Chemical Food Safety - contaminants

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Contaminants

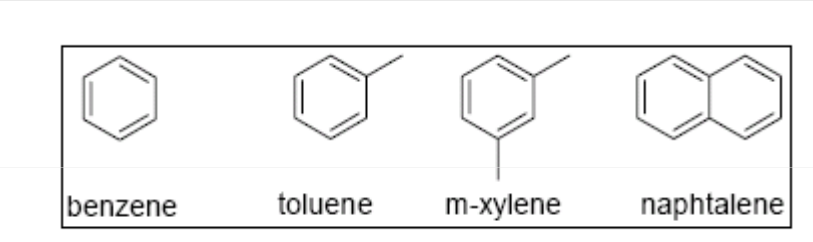
- environmental contaminants
- process contaminants
- microbiological contaminants

Environmental contaminants

- emission of inorganic and organic chemicals by industrial processes
- contamination of agricultural commodities and food products
- chemicals considered as prime importance:
  - production volume
  - pattern of usage or emission
  - possible fate in environment
  - likelihood of entering in the food chain
  - mechanism of entry in the food chain
  - persistance in the food chain
  - toxicity

Aromatic hydrocarbons

- e.g. benzene – alkylated benzenes (toluene, ethyl benzene, xylenes & naphthalene)



- sources of toluene : lead free fuel – motor vehicle exhaust gases
- other AH : released by industrial solvents used in paints and adhesives

Aromatic hydrocarbons

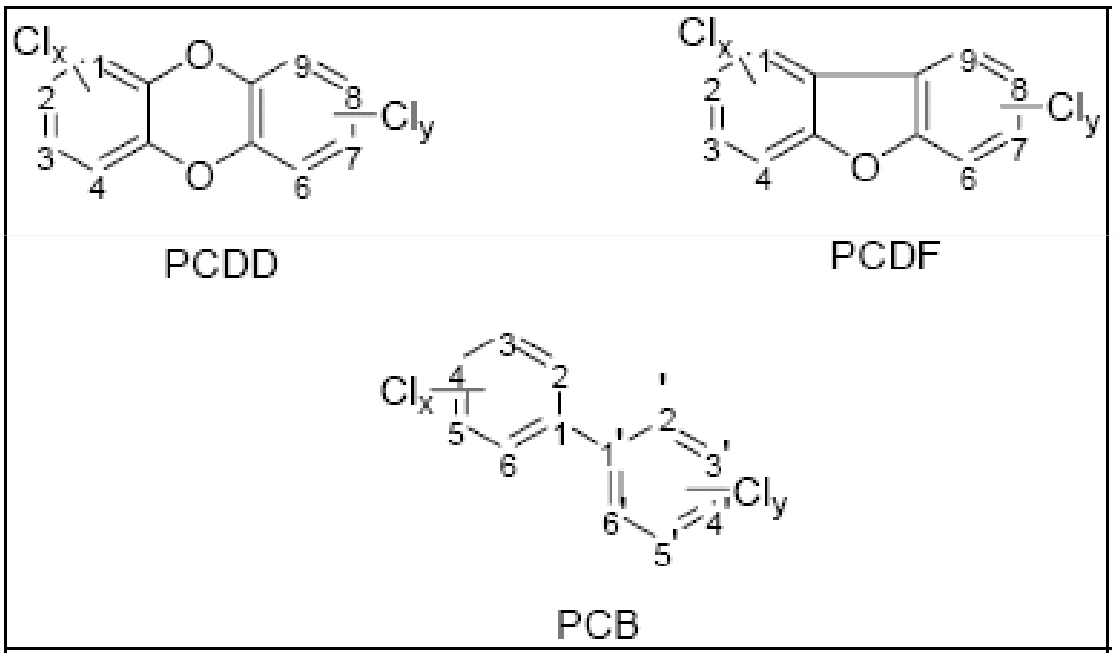
- entering the food chain:
  - direct absorption from the atmosphere by fatty foods
  - e.g. foods on sale at petrol shops contain higher concentrations

- direct exposure due to presence in urban air
- benzene
  - genotoxic carcinogen
  - potentially also via benzoic acid

Dioxins and dioxin-like compounds

- 2 type of compounds:
  - polychlorinated dibenzo-p-dioxins (PCDD's)
  - polychlorinated dibenzofurans (PCDF's)
- PCB's : polychlorinated biphenyls
- chemical structure: planar – triclyclic compounds composed of 2 benzene rings – interconnected by resp. two and one oxygen atom – at least one chlorine atom

Dioxins and dioxin-like compounds



Dioxins and dioxin-like compounds

- due to degree of chlorination and the place of the chlorination : high number of different PCDD and PCDF's
- congeners
- 75 PCDD congeners and 135 PCDF congeners and 209 PCB (polychlorinated biphenyl)
- attributed with an Arabic number – IUPAC protocol
- similar compounds apart from dioxins and PCB's : PBB (polybrominated biphenyls-flame retardants) and polychlorinated naphtalenes

Dioxins and dioxin-like compounds

- physicochemical characteristics:
  - highly lipophilic character >> increasing with the degree of chlorination
  - chemically and biochemically resistant towards degradation

- bioaccumulation in the food chain
- half-time of dioxins in human body appr. 10 years

Dioxins and dioxin-like compounds

- sources PCB's:
  - industrial production
  - applied as heat transfer in industrial installations such as transformators
  - applied as hydraulic fluids, plasticizers, lubricant inkts, paint additives,…

  - industrial production is banned from 1979 in industrial countries – developing countries in 2006
  - still present in old industrial sites - specialized collection and destruction

Dioxins and dioxin-like compounds

- sources of PCDD's and PCDF's :
  - chemical manufacture: during the production of organo chlorine compounds e.g. pesticides
  - bleaching processes : application of chlorine to bleach wood pulp, resulting in the production of dioxns
  - combustion processes: combustion of organic material in the presence of chlorine substances, PCDD's and PCDF's are produced (e.g. cigarette smoke – forest fires - ….)

Dioxins and dioxin-like compounds

- toxicity – symptoms :
  - chloracne – typically during incidental high exposure
  - interactions with the aryl hydrocarbon receptor in our cells
  - endocrine disruption
  - immunotoxicity
  - neurological alterations
  - teratogenic effects
  - 2,3,7,8-TCDD = human carcinogen:

Dioxins and dioxin-like compounds

- toxicity :
  - degree of chlorination
  - position at which the molecules are chlorinated
  - PCDD's and PCDF's chlorinated at positions 2,3,7 and 8 = greatest toxicity

- 75 PCDD congeners = only 7 are toxicologically relevant
- PCDF's = only 10 are toxic
- PCB's = only 12 exhibit dioxin-like toxicity

Dioxins and dioxin-like compounds

- complex nature >> risk evaluation is complex
- concept of Toxic Equivalent Factors (TEF value)
- estimation of the toxic potency of a compound related to the reference and most toxic compound 2,3,7,8-TCDD : TEF = 1

Dioxins and dioxin-like compounds

PCDDs and PCDFs	Toxic Equivalency Factor (TEF)	
	I-TEF (NATO/CCMS, 1988)	WHO-TEF (van den Berg *et al.*, 1998)
2,3,7,8-TCDD	1	1
1,2,3,7,8-PnCDD	0.5	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.001	0.0001
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PnCDF	0.05	0.05
2,3,4,7,8-PnCDF	0.5	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.001	0.0001

Dioxins and dioxin-like compounds

PCBs (IUPAC number)	Toxic Equivalency Factor (TEF)	
	PCB-TEF (Ahlborg *et al.*, 1994)	WHO-TEF (van den Berg *et al.*, 1998)
Non-*ortho PCBs*		
3,3',4,4'-TCB (77)	0.0005	0.0001
3,4,4',5-TCB (81)	-	0.0001
3,3',4,4',5-PnCB (126)	0.1	0.1
3,3',4,4',5,5'-HxCB (169)	0.01	0.01
Mono-*ortho PCBs*		
2,3,3',4,4'-PnCB (105)	0.0001	0.0001
2,3,4,4',5-PnCB (114)	0.0005	0.0005
2,3',4,4',5-PnCB (118)	0.0001	0.0001
2,3,4,4'5-PnCB (123)	0.0001	0.0001
2,3,3',4,4',5-HxCB (156)	0.0005	0.0005
2,3,3',4,4',5'-HxCB (157)	0.0005	0.0005
2,3',4,4',5,5'-HxCB (167)	0.00001	0.00001
2,3,3',4,4',5,5'-HpCB (189)	0.0001	0.0001
Di-*ortho PCBs*		
2,2',3,3',4,4',5-HpCB (170)	0.0001	-
2,2',3,4,4',5,5'-HpCB (180)	0.00001	-

Dioxins and dioxin-like compounds

- toxic Equivalent value = TEQ value :
  - combination of result of chemical analysis and the TEF value
  - represents the total 2,3,7,8-TCDD equivalent toxic potency

$$TEQ = \sum_{i=1\text{-}7}(PCDD_i \times TEF_i) + \sum_{i=1\text{-}10}(PCDF_i \times TEF_i) + \sum_{i=1\text{-}12}(PCB_i \times TEF_i)$$

- TWI by WHO = 7-20 pg/kg bodyweight for 2,3,7,8-TCDD

Dioxins and dioxin-like compounds

- EC 1881/2006

Section 5: Dioxins and PCBs (31)

