Reducing acrylamide formation during baking

Identification

Key words cereals, acrylamide, temperature, organic acid, carcinogen, baking, steam baking
Latest version 2011/09/01
Completed by SP

How does it work?

Primary objective Reducing acrylamide formation in cereal products
Working principle Acrylamide is a potentially carcinogenic compound that has been found in fried food products containing protein and carbohydrate, more specifically the amino acid (the building blocks of protein) asparagine and a reducing sugar (carbohydrate). Reduction of this compound is therefore wanted. Acrylamide formation is present in several reaction paths, but the most common one is via the so-called Maillard reaction. This reaction is rather a family of reactions that occurs when heating carbohydrates and proteins above 150°C. The most important process parameters in reduction of acrylamide in cereals are the temperature and moisture. During baking of white bread the crust temperature in combination with the water content have a significant effect on acrylamide formation. Higher temperatures results in higher acrylamide content. Steam baking and falling temperature baking decreases the acrylamide concentration. The use of steam for at least 10 min during baking of bread can reduce the acrylamide concentration by approximately 50% compared to baking without steam. Steam baking reduces the crust temperature, and the temperature difference between the crust and the crumb, resulting in lower acrylamide formations. Also, lowering the oven temperature after a few minutes could reduce the formation of acrylamide up to 67%, although the bread colour becomes lighter (2). Another limiting factor for the formation of acrylamide in cereals is the amino acid asparagine. Choosing a flour variety that is low in asparagine is desired. Addition of the enzyme asparaginase prior to main processing can reduce the formation of acrylamide by up to 90% in cereal products (1,8). For bread production the choice of sugar added to the bread is also important. If a non-reducing sugar such as sucrose is added instead of invert sugar (mixture of glucose and fructose) a reduction of 60% in acrylamide has been observed (1). Addition of glycin to the dough reduces the acrylamide content in flat bread and bread crust (3). Leaveners are also important. Several studies have shown that ammonium bicarbonate (NH4HCO3) increases the concentration of acrylamide compared to sodium bicarbonate (NaHCO3) (1).

Images

Additional effects Lowering temperature: increased process times, lighter bread colour.
Important process parameters Time, temperature, flour milling intensity (4), additives to product. Models can be used for estimation of acrylamide formation based on the important product and process parameters (9,10).
Important product parameters Moisture content, type of cereal, ash content of the flour, water content, variety, weather conditions during growth, asparagine content, reducing-sugar content.
What can it be used for?

**Products**
- Bread, cookies

**Operations**
- Baking, roasting

**Solutions for short comings**
- Reduction of a potential carcinogenic substance that has been given a lot of attention in media.

What can it NOT be used for?

**Products**
- Non-acrylamide forming food products (e.g. high-moisture food products).

**Operations**
- Acrylamide is only formed in processes with high temperatures (above app. 120-130°C for traditional baked bread (2)).

**Other limitations**
- Lower temperatures results in a lighter crust colour which might be unacceptable from a consumer standpoint. The aroma of the bread could also be affected when lowering the temperature.

**Risks or hazards**
- Replacement of ammonium bicarbonate with sodium bicarbonate will increase the sodium intake (6).
- Prolonging yeast-fermentation can decrease the formation of acrylamide but can also increase the formation of another contaminant i.e. 3-monochloropropaniol (6).

Implementation

**Maturity**
- Steam baking is commonly used during the initial stage of baking to improve crust texture and colour.

**Modularity**
- These technologies are generally easily implemented into the existing production lines. The additives can be added in the dough preparation step. Enzymatic treatment with asparaginase might need an extra step in the process chain. Steam baking and falling temperature baking are simple modifications of conventional baking.

**Consumer aspects**
- Positive, a reduction of a potential carcinogen is probably regarded as positive.

**Legal aspects**
- None known

**Environmental aspects**
- None known

Facilities that might be interesting for you

<table>
<thead>
<tr>
<th>Title</th>
<th>Institute/company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditorium IRTA</td>
<td>IRTA</td>
</tr>
<tr>
<td>Clean room – Histocell</td>
<td>Noray</td>
</tr>
<tr>
<td>Video observation system for market research and product development tasks - Keki</td>
<td>NAIK EKI</td>
</tr>
</tbody>
</table>

Further Information

<table>
<thead>
<tr>
<th>Institutes</th>
<th>Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP, SLU, National Food Administration</td>
<td>Novozymes, DSM</td>
</tr>
</tbody>
</table>
References


Source: