Acrylamide
Doubt or Danger ?

The Burning Issue

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What is Acrylamide ?

* Acrylamide is a chemical used in a number of industrial processes including making cosmetics and glues and removing particles from drinking water.

* Acrylamide is an odorless, free-flowing and white crystalline.

* It is water soluble and is considered an agent of irritation to the skin, eye, nose and throat.

*Acrylamide is formed when starchy foods are cooked at high temperature (fried or baked).

* The natural occurring amino acid (Asparagine) coupled with a carbonyl source such as reducing sugar like dextrose (Glucose) is a precursor to acrylamide in foods.

Identity

* **Asparagine** is alpha-aminosuccinamic acid (synonyms; beta-asparagine; althein; aspartamic acid; aspartamide) *NH2COCH2CH(NH2)COOH*
+ **Glucose** *OHC-(CHOH)4-CH2OH*

* ***Chemical structure*** CH2=CH-CO-NH2
* ***Chemical formula*** C3H5NO
* ***Synonyms*** Acrylic amide
Akcrylamide
Propen-amide
Propionic acid amide

Physical properties of acylamide

- **Acrlyamide is**

  * A white, odourless and crystalline solid.
  * Highly soluble in water.
  * Insoluble in solvents (methanol, ethanol and hexane).
  * At least 1% soluble in glycerol, ethyl acetate, glacial acetic acid and lactic acid.

- Reacts through its amide group or double bond.

Physical properties of Acrylamide

Appearance	White Crystals	
Molecular mass	71.08	
Melting point	84.5 ± 0.3°C	
Boiling point	87°C at 0.267 kPa	103°C at 0.667 kPa
	125°C at 3.33 kPa	
Density	1.122g/cm at 30°C	
Solubility (g/l solvent at 30°C)	Acetone 631	Benzene 3.46
	Chloroform 26.6	Ethanol 862
	Ethylacetate 126	n-heptane 0.068
	Methanol 155	Water 2155
Heat of polymerization	19.8 Kcal/mole	
Vapour pressure	0.009 kPa at 25°C	0.004 kPa at 40°C
	0.09 kPa at 50°C	

Which foods contain acrylamide ?

* High levels of acrylamide are found in starchy foods (foods containing complex carbohydrates, such as potatoes and cereals) that have been fried, oven-baked or microwaved, including: baked potatoes, bread, crisps, chips, biscuits.

Any cooking method that uses temperatures over 100 °C can produce acryalmide in starchy foods. This includes: frying, baking, oven cooking and microwaving.

*Acrylamide is also found in coffee, formed when the coffee beans are roasted.

* Lower levels of acrylamide are found in protein-rich foods, such as cooked beef and chicken.

* Very little or no acrylamide is found in uncooked or boiled foods.

Acrylamide in Foods (Microgram/ oz.)	
Water (8 oz)	0.12
Boiled potatoes (4 oz)	< 3
Taco Shells (3 oz)	1
French fries uncooked (3 oz)	5
French fries baked (3 oz)	28
Honey nut cheerios (1oz)	6-7
Tortilla Chips (1oz)	5
Corn Chips (1 oz)	11
Pringles Potato Crisps (1oz)	25
Wendy's French Fries, Biggie (5.6 oz)	39
Potato Wedges, Jumbo (6.2 oz)	52‘
Burger King French Fries, large (5.7 oz)	59
McDonald's French Fries, large (6.2 oz)	82

* Microwaved grated potato 650 ppb

* Frying beetroot generated 890 ppb

*Toast and soft bread 2.22 µg

* Breakfast cereal 7.3 µg

* Coffee 2 µg

* Foods such as milk, frozen vegetables and meat contain no acrylamide.

Top 20 Foods by Mean Acrylamide Intake

Food	Mean AA intake (µg/kgbw-day)	Cumulative Percentile
French Fries (RF)	0.058	0.13
French Fries (OB)	0.051	0.25
Breakfast Cereal	0.043	0.35
Potato Chips	0.041	0.45
Cookies	0.036	0.53
Brewed Coffee	0.029	0.60
Toast	0.023	0.66
Pies and Cakes	0.020	0.70
Soft Bread	0.019	0.75
Chile con Carne	0.015	0.78