	Foodstuffs	Maximum levels	
		Sum of dioxins (WHO-PCDD/F-TEQ) (32)	Sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB-TEQ) (32)
5.1	Meat and meat products (excluding edible offal) of the following animals (6)		
	— bovine animals and sheep	3,0 pg/g fat (33)	4,5 pg/g fat (33)
	— poultry	2,0 pg/g fat (33)	4,0 pg/g fat (33)
	— pigs	1,0 pg/g fat (33)	1,5 pg/g fat (33)
5.2	Liver of terrestrial animals referred to in 5.1 (6), and derived products thereof	6,0 pg/g fat (33)	12,0 pg/g fat (33)
5.3	Muscle meat of fish and fishery products and products thereof, excluding eel (25) (34). The maximum level applies to crustaceans, excluding the brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*)	4,0 pg/g wet weight	8,0 pg/g wet weight
5.4	Muscle meat of eel (*Anguilla anguilla*) and products thereof	4,0 pg/g wet weight	12,0 pg/g wet weight

Dioxins and dioxin-like compounds

- exposure to PCDD's, PCDF's and PCB's :
  - european study:
  - mean daily exposure = 0,4 – 1,5 pg 2,3,7,8-TCDD/kg bodyweight of dioxins
  - dioxin-like PCB's = 1-3 pg TEQ/kg bodyweight
  - 95 percentiles exposure amounted 2-3 times the mean exposure

- a significant proportion of the population is exposed to too high levels of dioxins and dioxin-like compounds

Dioxins and dioxin-like compounds

Table 16. Contribution of various foodstuffs in the total dietary dioxin exposure

Food	Percentage
seefoods	11-63
dairy products	16-39
meat products	6-32
vegetable products	6-26

Inorganic environmental contaminants

- heavy metals
- radionuclide‘s
- nitrate
  - over fertilisation
  - leafy vegetables
  - conversion to nitrite in body

Lead-sources

- application of lead pipes in water supply systems
- use of lead in the solder of some tin cans

Lead-toxicity

- 10% of the ingested lead is absorbed via the digestive system
- store in the bones of human body
- chronic exposure >> anaemia
- young children : indication of various neuropsychological indicators >> negative correlation with serum lead levels

Mercury-sources

- incidental and serious poisoning caused by the consumption of treaded grains >> pesticides
- environmental contamination >> industrial pollution of water
- natural processes e.g. volcano eruptions
- bioaccumulation as methyl mercury in the food chain
- sea foods : fish and fishery products

Mercury-toxicity

- toxicological effects >> on the level of the central nervous sytem
- exposure to foetuses >> brain damage
  - consumption of predatory fishes e.g. tuna by pregnant women should be limited

Cadmium-sources

- industrial activities – emission
- fertilizers ?
- cadmium is absorberd by plants and may accumulate.
  - e.g spinach
- sewage sludges

Cadmium-toxicity

- painful demineralisation of the skeleton occures – post-menopausal women (Japan)
- kidney cancer

Phthalates

- typically from migration
- present in sediments
- uptake by plants ??

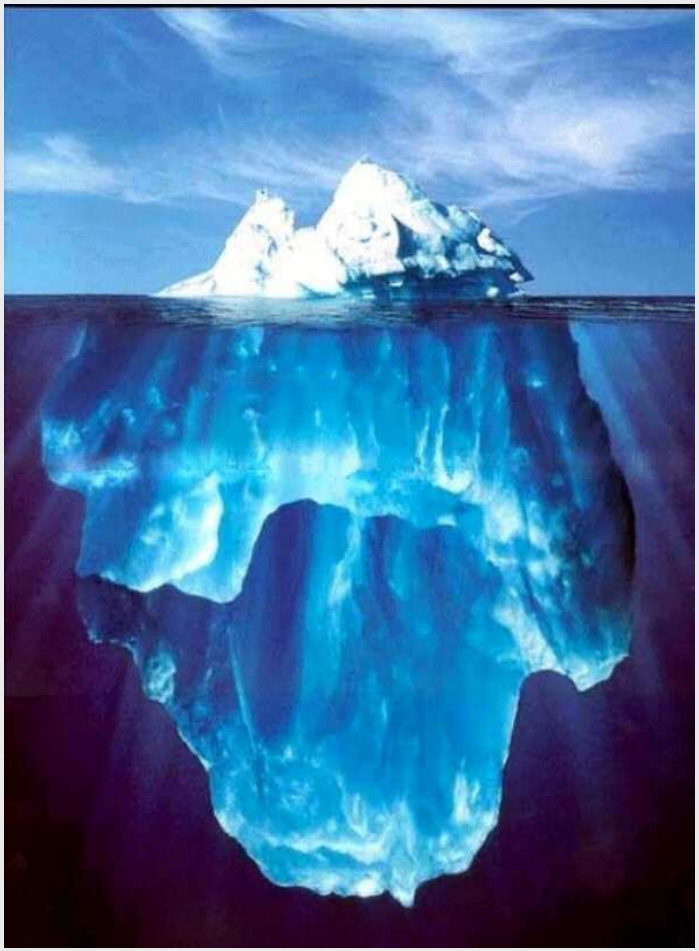
Process contaminants

- toxic compound produced during food processing, transformation, cooking, etc.
- emerging field

Process contaminants

- toxic compound produced during food processing, transformation, cooking, etc.
- emerging field
  - acrylamide (2002)
  - furan (2004)
  - MCPD-esters (2004)
- chloropropanols, benzene, heterocyclic amines,

Process contaminants



Polyaromatic hydrocarbons (PAH's)

- large and complex group with 2 or more fused benzene rings
- classification based on the number of benzene rings present

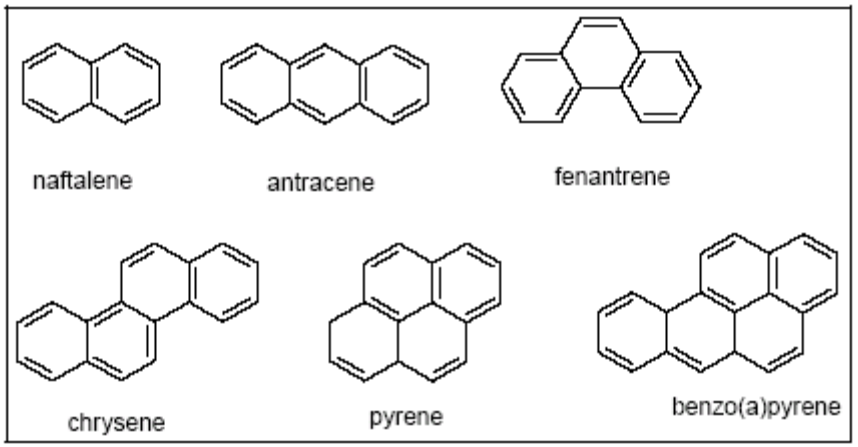


Figure 25. Chemical structure of some polyaromatic hydrocarbons

Polyaromatic hydrocarbons (PAH's)

- production by a pyrolysis of organic matter
  - industrial and geochemical activities
  - potential environmental contaminants
- migration from carbon black
- during food production:
  - heating / grilling
  - smoking
  - drying
  - when there is a direct contact with the heating sources !

Polyaromatic hydrocarbons (PAH's)

Polyaromatic hydrocarbons (PAH's)

- dilema :
  - quick drying
  - mould development
  - e.g. chocolate
- in oil
  - from drying oil seeds
  - environmental contamination
  - too drastic refining conditions
  - removal by deodorisation or active carbon treatment

Polyaromatic hydrocarbons (PAH's)

- toxicity:
  - associated with carcinogenesis
  - reference = benzo(a)pyrene
  - light vs heavy fraction
  - application of TEF values

Polyaromatic hydrocarbons (PAH's)

Table 17. TEF values for different polyaromatic hydrocarbons

Component	TEF (Nisbet & LaGoy, 1992)	TEF (U.S. EPA, 1993)
dibenz[a,h]antracene	5	1
benzo[a]pyrene	1	1
dibenzo[a,h]pyrene	-	1
dibenzo[a,i]pyrene	-	1
dibenzo[a,l]pyrene	-	1
benzo[b]fluorantene	0,1	1
dibenzo[a,e]pyrene	-	0,1
benzo[j]fluorantene	-	0,1
benzo[k]fluorantene	0,1	0,1
benz[a]antracene	0,1	0,1
indeno[1,2,3-c,d]pyrene	0,1	0,1
antracene	0,01	0,01
benzo[g,h,i]perylene	0,01	0,01
chrysene	0,01	0,01
acenaphthaene	0,001	-
acenaphthtylene	0,001	0,01
fluorantene	0,001	0,01
fluorene	0,001	0
2-methylnaphthalene	0,001	-
naphthalene	0,001	-
fenantrene	0,001	0
pyrene	0,001	0

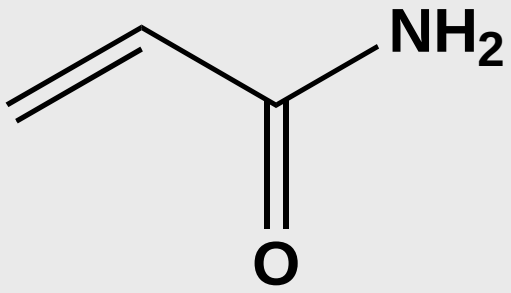
Polyaromatic hydrocarbons (PAH's)

- toxicity:
  - associated with carcinogenesis
  - reference = benzo(a)pyrene
  - light vs heavy fraction
  - application of TEF values
  - TDI not established
- maximum levels in EU Regulation 1881/2006
  - selected foods

Polyaromatic hydrocarbons (PAH's)

