

Acrylamide In Food

2002년 스웨덴 식품청의 식품 내 아크릴아마이드 존재 보고 이 후 전 세계적으로 생성기전 및 저감화, 독성, 분석기법, 식품 내 함량 등에 대한 연구가 진행되고 있으며 국내에서도 주 소비 식품의 아크릴아마이드 함량에 대한 분석을 지속하고 있다. 2003년, 2004년 국내에서 생산된 총 10개 군, 259여개의 식품을 선택하여 LC/MS/MS방법으로 아크릴아마이드함량을 분석하였다. Acrylamide는 고 탄수화물 식품을 고열에서 가열했을 때 생성되는 화학물질로서 IARC (국제암연구기관)에서 발암가능성물질로 분류하고 있다. 분석한 식품군의 아크릴아마이드 함량의 variability, 지금까지 밝혀진 생성기전, 식품 process 중 생성되는 아크릴아마이드의 저감화를 위하여 pH, precursors, 수분함량, 공정이 아크릴아마이드 생성에 미치는 영향을 제시한다.

Acrylamide in Food

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식품공학과

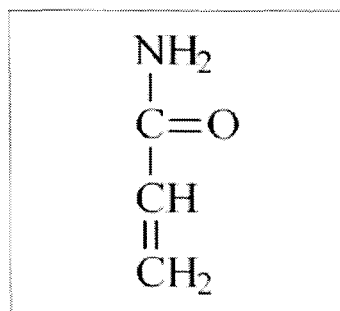
Brief History

- 2002. April. 24
 - Swedish National Food Administration
 - Stockholm University
 - Acrylamide in fried and oven-baked foods
- Norway
- UK
- Switzerland
- US
- Japan
- Korea

식품 중 발암물질

- 식품 중의 발암물질 섭취
(Generation to Generation)
- 발암물질 제거: 쉬운 방법 없음
- 해결방법: 진행 중

Acrylamide



Acrylamide

- 400,000 tons produced annually
- Over 95% used to produce polyacrylamide
- Water soluble

연구 분야

- **Formation and Reduction of Acrylamide**
- **Occurrence of Acrylamide and analytical techniques**
- **Toxicology**

Acrylamide Values in Domestic Food

(2002~2004년)

Food product	Number of samples	Concentration of Acrylamide (ppb)		
		Minimum	Maximum	
Dairy	butter	5	ND	<10
	cheese	4	<10	<10
	margarine	4	ND	<10
	milk	7	<10	11
	yoghurt	3	<10	<10
Meat/Fish products	bacon	2	<10	<10
	bacon, baked	4	<10	<10
	ham	5	<10	<10
	ham, baked	2	<10	<10
	porkcutlet, frozen	2	<10	<10
	porkcutlet, deep-fried	2	11	22
	sausage	4	<10	<10
tuna, canned	2	<10	<10	

