

Acrylamide formation during food processing

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Brief History

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

Keep in Mind

- 발암물질
- 식품중의 발암물질 섭취(Generation to Generation)
- 발암물질 제거 : 쉬운 방법 없음.
해결방법 : 연구중

Overall Goal

- 식품에 존재하는 아크릴아마이드의 위해가능성을 줄이거나 예방하는 것
- 소비자와 가공업자에게 이해가능성에 대하여 정보를 제공하고 교육하는 것 (평가과정, 연구를 통한 위해정보 습득)

소비자의 질문사항

- 어느 음식이 암을 유발하는가?
- 어느 음식이 안전한가?
- 특정음식 섭취를 중지해야 하는가?
- 조리방법을 바꾸어야 하는가?
- 나와 가족을 위하여 무엇을 변화시켜야 하는가?

소비자 권고사항(현재)

- 음식을 골고루 섭취

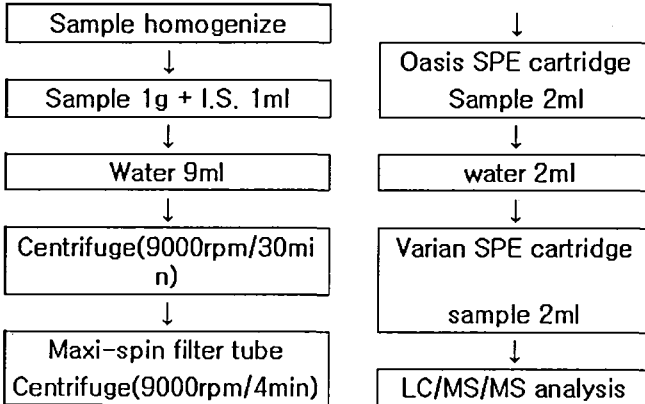
- 연구결과로부터 얻어진 과학적 지식에 근거하여 소비자 권고사항은 바뀌어야 하는가?

연구분야

- 아크릴아마이드 생성
 - 생성을 줄이는 방법
- 식품중 존재량
- 식품별 섭취량
- 아크릴아마이드 노출 평가
- 아크릴아마이드 노출에 의한 건강에의 영향

아크릴아마이드 분석방법

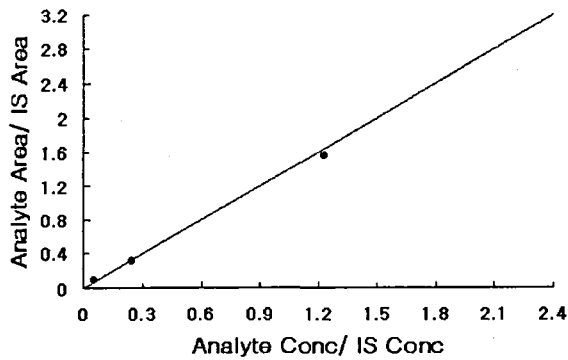
<Sample prep>



<LC/MS/MS Condition> (2003. FDA)

- Column : Aqua C₁₈ HPLC column(2×250mm)
- Mobile phase composition: Aqueous 0.1% acetic acid, 0.5 % methanol
- Column flow rate: 200 μ l/min
- Acrylamide elution time: 6.5 minutes
- Ionization Mode: Positive ion electrospray
- Collision energy: 19 volts (m/z 27 (80%), m/z 55 (100%) and m/z 72 (30%))
- Ions monitored: Acrylamide (m/z 72, 55, 27), Internal Standard (75, 58, 29)
- Quantitation: The ratio of peak areas for m/z 55 (acrylamide) and m/z 58 (internal standard)

3. Standard curve



3. 실험방법

- Dr. Steven Musser (FDA)
- Liquid chromatography/tandem mass spectrometry method (LC/MS/MS)
- Limit of quantitation (LOQ):
 - 10 parts per billion (ppb)

Acrylamide levels in different foods and product groups from Norway, Sweden, Switzerland, the United Kingdom and the United States of America

