Bundesinstitut
für gesundheitlichen Verbraucherschutz und Veterinärmedizin

Acrylamide in foods – serious problem or exaggerated risk?

Results of a BgVV information seminar on 29 August 2002

Acrylamide: History and use of an important base material of the plastics industry

The monomer, acrylamide, was synthesised for the first time in 1949. It has been used since the 1950s mainly to manufacture polyacrylamide. Today, 99% of the global production of this monomer is channelled into the manufacture of polyacrylamide. Polyacrylamide may contain a maximum 0.1% of the acrylamide monomer in order to avoid classification as a Class 2 carcinogen according to the German Dangerous Substances Ordinance and the ensuing labelling of the products. Acrylamide is not known as a degradation product of polyacrylamide.

Human beings are exposed through:

a) products made of polyacrylamide, which may contain traces of the monomer. They include:

- Packaging material made of polyacrylamide;
- Cosmetics, which may contain up to 2 % polyacrylamide;
- Paper and cardboard, in which polyacrylamide is used as a binding agent;
- Polyacrylamide as a component of dyestuffs and pigments,
- Polyacrylamide used as a flocculent in drinking water and wastewater treatment.

The main source of human exposure to acrylamide-based polymers are cosmetics. The estimated dermal exposure from cosmetics which remain on the skin is 65 µg daily and for other cosmetics approx. 2.5 µg daily according to a European report. Under adverse conditions, the consumer takes up a maximum of 0.25 µg daily if he drinks two litres of water a day. Exposure through other products is insignificant according to the current level of knowledge;

b) the workplace. The following areas are relevant:

- Plastics production,

- Use of sealing compounds, sealing mortars, grouting compounds and joint cements based on acrylamide. A problem with sealing compounds during tunnel construction work in Sweden in 1997 (incomplete polymerisation of the acrylamide contained in the compound) prompted studies of workers who had been exposed to high levels of acrylamide. Comparative studies revealed that not only the contaminated workers but also the control group had acrylamide adducts in their blood. In the search for the sources of this background contamination, the Swedish researcher group identified the previously unknown contamination path, food;

c) flash pasteurised, high-carbohydrate foods like potato products (crisps, chips), roasted cereals, bread (particularly crisp-bread and toast), fine bakery goods (biscuits) etc.

The working group Nutrition and Cancer Diseases of the International Agency for Research on Cancer, IARC) undertook, within the framework of the EPIC (European Prospective Investigation into Cancer and Nutrition) project, a provisional estimation of the exposure of the population to acrylamide. This was based on a survey of the eating habits of middle-aged

adults (around 55), including approximately 4,500 Germans. According to the survey, this group in Germany is exposed to acrylamide on a scale of 0.14 (women) and 0.15 (men) µg per kg body weight and day based on a limited basket of goods. In Germany in this age group, potato products accounted for around 50% of this exposure, bakery products and bread for around 20%.

Against the backdrop of these temporary findings and the fact that acrylamide is classified as genotoxic and as a probable carcinogen for man (WHO and EU bodies), BgVV proposed an action value of 1,000 µg/kg food in August 2002. The goal was and is to minimise the acrylamide burden of consumers in accordance with the ALARA principle (as low as reasonably achievable). Based on this proposal the *Land* authorities and the competent Federal Agency for Consumer Protection and Food Safety (BVL) have since begun work on a more comprehensive strategy based on product groups to minimise the contents of acrylamide in cooperation with the manufacturers (cf. presentation by Dr. Arnold).

Toxicology: What risk to health does acrylamide pose?

Acrylamide is readily water soluble; it is readily taken up by the body and distributed rapidly and evenly. It must be assumed that it migrates to breast milk and the foetus. In the body it can be converted into glycidamide, an epoxide.

At high doses acrylamide has a neurotoxic effect. For this effect a NOAEL (No Observed Adverse Effect Level) has been laid down which is 0.5 mg per kg body weight and day. In animal experiments, when a correspondingly high dose (15 mg/kg body weight) is administered over longer periods, it has an effect on fertility. For this effect the NOAEL is 2 mg/kg body weight and day.

In Europe the current average acrylamide burden of the consumer to from foods is estimated to be 0.3-0.8 µg/kg body weight and day. This is lower by a factor of 1,000 than the NOAEL for neurotoxicity, the most sensitive parameter. In extreme cases [the estimated intake is then 50 µg/kg body weight and day (400 g food contaminated with 4 mg acrylamide with a child's body weight of 30 kg)], the gap to the NOAEL shrinks to a factor of 10.

WHO bodies and other international bodies have, however, classified acrylamide as genotoxic and as a probable carcinogenic substance for man for which no threshold value can be given.