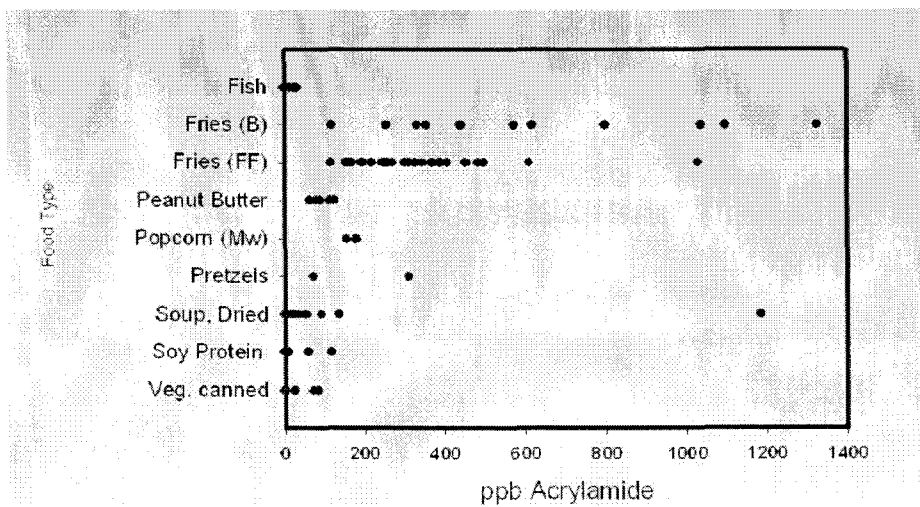
Food product	Number of samples	Concentration of Acrylamide (ppb)		
		Minimum	Maximum	
Grains/ Starches/ Baked products	biscuit	5	11	289
	bread	9	<10	33
	bread, toasted	9	<10	62
	cereal	7	<10	283
	cracker	8	13	459
	donut	2	<10	36
	grain	9	<10	17
	Hardtack (2189)	8	143	1,081
	popping rice	4	17	66
	porridge	4	<10	<10
	puffed corn	6	75	587
	rice cake	7	<10	<10
	rice, boiled	7	ND	17
	scorched rice	4	<10	19
Fruits/ Vegetables	bean, tofu	4	<10	<10
	bean, tofu, pan cooked	2	<10	<10
	fruit, canned	4	<10	<10
	olive, bottled	2	ND	<10
	olive, black, canned	2	258	681
	potato, raw	5	<10	<10
	vegetable, canned	4	<10	20

Food product	Number of samples	Concentration of Acrylamide (ppb)		
		Minimum	Maximum	
Snack foods	pop corn, not heated	3	<10	<10
	pop corn, popped	6	170	397
	potato, french fries, frozen	2	19	37
	potato, french fries, deep-fried	15	141	1896
	potato chip	4	278	1709
	potato snack	8	502	3,277
	snacks, other than potato snack	8	<10	150
	hot-dog, frozen	2	<10	11
	hot-dog, microwaved	2	<10	11
	Candy/Sweets	candy	7	<10
caramel		2	<10	<10
chocolate		8	15	63
Seasonings	bean paste	2	34	60
	bean paste, mixed	4	ND	51
	hot pepper paste	3	<10	56
	ketchup	4	ND	16
	mustard sauce	2	10	51
	pork cutlet sauce	4	ND	<10
	sesame oil	4	<10	51
	mayonnaise	2	ND	ND
	thousand island dressing	2	ND	ND
fermented soy bean paste products	12	<10	60	

Food product	Number of samples	Concentration of Acrylamide (ppb)		
		Minimum	Maximum	
Beverages	carbonated beverage	4	<10	<10
	coffee, brewed	5	<10	11
	coffee, powdered	5	70	1,026
	fruits drinks	5	<10	<10
	tea	7	<10	24
Food products sold on the road	waffle	2	41	53
	hot-dog	2	11	64
	baked squid	2	<10	<10
	dried fish	1		12
	pas (fried sweet potato)	1		57
Homemade foods	boiled down product	5	ND	218
	fried product	9	ND	12
	roasted fish product	2	ND	<10
	seasoned product	2	<10	<10
	soup products	6	ND	<10

