

# Acrylamide

## Fact sheet

**Acrylamide is a chemical that naturally forms when starchy foods are heated to temperatures above 120°C. Products which contain acrylamide include chips, crisps, coffee, breakfast cereals, (toasted) bread, Dutch spiced cake, biscuits and crackers.**

Animal testing has shown that acrylamide can cause cancer. The question is whether this also applies to people. The European Food Safety Authority (EFSA) has concluded that the consumption of acrylamide in food may increase the risk of developing cancer.

European legislation which specifies that food manufacturers, supermarkets, fast-food chains and restaurants must take measures to minimise acrylamide levels in their products was introduced in 2018. The aim is to reduce consumer intake of acrylamide.

Consumers can also take various measures at home to reduce their acrylamide intake, e.g. by eating a varied diet and avoiding the frequent consumption of products with high levels of acrylamide. When deep-frying, baking or roasting products at home, it is also important to 'go for gold' rather than allowing them to go brown.

This fact sheet covers the scientific foundation of the advice to consumers which tells them how to reduce their exposure to acrylamide.



### For whom is it relevant?

This fact sheet applies to food professionals, dieticians, policymakers, supermarkets, food manufacturers, hotels and catering establishments, among others.

### What issues are involved?

Acrylamide is a chemical which has been used in the chemical industry for many years as a raw material for polyacrylamide, a type of plastic. Polyacrylamide has numerous applications which include waste water treatment, waste processing and waterproofing dikes.<sup>1</sup>

In 2002, Swedish scientists discovered that acrylamide can also be formed if you heat starchy products such as potatoes and grains above 120°C.<sup>2</sup> Sugars and the amino acid asparagine are involved in the creation of acrylamide. Amino acids are building blocks for proteins. During the heating process, these substances react with each other (the so-called Maillard reaction). It is this reaction which produces the brown colour and enhances the flavour; but acrylamide is also formed during this process.<sup>1</sup>

This discovery led to various new studies into the mechanism, human exposure and the possible effects on health. In 2015, the EFSA took a close look at acrylamide in food. They reached the conclusion that exposure to acrylamide may form a possible health risk for humans and that exposure should be reduced as much as possible. Further to this analysis, European legislation was drawn up with the aim of minimising the formation of acrylamide during the production of foods such as chips, crisps and biscuits.<sup>3</sup>

At home, acrylamide is also formed when consumers deep-fry, bake, roast or toast products such as potatoes, biscuits and bread.

### Scientific state of the art: effects on health

As a result of the use of acrylamide in the chemical industry, the harmful effects of high doses of acrylamide on human health have been known for quite some time. Acrylamide can cause cancer. High levels of exposure may also damage the nervous system and reduce fertility. In the case of people who work in the chemical industry, the exposure is far higher than the intake through food.<sup>4</sup>

#### Cancer

Enzymes in the liver convert acrylamide into glycidamide, a highly reactive substance which can bind to the DNA. This may lead to mutations in the DNA, which in turn can lead to cancer in the long term. Acrylamide has therefore been classified by the International Agency for Research on Cancer (WHO-IARC) as a probably carcinogen for humans.<sup>5</sup>

In 2015, the EFSA carried out an in-depth analysis of the risks of exposure to acrylamide via food. Animal testing shows that in high doses, acrylamide causes cancer in mice and rats. Human studies are limited and give a varied picture. For example, some studies show an increased risk of uterine, ovarian and kidney cancer in humans while other studies do not show the same results. On the basis of animal testing, the EFSA has concluded that the intake of acrylamide may also increase the risk of humans developing cancer. It is not possible to say exactly how high the risk is. As a precaution, the advice is to limit the intake of acrylamide to the greatest possible extent.<sup>1</sup>

#### Damage of the nervous system

Acrylamide can affect the nervous system if people are exposed to large amounts. For example, this can occur in the chemical industry where people work



with acrylamide. The amount of acrylamide consumed in food may be too low to cause damage to the nervous system, but no relevant research has been carried out on human subjects.<sup>1</sup>

### Fertility

In animal tests, acrylamide leads to reduced fertility. However, the amount of acrylamide which you can ingest through food is far lower than the amount which has been shown to cause reduced fertility in animal tests. The EFSA has therefore concluded that the intake of acrylamide via food is not a cause for concern in terms of fertility and male reproductivity.<sup>1,3</sup>

### Growth and development of babies

It is known that acrylamide can pass through the placenta.<sup>1</sup> There are several human studies which suggest a relationship between the intake of acrylamide and a lower birth weight of the baby. A lower birth weight may adversely affect health later in life.

