Glycoalkaloids in Potatoes

Trade Consultation Forum

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食物環境衞生署
Food and Environmental Hygiene Department

食物安全中心
Centre for Food Safety

Background

In September 2015, CFS was notified of a food poisoning case

- two persons from the same household
- after eating cooked potatoes
  - ➢ tongue numbness
  - ➢ burning sensation in mouth

Glycoalkaloid was detected

- in the raw potato sample
- in a urine sample of one of the victims

Glycoalkaloids in Potatoes

Solanaceae family

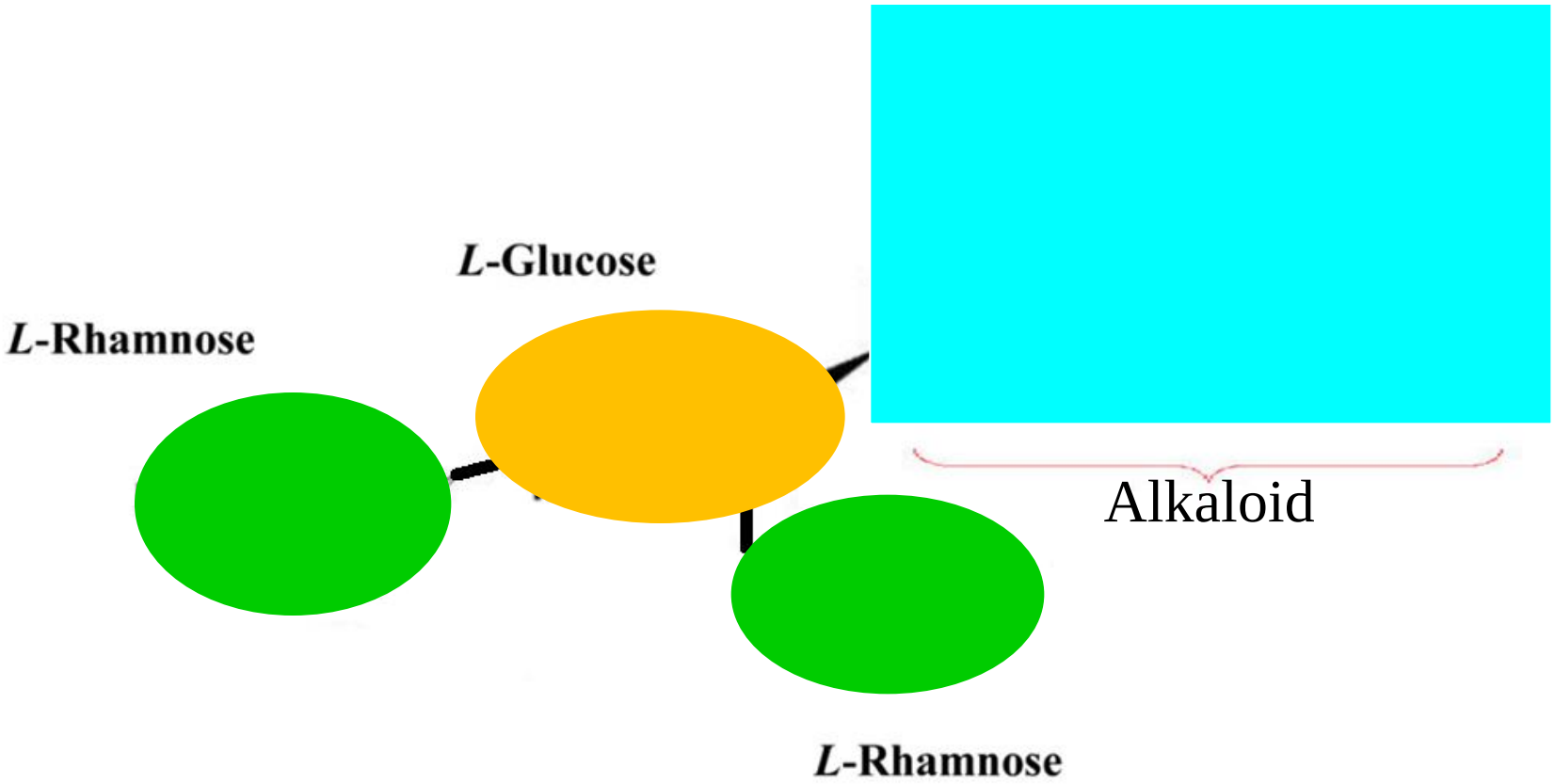
- glycoalkaloids
- defence against herbivores, pests and deseases
- naturally produced