	Foodstuffs	Maximum levels (µg/kg wet weight)
6.1	**Benzo(a)pyrene** ([35])	
6.1.1	Oils and fats (excluding cocoa butter) intended for direct human consumption or use as an ingredient in foods	2,0
6.1.2	Smoked meats and smoked meat products	5,0
6.1.3	Muscle meat of smoked fish and smoked fishery products ([25]) ([36]), excluding bivalve molluscs. The maximum level applies to smoked crustaceans, excluding the brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*)	5,0
6.1.4	Muscle meat of fish ([24]) ([25]), other than smoked fish	2,0
6.1.5	Crustaceans, cephalopods, other than smoked ([26]). The maximum level applies to crustaceans, excluding the brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*)	5,0
6.1.6	Bivalve molluscs ([26])	10,0
6.1.7	Processed cereal-based foods and baby foods for infants and young children ([3]) ([29])	1,0
6.1.8	Infant formulae and follow-on formulae, including infant milk and follow-on milk ([8]) ([29])	1,0
6.1.9	Dietary foods for special medical purposes ([9]) ([29]) intended specifically for infants	1,0

Acrylamide



- neurotoxic
- carcinogenic for animals (genotoxic)
- probable human carcinogen (IARC) (Group 2A)

Discovery of acrylamide in foods

- industrial application: soil stabilizer
- late 1990s, Sweden
- workers exposed to acrylamide during railroad tunnel construction
  - acrylamide in blood of exposed workers
  - high background levels in non-exposed control group (non smokers)
- rat feeding studies with fried food – same metabolites found
- results published in 2002
  - worldwide attention

Swedish researchers report acrylamide found in starchy foods

Researchers at Sweden's National Food Administration

(NFA) and Stockholm University announced on April 25 that

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ked. However, when the

tate or after boiling, no

and the European Com-

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Alert over tumour-causing chemicals in our food

CHIPS AND CRISPS ARE LINKED TO CANCER

By **Sarah Westcott**
Consumer Editor

MILLIONS of Britons could be exposed each day to a cancer-causing chemical found in chips, crisps and cereals, scientists revealed last night.

They have discovered that frying and baking creates critical amounts of acrylamide, which is proven to cause tumours in animals and brain problems in humans.

Worryingly, it is not known what is a safe level of exposure and how it gets into food. The revelation has sent shock waves around the world, with scientists working urgently to try to uncover the scale of the risk.

British scientists have found significant levels of the chemical in a wide range of popular products.

They also warned that acrylamide was likely to be found in other fried, baked, roasted or grilled food, including meat products. Dr Diane Benford, a toxicologist with the Food Standards Agency, stressed: "We

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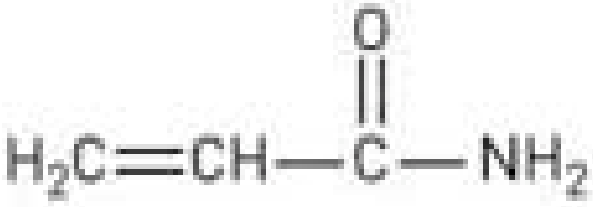
EXPRESS SHOCK REPORT SEE PAGE 4



research has been submitted for pub-

lication in the *Journal of Agricultural*

Typical foods

- cereal products
- coffee
- chocolate
- potato products

Formation mechanism

- reaction between reducing sugars and asparagine
- side reaction of Maillard reaction
- dilema, but also crucial problem
  - flavour, aroma, colour
  - acrylamide
  - change acrylamide levels without affecting other products characteristics

Mitigation

- joint efforts by industry, academia, government
- CIAA toolbox
- http://www.ciaa.be/documents/brochures/CIAA_Acrylamide_Toolbox_Oct2006.pdf

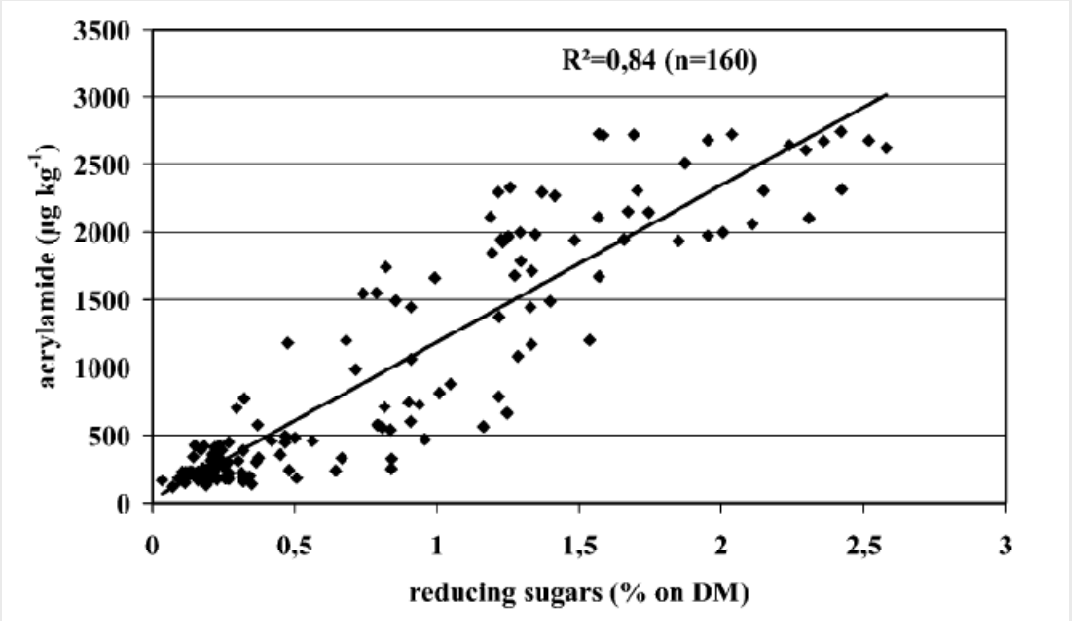
CIAA toolbox

Category	Toolbox Compartment: Agronomical	Recipe	Processing	Final Prep.
Potato Products	Sugar		Thermal input Pre-treatment	Color endpoint
Bread/Biscuits/ Bakery wares	Asparagine	NH_4HCO_3	Fermentation Moisture	Color endpoint
Breakfast cereals	Asparagine			
Coffee			Roasting conditions	Storage

: Low or no impact : High impact

Mitigation in potatoes

- importance of reducing sugar content
  - relatively high asparagine concentration in potatoes
  - reducing sugars are limiting factor !



Role of reducing sugars on acrylamide in potatoes

- importance of storage conditions

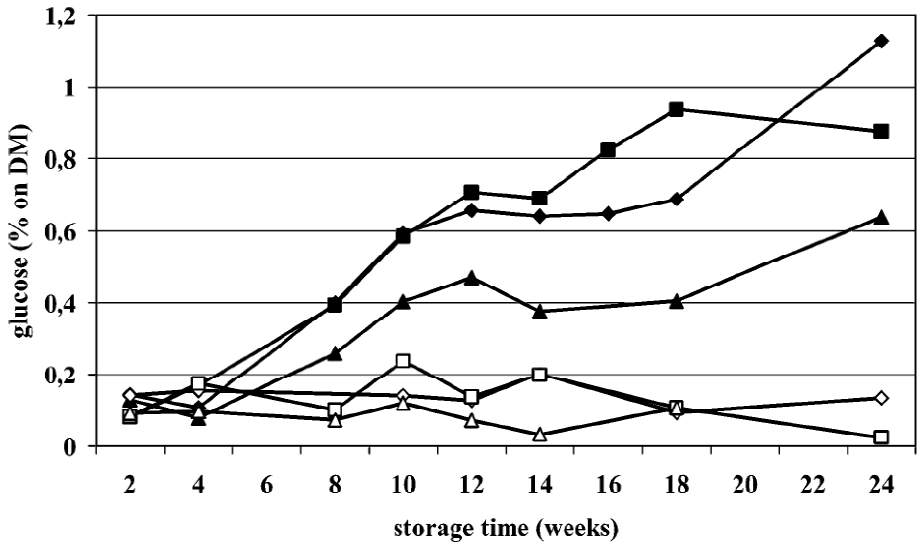


Figure 2. Influence of storage time and temperature on the glucose concentration of Bintje, Ramos and Saturna, expressed in % on DM. (◆ = Bintje, 4 °C; ■ = Ramos, 4 °C; ▲ = Saturna, 4 °C; ◇ = Bintje, 8 °C; □ = Ramos, 8 °C; Δ = Saturna, 8 °C.)