Food	Mean AA intake (µg/kgbw-day)	Cumulative Percentile
Corn Snacks	0.011	0.81
Crackers	0.011	0.83
Pizza	0.007	0.85
Pretzels	0.007	0.87
Popcorn	0.007	0.88
Canned Black Olives	0.005	0.89
Peanut Butter	0.004	0.90
Bagels	0.004	0.91
Soup Mix	0.003	0.92
Breaded Chicken	0.003	0.93

Top Eight Foods by Acrylamide Per Portion

Food	AA Conc (µg/kg)	Portion Size (g)*	AA (µg) Portion
Breakfast Cereal	**131.0**	**55**	**7.3**
Brewed Coffee	**8.5**	**240**	**3.2**
Postum	**93**	**240**	**22.3**
French Fries (RF)	**333.7**	**70**	**23.3**
French Fries (OB)	**697.8**	**70**	**48.8**
Potato Chips	**545.9**	**30**	**16.4**
Canned Black Olives	**550**	**15**	**8.2**
Prune Juice	**174**	**140**	**24.4**

* Portion Sizes From 21 CFR 101.12, Table 2

Minor uses of polyacrylamide

- Dental fillers
- Emulsion stabilizers
- Thickening agents
- Suspending agents
- Hair sprays
- Shaving creams
- Soil stabilizers
- Ion exchange polymers
- Resins to increase pigment-binding resins
- Gel electrophoresis
- Leather-treating agents
- Flooding agents for petroleum recovery
- Serve as plasticizing components
- Paper additives
- Stability of viscose ravon

Analytical Methods

* Acrylamide reacts with diazomethane in methanol–ether solution to form a pyrozoline derivative that can react with 4-dimethylaminocinamaldehyde to form a brightly coloured (purple) Sciff base complex.

* The GC and HPLC methods using the 2,3-dipropionamide derivative and the selective and sensitive ECD are the most suitable for trace level in environmental and biological samples (natural and polluted water, plasma, urine, tissue homogenates).

Analytical techniques for determining acrylamide concentrations

Technique	Application	Sensitivity
Titration (bromate/bromide method	Commercial product	± 0.3%
Bromination (EC-GC)	Vapor in air	5 µg/m^3
Bromination (EC/GC)	In water	0.1 µg/l - 1g/l
Bromination (EC/GC)	Plasma, tissue homogenates	20 µg/l
FID/GC	Vapor in air	0.01-1ppm
HPLC	Natural and polluted water	0.2 µg/l
HPLC	Acrylamide monomer	0.1 ppm

Digest and metabolism

The more food is cooked, the more difficult is it to digest and metabolize

- The higher the temperature that food is cooked, the longer it stays in the gut and the more difficult it becomes for our digestive mechanisms to digest it.

- This makes it more difficult for the food absorb and function at a cellular level where it needs to work.
When the food doesn't digest properly, it can sit in the gut, unable to be assimilated completely and it stars to become toxic.

- The carbohydrates start to ferment, the proteins begin to putrefy and the fats become rancid.

- This can poison the gut bacteria causing the ecology of the gut to become upset.

- Three hundred to four hundred of the bacteria species can become upset causing overgrowth of *Candida* and other pathogens.

- The irritation also makes the cells on the lining of the gastrointestinal tract to enlarge.

- Since it is the liver's job to detoxify toxins, the liver becames overloaded and less able to do its job.

- Acylamide is largely excreted as metabolites in *urine* and *bile, fecal* excretion is minimal.

- Protein –bound acylamide or acrylamide metabolites in the blood, and possibly in the nervous system, have a half-life of about 10 days.

Carcinogenicity

- Epidemiological studies in worker (March et al., 1999) and studies of dietary exposure to acrylamide have not shown an association with cancer (Mucci et al., 2003 and Pelucchi et al., 2003).

- Acrylamide as carcinogenic at several target sites in rats bioassays, and the TD50 in rats is 8.89 mg/kg/day.

- The EPA classified acrylamide as a group B2, which means it is a probable human carcinogen.

-The No observable Adverse Effect level (NOAEL) for acrylamide is 0.1 mg/kg body weight.
(UK Standard Agency, Feb. 2003)

- The mean daily dose of acrylamide to consumers eating hot chips and potato crisps, the highest known food sources of acrylaimde that are typically consumed, is about 0.3 µg/kg.

-This amount is three orders of magnitude below the NOAEL, and therefore represents a very low cancer risk.
(EU database of acrylamide activity, Feb. 2003)

- Earlier research has found that eating acrylamide does not increase the risk developing **Kidney, Bladder or Large Bowel Cancers.**

- Eating acrylamide-rich foods does not increase the risk development **Breast Cancer**.