Glycoalkaloids

- Sugar + alkaloid
  - α-chaconine
  - α-solanine

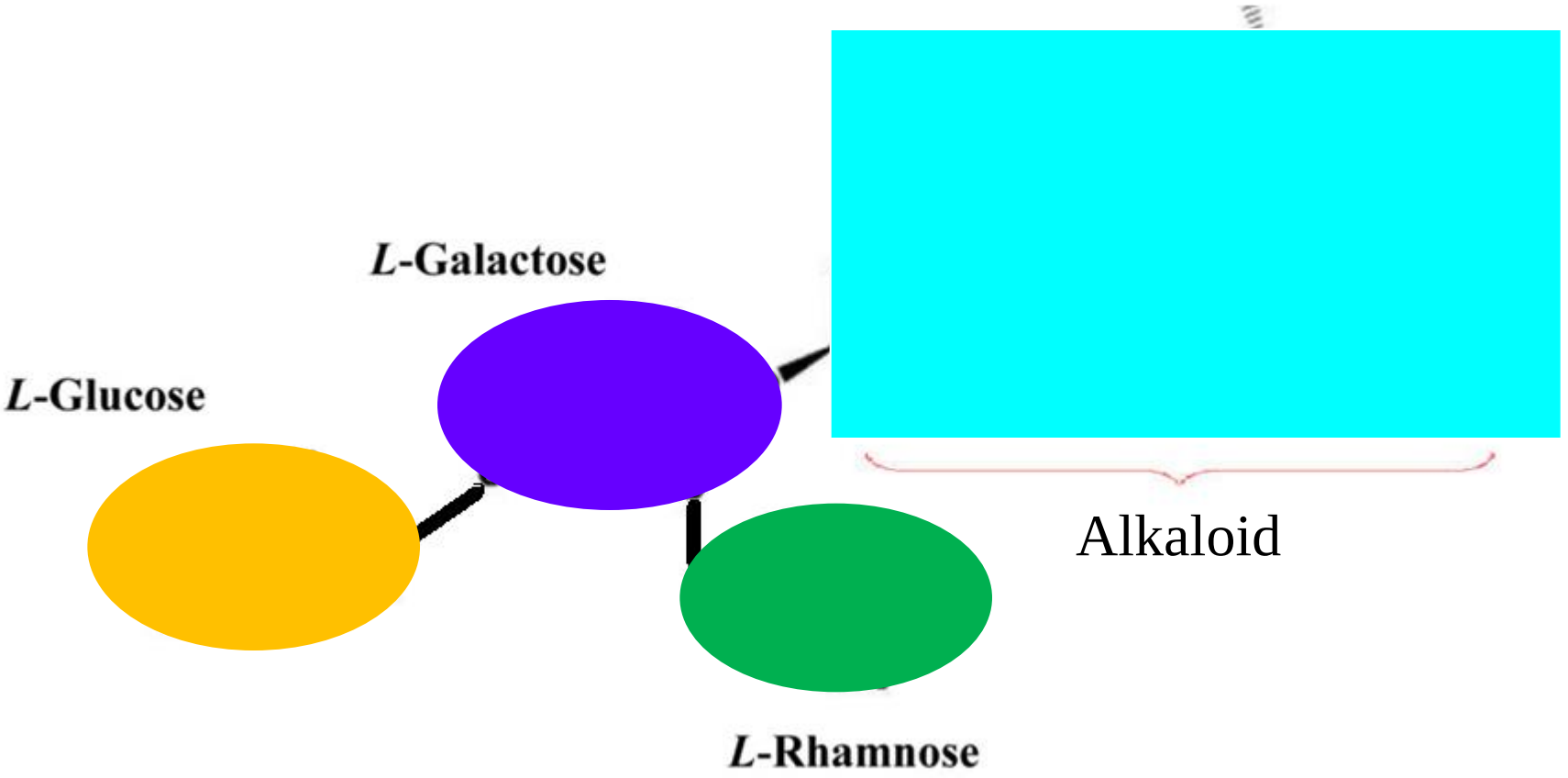
Glycoalkaloids in Potatoes

Chaconine : Sugar + alkaloid



Glycoalkaloids in Potatoes

Solanine : Sugar + alkaloid



Adverse health effects

Two toxic mechanisms

(1) disrupt of cell membrane

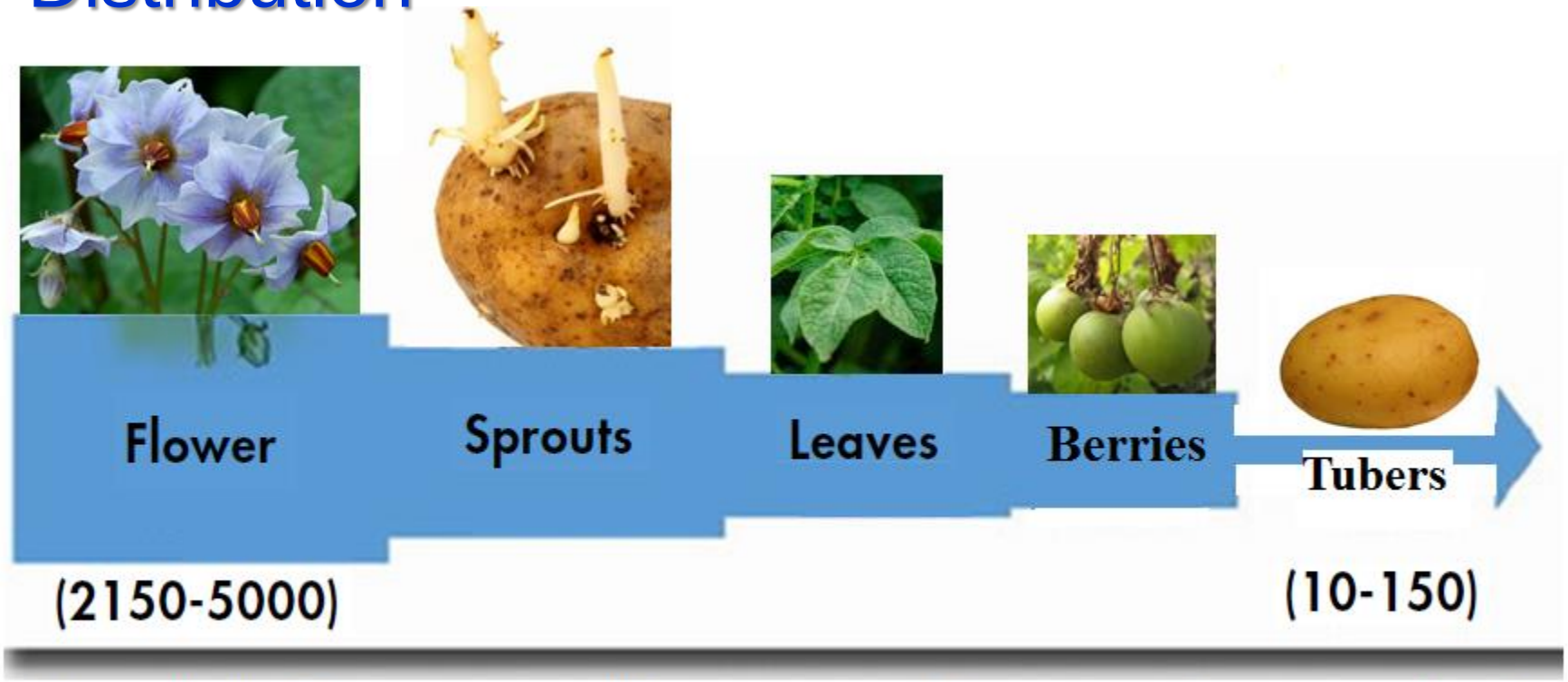
- adversely affect intestinal permeability
- nausea, vomiting, stomach and abdominal cramps, and diarrhea (1/2 to 12 hours after ingestion)

(2) interfere the message transmission between nerve cells

- neurological effects (i.e. drowsiness, apathy, restlessness, shaking, confusion, weakness, and disturbed vision)