Role of reducing sugars on acrylamide in potatoes

- importance of storage conditions

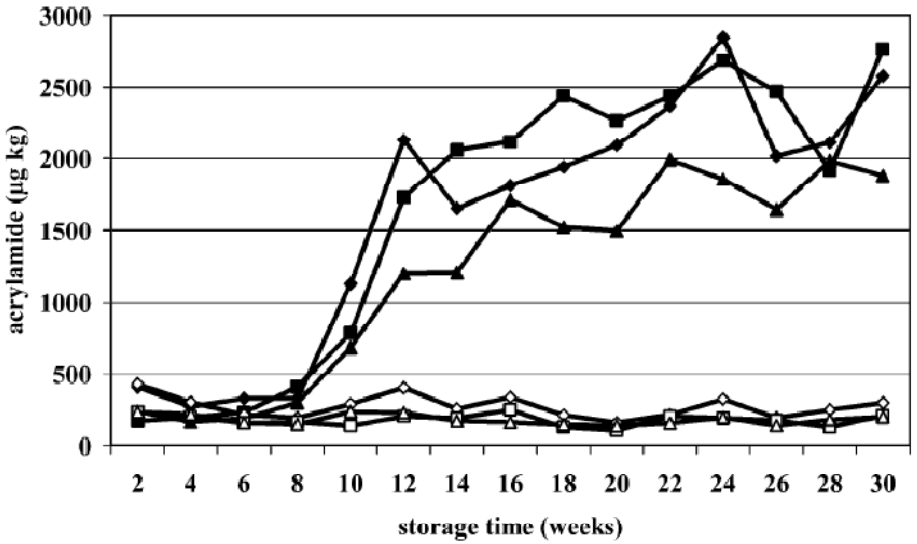
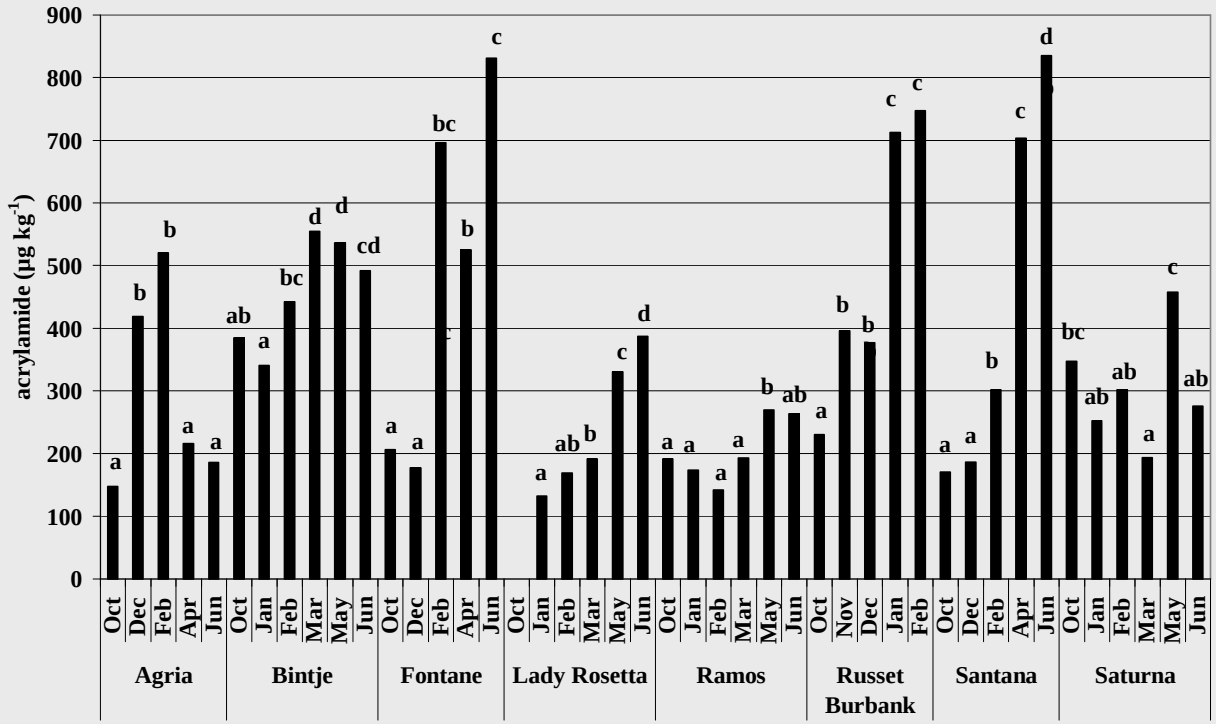


Figure 4. Influence of storage time and temperature on acrylamide formation during frying of three varieties (Bintje, Ramos, Saturna) stored at 4 °C and 8 °C over 24 weeks, expressed in μg kg^{-1}. (◆ = Bintje, 4 °C; ■ = Ramos, 4 °C; ▲ = Saturna, 4 °C; ◇ = Bintje, 8 °C; □ = Ramos, 8 °C; Δ = Saturna, 8 °C.)

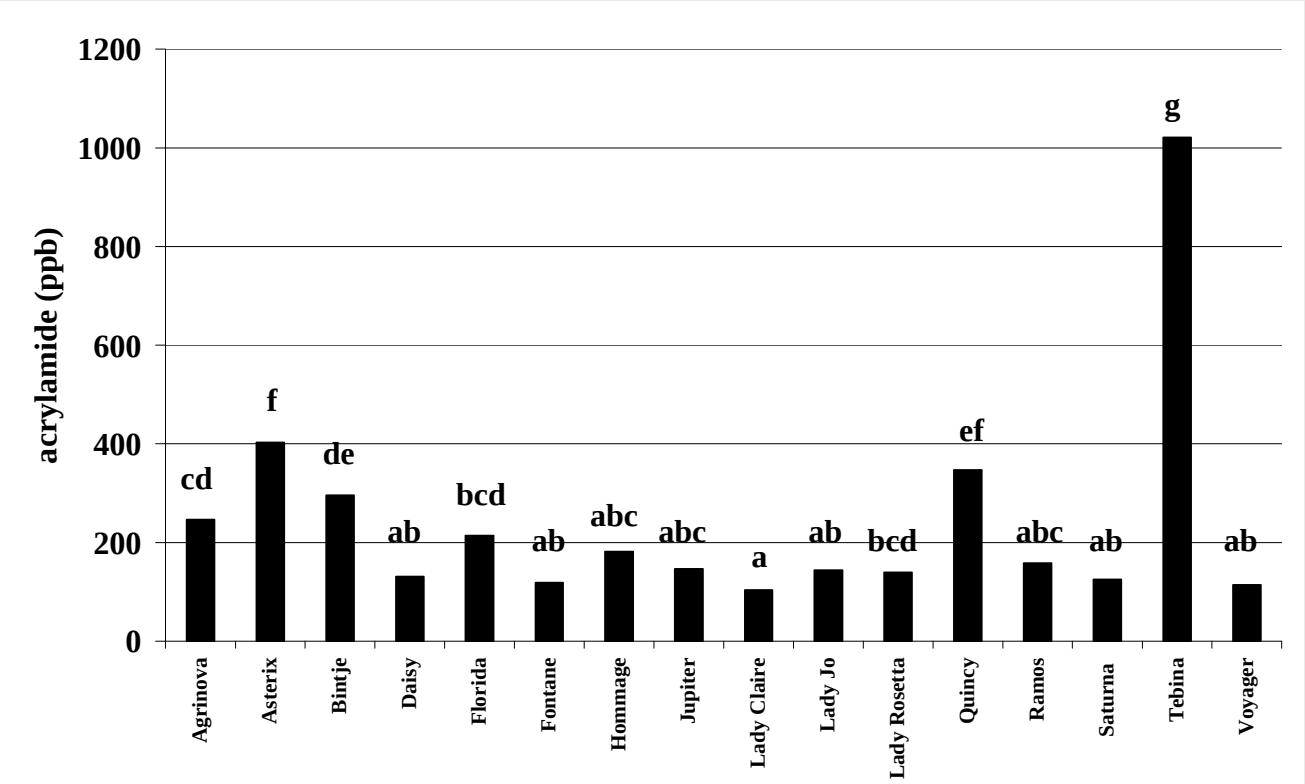
Role of reducing sugars on acrylamide in potatoes

- impact of variety and senescent sweetening



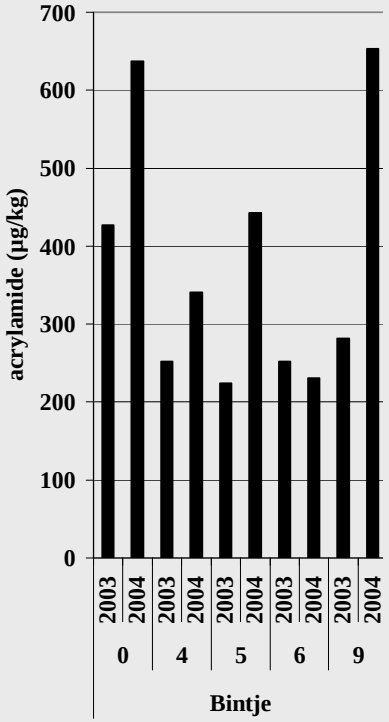
Role of reducing sugars on acrylamide in potatoes

