ACRYLAMIDE IN FOOD – IMPLICATION FOR THE FOOD INDUSTRY

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INTRODUCTION

It is a very complex and actual problem to assure a healthy and equilibrate feeding, because of the special importance that food has for human health.

The acrylamide contamination of food products or the formation during the technological processes are among the main risk factors for public health owed to the potential to generate toxicity from this contamination with multiple noxious effects.

Acrylamide is an instable organic compound, white crystals, odorless, water, ethanol and ether soluble. It has the composition, from chemical point of view, of an amide, with the chemical formula C₃H₅NO. Acrylamide is used in the plastic materials, paper, dyes, textile industry, also in construction and cosmetics etc. It is also used for making polyacrilamide, product used as water stabilizer and sewage water treatment and for gels electrophoresis.

Acrylamide is suspected for inducing cancer when it is present in small quantities in some food stuff.

Acrylamide was also defined as potential carcinogenic by the International Cancer Research Agency in Lyon back in 1994.

At international level, in 2002, following a scientific study, The Swedish National Food Administration announced that the food rich in starch, processed at high temperatures, contains large quantities of acrylamide. Given the carcinogen potential of acrylamide, the international scientific community and WHO immediately reacted, searching for the causes of acrylamide presence in food, for rapid methods to test the food stuff rich in starch and also for possibilities to reduce the formation of acrylamide in food. The substance, whose toxicity is well known by the international scientific community, is not part of initial composition of any food; its appearance is owed only to thermal treatment.

According to these studies, during the thermal preparation of the food based on starch raw material acrylamide is formed. High level of this substance was found also in food rich in glucids, fried or prepared at high temperatures. Among the food most rich in starch are: potatoes, wheat and rye flour, corn, rice, bread, pasta and chips.

The white bread, the different potato products, biscuits and over thermally done products are more noxious for human health then believed before, because of their high content in acrylamide.
The level of acrylamide increase in certain over temperature cooked food products. The specialists opinion is that acrylamide is put in evidence in the case of preparing potatoes and cereals at temperatures higher than 120°F.

Acrylamide shows different levels in the same food product, for different environmental factors, especially temperature, cooking duration. In order to reduce the level of acrylamide in food products, is mandatory that The National Sanitary Veterinary Authority for Food Security interferes alongside the food industry. The goal is to improve the food processing technology for the purpose to reduce significantly the acrylamide content in certain food products, particularly French fries, chips, pastry, biscuits and bread.

The main acrylamide formation mechanism in food products is through Maillard reaction. The Maillard reaction is a complex process generating important taste and flavour compounds and also colour compounds (fig. 1).

![Fig 1. The mechanism of Acrylamide formation during Maillard reaction](image)

Especially, heat reactions of amines, aminoacids, peptides and proteins with reducing sugars and Vitamin C induce food deterioration during processing and storage. Some of the adverse reaction is acrylamide formation, finally leading to reduced nutritional value and safety for the food product.

In most cases, acrylamide accumulates during the final processes of baking and frying, once the humidity lowers and surface temperature rises.

The food composition has also a great importance, the content in free Asparagic Acid and reducing sugars being crucial. Other important factors are Ph and water content.

The possible mechanisms for acrylamide formation in food products might also be:
- through thermal degradation of Glycerol or mono-Glycerides, from a three carbon Aldehyde whose structure is close to acrylamide’s, Acrolein (CH$_2$=CH–CHO), via Acrylic acid
- through Asparagine and Glutamine degradation (Strecker degradation)
- dehydroalanine amidation
- free radicals reactions of Asparagine or Glutamine
- degradation of Alanine, Serine, Cysteine, Malic acid or Tartric, via Acrylic acid
- combinations of lipid or aldehyd fragments (Acetaldehyde + Formaldehyde)
- sugars fragmentation (breaking and dehydration)
- thermal decomposing of N-glycozides of Asparagine, Glutamine and Methionine

**Table1** gives an overview of the range of acrylamide levels found into food groups for different countries (Sweden, Switzerland, UK and USA).