Glycoalkaloids in Potatoes

Distribution

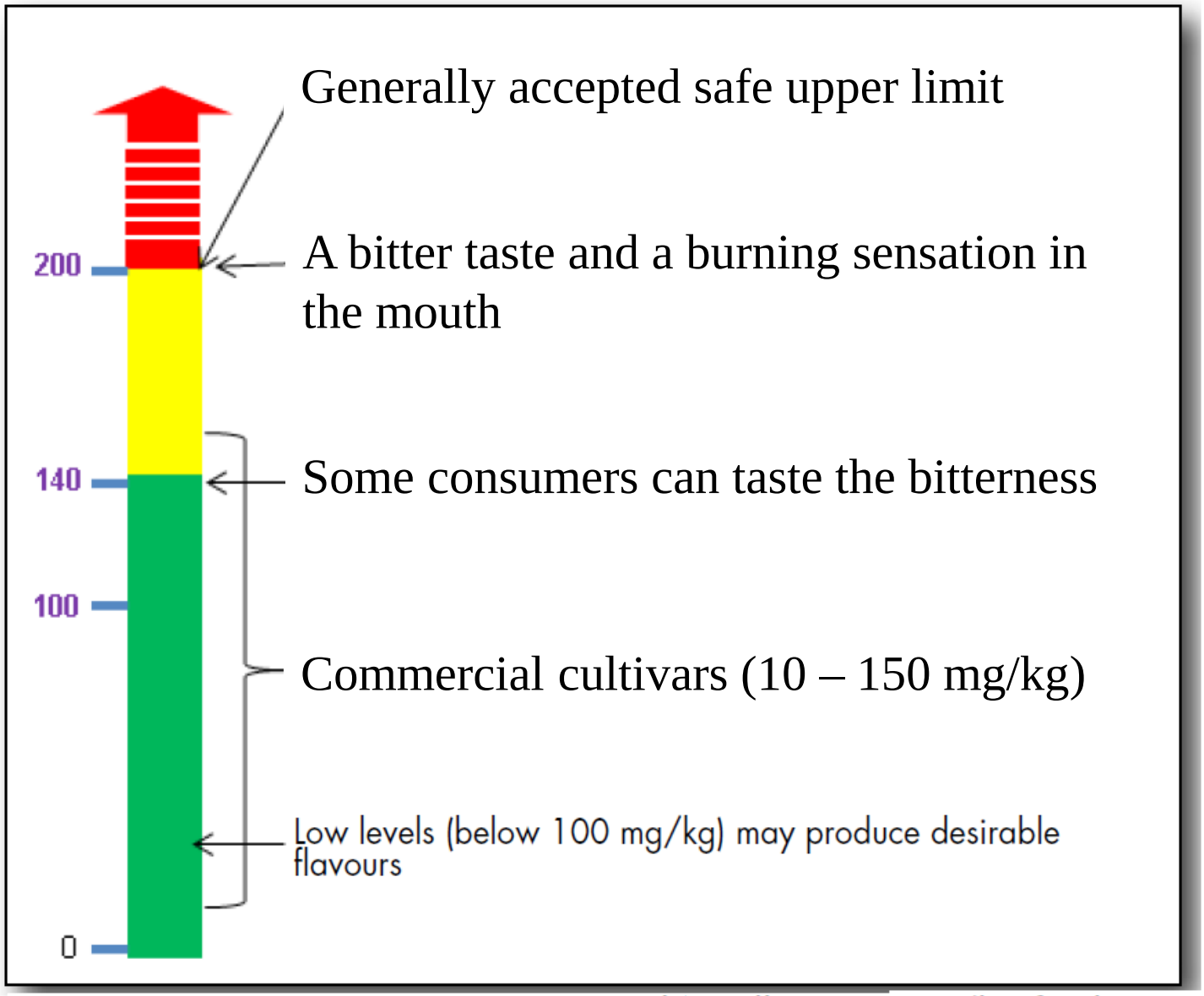


Glycoalkaloid contents in different parts of a potato plant, in order from highest to lowest concentration (mg/kg, not drawn to scale)

Glycoalkaloids in Potatoes

Plant part	Typical glycoalkaloids content (mg/kg, fresh weight)
Flowers	2150-5000
Sprouts	2000-9970
Leaves	230-1450
Berries	180-1350
Roots	180-850
Stems	23-33
Commercial cultivars of tubers	10-150