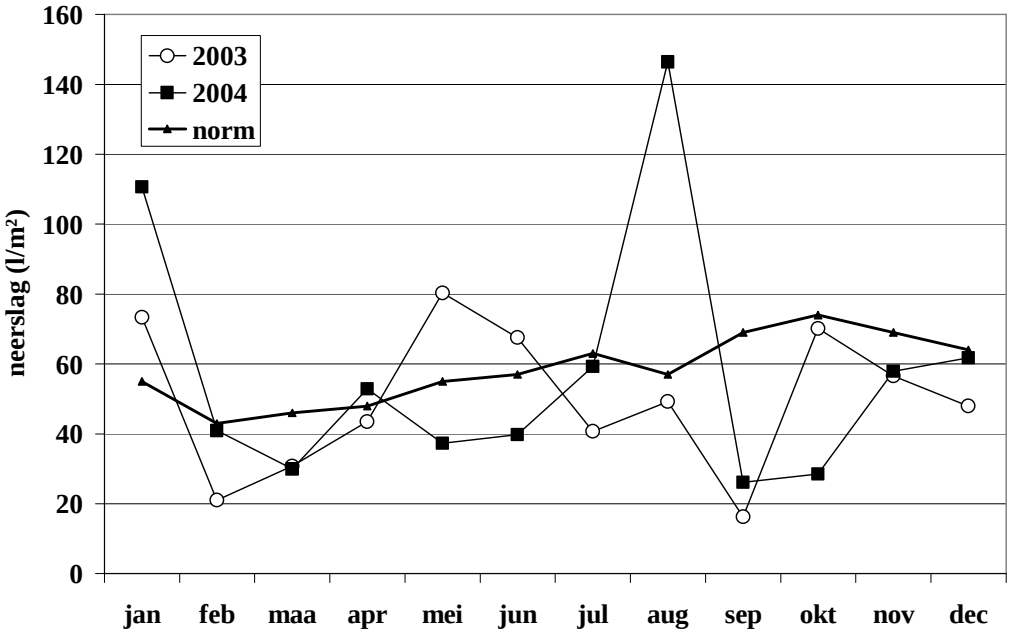
- impact of variety



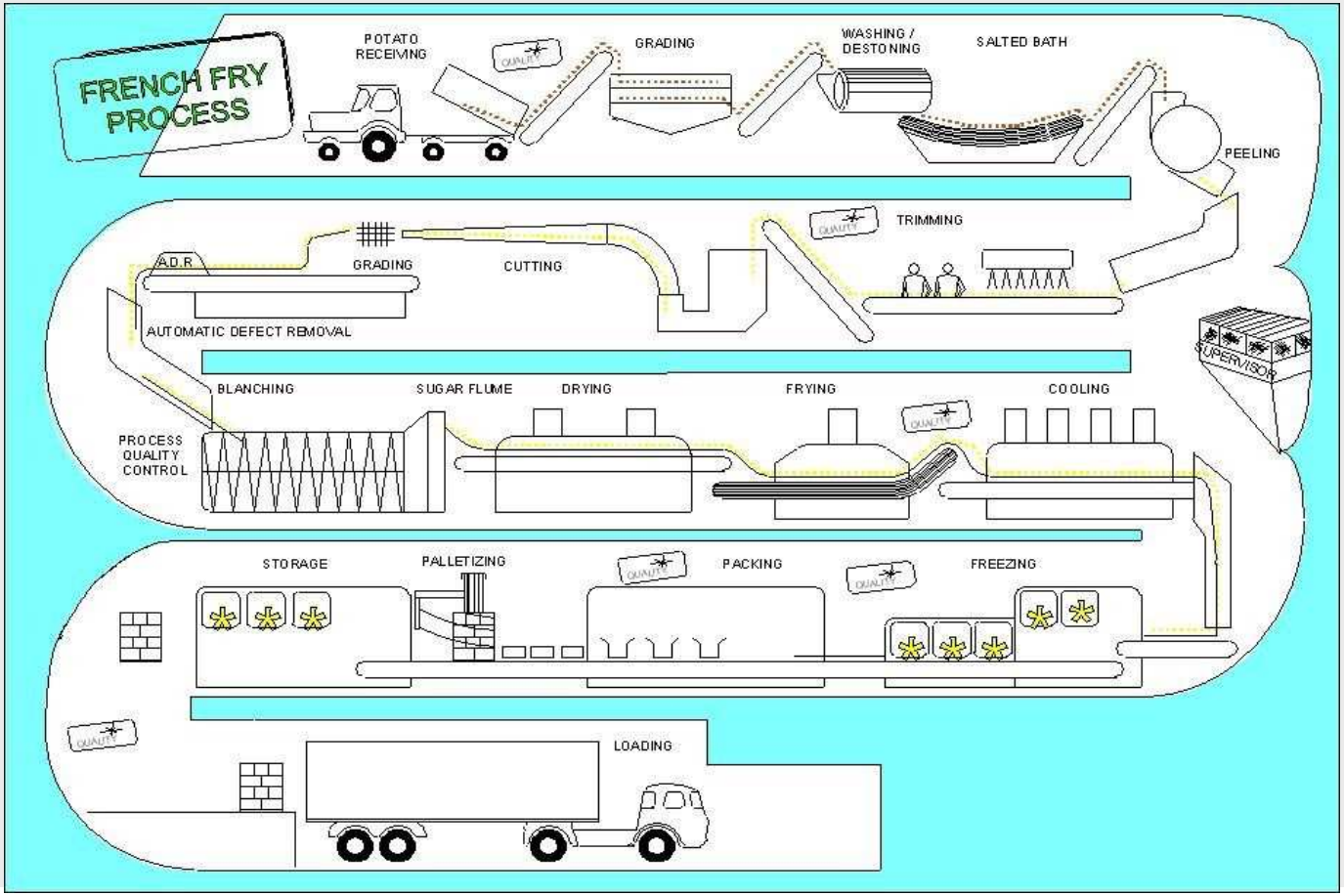
Role of reducing sugars on acrylamide in potatoes

- seasonal influence



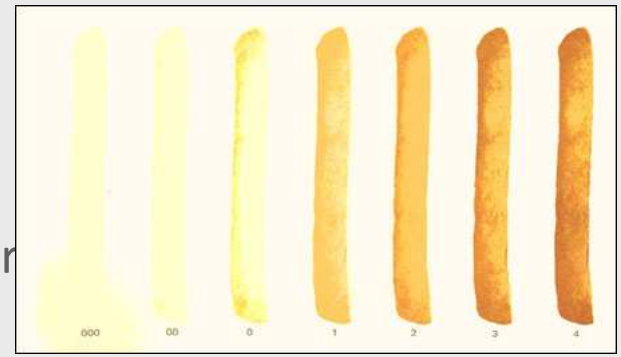


Potato processing



Mitigation during processing

- income control
  - USDA colour chart
  - correlation with acrylamide weak
  - other colour assessment tools better
- blanching
  - extraction of sugars
- addition of chemicals



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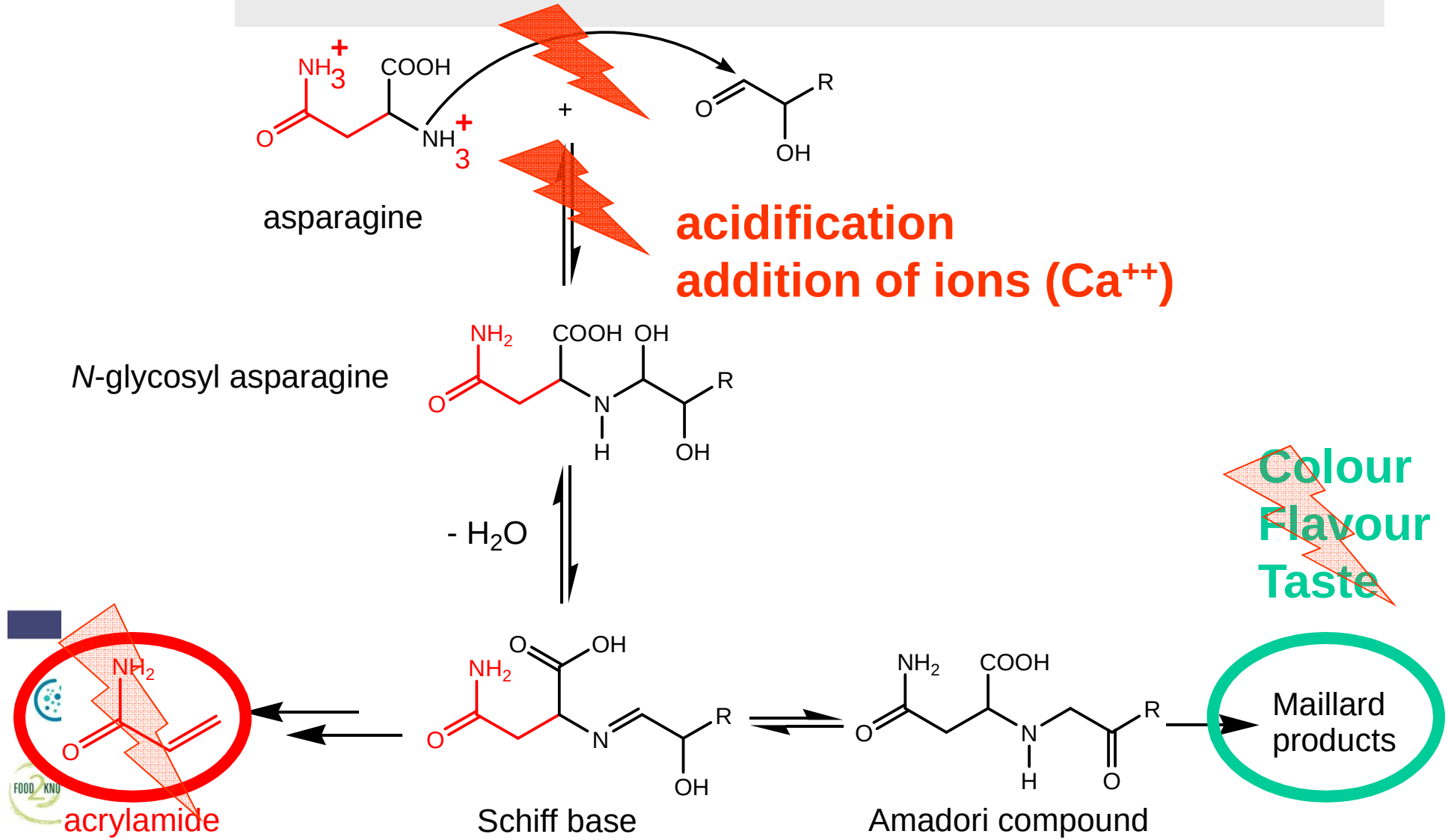

