Acrylamide mitigation in foods – an update

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Acrylamide mitigation in foods – an update

The European Commission is expected to release new benchmark guidelines on food acrylamide levels in 2018. These new guidelines, coupled with increasing consumer awareness of associated health risks, mean that food businesses must take steps towards being able to quantify and ultimately reduce levels of acrylamide in foods. In this white paper, June Swanston discusses why it has never been more important to understand the behaviour of acrylamide in your products.

What is acrylamide?

In 2002 the Swedish National Food Administration (SNFA) first reported the presence of a chemical called acrylamide in foods. They found that when certain foods are cooked at high temperatures (e.g. frying, roasting and baking), acrylamide can naturally form in a process known as the Maillard reaction. During heating, sugars (mainly glucose and fructose) can react with the amino acid asparagine, which results in the desirable browning of food, and the delivery of pleasant flavours and aromas. Unfortunately this reaction can also lead to the production of the potential human carcinogen, acrylamide.

Potential health risks

Reviews of animal studies[1] have concluded that acrylamide and its metabolite glycidamide are carcinogenic. However, human studies that take dietary intake into account are currently limited and inconclusive. Nonetheless, in 2015, the European Food Safety Authority (EFSA) concluded that acrylamide could increase the risk of developing cancer in all age groups, with children being most at risk due to their smaller size[2].

Current legal limits

Based on monitoring results from the EFSA[2], the EU Commission released a set of indicative acrylamide values for different food categories as part of regulation 2013/647/EU. Certain studies, including research results from the Food Standards Agency's (FSA) Total Diet Study, revealed that people in the UK were consuming higher levels of acrylamide than desirable[3]. In response to these and other findings, the EU Commission[4] will release new mitigation measures and benchmark levels as part of regulation (EC) No 852/2004, to reduce acrylamide levels in foods in April 2018. As part of this regulation, the setting of maximum limits in foods is to be discussed. This will put tremendous pressure on the food industry to demonstrate their knowledge of 'at risk' products and their ability to identify appropriate control measures. The industry will also be required to determine the acrylamide contents of their products, and to act accordingly.

To help manufacturers reduce acrylamide in their products, FoodDrinkEurope produced a

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document called Toolkit for this purpose[5]. This document contains the findings of over 10 years' experience and work between the food industry and EU national authorities to give suppliers, manufactures, retailers and local authorities vital information on ways to reduce acrylamide in their products.

Foods at risk

The highest levels of acrylamide can be found in starch-rich foods cooked at temperatures exceeding 120°C. Common foods containing acrylamide include potato-based products, bread, root vegetables, cereal products, coffee and bakery products (including biscuits). For both adults and children, fried potato products account for approximately 50% of the acrylamide exposure from foods[2]. One major problem is that acrylamide levels within these food groups can vary tremendously. For example, crisps with an indicative value set at 1000ug/kg can have levels between 117-4215ug/kg and chips with an indicative value set at 600ug/kg can have acrylamide levels ranging between 59-5200ug/kg[6]. For consumers, this is concerning as there is no way for them to know the exact acrylamide content of what they are eating.

Reducing acrylamide in foods

There are three main ways to potentially reduce acrylamide in foods:

1. Reduce acrylamide's precursors

For acrylamide to form in products there needs to be an inherent source of reducing sugars and asparagine. The reducing sugars content of potatoes has been found to be a major factor on acrylamide levels in cooked products, and this can vary greatly between different varieties. Elmore *et al* (2015) found that in general the potato varieties with the lowest reducing sugar levels produced cooked crisps with reduced acrylamide levels. For example, crisps made from Verdi potatoes, containing the lowest sugar levels, showed 50 times lower acrylamide levels compared with Pentland Dell potatoes which contained the highest sugar levels. The study found that from the five varieties recommended for crisp production including Hermes, Lady Claire, Lady Rosetta, Saturna and Verdi, all but Hermes potatoes produced crisps with acrylamide levels below the 1000ug/kg indicative value[7]. Another study by Muttucumaru *et al* (2017) found that on top of the differences between potato varieties, the levels of reducing sugars and asparagine were affected by the location in which the potatoes were grown, showing the influence of the soil condition, fertilization and weather[8].

These differences in growing conditions also seem to have different effects depending on the type of crops being grown. A decrease in nitrogen fertilization was found to increase the reducing sugar levels in potatoes, leading to an increase in acrylamide formation in the cooked products. Whereas for wheat, reducing sugars were not affected by an increase in fertilization used, but a decrease in acrylamide levels in the cooked products was noticed[9].

Both storage time and temperature of the crops from harvest have also been found to play a role in the final acrylamide levels of cooked products. The ideal storage temperature for potatoes is 8°C. Any lower and the reducing sugars content can increase, any higher and the potatoes could start to sprout[9].

These results demonstrate the complications that the food industry faces to try and control acrylamide levels. This is particularly true when considering crop varieties, precise growing conditions and the sheer number of factors involved. By choosing raw ingredients with lower amounts of reducing sugars, companies can attempt to decrease the precursors for acrylamide formation in the first place.

