NOTE OF THE MEETING OF EXPERTS ON INDUSTRIAL CONTAMINANTS IN FOOD:

ACRYLAMIDE WORKSHOP, 20-21 OCTOBER 2003

Information on Ways to Lower the Levels of Acrylamide Formed in Food

The presence of the chemical acrylamide in food was highlighted in April 2002. Acrylamide is formed in food as a result of cooking practices, some of which have been used for many years, even centuries. Therefore, finding ways to prevent its formation and to lower the levels in food is not straight-forward. Numerous studies and research activities have been developed to help better understand how to lower the levels.

On 20-21 October 2003, the European Commission held a meeting to discuss with stakeholder groups the progress made on ways to lower the levels of acrylamide formed in food. The participants of the meeting included representatives from the different sectors of the food industry (including producers, processors, retailers and caterers), consumer representatives, representatives of the EU Member States, of the European Food Safety Authority and of the European Commission's Directorates-General for Health and Consumer Protection, Agriculture, Research and the Joint Research Centre.

A number of approaches that have been found to lower the levels of acrylamide formed in food were discussed. Studies have generally applied to fried and baked cut potato and baked cereal products. The formation of acrylamide in these products has been linked to the interaction of certain sugars ('reducing sugars' such as glucose/dextrose, fructose) with the amino acid 'asparagine' when heated in low moisture conditions. Some approaches to lowering the formation of acrylamide can be readily applied. For example, avoiding over-frying or over-baking of potato products in particular (as indicated by excess browning) can significantly lower the levels of acrylamide formed when compared with products more lightly fried or more lightly baked. Other approaches to lowering levels of acrylamide require further investigation. For example, findings in laboratory studies may need testing for feasibility in commercial practice. The range of products in which acrylamide can be found is extremely wide and initial findings in some cases apply to only limited product types. Also, there is a need to further investigate agricultural factors, such as crop storage and the influence of climatic and seasonal variation on the potential for acrylamide formation.

As highlighted at the meeting, details of approaches found to lower the levels of acrylamide formed in food and a number of recommendations are listed below:

1. CUT POTATO PRODUCTS (FRIED & BAKED)

E.g. products such as potato crisps and french fries.

1.1 Low levels of reducing sugars

Select varieties

It is feasible to select potato varieties with low levels of reducing sugars. These varieties can be used for cut potato products intended for frying and baking to lower the levels of acrylamide formed. For example, a maximum of 1g/kg reducing sugars has been suggested as a way to significantly diminish the likely formation of acrylamide. Such information on sugar levels is sometimes already used by the industry. Information could be given to consumers to allow them

to select labelled varieties e.g. retail bags could be colour coded with a key, to indicate the suitability for use in frying and baking.

It is important to note that although the sugar content can depend upon the potato variety it also depends upon seasonal factors, cultivation and storage conditions (see below). These factors should be taken into account and further investigated where necessary.

Blanch/ soak
Levels of reducing sugars can be lowered by pre-blanching the cut potatoes in warm or hot water or soaking them in water at room temperature before they are fried or baked (N.B. after soaking cut potatoes immediately before frying, it is important to drain well before placing them in hot oil in the fryer. This will help to avoid the possible risk of a pan fire which otherwise can be caused if water is added to hot oil.) Blanching may be unsuitable for some products if it would cause unacceptable moisture uptake, leading to loss of consistency/ crispness or possible microbiological spoilage.

Low pH
Lowering the pH of the potatoes, for example with citric acid (e.g. 0.5-1.0% < 20minutes) has been shown to lower the levels of acrylamide formed. However, this approach can cause souring of flavour if a precise procedure is not followed and also the frying oil can become rancid. Further investigation on the feasibility of this approach is necessary.

Avoid cold storage
Storage of potatoes below 8°C (farm, barn, distributors, retail, caterers, domestic, etc) is known to cause increased levels of reducing sugars. Storage at 8°C or above will therefore reduce the potential for the formation of acrylamide in the potato product upon baking or frying. Avoiding cold conditions can be readily achieved for short-term storage. There is a practical problem for longer term agricultural storage. To maintain supplies of potatoes throughout the year it is necessary for producers to store potatoes for periods of several months. This can only be achieved successfully if the storage conditions prevent the potatoes from sprouting. Cool temperatures are often used to prevent sprouting. Alternatively, chemical treatments of potatoes with sprout suppressing agents can be used, although the use of such chemicals is not always desired by the consumer or may not be permitted.

Optimum long term storage regimes should be identified to limit the formation of sugars and consequently reduce the potential for acrylamide formation, whilst avoiding the problems associated with sprouting or spoilage.