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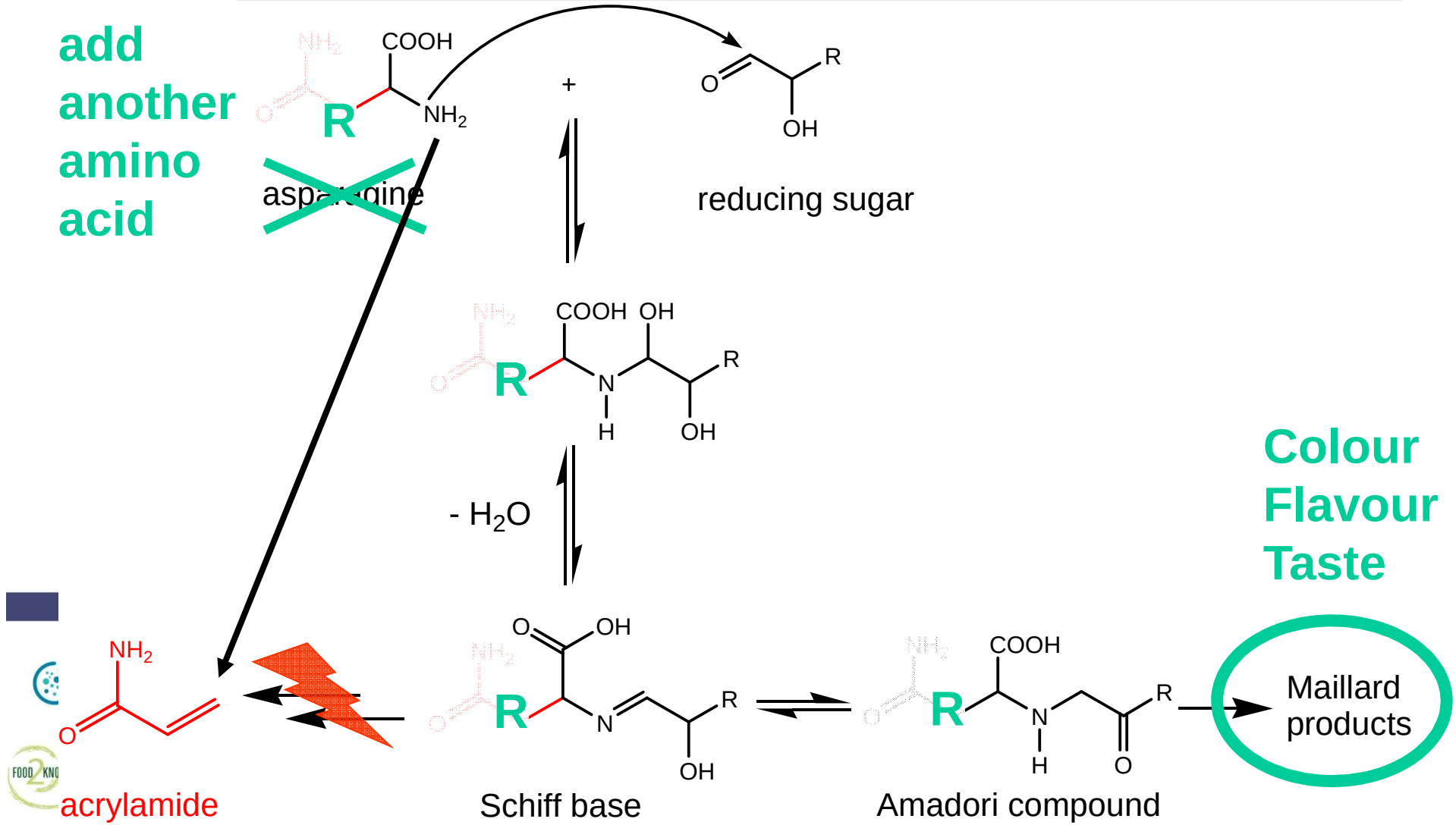


Mitigation during processing

	concentration (mol/L)	added component	oil content (%)	acrylamide reduction (%)
		water (control)	40	0
acids	0.025	citric acid	25	98
	0.025	acetic acid	29	80
	0.025	L-lactic acid	29	89
amino acids	0.05	glycine	35	58
	0.05	L-lysine	38	73
salts	0.1	NaCl	27	43
	0.05	$CaCl_2$	24	64
	0.03	$CaCl_2$ + Ca-lactate	23	50

Mitigation during processing

	concentration	added component	overall appraisal 0 = ☹ 5 = 😐 10 = ☺	
		water (control)	5.5	bcd
	0.025 M	citric acid	1.8	a
acids	0.025 M	acetic acid	5.2	bc
	0.025 M	L-lactic acid	5.3	bc
amino acids	0.05 M	glycine	6.0	bcd
	0.05 M	L-lysine	6.6	cd
salts	0.1 M	NaCl	5.7	bcd
	0.05 M	$CaCl_2$	7.5	d
	0.03 M	$CaCl_2$ + Ca-lactate	7.2	cd
combinations	0.025 M + 0.05 M	acetic acid + L-lysine	4.3	b
	0.025 M + 0.05 M	acetic acid + glycine	6.8	cd

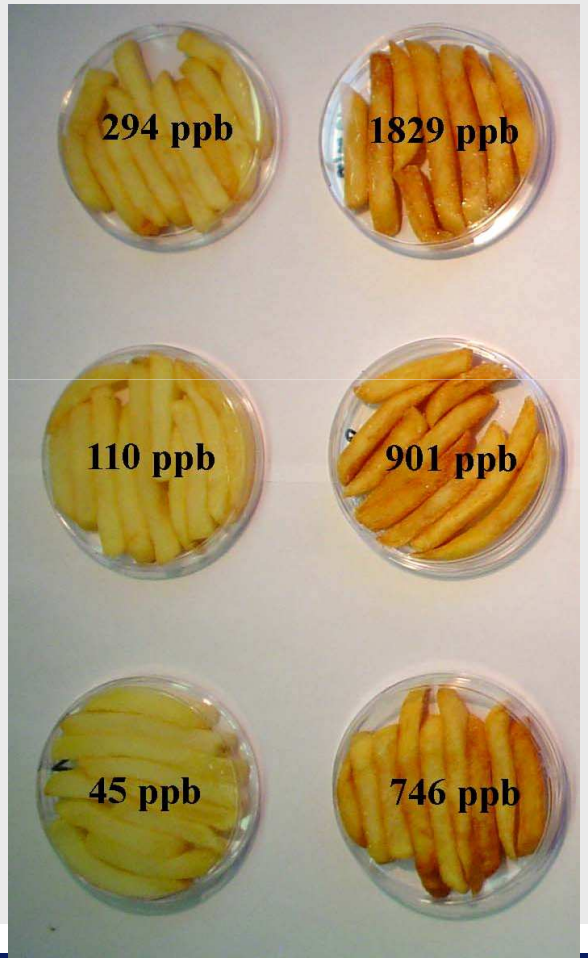
Different letters indicate significant difference ($P < 0.05$) by Tukey test

Mitigation during processing

- extrapolation to industrial trial

Pre-treatment	AA (ppb)
control	286 ± 45
acetic ac. pH 3.55	182* ± 41
acetic ac. pH 3.25	213 ± 15
citric ac. pH 4.00	227 ± 36
citric ac. pH 3.50	219 ± 41
Ca-lacate 6 g/L	291 ± 21
Ca-lacate 12 g/L	330 ± 19
asparaginase 5000 ASNU	309 ± 12
asparaginase 7500 ASNU	282 ± 25
asparaginase 10000 ASNU	312 ± 50
asparaginase 10000 ASNU	217 ± 48

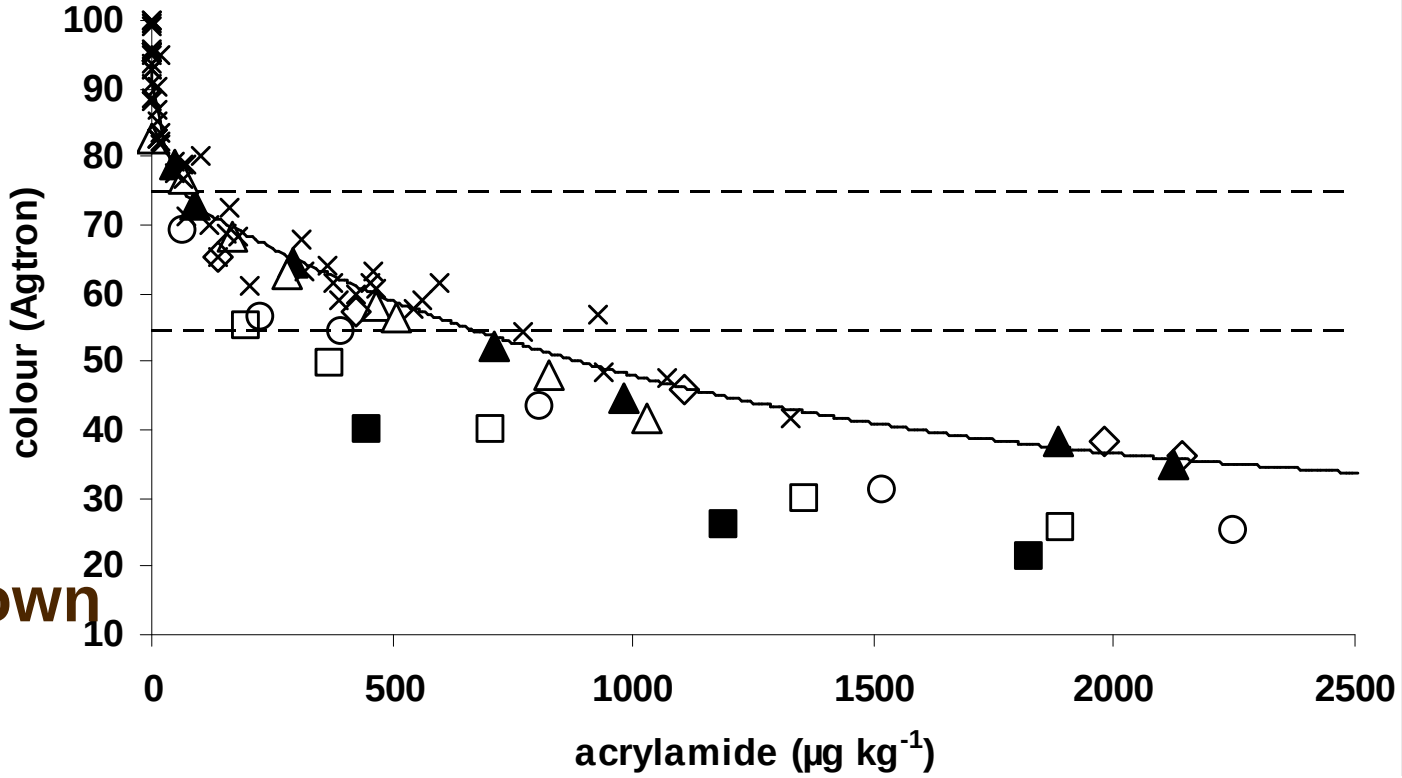
Final frying !