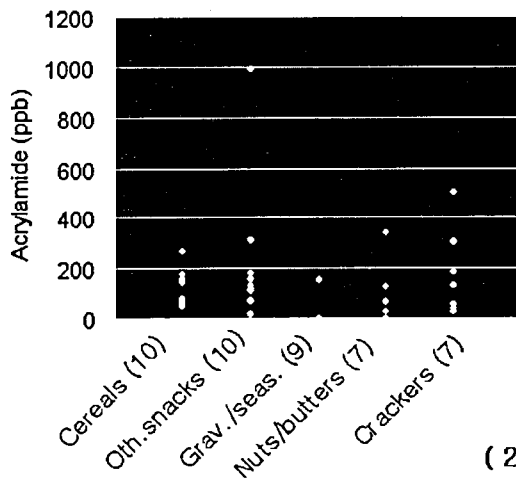
Food/Product Group	Minimum-Maximum	Number of samples
Crisps, potato/sweet potato	170-2287	38
Chips, potato	<50-3500	39
Batter based products	<30-42	2
Bakery products	<50-450	19
Biscuits, crackers, toast, bread crisps	<30-3200	58
Breakfast cereals	<30-1346	29
Crisps, corn	34-416	7
Bread, soft	<30-162	41
Fish and seafood products, crumbed, battered	30-39	4
Poultry or game, crumbed, battered	39-64	2
Instant malt drinks	<50-70	3
Chocolate powder	<50-100	2
Coffee powder	170-230	3
Beer	<30	1

<WHO website에서 발췌>

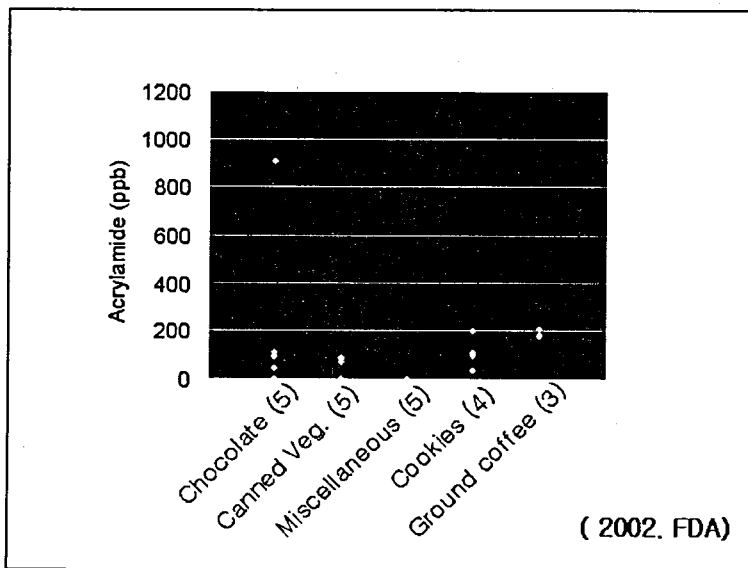
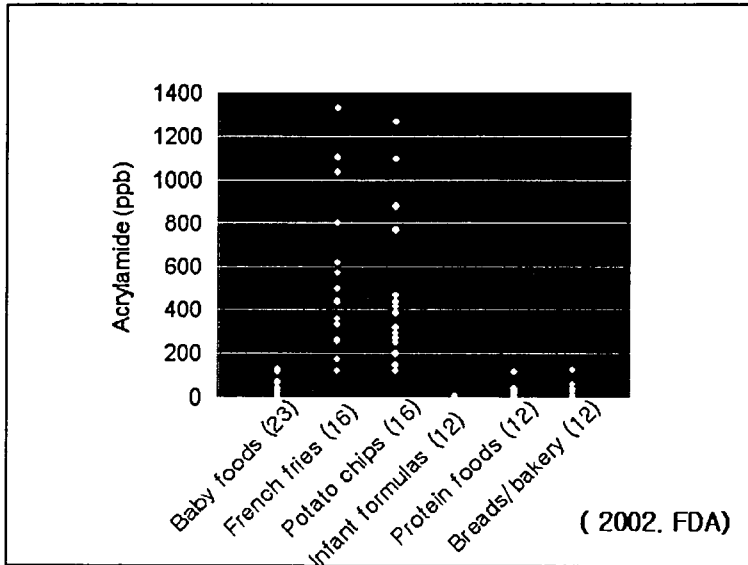
샘플