Avoid sugar dips/ coatings in part-cooked products
Processors of part-cooked cut potato products sometimes include a process of dipping the products in glucose/ dextrose solutions. These solutions can help to give the final fried or baked products an even golden colour. The use of reducing sugars in such dips/ coatings should be avoided where possible because they can cause the formation of significant levels of acrylamide.

1.2 Temperature/ cooking regimes
A straight-forward way to lower levels of acrylamide is to avoid browning when frying or baking, aiming for a ‘golden yellow’ colour.

For conventionally fried potato products, frying temperatures above 175°C have been shown to increase levels of acrylamide significantly. The initial frying temperature should not exceed 175°C and possibly should not exceed 170°C. (N.B. The addition of potato to the hot oil and the

subsequent evaporation of water cools the oil. In domestic preparation where smaller ratios of oil to potato are used it is likely that the frying temperature drops more than in commercial preparation. Consequently, the acrylamide levels might be lower, although this needs further investigation.) Further reduction of the formation of acrylamide can be achieved by further lowering the temperature to 150°C towards the end of cooking. However, use of lower temperatures for extended cooking times can affect quality, such as increased moisture. Increased moisture can result in loss of consistency/ crispness and for products which are not eaten immediately after cooking moisture can increase the risk of microbiological spoilage. Also, low frying temperatures can result in increased fat uptake which can have health implications.

To enable better control over frying temperatures, it is necessary to improve the reliability and accuracy of temperature controls on frying equipment, in particular for domestic fryers. The type of frying oil used appears to have little influence on the formation of acrylamide.

Oven baking temperatures should not be too high, for example not above 200°C in a conventional oven and not above 190°C in a fan-assisted oven.

Microwave heating to part-cook cut potato products before oven baking might increase the potential for acrylamide formation. This is possibly due to the microwave removing moisture before oven baking. Whether to avoid this way of part-cooking needs further investigation.

1.3 Asparagine levels

Asparagine is an important amino acid component of potatoes and it is not clear whether control of asparagine levels would be practicable. Whether levels can be changed would need long term assessment of potato varieties and feasibility studies.

The use of the enzyme asparaginase is a possible approach to interrupt the interaction of asparagine with reducing sugars (e.g. in doughs for some potato products), but further investigation is required.

2. CEREAL PRODUCTS

2.1 Baking temperatures/ shorter baking time

For many bakery products perhaps the most straight forward way to lower the levels of acrylamide formed is to reduce the baking time to avoid excess browning. Reducing the baking temperatures can also help to achieve reduction. For example, lighter baking of sweet biscuits has resulted in significantly lowering levels of acrylamide in some products. However, for some bakery products excess baking can have the same effect and also lead to lower levels of acrylamide. This is believed to result from a balance between formation and destruction of acrylamide at high temperatures. Manufacturers should explore how their products are affected by baking time and temperature. In dry, crisp products a balance is needed to avoid unacceptable product quality, in particular moisture levels should be checked to maintain a desirable texture and to avoid microbiological and spoilage implications.

2.2 Asparagine levels

Higher levels of asparagine in different cereal types can lead to higher levels of acrylamide in products. Grain varieties can be selected for lower asparagine levels e.g. broadly, rye can contain more asparagine than wheat and oats, which can contain more than rice and maize. It is unclear whether changes in agricultural practice could consistently reduce the content of asparagine in the different varieties of grain and studies would be necessary to clarify this. However, the extent of milling of grain can also affect the asparagine. For example, higher levels of acrylamide can

result from less milled flours and darker breads. The nutritional effect of selecting alternative grains and alternative processing should be carefully considered. The use of the enzyme asparaginase is a possible approach to reduce asparagine, but further investigation is required.

2.3 Low levels of reducing sugars

The levels of reducing sugars that are naturally present in cereals appear to be difficult to change. Also, their influence on potential acrylamide formation is less clear than for potatoes. Longer term studies are needed on different cereal varieties to clarify the extent to which varieties could be selected for lower levels of reducing sugars and on whether this approach would help to reduce the formation of acrylamide. Despite difficulties in managing the levels of naturally present sugars, the effect of reducing sugars on acrylamide formation in sweetened bakery products can be more readily managed by carefully selecting other ingredients. The selection of ingredients to avoid high levels of reducing sugars can diminish the potential for acrylamide formation e.g. alternatives to using glucose, fructose and honey can result in lower levels of acrylamide. However, care is important when considering changes for different products, to ensure that such changes would indeed lower the levels of acrylamide and would not unduly compromise the nutritional and health value of the products.

2.4 Alternative raising agents

The use of the raising agent ammonium bicarbonate has been found to increase the potential for acrylamide formation due to the ammonium component. Ammonium appears to be an important factor in acrylamide formation, such as in sweetened bakery products. Replacing ammonium bicarbonate with other raising agents e.g. sodium hydrogen carbonate can significantly lower the levels of acrylamide formed in many cereal products. The amounts of sodium used in raising agents are unlikely to contribute significantly to dietary sodium intake. The flavour implications also need to be carefully considered for some products.

