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Acrylamide in Foods: A Review and Update[1]

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Introduction

News reports of high levels of acrylamide in many fried and baked foods surfaced in 2002 following publications of research done in Sweden. These news reports have raised concerns among consumers and professionals because acrylamide is known to be toxic and can cause cancer in animals. This publication provides background information on acrylamide along with its content in foods. This publication will be revised periodically to include new information as it becomes available.

What is acrylamide?

Acrylamide is a versatile organic compound that finds its way into many products in our everyday life. Acrylamide exists in two forms: a monomer (single unit) and a polymer (multiple units joined together by chemical bonds) (1). The single unit form of acrylamide is toxic to the nervous system, a carcinogen in laboratory animals, and a suspected carcinogen in humans. The multiple unit or polymeric form is NOT known to be toxic.

Acrylamide Uses

The monomeric acrylamide is primarily used in research laboratories for gel preparation. The acrylamide gel is used for electrophoresis, a technique for protein separation. It is also used to produce grout, dyes, contact lenses, and in the construction of dams, tunnels, and sewers.

Acrylamide polymers are used as additives for water treatment, flocculants, paper making aids, thickeners, soil conditioning agents, textiles (permanent-press fabrics), production of organic chemicals, and ore and crude oil processing. Although the polymer polyacrylamide is not toxic, a small amount of the acrylamide monomer may leach from the polymer.

Acrylamide Exposure

Traditionally, acrylamide (monomeric form) exposure to human was believed to occur only in workplaces or other environments with little relevance to the public at large. However, smokers, who absorb the chemical from tobacco smoke and those exposed to second hand cigarette smoke. Acrylamide can be absorbed through skin contact, breathed in, or consumed from contaminated foods or water. Once in the body, acrylamide binds to red blood cells. Both the World Health Organization (WHO) and the US Environmental Protection Agency (EPA) have set the maximum contaminant levels for acrylamide in drinking water at 0.5 parts per billion (ppb) or at 0.05 microgram per liter. Currently, data on acrylamide intake from foods and its fate in the body after the intake are limited.

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Once inside the body, acrylamide binds to red blood cells. Potential symptoms of overexposure to monomeric acrylamide include numbness of the limbs, and weakness and lack of coordination in the legs. Long-term exposure to small doses of acrylamide causes nerve damage in the extremities. Some tunnel construction workers have experienced neurological damage from exposure to acrylamide in grout. Animal studies have shown acrylamide to be carcinogen although cancer in humans following occupational exposures has not been reported.

Why the sudden concern about acrylamide in fried and baked foods?

A group of Swedish researchers found that some fried or baked high carbohydrate foods such as potato chips and French fries contain high levels of acrylamide. Because these foods are widely consumed in significant amounts, much interest and concern was generated from their report published in April 2002 (2).

The researchers reported moderate levels of acrylamide (5-50 ppb) in heated protein-rich foods and higher contents (150-4000 ppb) in carbohydrate-rich foods such as potato, beetroot, and selected commercial potato products. Median levels of acrylamide were 1,200 ppb in potato chips, 450 ppb in French fries, and 410 ppb in biscuits and crackers. The same group of researchers also stated that acrylamide was not found in the same foods in the raw state or in foods prepared by boiling(2). The researchers examined the heated foodstuffs for acrylamide because they have consistently found acrylamide in red blood cells of some Swedish adults who apparently had no known sources of exposure to acrylamide.

Based on these findings, the Swedish National Food Administration and the researchers at Stockholm University estimated an average intake of acrylamide from food in Sweden to be 35-40 micrograms per day.

How is acrylamide formed in foods?

Acrylamide has been found in certain foods that have been cooked or processed at high temperatures. The levels of acrylamide appear to increase with the time of heating. However, the mechanism of acrylamide formation in foods is not well understood. Acrylamide appears to be formed as a byproduct of the Maillard reaction. The Maillard reaction is best known as a reaction that produces the tasty crust and golden color in fried and baked foods. The reaction can occur during baking or frying, when there is a proper combination of carbohydrates, lipids, and proteins in foods(3). FDA recently proposed that one mechanism may involve the amino acid asparagine which, when heated in the presence of glucose, forms acrylamide. Since the asparagine content of foods within a certain category (e.g., potatoes) varies greatly, this asparagine-dependent reaction may explain the tremendous variability in acrylamide levels even within one food category. There may be more than one way that acrylamide forms in foods. An understanding of how acrylamide forms in various foods may lead to the development of methods to prevent or limit its formation (4, 5).

What has been done?

The Swedish study prompted the United Nations WHO and the United Nations Food and Agriculture Organization (FAO) to convene an Expert Consultation to examine the issue. On June 25-27, 2002 a panel of 23 experts met and prepared a report on behalf of the FAO and WHO. The report notes that information on the presence of acrylamide in food is incomplete and that the magnitude of cancer risk for humans has not been quantified. The report suggests further studies in areas such as dietary intake and the toxicology of acrylamide, the modes of formation, fate and levels of acrylamide in foods, and the development of sensitive, reliable, and low-cost methods of analyses.

The US Food and Drug Administration has recently made available its methodology for the determination of acrylamide. **At this writing (October 2002), the FDA does not believe there is sufficient information to make a statement regarding the possible health risk associated with acrylamide in foods.**

According to the FAO/WHO report, which is based on the available published data, food is estimated to make a significant contribution to the total exposure of acrylamide. Average intakes of acrylamide were estimated to be 0.3-0.8 microgram acrylamide per kilogram of body weight per day in diets of people in

developed countries. Dietary intakes of acrylamide may vary greatly from person to person. FDA recently initiated a survey for acrylamide in foods in the U.S. This information can be found at http://www.cfsan.fda.gov/~dms/acryposn/sld001.html

What consumers can do?

Many potentially harmful chemicals are present at extremely low levels in both the environment and our foods. In many cases the levels of these is far below those expected to have an effect on human health. In recent years, analytical methods and instrumentation have advanced considerably, allowing detection of very small levels of chemicals that may or may not have adverse effects on human health (6). Although the information on acrylamide in foods and its implications for human health is not yet complete, the FAO and WHO have issued interim advice based on current knowledge to minimize existing risks.

1. **Foods should not be cooked excessively (for too long or at too high a temperature), but they should be cooked thoroughly enough to destroy foodborne pathogens.**

2. **People should eat a balanced and varied diet that includes plenty of fruits and vegetables, and should moderate their consumption of fried foods.**

Sources and References

1. The Merck Index, 12 ed. 1996. p.132.

2. Tareke, E., Rydberg, P., Karlsson, P., Ericksson, S., and Törnqvist, M. 2002. Analyses of acrylamide, a carcinogen formed in heated foodstuffs. *J. Agric. and Food Chem*. 50:4998-5006.

3. Tareke, E., Rydberg, P., Karlsson, P., Ericksson, S., and Törnqvist, M. 2000. Acrylamide: A cooking carcinogen? *Chem. Res. Toxicol*. 13, 517-522.

4. Janet Raloff. 2002. FDA Launches Acrylamide Investigations. *Science News* 162(15).

5. Mottram, D.S., Wedzicha, B.L. and Dodson, A.T. 2002. Acrylamide is formed in the Maillard reaction. *Nature* 419:448-449.

6. AOAC International. Inside Laboratory Management. September/October 2002. Pp. 8-9.

Pertinent reports and additional information on the subject can be found at:

http://who.int/fsf/Acrylamid_Summaryreport.pdf

http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=52015

www.cfsan.fda.gov/~dms/acrylami.html.