• ND : not detected

Variability within Selected Food Groups



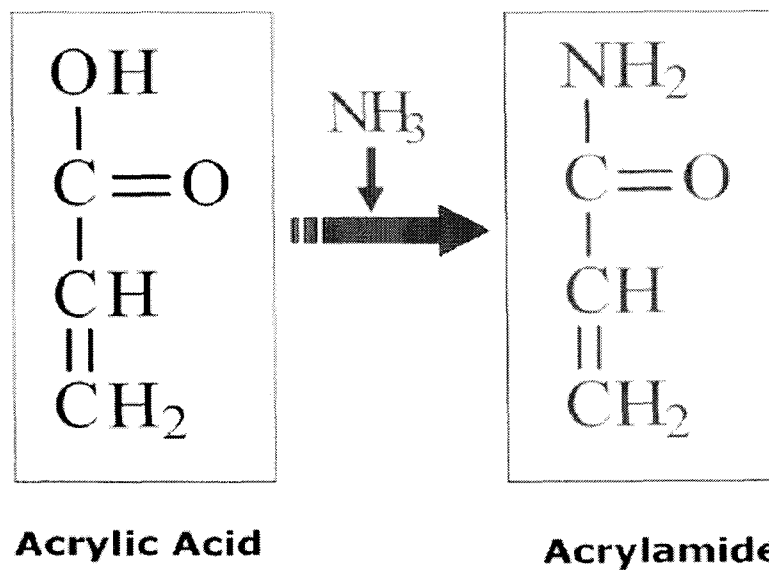
Mechanisms

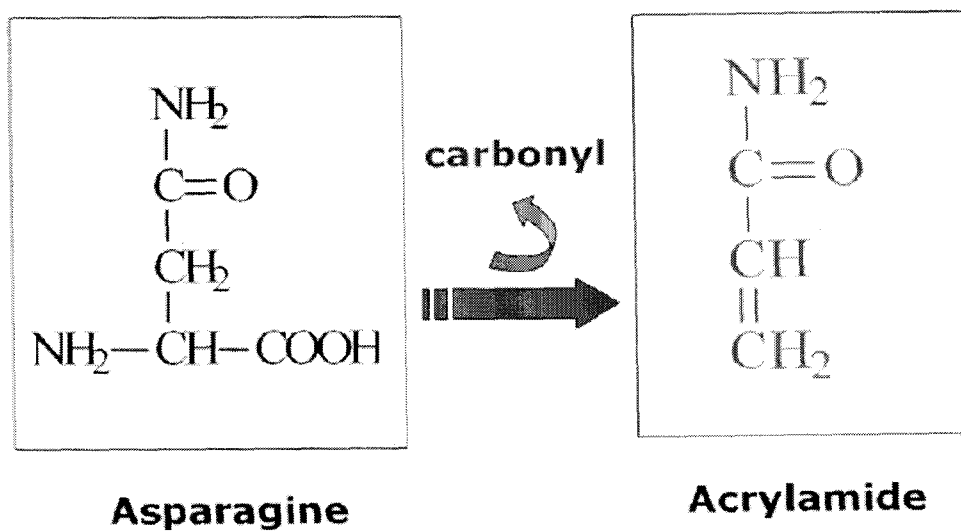
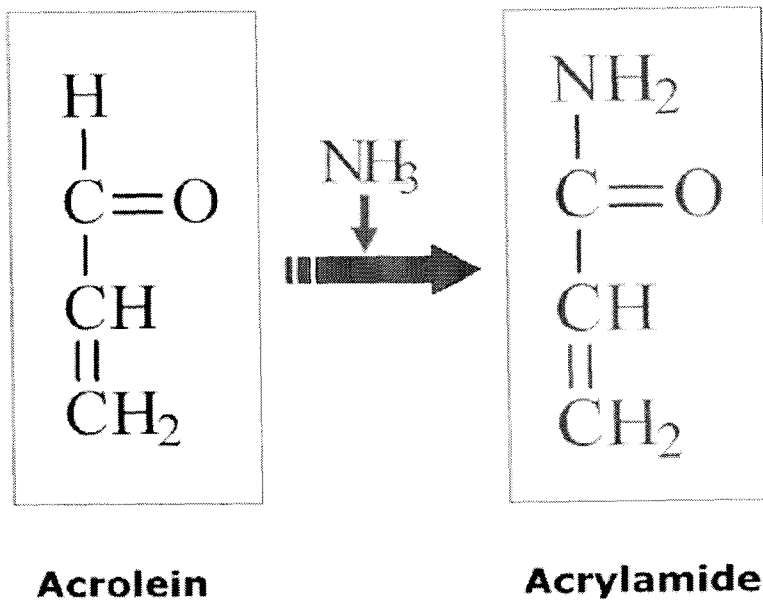
➤ Substrates

