Trade Guidelines on Reducing Acrylamide in Food

食物安全中心
Centre for Food Safety

Purpose

This set of guidelines provides recommendations to help the trade minimise the formation of acrylamide in food, especially potato and cereal based products, and stir-fried vegetables, with reference to the Codex Code of Practice for the Reduction of Acrylamide in Foods (CAC/RCP 67-2009) and the findings of the First Hong Kong Total Diet Study. The Guidelines is applicable to all manufacturers and caterers, in particular those producing high temperature processed potato and/or cereal based products and serving stir-fried vegetables.

Background

Acrylamide is an industrial chemical used in the manufacture of polyacrylamides. In 2002, studies conducted in Sweden for the first time found that relatively high levels of acrylamide are present in a variety of fried and baked carbohydrate-rich foods.

Following to the discovery of acrylamide in food, many food authorities including the Centre for Food Safety (CFS) have analysed the acrylamide level in different foods. The studies conducted by the CFS showed that relatively high level of acrylamide was present in some high temperature processed potato products such as potato chips, cereal products such as biscuits, as well as some stir-fried vegetables (Table 1). Moreover, the First Hong Kong Total Diet Study on acrylamide revealed that stir-fried vegetables were found to be the major sources of acrylamide exposure of the local population.

Table 1: Acrylamide levels found in some local food

Food items	Acrylamide level range (μg/kg)
Potato chips	160 – 3 000
Other crisps	<3 – 480
French fries and waffle fries	74 – 890
Baked potatoes	15 – 160
Biscuits	32 – 2 100
Breakfast cereals	29 – 460
Stir-fried vegetables	1 – 360

Toxicity of acrylamide

The adverse effects of acrylamide on the nervous system in humans following high occupational and accidental exposures are well-documented. Studies have shown that acrylamide is toxic to genes and causes cancers, reproductive and developmental problems in animals. However, currently there is inadequate evidence in humans for the carcinogenicity of acrylamide. The International Agency for Research on Cancer (IARC) under the World Health Organization (WHO) has classified acrylamide as "probably carcinogenic to humans" (Group 2A). In addition, epidemiological studies do not provide any consistent evidence that occupational exposure or dietary exposure to acrylamide is associated with cancer in humans.

In order to protect public health, appropriate efforts, including from members of the trade, to reduce the amount of acrylamide in food should be done continuously.

Formation of acrylamide in food

AAcrylamide is mainly formed unintentionally in the Maillard reaction when the free amino acid asparagine reacts with the reducing sugars, especially glucose and fructose that are present in food. The formation of acrylamide usually takes place during high temperature (>120ºC) processing such as frying, baking, roasting, toasting and grilling. Various factors such as food composition, ratio of surface area to volume of the food, cooking methods and conditions including temperature and time, etc. can affect the acrylamide formation.

Major food items contaminated by acrylamide include potato chips, crisps, bakeries, fried vegetables and coffee. Foods prepared by boiling do not typically produce acrylamide.

** Maillard reaction is a complex chemical reaction between an amino acid and a reducing sugar, usually requiring heat. The chemicals formed in the Maillard reaction are responsible for a range of odours and flavours found in foods. Acrylamide is one of the products formed when the amino acid asparagine and reducing sugars such as glucose and fructose react during the Maillard reaction. Low moisture, high temperature and alkaline pH have a positive influence on the reaction.*

Scope

This set of guidelines cover three main strategies for reducing acrylamide formation in potato and cereal based products and stir-fried vegetables -

(i) **Raw materials** e.g. levels of reducing sugars and asparagine;

(ii) **Recipes** e.g. use of raising agents, asparaginase and other minor ingredients, and selection of cooking methods;

(iii) **Food processing conditions** e.g. pre-treatment, temperature, time and moisture control.

Specific ways to reduce acrylamide level in potato products such as French fries, potato chips and potato snacks

Raw materials

1. Select potato varieties with low reducing sugar levels, taking into account regional and seasonal variability.
2. Check the reducing sugar levels in incoming deliveries of potatoes or fry test them, aiming for a light golden colour.
3. While potatoes should be stored in a cool, dry and dark environment to avoid sprouting or spoilage, the temperature should be above 6°C. Low temperature storage increases reducing sugar levels in potatoes. Potatoes that have been stored at low temperatures should be reconditioned over a period of a few weeks at higher temperatures i.e. 12-15ºC.
4. Select potatoes before use and avoid using immature tubers for high temperature processing. Immature tubers tend to have higher levels of reducing sugars.

Recipes

5. Consider adding asparaginase (an enzyme) to reduce asparagine level in potato products made from potato dough.
6. Partially replace the potato with other ingredients e.g. rice flour which contains lower levels of reducing sugars and/or asparagine in reconstituted potato based snacks made from potato dough.
7. Avoid using reducing sugars as sugar dips/ coating.
8. Consider treating French fries with sodium acid pyrophosphate and potato products with calcium salts e.g. calcium lactate and calcium chloride before processing. Excessive level of sodium acid pyrophosphate and calcium salts can, however, create off-flavours.