Acrylamide
- causes chromosomal breaks *in vivo* & *in vitro*
- causes gene mutations *in vivo* & *in vitro* (somatic & germ cells)
- is genotoxic (mutagenic)
- increases the incidence of cancer in rats at doses of 1-2 mg/kg body weight and day

The actual additional cancer risk to the population through the uptake of acrylamide from foods cannot be estimated with the data currently available.

Compared with other carcinogenic substances in foods for which statutory provisions have already been introduced, like aflatoxins, there is an urgent need for action to minimise the level of acrylamide in foods. A reference value for risk assessment here is the MOE (Margin of Exposure). The MOE is calculated by dividing the dose which leads to tumours in animals by the uptake volume of man. The higher the MOE, the more favourable the risk situation.

For acrylamide the MOE is 1000. By way of comparison, a value of 100,000 is reached for aflatoxins and volatile nitrosamines; for nitrofurans the MOE is 1,000,000. In the case of acrylamide the situation is less favourable by a factor of 100 than for aflatoxins or by a factor of 1,000 than for nitrofurans. Against this backdrop, it is understandable why the current high

level of acrylamide in certain foods is unacceptable from the angle of consumer health protection and steps to minimise these levels must be taken immediately (cf. presentation Dr. Schlatter)

Position with the development of analytical methods

When the Swedish acrylamide findings for deep-fried, fried and baked foods with a high carbohydrate content became known in March 2002, there was no sufficiently validated method for the detection of acrylamide in Germany or in other European countries aside from Sweden. Since then, a number of methods has been developed by BgVV, the laboratories of the control authorities and some research and private laboratories. They permit both the quantitative and qualitative detection of this substance in foods. These new methods supplied comparable data for a sample with a defined acrylamide level and proved to be sufficiently precise.

At present, the official analytics for acrylamide are going through the phase of quality assurance. This involves a proficiency test (samples of various matrices with different but unknown levels of acrylamide are analysed in the participating laboratories with the methods available to them and the results of the laboratories are then compared) which will be concluded in September.

The next step must be to commission competent laboratories to determine comparable data for the calculation of exposure and risk assessment using proven, suitable methods. Furthermore, rapid methods are to be developed in order to be able to process a high sample through-put in a short period of time. These methods could then be used to assess technological test series in order to determine which technological measures are capable of bringing about reductions of acrylamide levels in foods (cf. presentation Dr. Wittkowski)

The burden situation in Germany

At the same time, the examination of foods for acrylamide has already begun in Germany. The first results from various laboratories of official food control largely confirm the acrylamide levels which were determined in Sweden, the United Kingdom, the Netherlands and Switzerland in carbohydrate-containing foods like chips, crisps, bakery goods, bread and cereal products.

According to these results, potato products (chips, crisps) have, in some cases, relatively high levels of acrylamide. However, the variation range is very large and this was also found for cereals and fine bakery goods. With the exception of some specific types of rich tea biscuits, they had a lower level of contamination. In the case of bakery goods, bread and rolls had relatively low values whereby the highest levels were found in the crust of the bread whereas the crumb contained almost no acrylamide. One exception was crisp-bread. For this product group, very high but also low levels were found in the different samples. Examinations of coffee (powder and infusion) produced very different values (up to 490 µg/kg coffee powder and up to 4 µg acrylamide per cup of coffee).

These initial study results also showed that the acrylamide levels may vary considerably in individual batches of the same product. No acrylamide levels have been detected up to now in meat, fruit or vegetable samples (cf. presentation Dr. Galle-Hoffmann)

Formation of acrylamide in foods:

Very few findings are available at present about the formation of acrylamide in specific foods through preparation techniques like deep-frying, baking, frying or roasting. The current hypotheses assume that the formation of acrylamide is part of the Maillard reaction. (A Maillard reaction occurs when, at high temperatures of up to 200 degrees Celsius, starch

degradation products, i.e. various sugars like maltose, dextrose, etc. react with protein components, the amino acids. This leads to the formation of numerous new substances which largely contribute to the taste of roasted, baked, fried and deep-fried foods).

It would, however, appear that when specific starting substances like free sugars, nitrogen compounds, etc. are present and this is combined with high temperatures and a low water content, acrylamide can be formed via various reaction paths in foods depending on the cooking time (cf. presentations Prof. Meuser and Dr. Haase)

Initial studies have provided clear indications that at temperatures above 175 degrees Celsius depending on the deep-frying time, the level of acrylamide in the deep-fried potato products increases considerably. It was also shown that specific additives to the frying oil like, for instance, silicon, can have a major impact on the acrylamide content in the final product (cf. presentation Dr. Gertz).