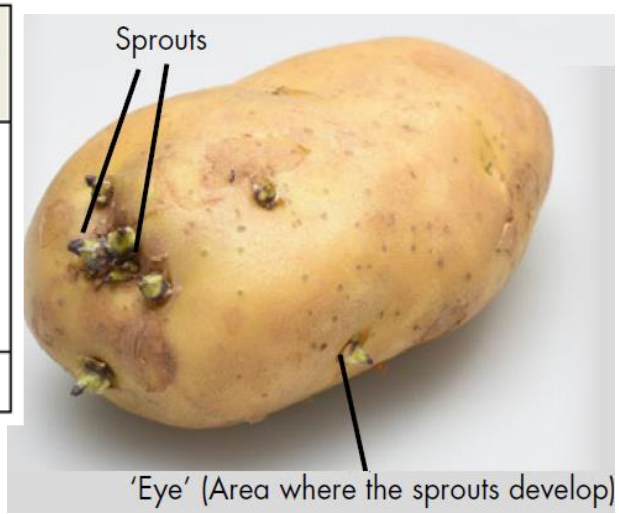
Glycoalkaloids in Potatoes

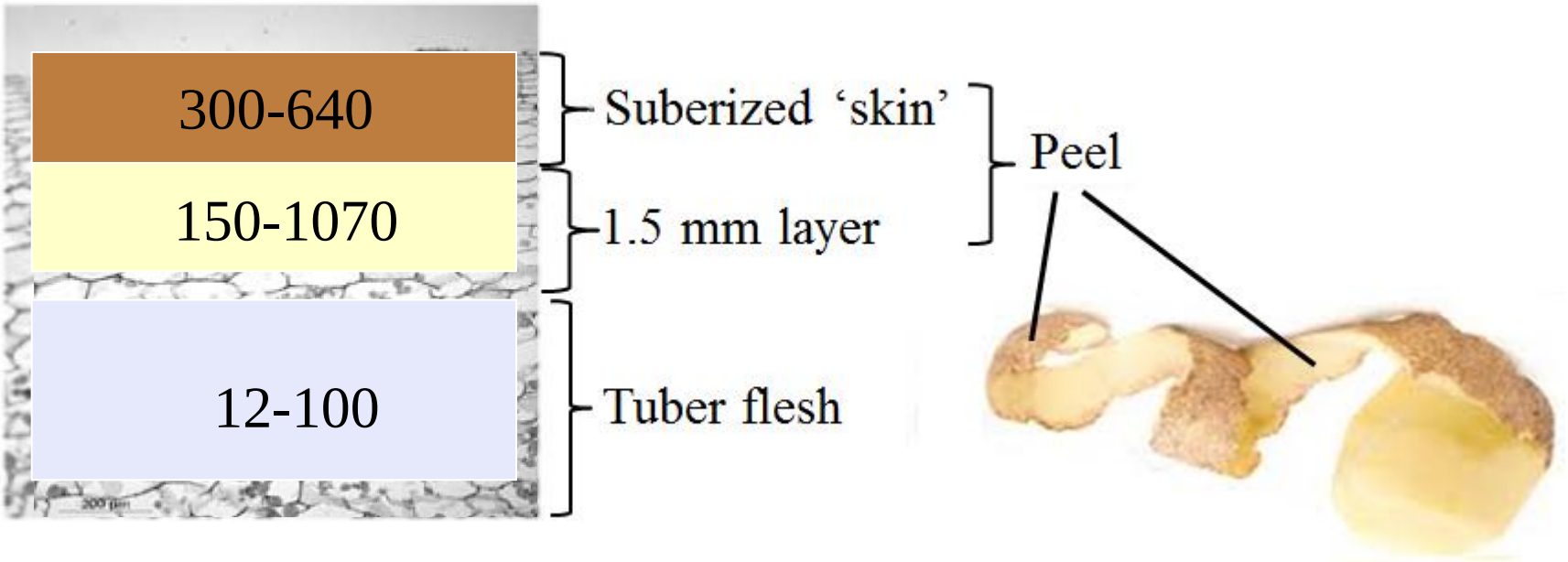


Effects of different concentrations of glycoalkaloids (mg/kg fresh weight)

