndicat national de la chicorée française) /FEDALIM (Pôle de regroupement de 7 organisations professionnelles de

l'industrie alimentaire) Code of Practice on managing acrylamide formation in coffee substitutes mainly containing chicory.

BB – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR BABY BISCUITS AND INFANT CEREALS

Product Design, Processing and Heating

1. Asparagine is the key determinant of acrylamide formation in baby biscuits and infant cereals. Free asparagine can vary widely within and between individual varieties of cereal grains and is also dependent on specific growing conditions. At present it is not possible to source specific cereals or grains with controlled low levels of asparagine.
2. Manufacturers that cannot use asparaginase, for example due to the processing/product design, shall choose flour raw material low in acrylamide precursors e.g. reducing sugars [fructose and glucose] and asparagine for production of foods for infants and young children. Where feasible, asparaginase shall be used to reduce the levels of asparagine in the flour raw material.

Manufacturers should make an assessment during recipe development that provides information on reducing sugars and asparagine, and includes options on achieving low reducing sugars in the final recipe. This need for this assessment will be dependent on use of asparaginase in the recipe.

3. Manufacturers shall ensure that suppliers of heat treated ingredients which are susceptible to acrylamide formation develop an ingredient acrylamide risk assessment and implement the appropriate mitigation measures. The suppliers of these raw materials should be asked to demonstrate that acrylamide is ALARA.

For raw materials/ingredients which have been analysed as part of the supply of heat treated ingredients and in the final product the EU Indicative Values are exceeded, they shall be subject of a review to look for improvement, or confirm and document that all effective and reasonable mitigation measures are appropriately applied.

4. Manufacturers shall have a change control procedure in place to ensure that they do not make any supplier changes that inadvertently increase acrylamide.

Recipe

5. In general, products based on maize and rice tend to have less acrylamide than those made with wheat, rye, oats and barley, therefore these grains should be considered in new product developments.
6. Generally, products based on wholegrain cereals and/or with high levels of cereal bran tend to have higher levels of acrylamide. Manufacturers should consider this in the product acrylamide risk assessment.
7. The impact of the addition of reducing sugars (e.g. fructose and glucose) and ingredients containing reducing sugars (e.g. honey) prior to heat-treatment stages shall be assessed and, if they do have a significant impact, the addition levels shall be carefully controlled as these are precursors to acrylamide formation.
8. Certain ingredients that have been heat-treated by the supplier can have elevated acrylamide levels (e.g. roasted/toasted nuts and oven-dried fruits). The contribution from these ingredients to the total acrylamide level shall be assessed and, if significant, alternative solutions shall be considered.

Processing

9. Manufacturers shall identify the key heat-treatment step(s) in the process that generate(s) the most acrylamide in order to focus further acrylamide reduction/control efforts most effectively. This could be achieved either via a risk assessment or by directly measuring the acrylamide levels in the product before and after each heat-treatment step. It is important to measure the moisture content, and express acrylamide concentration on a dry mass basis to eliminate the confounding effect of moisture changes.
10. Do not over-bake or over-toast. In general, higher heating temperatures and longer heating times generate higher acrylamide levels. Manufacturers shall therefore identify an effective combination of temperature and/or heating times to minimise acrylamide formation without unacceptably compromising the taste, texture, colour, safety and stability (shelf-life) of the product.
11. Good control of heating temperatures and times in the key heat-treatment steps are essential to avoid generating acrylamide spikes. Feed-rate and temperature control measurement systems should be calibrated regularly and these operating conditions controlled within set limits. These tasks shall be incorporated into a HACCP Pre-requisite Programme.
12. Monitoring and controlling product moisture content after the critical heat-treatment steps has proved to be effective in controlling acrylamide levels in some processes and, therefore, in these circumstances, this process can be an adequate alternative to controlling heating temperatures and times, hence shall be employed.

Monitoring and Verification

13. Finished products and heat-treated raw materials shall be tested on a risk assessment basis for acrylamide to verify that the control measures are effective in keeping acrylamide levels to ALARA.
14. Products, which have been analysed as part of the monitoring to exceed the EU Indicative Valuesⁱⁱⁱ shall be subject to a review to look for improvement, or confirm and document that all effective and reasonable mitigation measures are appropriately applied.
15. Acrylamide testing must be carried out by an ISO17025 accredited laboratory/method.

Further Guidance

16. In addition, further detailed guidance for FBOs is available in the Codes of Practice on managing acrylamide formation in breakfast cereals and fine bakery wares.

BJ – SPECIFIC MITIGATION MEASURES FOR MANDATORY ASSESSMENT BY FBOS FOR BABY JAR FOODS (LOW-ACID AND PRUNE-BASED FOODS)

Raw Materials

1. Manufacturers shall choose raw material varieties with low acrylamide precursors e.g. reducing sugars [fructose and glucose] and asparagine for production of foods for infants and young children.

2. For prune-based baby food products manufacturers shall include in the specifications of prune purée the relevant requirements to optimize heat treatment regimes that prevent occurrence of high acrylamide.
3. Manufacturers shall ensure that suppliers of heat treated ingredients that are susceptible to acrylamide formation develop an ingredient acrylamide risk assessment and implement the appropriate mitigation measures. The suppliers of these raw materials should be asked to demonstrate that acrylamide is ALARA.

Products which have been analysed as part of the supply of heat treated ingredients and exceed the EU Indicative Values shall be subject to a review to look for improvement, or confirm and document that all effective and reasonable mitigation measures are appropriately applied.