Final frying !

Yellow

Dark brown



Agtron colour change as a function of acrylamide for the potatoes *A*, *B* and *C*, soaked in water (*A*: ▲, *B*: Δ & *C*: x, —), in 10 g/L glucose (*A*: ■; *B*: □), in 10 g/L fructose (*B*: ◊) and in 10 g/L glucose/fructose mixture, ratio 1.3 (*B*: o) prior to frying

Microbiological contaminants

- fungal toxins or mycotoxins
- algae toxins

Mycotoxins

- fungal secondary metabolites
- discovered in 60's
  - Turkey X disease, UK
- not new, but unidentified
  - 600 BC:n oxious pustule in the ear of grain

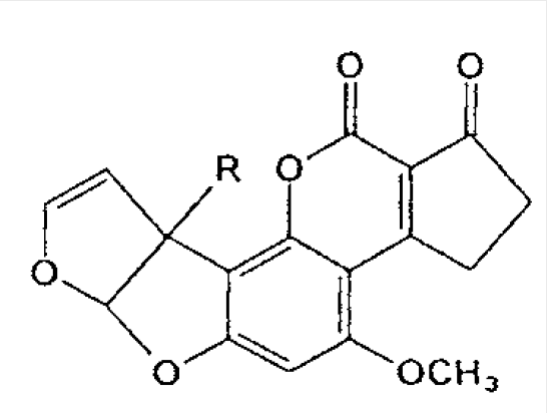
Mycotoxins

- St Anthony's fire

Mycotoxins

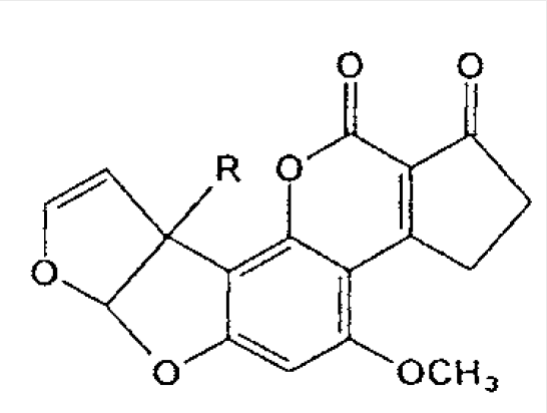
- fungal secondary metabolites
- discovered in 60's
  - Turkey X disease, UK
- not new, but unidentified
- multitude of toxins have been discovered since…
- safety concern
  - human food
  - animal feed

Aflatoxins



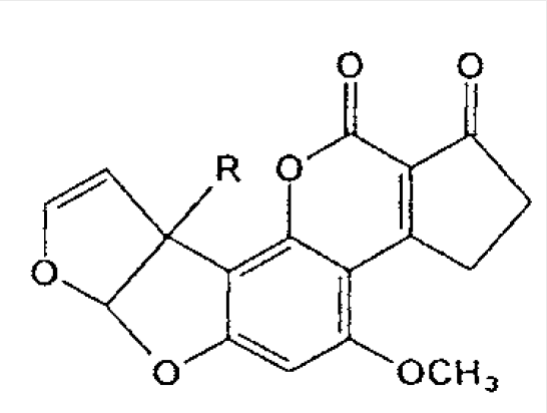
- cause of Turkey X disease
  - contaminated groundnut meal
- first discovered mycotoxin
- first isolation from ***A**spergillus **fla**vus*
- *Aspergillus flavus, A. parasiticus, A. nomius, A. pseudotamarii*
- about 20 compounds, all difuanocoumarines
- most important ones : B_1, B_2, G_1, G_2
- metabolisation in lactating animals : M_1, M_2

Aflatoxins-foods



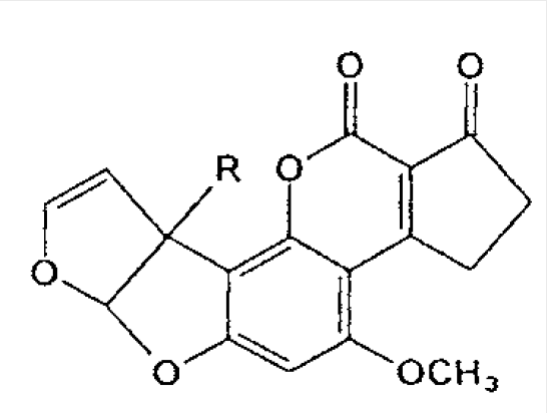
- cereals (corn, wheat, oats, …)
- oilseeds
- spices
- tree nuts (pistacio, brazils
- groundnut
- spices
- dried fruit : figs
- dairy products (M)

Aflatoxins-toxicity



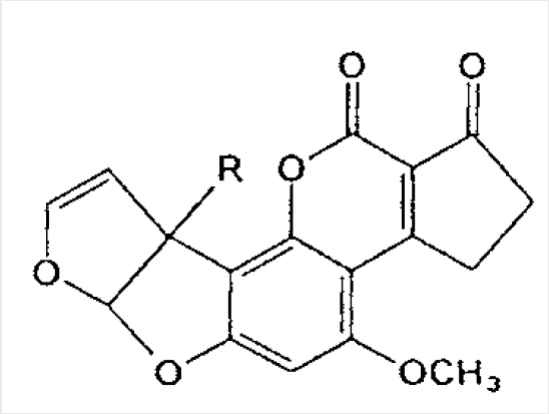
- acute toxicity
  - Kenya 2004, 125 †, contaminated corn
- primary target organ : liver
- B_1 genotoxic carcinogen
- liver cancer, hepatitis, cirrhosis, impaired nutrient conversion
- growth retardation in children

Aflatoxins-control options



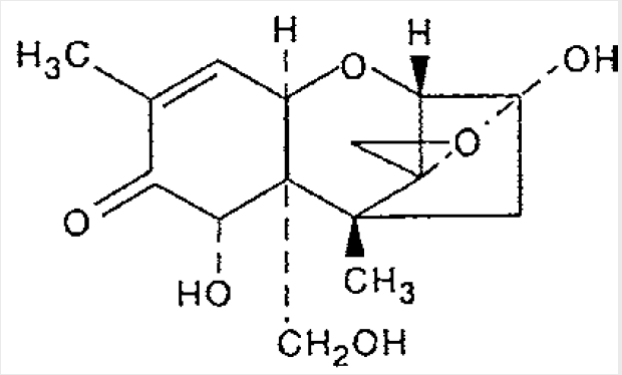
- preharvest
  - removal of old crop waste
  - crop rotation
  - use of fertiliser
  - irrigation
  - particular varieties (GMO ?)
  - pest control
  - harvest at correct moment (moisture level of crop)

Aflatoxins-control options



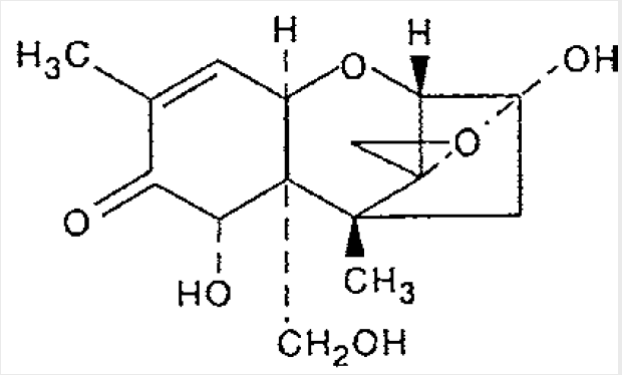
- post-harvest and storage
  - control of moisture content
  - avoidance of wet spots
  - avoid insect and animal pest damage
  - sorting of damaged kernels
- decontamination
  - quite stable
  - only ammoniation in feed succesful