2.5 Use of previously baked crumbs e.g. in crispbread/ crackers and multiple-baking

Crumbs from a previous bake are sometimes re-used and re-baked (known as 'rework') e.g. to coat and give texture to a product. Reports indicate that the use of 'rework' in baked cereal products sometimes can cause significantly higher levels of acrylamide, although there are differing views on the extent of the contribution. Further studies are needed, but in the meantime the use of 'rework' should be avoided where possible for uses where it is known to significantly increase acrylamide levels. The issue of multiple-baking can be complicated, for example cereals might be necessarily toasted or baked before being incorporated into a cereal bar for final baking. Further investigation is needed into the influence of such multiple-baking processes.

3. COFFEE

Acrylamide can be formed in coffee during the roasting process. Roasting is an essential part of processing for coffee and the levels of acrylamide in different products appear not to vary considerably. This makes it difficult to identify how to optimise the roasting and processing to lower the levels of acrylamide. Coffee can contribute significantly to the total dietary intake of acrylamide for some groups of consumers, although this is generally a result of drinking large amounts of coffee. No obvious ways to lower the levels of acrylamide formed in coffee or coffee substitutes have been demonstrated and further investigation is needed. For example, convection roasting has been indicated as a possible approach, but whether this would be feasible is not yet clear. Also, the feasibility of lowering the levels of reducing sugars in raw coffee is unclear.

RECOMMENDATIONS FROM THE MEETING

To food producers and processors

1. Fried and baked cut potato products should be golden yellow and not browned.

2. Where appropriate, e.g. for potatoes destined for cutting and frying or baking, select potato varieties with low levels of reducing sugars.

3. For long term storage of potatoes destined for cutting and frying or baking avoid storage below 8°C whenever possible. For short term storage of potatoes, avoid storing below 8°C whenever possible. Investigate and optimise storage conditions to keep levels of reducing sugars low whilst avoiding sprouting or spoilage.

4. For conventionally-fried cut potato products, the frying temperature should not exceed 175°C.

5. Oven baking temperatures for cut potato products should not exceed 200°C for conventional ovens and should not exceed 190°C for fan-assisted ovens.

6. Where possible part-cook/ blanch or soak cut potato products in water (and drain well) before frying or baking.

7. Avoid using glucose/ dextrose or other sugar dips/ coatings for products to be fried or oven baked whenever possible.

8. Part-cooked potato products should be labelled with instructions to cook until golden yellow and to avoid browning. Accurate cooking temperature/ time instructions should be given to avoid too hot frying and baking temperatures.

9. Avoid excess browning of baked cereal products.

10. In bakery products use raising agents other than ammonium bicarbonate whenever possible and acceptable, e.g. sodium hydrogen carbonate.

To retailers

1. Avoid storing potatoes below 8°C where feasible and otherwise investigate alternative storage practices. Ideally store potatoes in the dark at a temperature of 8°C or slightly higher.

2. Investigate the feasibility of labelling potato varieties which are low in reducing sugars and most suitable for cutting and frying or baking.

3. Check that suppliers are aware of the above recommendations and where possible follow them.

To caterers

1. Avoid storing potatoes below 8°C. Ideally store potatoes in the dark at a temperature of 8°C or slightly higher.

2. Fried and baked cut potato products should be golden yellow and not browned.

3. Where possible, blanch or soak cut potato products (and drain well) before frying or baking.

4. Frying temperatures for cut potato products should not exceed 175°C. Ensure temperature controls on fryers are reliable and accurate.

5. Oven baking temperatures for cut potato products should not exceed 200°C for conventional ovens and should not exceed 190°C for fan-assisted ovens.

6. Avoid excess browning of baked cereal products.

7. Follow uptodate preparation instructions given by suppliers.

To consumers

1. Avoid storing potatoes below 8°C – do not store them in the refrigerator. Ideally store potatoes in the dark at a temperature of 8°C or slightly higher.

2. Fried and baked cut potato products should be golden yellow and not browned.

3. Frying temperatures for cut potato products should not exceed 175°C.

4. Oven baking temperatures for cut potato products should not exceed 200°C for conventional ovens and should not exceed 190°C for fan-assisted ovens. For processed potato-based products follow the cooking instructions on the food packets.

5. Where possible blanch or soak cut potato products (and drain well) before frying or baking. For pan-fried potatoes use already boiled potatoes rather than raw potatoes.

6. Avoid excess browning of baked cereal products.

7. Follow carefully the cooking instructions on food packets.