- Starch
- Sugars
- Amino acids
- Oil/Fat
- Degradation products

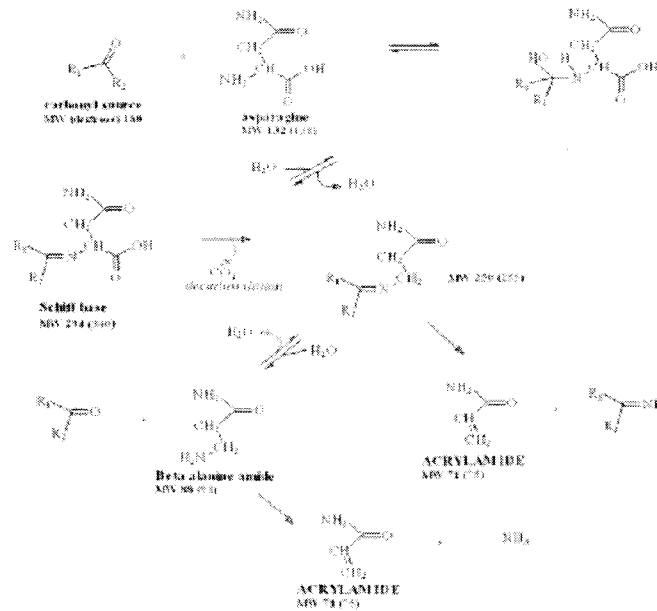
➤ Potential mechanisms

- Maillard reaction products
- Oil/fat pyrolysis products
- Oxidation products
- Free radical reactions





Acrylamide Formation Mechanism



Approaches to Reducing Acrylamide in Food

- Remove reactants
- Disrupt reaction
- Remove acrylamide after formation

Concentrations of Sugars and Amino Acids in a Potato Cultivar Used Chipping

sugar		Concn (g/100g)	
glucose		0.1	
fructose		0.08	
sucrose		1.07	
amino acid	Concn (mg/100g)	amino acid	concn (mg/100g)
Ala	4.7	Lys	4.7
Arg	16.4	Met	4.7
Asn	93.9	Phe	4.7
Asp	4.7	Pro	4.7
Gln	28.2	Ser	4.7
Glu	9.4	Thr	18.8
Gly	0	Trp	0
His	7	Tyr	7
Ile	7	Val	9.4
Leu	4.7		

< Martin *et.al.* J. Agric. Food Chem.2001.19: 3885 >

What Factors Affect Acrylamide Formation?

- Food composition
 - Precursors
 - pH
 - Moisture
 - Other compounds

- Processing conditions
 - Time
 - Temperature
 - Other

What Factors Affect Acrylamide Formation?