Glycoalkaloids in Potatoe tubers

Plant part	Typical glycoalkaloids content (mg/kg, fresh weight)
Commercial cultivars of tubers	10-150
• Skin (2-3% of tuber)	300-640
• Peel (10-12% of tuber)	150-1070
• Flesh	12-100
Sprouts	2000-9970





Glycoalkaloids in Potatoe tubers

Distribution of glycoalkaloids

- the whole potato tubers
- concentrate
  - sprouts
  - peel (a small 1.5 mm layer immediately under the skin)
  - the area around the potato ‘eyes’

Way to reduce

- peeling of potatoes greatly reduces the levels of glycoalkaloids present

Local study by the CFS (2006)

Glycoalkaloids in Flesh and Peel of Various Potatoes (mg/kg)

Variety	α–solanine		α–chaconine		Glycoalkaloids (Whole potato)
	Flesh	Peel	Flesh	Peel	
New Potato	ND	120	ND	200	72
Russet	ND	20	ND	70	26
Red-skinned	ND	30	ND	110	36
Yellow-skinned 1	ND	100	ND	300	88
Yellow-skinned 2	ND	60	ND	200	60

ND: not detected; Limit of Detection (LOD) = 10 mg/kg

Local study by the CFS (2006)

Glycoalkaloids in sprouts and flesh of potatoes (mg/kg)

Variety	α–solanine		α–chaconine	
	Flesh	Sprout	Flesh	Sprout
Sprouted red-skinned potato	ND	3500	ND	4100

ND: not detected; Limit of Detection (LOD) = 10 mg/kg

Glycoalkaloids in Potatoes

Commercial cultivars of tubers

- vary between 10 and 150 mg/kg
- most beneath 100 mg/kg

Bitter varieties

- four **wild potato** species in Mexico (*S. polytrichon*, *S. stoloniferum*, *S. ehrenbergii*, *S. cardiophyllum*)
- considerable high levels (1080 – 5540 mg/kg)

Factors affecting the levels of glycoalkaloid

- cultivars
- cultivation and management

- stresses after harvest
  - injury
  - light
  - storage temperature

Factors affecting the levels of glycoalkaloid

Cultivars

- most important
- considerable variation among cultivars
- genetically controlled
- commercial cultivars vary between 10 and 150 mg/kg

Lenape variety (1960s)

- for pest resistance: *Solanum tuberosum* × *Solanum chacoense*
- breeders and professionals — ended up with severe nausea
- high alkaloid content (300 mg/kg)
- was not released for commercial planting

Factors affecting the levels of glycoalkaloid

Cultivation and Management

- stresses during growth
  - unusual weather (cold, hot, rainy, dry)
  - unusual insect attack

- in 1986, 11 people became ill
- 66% Magnum Bonum samples exceeded 200 mg/kg
- a sales ban on such potatoes
- unusually cold and rainy growing season is partly responsible

Factors affecting the levels of glycoalkaloid

Cultivation and Management

- stresses during growth
  - unusual weather (cold, hot, rainy, dry)
  - unusual insect attack
- degree of maturity
  - immature tubers have higher metabolism
  - have higher glycoalkaloid
  - e.g. “new” potatoes

Variety	α–solanine		α–chaconine		Glycoalkaloids (Whole potato)
	Flesh	Peel	Flesh	Peel	
New Potato	ND	120	ND	200	72
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Factors affecting the levels of glycoalkaloid

Injury

- pest infestation
- mechanical injury
- stimulate glycoalkaloids production

Light

- prolonged exposure
  - ➢ chlorophyll synthesis
  - ➢ ‘greening’ of the tuber
- stimulate glycoalkaloids production
- independent reactions but occur at the same time

