

Federal Institute for Risk Assessment (BfR)

Assessment of acrylamide uptake from highly contaminated foods in Germany

Abbreviated version of a BfR study from 15 July 2003

In its study BfR assessed how much acrylamide is taken up by the German population from highly contaminated foods. The data from the National Consumption Study (NVS 1989) and from the Federal Health Survey 1998 (BGS 1998) were evaluated for six highly contaminated product groups (chips, crisps, biscuits made from short-crust pastry, breakfast cereals, crispbread, coffee powder). The acrylamide levels in the individual product groups were taken from measurements of the food control bodies in the individual federal states which were collected by the Federal Agency for Consumer Protection and Food Safety.

According to the data from the 1989 National Consumption Study, young male adults aged between 19 and 24 take up 50 µg acrylamide per day from highly contaminated foods on a weekly average.

In a feasibility study BfR also collected data on the consumption of critical foods in the 15-18 age group. 1,085 Berlin pupils in 10th grade (German education system) at general secondary schools were asked about their consumption of eleven product groups including in addition toast, fried potatoes and other nibbles. The survey gives the current, mean consumption of products of this kind by 15 to 18-year old Berlin pupils in winter.

According to the results of the BfR survey, the average acrylamide uptake of this age group is 69 µg/day or 1.1 µg per kg bodyweight daily (1.1 µg/kg body weight and day) in respect of consumption of all the product groups considered. A further major share of this uptake is from self-prepared foods, i.e. toast (7 µg/day) and fried potatoes (5 µg/day, low scenario).

If the average is calculated for all Berlin pupils in 10th grade, this leads to a mean uptake of 57 µg/day or of 0.9 µg daily per kg bodyweight (0.9 µg/kg bodyweight and day). This evaluation also permits statements on variation. Assuming a mean burden of foods and average portion size, 5% (corresponds to approximately 1,650 Berlin pupils in 10th grade) take up as a monthly average more than 180 µg/day or 3.2 µg/(kg bodyweight and day) of acrylamide. For 1% or 330 pupils it is more than 250 µg/day or 5.1 µg/(kg bodyweight and day).

This burden is relatively high and confirms that increased efforts must be made to minimise the population's acrylamide uptake.

1. The need for an exposure assessment

The risk assessment of acrylamide is done in four stages: 1) identification of a possible hazard, 2) characterisation of the hazard potential, 3) assessment of exposure of the population and 4) summary quantitative risk characterisation including the recommendation of action options.

When it discovered unexpectedly high levels of acrylamide in heated, starch-containing foods like chips, crispbread, breakfast cereals and chips, the Swedish National Food Administration drew attention to a previously unknown risk in April 2002.

Nevertheless, there had been awareness of the hazard potential of acrylamide from studies on its neurotoxic, carcinogenic and mutagenic effects for some time. However, up to then it had been assumed that acrylamide was only taken up by man in negligible amounts from drinking water and the use of cosmetics.

The publication of the new, important uptake paths, i.e. from various foods, led to the need to undertake a new assessment of the population's exposure.

2. Prerequisites

The first step in the assessment of acrylamide uptake in the German population involved identifying the responsible foods and determining the acrylamide levels in these product groups.

The main uptake paths for acrylamide were identified in a broadly based measurement programme by the German food control bodies and by laying down signal values for six highly contaminated product groups by the Federal Agency for Consumer Protection and Food Safety in September 2002 (BVL 2002). Together with data on product consumption, they are the basis for assessing the average uptake of acrylamide from highly contaminated foods.

3. Existing data sources and findings

Various data sources are available to assess consumption in Germany. A rough distinction must be made between data on consumption amounts and consumption frequency. Two representative studies, the National Consumption Study (NVS 1989) and the Federal Health Survey (BGS 1998) are generally available as public use files for evaluation purposes. By contrast, more up-to-date and comprehensive data, like the Nutrition Survey 1998 and the DONALD Study are not freely accessible and can only be accessed through cooperation with the data holders for the purposes of assessing acrylamide intake. In the case of future surveys like the new National Consumption Study or the Jugend-Gesundheit2.1de-Studie, there are plans for the timely publication of data in the form of a public use file.