Other studies have shown that the choice of the type of potato and storage (storage temperature and duration) may also influence acrylamide formation and the acrylamide content in the deep-fried end product because the sugar composition varies in the raw material, potato.

In the case of crisp-bread and biscuits, the composition of the dough, the use of specific starting products and the cooking methods seem to have a major influence on whether high or low levels of acrylamide are found in these bakery goods.

Research activities and concepts for the reduction of acrylamide

Industry, various research institutes of the Federal Government and universities are currently launching programmes to carry out research into the factors which must be changed when selecting raw materials and production processes for an individual product group in order to reduce the formation of acrylamide in foods as far as possible. These research projects are financed partly by the food industry and partly from public funding.

At the same time, industry wants to press ahead with the development of rapid and cost-effective analytical methods.

Further research projects, some of which BgVV will help to initiate and carry out, will focus on methods for the more precise estimation of exposure and on the mechanisms of the toxic effects. Here, attention should mainly be given to determining whether there is a possible threshold value for the onset of cancer.

In order to reduce the acrylamide burden of consumers as quickly and as far as possible in premade foods right now, the Federal Government and *Länder* under the aegis of BVL have proposed a favourably received dynamic concept for the minimisation of acrylamide which goes far beyond the action value proposed by BgVV. BVL would record the study results of the *Länder* and process them in such a way that the products could be identified which belong in their product group to the 10% with the highest acrylamide levels. The control bodies would then first of all contact the manufacturers of these products in order to launch measures possible now to reduce the acrylamide levels. The concept aims initially to reduce the peak burden and would then, depending on the success of the measures for the products with the highest levels, move on to other companies.

In order to achieve rapid minimisation, priority should be given to tackling those products which contain more than 1000 µg acrylamide per kg food. The action value proposed by BgVV in August has thus become a signal value in conjunction with this dynamic minimisation concept. In parallel, the Federal Ministry for Consumer Protection, Food and

Agriculture will hold sector talks in order to promote the exchange of information within industry on the opportunities and measures for the reduction of the acrylamide burden.

All the same, the measures and concepts agreed up to now can only contribute to minimising the acrylamide contamination of foods which have been industrially manufactured. A special problem is posed by the preparation of deep-fried, baked or fried foods in the home, mass catering facilities and restaurants. Experiments show that this critical substance is also formed there. At present, it is still difficult to elaborate concrete tips for consumers for deep-frying and frying particularly as the temperature controls of the small chip pans used in the home are too imprecise and temperature deviations of between 10-20 degrees from the set temperature have been observed. The same applies to the temperature accuracy in the frying pan and oven.

The situation is different in the case of restaurants. Technical monitoring can indeed ensure that the deep-fat fryers function correctly from the technical point of view.

Problems of risk communication

When it comes to acrylamide, consumer protection is caught between the statutory task of providing comprehensive information to consumers on health risks and protecting products and manufacturers from economic damage.

It has been shown that the consumer is currently helpless when it comes to the phenomenon of acrylamide in foods. If one takes the thesis of the responsible citizen seriously whereby he should himself decide which risk he wishes to assume when consuming a food, then he must know how high the level of contamination of the individual foods, which he purchases and eats, actually is. The right of the responsible consumer to comprehensive information conflicts with current legislation which prohibits the authorities from publishing the results of studies or revealing the respective product name as long as there is no concrete threat to health.

In contrast to other European countries, the German food industry, represented by its umbrella association, has clearly indicated that it is not willing to publish data about the contamination of products with acrylamide on a voluntary basis. Whereas, for instance in the United Kingdom, FSA can publish data and reveal product names with the consent of industry, consumers in Germany will have to do without important data. This means that the consumer is not free to influence his risk, along the lines of the precautionary principle, by buying a product with a higher or lower level of contamination which is perhaps, however, cheaper.

This confronts consumer protectionists and consumer advisors in Germany with a dilemma: on the one hand there is a statutory obligation for consumer health protection to name and communicate these risks when data about possible risks are available. On the other hand, only general statements can be made without hard data. In cases of doubt consumer protectionists and advisors will, therefore, advise against eating entire product groups and thus inevitably discriminate products which have very low levels (cf. presentation Michel-Drees)

In a globalised world in which data on the contamination of foods with problem substances spread like wildfire from one continent to another and, of course, to the media, any communicational reticence seems suspicious. Consumer confidence can only be obtained through transparency and not by withholding information. This is the opinion not only of consumer advice bureaus. In the case of acrylamide in foods, they, therefore, called on industry to show more transparency about the contamination of their products.