- However, it has **never been** shown that acrylamide **actually** causes **cancer** in human.

-Acylamide can affect **The Nervous System** if high does eaten, inhaled, or people exposed to it long-term. For example, people working in an industry using the chemical.

(Eurekalert, JAMA 2005)
(Cancer Res., 2003).

- It increased the incidence of **Lung Tumors** in mice-screening assays.

- Administration over 2 years of 2 mg acrylaimde/kg body weight/day not only increased the incidence of a variety of tumor types but also decreased the life expectancy in both male and female rats.

-The **Immune System** was not designed to do this on a daily basis, every time we eat over-cook foods or over-processed food.

- Over a period of time the immune system becomes *exhausted* and *the door is opened to infectious* and *degenerative diseases*.

- Absorbed dose of 0.12 mg/kg body weight/day *could cause adverse neurological effects in man*.

- Appling the safety factor of 10 to the extrapolated minimum dose for neurological effects would indicate that an absorbed dose of 0.012 mg/kg/day *should not be exceeded*.

Clinical signs of acute acrylamide intoxication in mammals

Species	Route	Dose (mg/kg bw)	Clinical signs
Mouse	Oral	100-1000	Postural and motor incoordination; convulsions; death
Rat	Oral	100-200	Tremor; general weakness; death
Rat	Oral	126	Slight weight loss, Coma
Rat	Oral	256	Death within 24 h.
Rat	Ip	100-1000	Ataxia, general weakness, death
Guinea-pig	Oral	126	Tremors; pupil dilation
Guinea-pig	Oral	252	Death within 24 h

Rabbit	sc	500	Postural and motor incoordination; convulsions; death
Rabbit	Oral	63	Slight weight loss
Rabbit	Oral	126	Tremors, pupil dilation
Rabbit	Oral	252	Death within 24 h
Rabbit	Dermal	500-1000	Oedema; death
Cat	iv	5000	General weakness; circulatory collapse or death
Cat	ip	100	Unconsciousness after 24h; Severe effects or death
Dog	oral	100	Convulsions; postural and motor incoordination

Neurotoxicity and lethality of acrylamide and related analogues

Compound of formula	Neurotoxicity	Lethality (mg/kg) (oral LD50)
Acrylamide CH2=CH-CONH2	+	256
Methyl acrylate CH2=CHCO2-CH3	–	825, 200 Rabbit
Sodium acrylate CH2=CHCO2Na	+	
N-methylacrylamide CH2=CHCONH-CH3	+	480, 477
N-ethylacrylamide CH2=CHCONH-C2H5	+/-	
N-hydroxymethyl-acrylamide CH2=CHCONH-OH	+	560, 576

N-isopropylacrylamide CH2=CHCONHCH(CH3)2	+/-	350, 419
N,N-dimethylacrylamide CH2=CHCON(CH3)2	–	675, 677
N,N-diethylacrylamide CH2=CHCON(C2H5)2	+/-	1412, 1399
Methacrylamide CH2=C-CH3-CONH2	+/-	600, 451
N-methymethylacrylamide CH2=C-CH3-CONHCH3	–	

Cortonamide CH(CH3)=CH-CONH2	–	512, 2724
Senecioic acid amide (CH3)2-C=CH-CONH2	–	
Allyl acetamide CH2=CH-CH2-CONH2	–	
N,N-methyl bis-acrylamide (CH2=CH-CONH)2-CH2	+/-	399, 401
Acrylonitrile CH2=CH-CN	–	

Case of acrylamide intoxication in man

Year	Number of patients	Occupation	Length of exposure
1953	5 - 6	Production of acrylamide from Acetonitrile	5 months
1961	10	Acetonitrile	3 months
1967	1	Dissolution of Acrylamide	2 weeks
1969	6	Production of acrylamide	6 months
1971	10	Production of paper	2 months
1971	3	Weighing of acrylamide	10 days
1975	5	Non-occupational exposure	10 days
1976	1	Mixing of acylamide	3 months
1977	6	Polymaryzation of acrylamide in road tunnelling	2 weeks
1977	5		4-12 weeks

History and Background

- Sweden – April 2002
  - Estimated Mean Exposure to Acrylamide
    - 40 µg/person/day (0.67 µg/kgbw-day, 60 kg bw/person)
    - Very limited data, included "expected" value for food groups not covered in their sampling
- FAO/WHO – June 2002
  - "Long-Term" Exposure Estimates
    - 0.3 - 0.8 µg/kgbw-day

- The estimate for average consumption of dietary acrylamide in Swedan is 40 µg/day *(Tareke et al., 2002).*

-The (Human Exposure/Rodent Potency Index) HERP would be 0.01%.