The National Consumption Study with 7-day weighing protocols for around 25,000 participants from 1985-89 permits the calculation of the average consumption amount by assessing the acrylamide uptake of people who have consumed the relevant foods at least once a week. The assessment of acrylamide intake is undertaken over the weekly average and broken down according to gender and age group from four years old.

According to the data of the National Consumption Study, acrylamide uptake reaches its absolute maximum in young adults aged between 19 and 24 who consume the

highly contaminated foods. Here, the mean intake is 50 µg/day on a weekly average in male consumers. This corresponds to 0.7 µg kg bodyweight.

Since children and adolescents eat more food in relationship to their bodyweight, relative consideration of acrylamide uptake referred to bodyweight reveals a different picture. Here, the relative burden decreases with age and increasing body mass. Children aged between four and six belong to the group with the highest acrylamide burden. On average, they take up more than 1.2 µg kg bodyweight daily (1.2 µg/kg bodyweight and day) from the highly contaminated foods examined. In the case of adolescents it is on average 0.9 µg kg bodyweight daily (0.9 µg/kg bodyweight and day). By contrast, the daily uptake of adults amounts to only 0.6 µg/kg bodyweight (0.6 µg/kg bodyweight and day).

When considering lifelong acrylamide uptake and, by extension, the resulting long-term health risk, it must be borne in mind that childhood only accounts for approximately 25% of a person's lifespan. The uptake amounts of acrylamide in childhood and adulthood must, therefore, be correspondingly weighted when assessing the risk throughout an entire life.

The relative burden referred to bodyweight constitutes a rough yardstick for organ burden. For the correct assessment of resorption and metabolisation of acrylamide in the human body, further studies are necessary in which additional differences may result between the genders and age groups. Furthermore, it has still to be clarified which organs could be sensitive target organs for an assessment of this kind.

Closer consideration of the individual foods shows that in the course of a person's life, specific contaminated product groups are consumed to differing degrees. A distinction must be made between products with almost constant consumption amounts throughout a person's life like biscuits and waffles, products with a high level of consumption during youth like crisps and chips and products with a growing level of consumption as people grow older like coffee.

This becomes more obvious when the consumption frequencies from the Federal Health Survey are included in the assessments. It is true that information on consumption is only available for five larger product groups for adults aged between 18 and 79. This reveals the influence of age on the frequency with which highly contaminated foods are consumed. Whereas nibbles are eaten less and less frequently as people grow older, coffee consumption reaches its maximum spread from 25 years of age onward with a daily consumption probability of 70%. Coffee consumption, therefore, constitutes a main uptake source of acrylamide for adult Germans.

The beverage, coffee, also has one special feature when it comes to its acrylamide content. There are comparatively small amounts of acrylamide in the finished beverage which can only be detected with complicated analytics. Consequently, it cannot really be described as a highly contaminated food. The acrylamide contents for the assessment come from an extrapolation of the acrylamide level in coffee powder to the beverage: 6g coffee powder in a 120 ml beverage with 100% migration of the acrylamide from the powder to the liquid coffee. The mean burden of 355 µg acrylamide per kg powder thus leads to 18 µg/l in the beverage. The complete dissolution is due to the high solubility of acrylamide in water. Differences in preparation were not taken into account.

The major importance of coffee is due to its widespread distribution and the high average consumption amount of approx. 0.4 l/day (3-4 cups/day). Similarly high

consumption amounts and frequencies were also reached by beer and bread. From this angle, the acrylamide measurements below the determination limit – as a rule 30 µg/kg – are also important. However, in order to be able to present an exposure assessment for the German population, there is a need for further and more exact measurements of acrylamide in these foods, large amounts of which are frequently consumed.