➤ Food composition

- Amino acids

ASN, MET, GLN, ASP, CYS

Other amino acids- LYS

- Sugars

Fructose > glucose > sucrose

- pH

pH 8.0 > 5.5 > 3.0

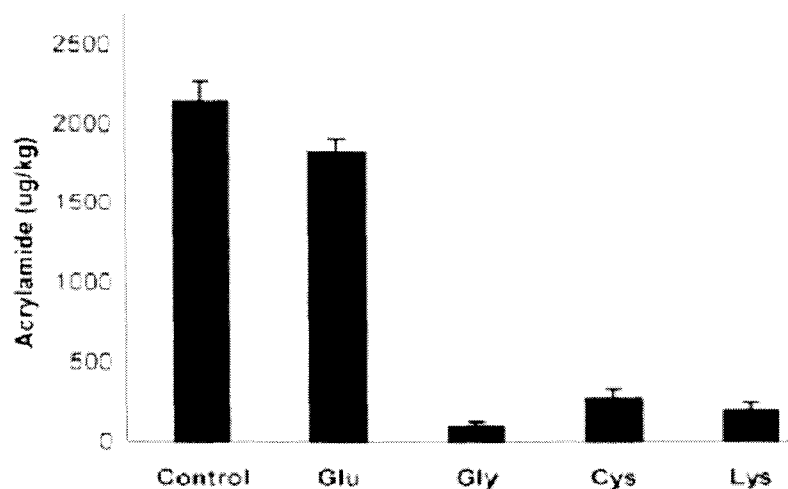
- Moisture content

Effects unclear

- Others

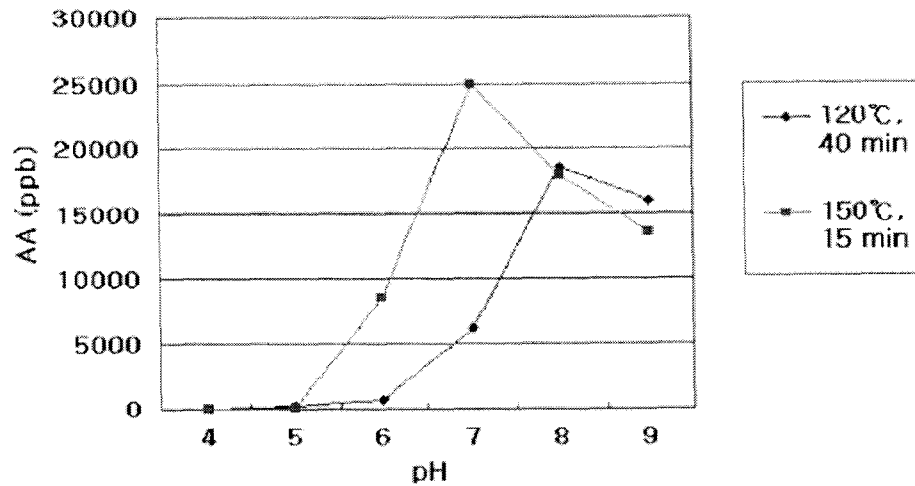
< 2003, FDA >

Effects of Amino Acids



< 2005, 김성태 >

Effect of pH on Acrylamide Formation



< 2002, FDA >

What Factors Affect Acrylamide Formation?

➤ Processing Conditions

- Temperature
- Time

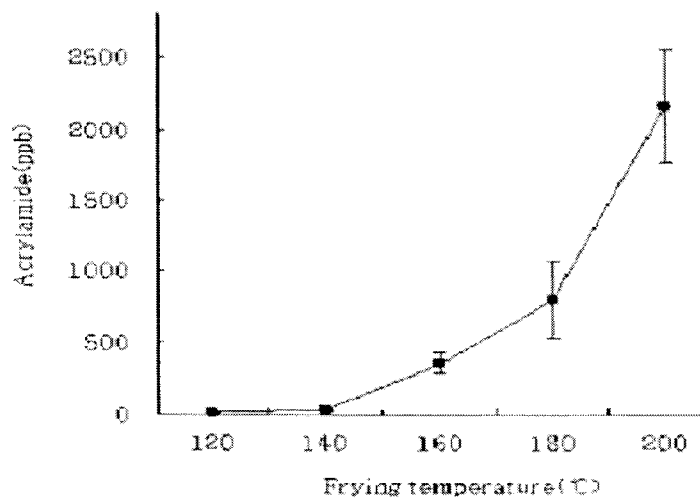
< 2003, FDA >

Effect of Temperature

In food

- Boiling and retorting produce little to no acrylamide
- Frying and baking result in modest to high levels
- Acrylamide levels increase with cooking/processing temperature