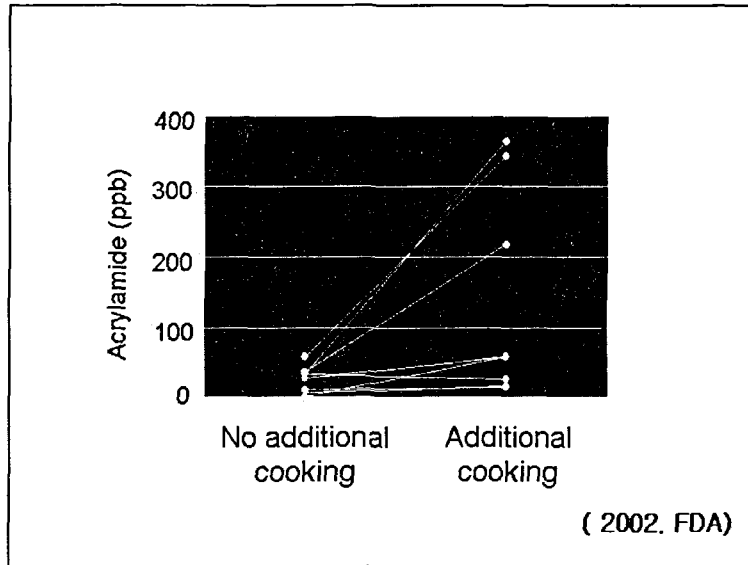
- Baby foods
- Canned vegetables
- Cereals
- Chocolate products
- Coffee
- Cookies
- Crackers
- French fries
- Gravies and seasonings
- Infant formulas
- Miscellaneous
- Nuts/nut butters
- Potato chips
- Protein foods
 - Meat, Fish, Chicken, Soy
- Snack foods (other)

실험결과



(2002. FDA)





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

sugar		concnr(g/100g)	
glucose		0.1	
fructose		0.08	
sucrose		1.07	
amino acid	concnr(mg/100g)	amino acid	concnr(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>

Which Amino Acids Form Acrylamide? Potato Chip Model System Studies

● Acrylamide Formation

- Potato starch	< 50 ppb
- Potato starch + glucose	< 50 ppb
- Potato starch + asparagine	117 ppb
- Potato starch + glucose + asparagine	9270 ppb

● Other Amino Acids

- Alanine	< 50 ppb	Arginine	< 50 ppb
- Aspartic Acid	< 50 ppb	Cysteine	< 50 ppb
- Lysine	< 50 ppb	Methionine	< 50 ppb
- Threonine	< 50 ppb	Valine	< 50 ppb
- <i>Glutamine</i>	<i>156 ppb</i>	Asparagine	9270 ppb

From: Sanders et al. (2002)

What Factors Affect Acrylamide Formation?

- **Food composition**
 - Precursors
 - pH
 - Moisture
 - Other compounds
- **Processing conditions**
 - Time
 - Temperature
 - Other

(2003. FDA)

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

(2003. FDA)

What Factors Affect Acrylamide Formation?

- **Food composition**

- **Moisture content**

- Effects unclear

- **Others**

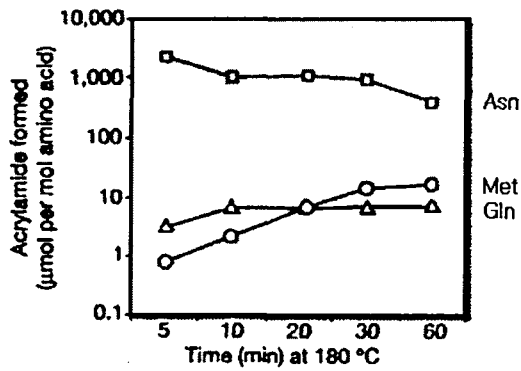
(2003. FDA)

What Factors Affect Acrylamide Formation?