4. Criticism of the existing consumption studies

The use of data from the available consumption studies to assess the acrylamide exposure of the population via foods has several weaknesses. Firstly, the product groups in the study are not compatible with each other; the selection is not appropriate, in some cases, for the question in hand. All previous consumption studies were designed to assess nutrient uptake and not to assess the uptake of contaminants. This means that the National Consumption Study mainly records uncooked products and so-called convenience products (e.g. pre-cut and deep-frozen chips, industrially produced biscuits) and not foods prepared from scratch by the test persons (fried potatoes, chips, biscuits etc. they made themselves). Strictly speaking, the results only describe consumers who eat the corresponding prepared foods. Particularly when it comes to assessing acrylamide uptake from food, detailed information about preparation is of major importance since the method of preparation has a major impact on the acrylamide level. The recording of preparation data in future consumption studies with weighing protocols is, therefore, an important demand when it comes to exposure assessment.

The highly contaminated foods are particularly popular with young people. It is also questionable whether the data of the National Consumption Study (which are more than 13 years old) on the consumption of these foods still give an accurate picture of the consumption behaviour of today's adolescents.

Finally, it is not possible to combine the data on consumption amounts from the National Consumption Study with the data on consumption frequencies from the 1998 Federal Health Survey owing to rough and different product groups. A population-related exposure assessment is, however, dependent on both types of data for its modelling.

5. New data sources

In order to be able to demonstrate the possibilities of an exposure assessment for acrylamide from highly contaminated foods, new data from Berlin adolescents in 10th grade in cooperation with the children and adolescent health centres were collected in seven Berlin districts in the limited context of a feasibility study.

The study data are not representative and must always be interpreted in comparison to the results of the national studies. The goal here was to obtain specific, up-to-date data on this subject and to try out suitable collection instruments. By way of summary, it can be observed for this aspect that valid data for an exposure assessment can be obtained on a concrete, topical issue like the "uptake of acrylamide from food" using a self-explanatory questionnaire which takes about 20 minutes to complete.

The survey covered around 3% of the target population of "Berlin pupils in the 10th year in general secondary schools" involving some 1,085 assessable questionnaires. There were only minor deviations in terms of gender and age between the random sample and the population. All the same, the tying of the survey to the first study

pursuant to the Youth Work Protection Act led to a lower proportion of grammar school pupils in the random sample. To balance this, a standardisation was undertaken according to gender, age and type of school.

There are still deviations in the standardised random sample from the target population in respect of school location and linguistic origin of the participants. The random sample contains too many participants from western city districts and an overly high proportion of foreigners. Both data correlate to a high degree in Berlin.

The random sample was also found to have a larger proportion of overweight participants compared with the federal German reference. This deviation is a general one and does not seem to be a specific problem of the survey. The growing number of overweight adolescents is currently under discussion as a central problem in health policy.

As a consequence of the deliberately short survey period from October to December 2002, the study does not have any temporal representativeness for a year but reflects far more the situation in the autumn of 2002 with the seasonal specificities, i.e. pre-Christmas period. Most of the measurements of acrylamide levels in foods come from the same time window.

The questions about the day before the respective measurements correspond to the correct ratio of workdays to weekends in a week. By contrast, there are structural differences between workdays and weekend days because of the type of survey. For instance, there are no consumption amounts for Fridays.

Despite these weaknesses, the results of the survey demonstrate a high level of internal and external consistency. There are scarcely any differences between the frequency data and the protocol frequencies for “yesterday” and the “day before yesterday”. Furthermore, the evaluations of consumption amounts on the two protocol days lead to the same results.

There are only a few major deviations from the evaluations of the representative consumption studies. A comparison of the consumption frequencies in the survey with the Federal Health Survey 1998 reveals a high degree of correlation. Hence, systematic errors caused by socially undesirable response behaviour also seem to be unlikely. The introductory text to the questionnaire touches on the acrylamide problem in order to encourage people to participate because they themselves are affected.

If one compares the consumption amounts in the survey with those of the National Consumption Study, a few differences are revealed. The higher amounts in the consumption of biscuits, waffles and nibbles in the survey can be explained by the season fluctuations during a year and the higher consumption during winter. The drop in the consumption of chips in the survey compared with the National Consumption Study could be interpreted as the effect of the acrylamide debate, as special behaviour of Berlin adolescents or as a long-term trend. More detailed information is not available on this.