Recipe

4. Generally, products based on wholegrain cereals and/or with high levels of cereal bran tend to have higher levels of acrylamide. Manufacturers should consider this in the product acrylamide risk assessment.
5. Products containing sweet potatoes and prunes are of greater risk, due to relatively higher amounts of acrylamide precursors. Manufacturers shall choose varieties for processing, which are as low as possible in acrylamide precursors i.e. reducing sugars [fructose and glucose] and asparagine.
6. The impact of the addition of reducing sugars (e.g. fructose and glucose) and ingredients containing reducing sugars (e.g. honey) prior to heat-treatment stages shall be assessed and, if they do have a significant impact, the addition levels shall be carefully controlled as these are precursors to acrylamide formation.

Processing

7. Manufacturers shall identify the key heat-treatment step(s) in the process that generate(s) the most acrylamide in order to focus further acrylamide reduction/control efforts most effectively. This has to be achieved either via a risk assessment or by directly measuring the acrylamide levels in the product before and after each heat-treatment step.
8. Good control of heating temperatures and times in the key heat-treatment steps are essential to avoid generating acrylamide spikes. Feed-rate and temperature control measurement systems shall be calibrated regularly and these operating conditions controlled within set limits.
9. Any changes with regards to lowering of thermal input to reduce acrylamide in baby foods shall be carefully considered to ensure that they do not result in more severe microbiological risks.

Monitoring and Verification

10. Finished products and heat-treated raw materials shall be tested on a risk assessment basis for acrylamide to verify that the control measures are effective in keeping acrylamide levels to ALARA.
11. Products, which have been analysed as part of the monitoring to exceed the EU Indicative Valuesⁱⁱⁱ shall be subject to a review to look for improvement, or confirm and document that all effective and reasonable mitigation measures are appropriately applied.
12. Acrylamide testing shall be carried out by an ISO17025 accredited laboratory/method.

Further Guidance

13. In addition, further detailed guidance for FBOs on potato ingredients used in baby jar foods is available in the Codes of Practice on managing acrylamide formation in different potato products.

ⁱ EFSA Journal 2015;13(6):4104

<http://www.efsa.europa.eu/en/efsajournal/pub/4104>

ⁱⁱ Acrylamide Toolbox 2013

http://www.fooddrinkeurope.eu/uploads/publications_documents/AcrylamideToolbox_2013.pdf

ⁱⁱⁱ As currently defined in COMMISSION RECOMMENDATION of 8 November 2013 on investigations into the levels of acrylamide in food (Text with EEA relevance) (2013/647/EU)

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:301:0015:0017:EN:PDF>

^{iv} 'The European Cultivated Potato Database' <http://www.europotato.org/menu.php> (last retrieved 21/12/2015)

^v <http://jxb.oxfordjournals.org/content/early/2014/11/25/jxb.eru473.abstract>

APPENDIX 1: ASSESSMENT FORM

Product Description

Product/ Product Group Description:	Date:
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List of Mitigation Measures

No.	Mitigation Measures

Measures selected to reduce acrylamide formation and link to the Food Safety Management or HACCP System

Details of application, reductions achieved and assurance of successful implementation (e.g. related PRP)

Measures that are judged not to be applicable in the context of the ALARA concept

Evaluation and justification



The Concept of ALARA

“ALARA” is an acronym for the concept “As Low As Reasonably Achievable”.

ALARA means that a Food Business Operator (FBO) shall take every reasonable measure to reduce the presence of a given contaminant in a final product taking into account other legitimate considerations.

To ensure continuing compliance with the ALARA concept, the FBO shall monitor the effectiveness of the implemented measures and shall review them as necessary.

ALARA as Applied to Acrylamide

In the context of acrylamide and other process contaminants, which are the result of naturally occurring chemical reactions in heated foods and for which there are currently no levels that regulators have agreed upon as being ‘safe’, ALARA means that the FBO shall make every reasonable effort (based upon current knowledge) to reduce levels in final product and thereby reduce consumers’ exposure. For example, ALARA could mean that an FBO changes parts of a process or even a whole process if technologically feasible.

The mitigation measures identified in this Code of Practice are designed to limit acrylamide levels in foods through interventions at various stages of production (agronomy, recipe, processing, and final preparation). They are based upon scientific knowledge and practical application in specific circumstances.

As technology develops, new and better mitigation measures for acrylamide reduction may become available. As part of a continuous process, FBOs shall, on a regular basis, review what mitigation measures are available in the Code of Practice, and consider whether they can implement these measures for their products and processes.

If a FBO chooses not to implement an available mitigation measure then the onus shall be placed on that FBO to demonstrate why its application is believed to be unreasonable or ineffective.

Considerations may include:

- potential impact that use of a known acrylamide mitigation tool will have upon levels of acrylamide in the final product;
- potential impact that use of a known acrylamide mitigation tool may have upon the formation of other process contaminants (e.g. furan) and/or reduction in control of other hazards e.g. microbiological;
- feasibility of implementing the identified controls, e.g. legal compliance, commercial availability of the mitigation tool, occupational health hazards, timescales and costs associated with upgrading or replacing plant equipment;
- impact that use of a known acrylamide mitigation tool will have on organoleptic properties and other quality aspects of the final product as well as product safety (the ideal method would have no adverse effects);
- known nutritional benefits of using certain ingredients in preference to others, e.g. use of whole grain cereals instead of refined cereals.