<table>
<thead>
<tr>
<th>Food/Product group</th>
<th>Acrylamide levels (µg/kg) minimum – maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crisps, potato/sweet potato</td>
<td>170 – 2287</td>
</tr>
<tr>
<td>2. Chips, potato</td>
<td>&lt;50 – 3500 (3.5 mg/kg)</td>
</tr>
<tr>
<td>3. Bakery products</td>
<td>&lt;50 – 450</td>
</tr>
<tr>
<td>4. Biscuits, crackers, toast</td>
<td>&lt;30 – 3200</td>
</tr>
<tr>
<td>5. Breakfast cereals</td>
<td>&lt;30 – 1346</td>
</tr>
<tr>
<td>6. Bread soft</td>
<td>&lt;30 – 162</td>
</tr>
<tr>
<td>7. Instant malt drinks</td>
<td>&lt;50 – 70</td>
</tr>
<tr>
<td>8. Coffee powder</td>
<td>170 – 200</td>
</tr>
</tbody>
</table>

Toasted bread is a representative product for acrylamide formation, mainly formed in the outermost crust layer – the levels of acrylamide are higher in the base crust than the top crust.

The levels of acrylamide will be higher for the unlidded crust because the rate of loss of moisture from the lidded crust is less than that from the unlidded crust.

Crust color is a good predictor of acrylamide formation in bread crust.

<table>
<thead>
<tr>
<th>Baking profile</th>
<th>Acrylamide (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat, lidded</td>
<td>91.8</td>
</tr>
<tr>
<td>Falling, unlidded</td>
<td>103.6</td>
</tr>
<tr>
<td>Flat, unlidded with egg wash</td>
<td>108.7</td>
</tr>
<tr>
<td>Flat, unlidded (control)</td>
<td>110.1</td>
</tr>
<tr>
<td>Rising, unlidded</td>
<td>148.4</td>
</tr>
</tbody>
</table>

Biscuits have a wide range of different products, recipes and technologies. Due to this diversity, it hasn’t been possible to identify a single route for acrylamide formation.

A reasonable hypothesis for lowering the level of acrylamide is to lower the reducing sugar content in the biscuits recipe. The sugars which are commonly used in biscuit
production are sucrose, glucose and occasionally fructose. Glucose and fructose are reducing sugars, while sucrose is not – usually sucrose is the main sugar component of the biscuit recipes.

Rising agents like sodium and ammonium bicarbonate are commonly used in biscuit production. There does seem to be clear evidence that the presence of ammonium bicarbonate has a significant effect on acrylamide formation in biscuits (1). Eliminating ammonium bicarbonate from baking powder and using sodium bicarbonate lead to an increase in the sodium level of the finished product which is not quite desirable (risk/benefit).

CONCLUSIONS

Food industry is committed to understanding how acrylamide is formed during food processing and to investigate all possible ways of reduction.

Changing the conditions for acrylamide formation, several other product parameters may also be affected, including the risk of other undesirable compounds being formed or increased, or the loss of desirable food properties:
  - sodium bicarbonate may reduce acrylamide formation but will increase the sodium level;
  - avoiding high protein, full grain, may reduce asparagine levels, but will also reduce the nutritional benefits of full grain products.

Consumers and food authorities must help to educate the public and to ensure that the learnings are translated to home preparation of food.

Providing coherent recommendation on home preparation procedures, e.g.: cooking instructions with fryers for home purposes should be consistent with the advice on the labels for preparation of industrially-produced foods.

There are several principles that can be applied to minimize possible risks associated with acrylamide:
  - food should not be cooked excessively, for too long or at too high temperature;
  - people should have a balanced and varied diet, which includes plenty of fruits and vegetables, and should moderate their consumption of fried or fatty foods.

The information on the levels of acrylamide in food are far from complete.

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