However, the studies which have examined this issue have not found conclusive evidence for a clear causal link. The EFSA has concluded that more research is required into the connection between acrylamide and birth weight, as well as the connection between acrylamide and other indicators of foetal development.<sup>1</sup>

Small quantities of acrylamide may also be present in breast milk. In humans, it is not known whether this will affect the development of the baby. The effects are visible in animal tests but only when extremely high concentrations of acrylamide are given to the animals, far higher than we would consume in food. For the time being, there are no indications that health effects are to be expected as a result of babies being breast-fed.<sup>1</sup>

### Young children

In relation to their body weight, children eat more than adults. As a result, they also consume more acrylamide in relation to their body weight. In addition, they have different eating habits which may also increase their consumption. Calculations show that per kilo of body weight, children can easily consume twice as much acrylamide as adults. Children are a vulnerable group and it is therefore even more important for them to only eat products with relatively high acrylamide levels (such as chips and crisps) on an exceptional basis.<sup>1</sup>

### The risks of acrylamide in perspective

If we look at food and cancer, the relationship between obesity, alcohol or a one-sided diet and the development of cancer has been clearly demonstrated.<sup>6</sup>



In the case of acrylamide, this relationship is much less clear. Calculations by the Netherlands National Institute for Public Health and the Environment (RIVM) show that the intake of acrylamide by the section of the population which consumes many products containing acrylamide is higher than the level which can be regarded as safe. As a result, effects cannot be excluded.<sup>7</sup> It is difficult to determine the actual effect of a high intake on human health. The health issues are often not immediately perceptible; long-term effects are found instead.<sup>8</sup>

In general, the advice is to eat a varied and healthy diet in accordance with the Wheel of Five. This ensures that you consume as few harmful substances as possible.

### Scientific state of the art:

#### foods

Acrylamide can occur when starchy foods, such as potatoes and grains, are heated at high temperatures without water. This occurs when foods are deep fried, roasted, barbecued, baked, fried, grilled or toasted. No acrylamide is formed when foods are boiled. In 2014, the RIVM calculated the contribution of the various foods to the intake of acrylamide by Dutch consumers. This was carried out both for children (between the ages of 7 and 15) and for adults (between the ages of 16 and 69).<sup>7</sup>

Products such as chips, potato croquettes and fried or roasted potatoes give the highest contribution to the intake of acrylamide. Coffee is another important source for adults, followed by crisps. For children, crisps, (fruit) crackers and biscuits also make a significant contribution. For both adults and children, products such as bread (mainly toasted), crackers, Dutch spiced cake, breakfast cereals and peanut butter make a smaller contribution to the intake of acrylamide.<sup>1,7</sup>