Processing Conditions

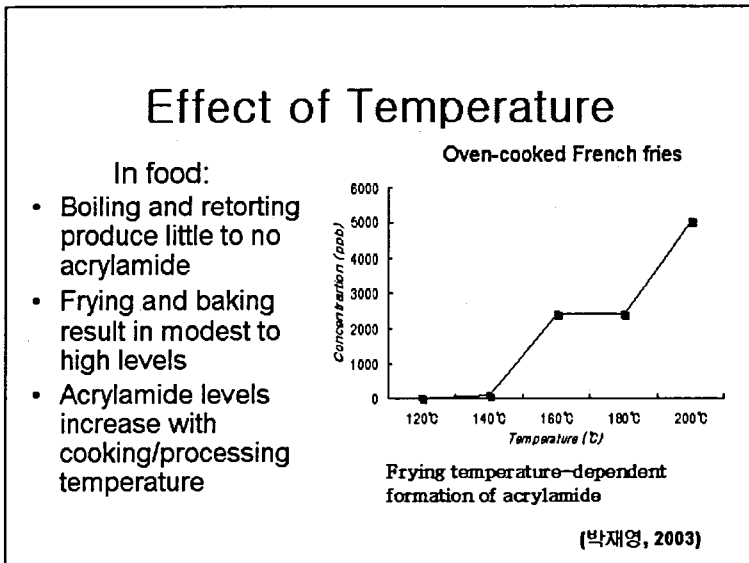
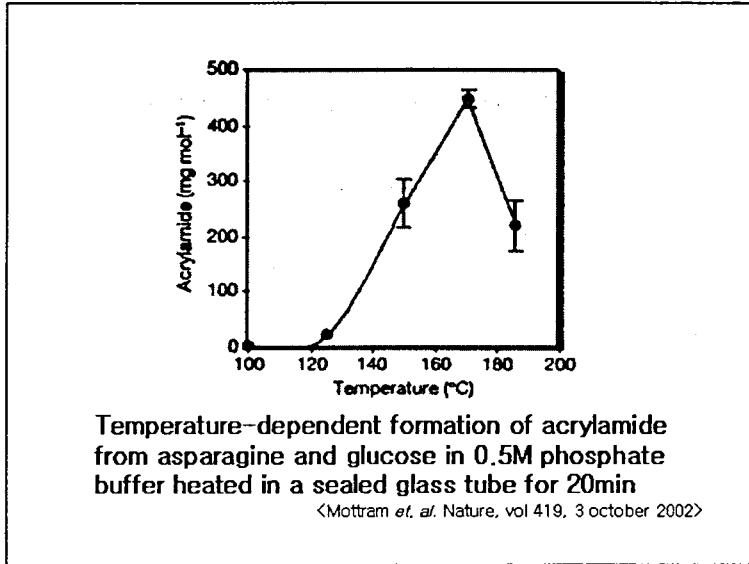
- Temperature- Yes
- Time- Yes

(2003, FDA)



Production of acrylamide from *N*-glycosides

< Mottram *et. al.*, Nature, vol 419, 3 october 2002 >



Effect of Temperature

- Acrylamide levels increased with frying oil temperature

(2003. FDA)

Effect of Time

- Acrylamide levels increased with frying time

(2003. FDA)

Acrylamide Issue

1. Remove reactant
2. Disrupt reaction
3. Remove acrylamide after formation
4. Toxicology

(2003. FDA)