-The US Food and Drug Administration has established a maximum acrylamide residue level of 0.2% (2g/kg).

-Polyacrylamide used as an agent for retention in foodstuff packaging should not exceed 0.3%.

-In the USA, polyacrylamide used in the washing of fruits and vegetables must not contain more than 0.2% (2g/kg) acrylamide monomer.

- In Federal Republic of Germany, the level of residual monomer in polyacrylamide used in hair sprays in limited 0.1%.

How to Reduce Acrylamide In Fried and Baked Foods ?

1- Use low temperatures for frying or baking (under 170°C).

2- Change your eating habits:

*Try to like white chips or French Fries.

* Refuse golden brown ones as they were overheated and bear high amount of acryalmide.

3- Avoid excessive loss of humidity of the surface of the food.

4- Don't toast your bread as the high temperature and low moisture of bread soars up acryamide.

5- Don't let bread and cake get brown, hard and dry surface because this is a sign that acrylamide could have been formed.

6- Pizzas are low in acrylamide but do not let the edge get brown or dried.

7- Avoid any kind of corn flakes, crispbread, cookies chocolate, cocoa, coffee, tortillas as in some breads high amount of acrylamide were found.

8- Cover all dishes when using microwave.

(*Microwaveing exposes food up to 200 °C*)

9- Use margarine instead of oil or cooking fat. Margarine can't be heated as high as oil avoiding overheat during frying.

10- Prefer cooked food as the water avoids overheating of potatoes and cereal products.

(*Steaming and boiling expose food to heat not exceeding 100 °C*)

11- The storage of potatoes influence the acrylamide being formed during processing.

* Potatoes should be fresh.
* They should not had been kept in refrigerator.
* Stored at no less than 10°C .

12- Use cooked potatoes to make fried potatoes.

* If you have to use potatoes you can leave them in water for two hours before frying. The reducing sugars are then diminished in the surface which is most like to develop acrylamide.

* If you use raw fresh potatoes for your French fries leave them after cutting for one hour in water.

Preparation producers were optimized to produce a minimum of acrylamide

Potatoes with less than 0.2g/kg fresh weight fructose and glucose are not suitable for roasting (insufficient browning and flavor), while roasted products of minimum crispiness prepared from potatoes with more than 1g/kg reducing sugar contain more than 500 µg/kg acrylamide.

The German Ministry of Consumer Affairs announced on 25 Jan. 2003, on its recommendation, German food processors have agreed to cook chips (for US readers, French fries) at the reduced frying temperature of 347 F (175 C) and baking at 356 to 374 F to reduce the build up of acrylamide, and to recommend this on packaging of chip for frying in the home (2003).

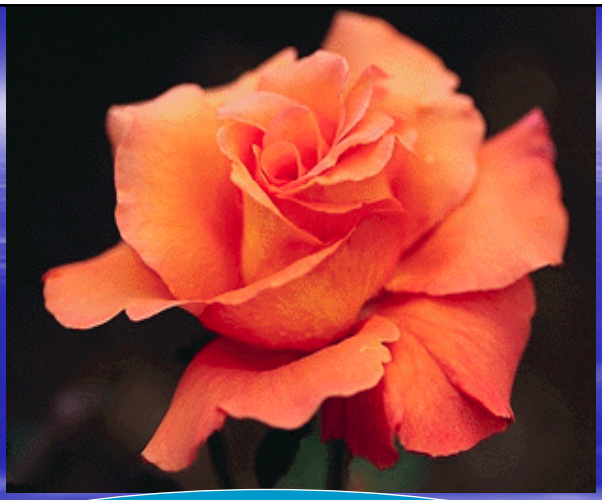
Thoms Amrein has found that

- The baking agent, Ammonium Hydrogen Carbonate, markedly enhanced acrylaimde formation.

- The use of Sodium Hydrogen Carbonate as the baking agent reduced the acrylamide content in gingerbread by more than 60%.

- And replacing reducing sugars with sucrose, adding citric acid and glucine to the dough all reduced acrylamide formation.

(J. Agric. Food Chem., 2004)



Thanks for Listening