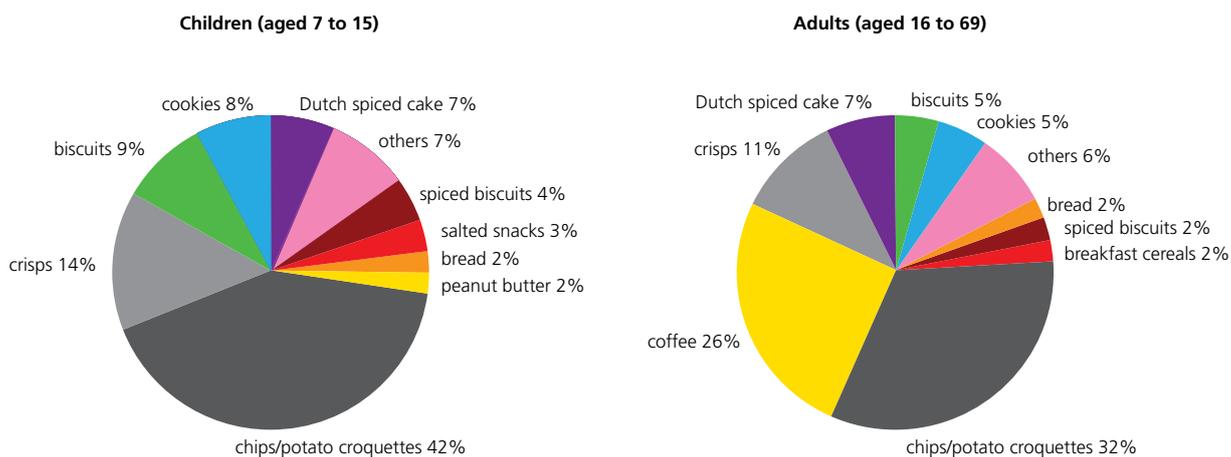


Figure 1: Contribution of different product groups to the acrylamide intake<sup>7</sup>

The figure above does not take very young children into account. The EFSA did look at this age group for the European situation and has concluded that children below the age of 2 also consume acrylamide in the form of baby food, baby biscuits and cereal-based products for infants.<sup>1</sup> For these product groups, manufacturers must also take measures to keep the amount of acrylamide as low as possible.

#### Potato products

Baked and deep-fried potato products such as crisps, chips and baked potatoes make a significant contribution to the total intake of acrylamide. This is because the acrylamide content in these product groups can be relatively high compared with other product groups. Chips made of potato dough show particularly high levels of acrylamide. On the basis of 40,455 items of data collected for the period from 2002 to 2011, however, the EFSA has noticed a falling trend in the acrylamide content in the potato product group.<sup>1</sup>

The legislation includes various measures which aim to reduce the formation of acrylamide during the production and preparation process. For example, the variety of potato plays a role here as potatoes with higher quantities of sugars and asparagine produce higher levels of acrylamide. The storage conditions and temperature of the potatoes are also important. Storing potatoes below 6°C greatly increases their sugar content. This leads to the formation of more acrylamide if they are baked or deep-fried. Manufacturers are obliged to provide consumers with the correct advice on the label to allow them to prepare the products properly at home,<sup>3</sup> e.g. to deep-fry at a maximum temperature of 175°C and only until a golden colour.

#### Bread, biscuits and breakfast cereals

A smaller proportion of the acrylamide intake comes from a very varied group of foods such as biscuits, (fruit) crackers, Dutch spiced cake and breakfast cereals (see figure 1). The legislation also includes measures for these product groups which aim to reduce the formation of acrylamide during the production process.<sup>3</sup>

At home, you can influence the formation of acrylamide when toasting bread or baking biscuits, for example. Keeping the baked or toasted product as pale as possible allows you to limit the quantity of acrylamide.<sup>1</sup> After baking or toasting, rye-based products have higher concentrations of acrylamide than wheat-based products.<sup>1</sup>

#### Coffee

In adults, 25% of the acrylamide intake comes from coffee. Coffee surrogates (which generally consist of a mixture of grains and chicory) contain the highest levels of acrylamide, followed by dried, ground coffee. However, dilution with water means lower acrylamide levels in the drink itself.<sup>1</sup> Manufacturers can take measures when roasting the coffee beans, e.g. by means of an optimal combination of time and temperature. The type of coffee bean also makes a difference. Robusta beans often have higher acrylamide levels than arabica beans.<sup>3</sup> Coffee is a typical example of an everyday food with both positive and negative properties. In 2015, the Dutch Health Council conducted comprehensive studies into the health effects of coffee. The conclusion was that no link has been demonstrated between drinking coffee and breast cancer, bowel cancer and lung cancer. Drinking two to four cups of coffee per day leads to a lower risk of coronary heart disease and strokes. The consumption

of five cups of coffee per day is also linked to a lower risk of type 2 diabetes.<sup>9</sup>

The advice of the Netherlands Nutrition Centre is that coffee without sugar fit into a healthy eating pattern in accordance with the Wheel of Five. However, coffee made by using a cafetière or percolator is not included in the Wheel of Five as this contains high levels of cafestol, a substance which increases LDL cholesterol. Further restrictions apply because of the caffeine in coffee. Healthy adults can consume around 400 milligrams of caffeine per day without expecting negative effects. This is around four cups of coffee per day.<sup>10</sup>

### Home cooking

The way in which people cook chips or toast bread at home, affects the formation of acrylamide and the ultimate intake by consumers. The EFSA has examined various scenarios and assessed the influence of specific habits (e.g. always eating dark-coloured chips) on the total acrylamide intake and exposure.