Acrylamide Precusors—Where to Intervene

Asparagine

Reducing sugars

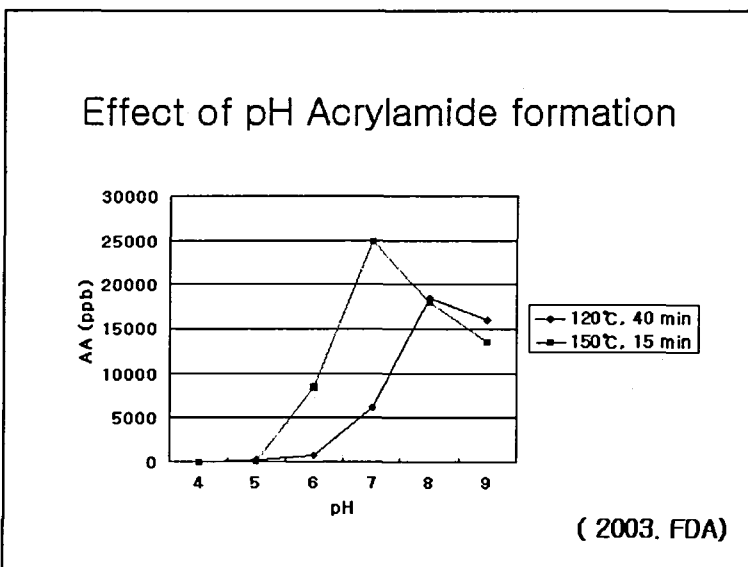
- Glucose
- Fructose
- sucrose hydrolysis

- Factors affecting asparagine and reducing sugars
 - Variety of potato
 - Storage conditions

(2003. FDA)

Frozen frying chips	Acrylamide Concentration($\mu\text{g}/\text{kg}$)		Yield of acrylamide increase substantially with browning
As sold	200	100	
Cooked	3500	3500	
Over cooked	12800	12000	

(2003. FDA)



Prevent Asparagine and Glucose Reaction

The Idea

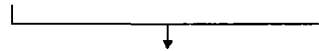
Raw Food + Reaction Inhibitor + cooking → Reduced Acrylamide

Remove After Formation

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

Key Elements

- 아크릴아마이드 생성 생성속도조절



아크릴아마이드 저감화

- 아크릴아마이드 노출시 건강에의 영향

노출평가

- 식품 중 아크릴아마이드 정량분석
- 평균 노출량: 0.3-0.5 μ g/kg/day 추정
(FDA 추정)

노출평가

- 노출량 : 식품별 섭취에 따라 큰차이
- (예) 2,000 cal/성인/day
French fries 섭취시, 존재하는
아크릴아마이드가 건강에 영향이 있느냐?

아크릴아마이드 독성 연구

- 신경독에 의한 결과
- 유전인자에의 영향
- 발암의심물질의 역할

현재 증명된 위해 data

- 동물 실험
 - mg/kg 범위
 - 사람에 대한 실험 data 전무
- 사람 epidemiological studies
 - 직업에 의한 노출-암과 관계없음
 - 식품에 의한 노출 연구-1 study

Human Epidemiological Study

- 고려사항
 - Dose
 - 노출기간
 - 나이
 - 유전인자(genetic susceptibility)
 - Synergistic factor
 - 중앙종류
 - 대상
 - 대장, 신장, 방광
- [British Journal of Cancer 2003;88:84-89]

Human Epidemiological Study

[British Journal of Cancer 2003;88:84-89]

- 538 Controls
- 591 cases of large bowel cancer
- 263 cases of bladder cancer
- 133 cases of kidney cancer
- Dietary consumption of certain foods in prior 5 years via questionnaire
- Most ‘high-acrylamide’ foods included in questions

연구자 결론

- 식품노출(아크릴아마이드)은 대장, 방광, 신장암과 no positive association.

[British Journal of Cancer 2003;88:84-89]

- 한정된 sample size
- 한정된 아크릴아마이드 함유식품
- 기타 암에의 영향

연구고려사항

- 동물독성 (mg/kg body)
사람노출 (μ g/kg body)
- 아크릴아마이드에 의한 위해정보 부족
- 특정식품소비에 의한 아크릴아마이드 섭취량
과다시 노출정도

소비자에게 줄 수 있는 Advice!

Risk Management (FDA)

- We do not want to create one problem by solving another

미국 FDA 음식섭취 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.

연구 기대 사항

- 저감화 방법
 - 산업체 제조시
 - 주방 조리시(가정)
- 위해 이해