Food processing conditions

For French fries

9. Reduce the surface area of the product e.g. cut potatoes into thicker slices as they contain less acrylamide than thinly cut ones. Food producers using thin cuts of French fries should be particularly vigilant in following the optimal cooking time and temperature to produce products with a golden-yellow colour.
10. Blanch or soak cut potato products in water to remove reducing sugars before frying or baking. However, it may affect the flavour and texture of final product. Adding various reagents e.g. sodium acid pyrophosphate for lowering pH (excessive level of sodium acid pyrophosphate can create off-flavours) during the latter stages of blanching and blanching in sodium chloride solution (this may increase dietary exposure to sodium) can further reduce acrylamide levels.
11. Optimise temperature and time cooking profile and cooker setting to produce French fries with a golden-yellow colour. The initial oil temperature for frying French fries should set to no more than 175°C and do not overcook.
12. Immerse the amount of French fries aim at giving an actual frying temperature starting from 140°C and ending at about 160°C, depending on the heating power of the fryer. When frying small amount of French fries, reduce the frying time. A bigger long-lasting temperature drop after the addition of potato will increase the fat uptake and a higher end temperature will lead to excessive acrylamide formation.
13. For manufacturers of prefabricated potato products, provide recommended frying temperature at not exceeding 175°C on package.

For potato chips

14. Optimise temperature/time cooking profile and cooker setting to produce potato chips with a golden-yellow colour.
15. Carry out in-line colour sorting to remove dark chips.

Specific ways to reduce acrylamide level in cereal based products such as bread, biscuits, bakery wares and breakfast cereals

Raw materials

1. Consider reducing the proportion of cereals with high asparagine level and replacing those with low asparagine level in mixed cereal products.
    - In general, asparagine ranges from 75 to 2 200 mg/kg in wheat, from 50 to 1 400 mg/kg in oats, from 70 to 3 000 mg/kg in maize, from 319 to 880 mg/kg in rye and 15 to 25 mg/kg in rice. It is noted that asparagine level within and between cereal types may vary widely.

Recipes

2. Consider the type of flour to be used. High extraction flours contain significantly less asparagine than wholemeal flours. However, reducing the wholemeal content will decrease the nutritional benefits of the final product.

For bread

3. Avoid adding reducing sugars in the recipe.
4. Add calcium salt such as calcium carbonate may reduce acrylamide formation.

For biscuits and bakery wares

5. Reduce the use of ammonium bicarbonate as raising agent in baked products. Consider the following alternatives:
    - Sodium bicarbonate + acidulants
    - Disodium diphosphate + sodium bicarbonate + organic acids
    - Potassium bicarbonate + potassium bitartrate
    - Sodium bicarbonate + sodium acid pyrophosphate
6. Add asparaginase in hard, wheat-dough based products such as cookies and crackers.
7. Try investigating the effect of different spices in respect to the formation of acrylamide in the recipes. Inclusion of ginger, honey and cardamom increase the formation of acrylamide during biscuit production. Adding nutmeg may decrease the acrylamide level.

For breakfast cereals

8. Add sugars after instead of prior to the baking process in sweetened breakfast cereals.

Food processing conditions

9. Do not over bake and manage to achieve a uniform colour for the product.

For bread

10. Consider using yeast fermentation of wheat bread dough. Yeast fermentation of wheat bread dough reduces the free asparagine content.
11. Modify temperature/ time baking profile, in particular, decrease the temperature in the final stages when the product reaches the low moisture phase. Avoid excessive browning of the crust.

Specific ways to reduce acrylamide level in stir-fried vegetables

Raw materials

1. Consider serving vegetables prepared by boiling or steaming or vegetables that can be eaten raw.

Recipes

2. Develop recipes for vegetable containing dishes prepared by boiling or steaming, instead of frying.

Food processing conditions

3. For stir frying vegetables, consider blanching them first before frying.
4. Avoid frying vegetables for too long or at too high temperature.

Important notes

In most cases, there is no single solution to reduce acrylamide level in food. The level of acrylamide formed can be quite variable e.g. within a batch produced at the same plant, or between plants using the same process and recipe. Variability of the raw materials and poorly controlled heating devices may also set hurdles in the trials of mitigation strategies. Members of the trade are advised to investigate and adopt those approaches that are most suitable to the specific product, its processing and product quality specification.

It is also important that all measures to be taken to reduce acrylamide level do not compromise the chemical (e.g. formation of other undesirable chemicals) and microbiological (e.g. inadequate reduction of microorganisms) safety of the food.

In addition, changes in product composition and/or processing may affect the nutritional quality (e.g. increase fat uptake and loss of minerals and vitamins) as well as the organoleptic properties and consumer acceptability (e.g. change in flavour and texture). Members of the trade should thoroughly evaluate the proposed interventions before making any changes to avoid creating a potentially larger risk.

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