The EFSA concluded that people who cook chips at home until they are pale in colour consume up to 80% less acrylamide than people who always cook them until they are dark in colour. The effect on the intake is less pronounced when it comes to toasting bread until it is dark or light in colour (less than 8%).<sup>1</sup> The darker

starchy products become when baked, the more acrylamide is formed in these products..

### Standards and legislation

The acrylamide content in products which are susceptible to acrylamide formation, such as chips, coffee, bread, breakfast cereals, biscuits and crisps, is regularly checked by manufacturers and the Netherlands Food and Consumer Product Safety Authority (NVWA). Campaigns have been ongoing in this area since 2012 and at that time, the industry also started to reduce the quantity of acrylamide in products. A European regulation which states that food producers, supermarkets, fast-food chains and restaurants must minimise the levels of acrylamide in their products entered into force in April 2018.<sup>3</sup> Risk-reducing measures have been included for each product category, such as chips or biscuits. Standards (reference levels) have also been established for each product group. If a company or the NVWA finds an acrylamide content which is higher than the reference value in a food during laboratory testing, the company in question must take measures to reduce the content.

The NVWA monitors compliance with the law and takes samples from companies in order to monitor acrylamide levels by means of laboratory tests.

## Nutritional advice

It is virtually impossible to avoid acrylamide completely as it is found in many different foods. However, various precautions will help you to reduce your acrylamide intake. The most important thing is not to eat many deep-fried products and to eat a varied diet in accordance with the Wheel of Five. The correct preparation method is also important.

- Eat and drink a healthy and varied range of products. Only eat deep-fried products, biscuits and crisps on an exceptional basis. This certainly applies to children. Alternate coffee with tea and water.
- Bake potatoes and potato products (e.g. chips, croquettes, sliced potatoes) until they have a golden colour rather than brown ('go for gold').
- Toast bread and sandwiches as light as possible.
- Follow the instructions on the packaging label of potato products and chips and cook them in small portions. Cook a maximum of 150 grams at once; the ratio should be around 100 grams of chips per litre of oil. Do not deep-fry oven chips. Oven chips contain more sugar which will also create more acrylamide during the cooking process.
- Deep-fry at a temperature between 150°C and 175°C and for no longer than necessary.
- In a convection oven, cook potato products at a maximum of 180°C with air circulation and a maximum of 200°C without air circulation.
- If you are baking or deep-frying chips or potato slices which you have prepared yourself, it is best to blanch (briefly boil) them before you do so. This can help to reduce the amount of sugars on the outside, leading to less brown colouration and therefore the reduced formation of acrylamide during the frying process.
- Store potatoes in a cool and dark place such as a cellar. If you do not have a cellar, you can store potatoes in the fridge if you are going to boil them. This does not apply to potatoes which you are going to deep-fry, bake or roast. In the fridge, the starch in the potatoes can turn into sugars which will then lead to the formation of more acrylamide when they are deep-fried, baked or roasted. Keep these potatoes in a kitchen cupboard or in the shed.
- Ordering chips away from home? If so, make sure that the chips are gold in colour, or ask them to fry the chips until they are gold rather than brown.

### Looking to the future

The formation of acrylamide and the potential health risks of this substance are subjects which are still relatively unknown among consumers. Research by the UK Food Standards Agency in 2014 showed that few consumers knew the term 'acrylamide' and therefore did not consciously take the formation of acrylamide into account when preparing food.<sup>11</sup> The situation is not expected to differ greatly in the Netherlands in 2018.

In 2018, the Netherlands Nutrition Centre wishes to actively inform consumers about ways to reduce the development of acrylamide.

If consumers are better informed about the development and risks of acrylamide, this may also help to encourage food manufacturers, caterers and restaurant staff to keep products pale or golden during the baking process.

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