There are currently a number of industry-led projects underway hoping to gain a better understanding of how to develop new crops that can produce products containing less acrylamide when cooked.[10]

2. Reducing acrylamide formation during processing/cooking/re-heating

Acrylamide formation relies heavily on the cooking process, temperature, time and moisture content of the product. Altering any one of these factors can have a significant effect on the final acrylamide level.

In general, higher cooking temperatures and longer cooking times result in greater levels of acrylamide in a product. Any attempts to therefore reduce temperature or cooking time can have positive effects. For example, the use of vacuum frying has been found to reduce acrylamide levels in potato crisps by up to 90%, taking the crisps from containing roughly 2000ug/kg to just 200ug/kg[11]. In bakery products, combining traditional cooking methods with microwave heating or steaming has helped to decrease levels of acrylamide. Acrylamide formation takes place in products when the water activity is lower than 0.8, and more so when below 0.4[9]. Crucially, acrylamide formation can even occur below the critical cooking temperature of 120°C at low water activity[12]. Therefore, increasing the water activity can have a major impact on acrylamide levels in cooked products.

Blanching potatoes, which is commonly carried out when making chips, helps to reduce acrylamide formation by removing reducing sugars[13].

Due to the complex nature of the Maillard reaction and food matrices, there are many other factors that can reduce acrylamide formation. These include; reducing the pH (below pH5), increasing fermentation time, addition of antioxidants (e.g. rosemary) and decreasing the surface to volume ratio. The addition of amino acids, such as glycine, have also shown promising results in reducing acrylamide[14]. However, a major problem with these methods is their potentially negative effect on the end product. These can include; an alteration of the taste, appearance, texture or aroma due to their interference with the Maillard reaction.

A relatively new and promising technique is the addition of the enzyme asparaginase. This enzyme can reduce the asparagine content by its conversion into aspartic acid. As the enzyme does not interfere with the Maillard reaction, it has the potential advantage of keeping the desired sensory qualities to the final product. One major challenge with this method is the effective distribution of the enzyme within the product. Adding the enzyme during the blanching process has seen some success, and asparaginase use in dough-based cereal products has seen up to 90% reductions in acrylamide levels[15].

For many products, consumers must either reheat or cook foods themselves. With these types of products, it is important to have accurate, detailed cooking instructions available. This helps to keep the food safe/edible, within the minimum cooking temperature and time.

3. Removing acrylamide from the product

In most foods acrylamide is very stable, however in coffee, for example, significant decreases of up to 30% (from 300 to 200ug/kg) have been reported over six months' storage. This is believed to have been caused by acrylamide reacting with the sulfhydryl group containing chemicals in coffee[16].

Acrylamide has been successfully removed from biscuits and chips that have water activities above 0.8 using vacuum treatments, but it is important to keep the treatments as short as possible to keep the desired sensory attributes[17].

Quantifying acrylamide levels in foods

At present there are two main analytical methods for determining the acrylamide content of food, including liquid chromatography-mass spectrometry and gas chromatography-mass spectrometry. Both methods produce accurate, reliable results with low limits of detection. However, they are also relatively expensive and time-consuming.

At present there are no commercially available rapid methods for acrylamide detection or quantification. Many new methods are being researched, some that look promising include:

- Computer vision – using the colour of food (browning) to estimate acrylamide levels[18].
- Near-infrared spectroscopy – a non-destructive method that scans the product using the near infrared region of the electromagnetic spectrum (780 nm to 2500 nm)[19].
- Biosensor – uses a biological substance to bind with the analyte of interest (acrylamide) and is quantified using a physicochemical detector[20].

Summary

Within many staple food products, acrylamide is of major concern and is currently very difficult to control. The reaction which creates it is desired for its other effects including aroma, texture, flavour and appearance and acrylamide cannot at present be eliminated from most food. The chemical compound can however, potentially be reduced and controlled. With new guidelines and potential legal limits being set by the European Commission it is important for industries to know the acrylamide content of their products and keep these levels as low as possible due to the associated health implications. Many organisations have been helping with this, including the FSA who have been conducting and publishing annual monitoring data for acrylamide in foods[10]. Consumer awareness is also of vital importance as an individual can reduce their acrylamide intake by having a varied diet, using different cooking methods, not overcooking, and minimising the risk through appropriate storage and preparation of ingredients.

How Leatherhead can help

Leatherhead Food Research provides expertise and support to the global food and beverage sector. Our significant experience in food science, safety practices, manufacturing processes, cooking instructions, and food law and regulation enables us to provide invaluable advice and expert consultancy to our clients.

About the author

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About Leatherhead Food Research

Leatherhead Food Research provides expertise and support to the global food and drinks sector with practical solutions that cover all stages of a product's life cycle from consumer insight, ingredient innovation and sensory testing to food safety consultancy and global regulatory advice. Leatherhead operates a membership programme which represents a who's who of the global food and drinks industry. Supporting all members and clients, large or small, Leatherhead provides consultancy and advice, as well as training, market news, published reports and bespoke projects. Alongside member support and project work, our world-renowned experts deliver cutting-edge research in areas that drive long-term commercial benefit for the food and drinks industry. Leatherhead Food Research is a trading name of Leatherhead Research Ltd, a Science Group (AIM:SAG) company.

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