The dramatic rise in the consumption of toast introduces a further aspect into the debate about acrylamide exposure. Toast and fried potatoes have not been recorded up to now in the measurement programme of the food control bodies as the acrylamide exposure only emerges when these foods are prepared by the consumers. There are scarcely any measurement values for foods of this kind prepared by the consumers.

In the case of toast, this assessment is based on a few measurements which were published in the corresponding literature. The Federal Institute for Risk Assessment is currently evaluating a measurement programme for toast in which various types of bread are prepared at different temperatures and toasting durations. The results will remedy the previous lack of accuracy.

In the case of fried potatoes, the evaluation is based on two scenarios which serve as the realistic lower and higher assessments of exposure. In the scenario with the classical fried potatoes the mean values are four times lower than in the scenario with the potato pancakes fried in oil.

In terms of consumption amount and consumption frequency (toast), toast and fried potatoes constitute an important path for acrylamide uptake by adolescents. The ongoing uncertainty about the acrylamide levels in these foods has, therefore, been transferred to the current exposure assessment.

The results of the survey give the current mean consumption of 15 to 18-year-old Berliners in winter. No high correlations were observed between the product groups either for consumption frequencies or for consumption amounts. However, the distributions of consumption frequencies and consumption amounts did reveal major variations. The variation within the gender and age groups is greater than the variation between the groups.

The mean acrylamide intake is 69 µg/day (1.1 µg/kg bodyweight and day) in young consumers. The increase compared with the intake assessment at the beginning of the study is mainly due to the increase in the foods studied from 6 to 11 (+1) product groups. Most of this concerns self-prepared foods, i.e. toast (7 µg/day) and fried potatoes (5 µg/day, lower scenario).

If the average is calculated for all Berlin pupils in the 10th grade, this leads to a mean intake of 57 µg/day or 0.9 µg/(kg bodyweight and day).

At least in winter, crisps and biscuits or waffles head the list of uptake paths. However, fried potatoes and toast could prove to be almost as important if the examination of acrylamide levels confirms the data used.

The assessment also permits statements on variation within the Berlin pupils. To this end, all parameters of exposure assessment were specified as a distribution. Two highlights show, for instance, the variation between the participants.

For questions concerning the acute health impact, the short-term uptake of acrylamide on one day is important. Based on the assumption of a mean burden of foods, around 5% (this corresponds to approximately 1,650 Berlin pupils in 10th grade) consume more than 190 µg/day or 3.4 µg/(kg bodyweight and day) of acrylamide on any given day. For 300 pupils (1%) it is more than 400 µg/day or 6.9 µg/(kg bodyweight and day). However, as a rule this burden is not permanent.

For questions about the long-term health impact like for instance the risk of cancer, the uptake determined over time must also be taken into account on the individual level. Assuming a mean burden of foods and average portion sizes, 5% (corresponding to around 1,650 Berlin pupils in 10th grade) take up on a monthly average more than 180 µg/day or 3.2 µg/(kg bodyweight and day) of acrylamide. 1% (330 pupils) takes up more than 250 µg/day or 5.1 µg/(kg bodyweight and day). These figures indicate the acrylamide exposure of adolescents in winter. The

consumption frequencies of these products and product groups used in the calculation are, however, less influenced by seasonal fluctuations which means that the results of the survey give a more realistic, overall picture of the acrylamide uptake of adolescents distributed over the whole year.

By way of summary, the survey involving Berlin pupils was able to identify the practical viability of a simple survey instrument for a concrete question and introduce other aspects into the discussion of the risks from acrylamide in foods.

References:

A comprehensive presentation of the study and its results (in German) can be found in the BfR publication by O. Mosbach-Schulz, I. Seiffert, C. Sommerfeld entitled "Abschätzung der Acrylamid-Aufnahme durch hochbelastete Nahrungsmittel in Deutschland", Berlin 2003, published on the Internet on: www.bfr.bund.de