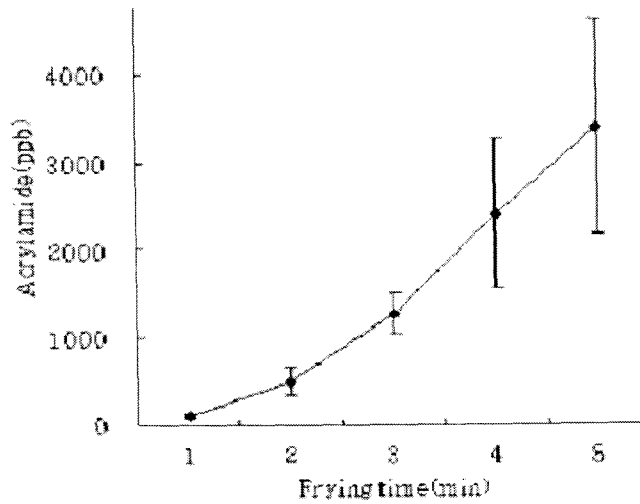
Effect of Temperature



→ Frying temperature-dependent formation of acrylamide

< 2003, 박재영 >

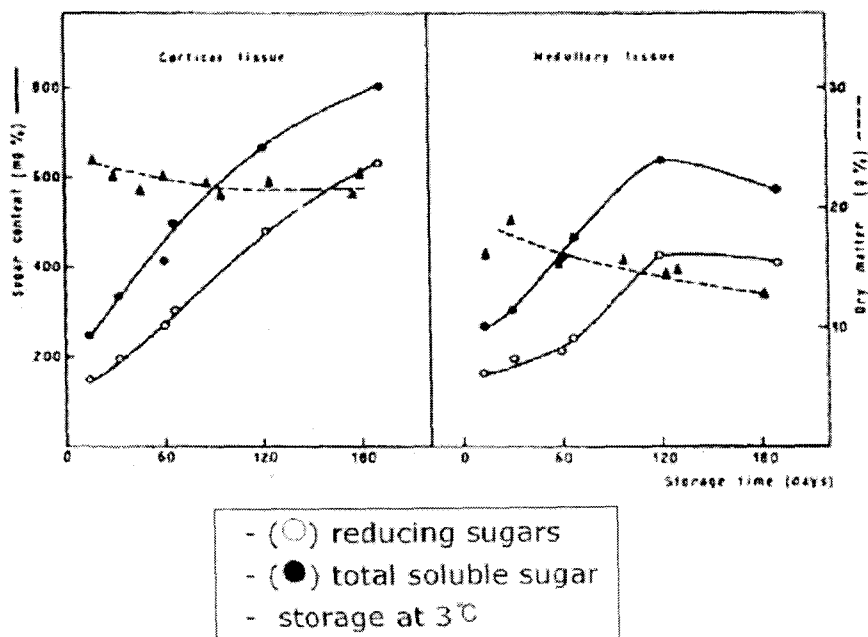
Effect of Time



→ Acrylamide levels increased with frying time

< 2003, 김예영 >

Changes in sugars during storage



Remove After Formation

- **Supercritical CO₂**
Removes everything,
but destroys the product
- **UV light**
No effect,
several wavelengths including visible

Toxicology of Acrylamide

- Classified by IARC as category 2A
→ Probably carcinogenic to humans
- Acutely neurotoxic
- Genotoxic in a range of assays
- Metabolized to glycidamide; forms DNA adducts

음식 섭취 가이드라인

(consumer advice)

- Choose a variety of grains daily, especially whole grains
- Choose a variety of fruits and vegetables daily
- Choose a diet that is low in saturated fat and cholesterol and moderate in total fat
- Choose a diet moderate in sugars
- Choose and prepare foods with less salt
- Aim for a healthy weight
- Be physically active each day

Toxicokinetics of Acrylamide

(Cancer Epidemiology Biomarkers Prev 2006;15(2):266-71)

- Toxicokinetics of Acrylamide in Humans after Ingestion of a Defined Dose in a Test Meal to Improve Risk Assessment for Acrylamide Carcinogenicity

FAO/WHO Expert Consultation

(Rome, June, 2002)

- Estimated average chronic human dietary intake is in the order of 1 μ g/kg body weight/day
- NOAEL for acrylamide neuropathy is 500 μ g/kg body weight/day
- Generally recommended that exposures be "as low as reasonably achievable (ALARA)"

Toxicology of Acrylamide

- Carcinogenic in animal (rodent) studies
- Three human cohort studies; (1986, 1989, 1999)
 - No evidence of a causal relationship between exposure and cancer incidence

Human epidemiological study

(British Journal of Cancer 2003; 88: 84-89)

- **Authors concluded**
 - No positive association between dietary exposure to acrylamide and risks of bowel, bladder or kidney cancer