Factors affecting the levels of glycoalkaloid

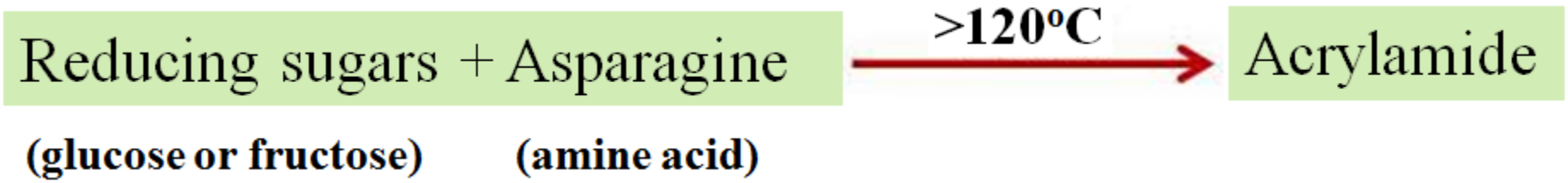
Storage temperature

- elevated temperature
  - ➢ promote sprouting
- low temperature (< 7°C)
  - ➢ promote conversion of starch to sugar

Increase in sugar

- darken during cooking
- produce acrylamide

Factors affecting the levels of glycoalkaloid



Low storage temperature (< 7°C)

- promote conversion of starch to sugar
- cooking (>120°C) may increase amount of acrylamide

Factors affecting the levels of glycoalkaloid

Advice (storage temperature) from other authorities:

Storing potatoes in the refrigerator can result in increased **acrylamide** during cooking. Therefore, store potatoes outside the refrigerator, preferably in a dark, cool place, such as a closet or a pantry, to prevent sprouting.
– *US Food and Drug Adminstration*

Do not store potatoes below 8°C (low temperature storage can increase the components that contribute to **acrylamide** formation). – *Health Canada*

Factors affecting the levels of glycoalkaloid

Advice (storage temperature) from other authorities:

Do not store potatoes in the refrigerator as this increases sugar levels (potentially increasing **acrylamide** production during cooking). Keep them in a **dark, cool** place.
– *European Food Safety Authority*

For some fruits that need to ripen, keeping them in the fridge can affect the taste. The most important food **not to keep in the fridge** are potatoes, when these are stored in the fridge the starch in the potato is converted to sugar. When baked or fried these sugars combine with the amino acid asparagine and produce the chemical **acrylamide**, which is thought to be harmful. – *UK Food Standards Agency*

Factors affecting the levels of glycoalkaloid

Advice (storage temperature) from other authorities:

Don't store potatoes at temperatures below 8°C because this can increase the components that prompt **acrylamide** formation.
– *Food Standard Australia New Zealand*

Keep them in a **dark place**, handle them gingerly and protect them from being bumped against; otherwise they are vulnerable to the formation of solanine, a toxic substance. If the pantry is also cool, you can retard softening and sprouting as well. Otherwise **room temperature works just fine**.
– *National Food Agency, Sweden*

Regulatory control

Codex

- not established any safety standard

Generally accepted safety upper limit is 200 mg/kg of potato

Health Canada

- established a maximum level for glycoalkaloids
  - 200 mg/kg total glycoalkaloids (fresh weight)
- this level applies to all commercially sold potatoes

Regulatory control

The National Food Agency, Sweden

- Regulations on Certain Foreign Substances in Food (2002)

Substance	*Food*	*Maximum level, mg/kg*
Glycoalkaloids, total level of solanidine glycosides (α-chaconine, α-solanine etc.)	Potatoes, raw and unpeeled	200

(Source: FAOLEX - legislative database of FAO Legal Office)

The Federal Office of Consumer Protection and Food Safety (Germany)

- considers amounts up to 200 mg/kg in potatoes for safe

Advice to Trade

Handling

- know the cultivars, maturity (“new” potatoes)
- handled with special care

Light

- display in areas with low light intensity
- shut lights off at night over the potatoes
- cover with brown paper sacks.
- packing in paper bags or in plastic bags that are opaque on one side.

Temperature

- Keep potatoes cool and dry

Reference

The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks (Agricultural Research Service, USDA) (Revised 2016)
http://www.ars.usda.gov/is/np/CommercialStorage/CommercialStorage.pdf

Retail Handling of Fresh Potatoes (Agriculture Victoria)
(Updated: August 2010 and 2013)
http://agriculture.vic.gov.au/agriculture/horticulture/vegetables/potatoes/retail-handling-of-fresh-potatoes

Toxic Glycoalkaloids in Potatoes (Centre for Food Safety)(November 2015)
http://www.cfs.gov.hk/english/multimedia/multimedia_pub/multimedia_pub_fsf_112_01.html

Thank you