Deoxynivalenol



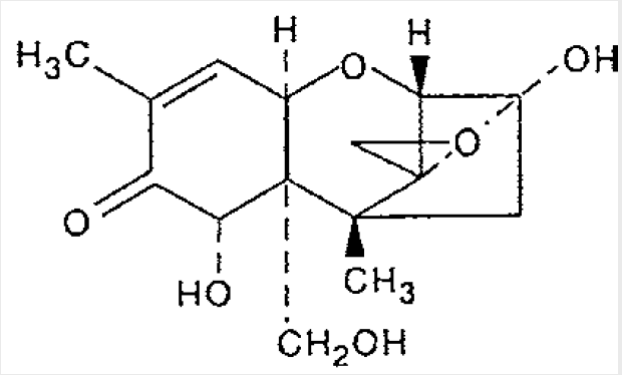
- DON or vomitoxin
- group of trichothecenes
  - tetracyclic sequiterpenes
  - broad group of +/- 150 coumpounds
- *Fusarium sp: F graminearum, F culmorum*
  - *Fusarium* head blight in wheat
  - ear rot in corn

Deoxynivalenol - foods



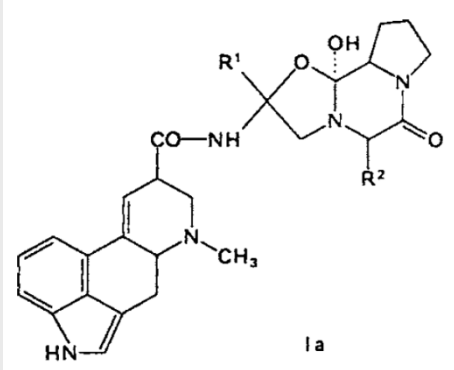
- almost exclusively in cereals
  - and processed derived foods
  - beer, bread, breakfast cereals, etc
- typical for temperate regions
- concentration can be very high (ppm level)
- exposure mainly via wheat (EU) and rice (far east)
- no transfer to milk and eggs

Deoxynivalenol – control options



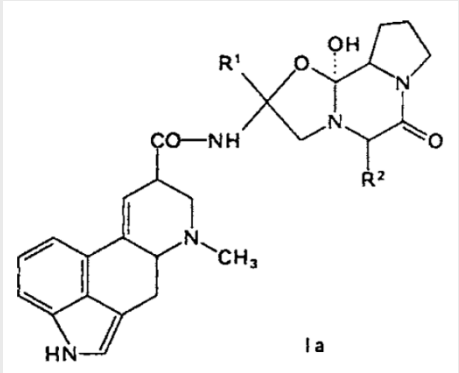
- typical preharvest problem
  - proper land preparation (debris)
  - crop rotation
  - fungal resistant varieties
  - application of fungicides
  - harvesting at proper maturity
- post harvest
  - dry storage
- decontamination
  - alkaline treatment of corn during corn flour production
  - otherwise very stable

Ergot



- sclerotia in cereals
- *Claviceps purpurea, C fusiformis*
- different types of alkaloids
  - ergotamine, erometrine, ergosine, …
- derivatives of hallucinogenic drug lysergic acid (LSD)
  - St Anthony's fire

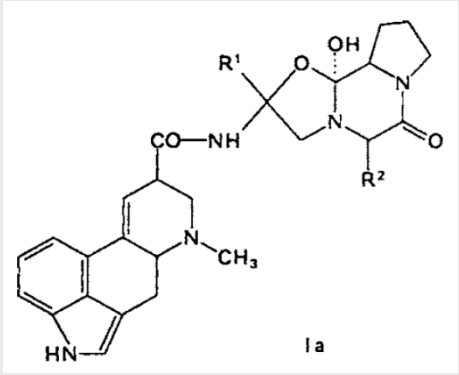
Ergot - foods



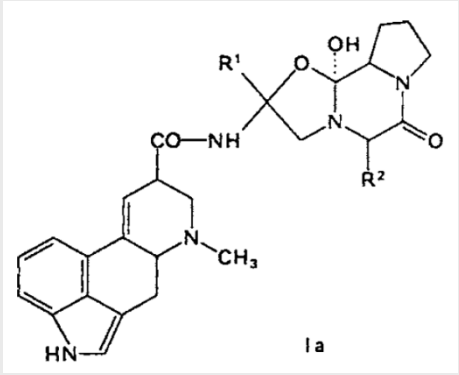
- typically for cereals
  - wheat, barley, oats, rye, millet, sorghum, maize, and rice
- expressed as % of infected scerotia
- no transfer to animal products

Ergot – control options

- pre-harvest problem
  - GAP
- grain selection

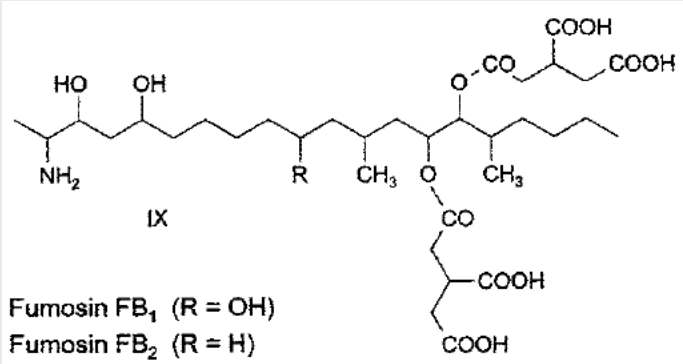


Ergot - toxicity



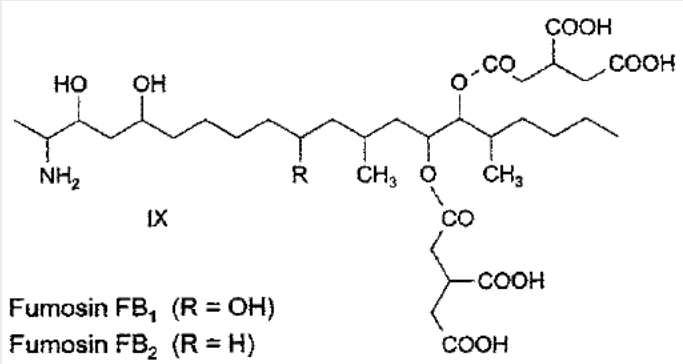
- acute effects
  - rare in humans
  - reported in life stock
  - ergotism
    - convulsive : neurotoxic effects – feed refusal, dizziness, convulsions, hallucinations
    - gangrenous : vasoconstriction, reduced blood circulation to extremities (gangrene, lame animals) – burning sensations (St. Anthony's fire)

Fumonisins



- discovered in 1988 (S. Africa)
- about 15 metabolites
- 5 groups A, B, C, P and H
  - B fumonisins most wide spread and toxic (B_1)
- *Fusarium : F verticillioides (moniliforme), F proliferatum,*

Fumonisins



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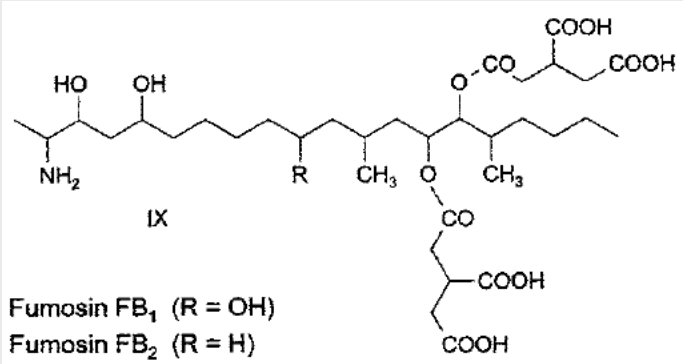
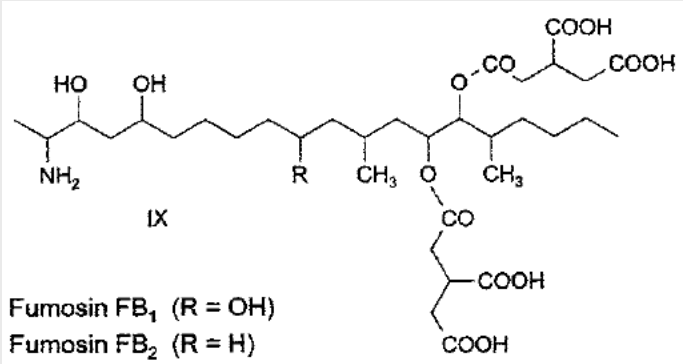
Fumonisins - foods



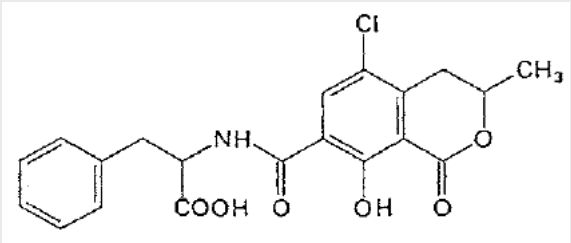
- typically in corn
- not exclusively
  - rice, sorghum, mung beans
- also in processed foods derived from corn
- association with hot and dry weather followed by humid period (highly dependent upon climate)
- levels up to several ppm's

Fumonisins - toxicity



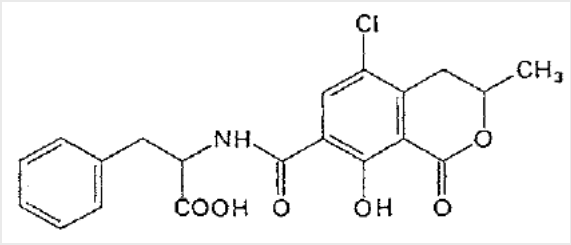
- acute toxicity : rare
- analogue of spingolipids
- effects on lifestock (horses, pig)
  - equine leucoencephalomalacia (neurotoxicity, liver and brain damage) (horses)
  - pulmonary oedema – respiratory problems (pigs)
- humans
  - link with oesophagal cancer (epidemiologically suported : Transkei, Italy, China)
  - possibly carcinogenic (IARC Group 2B)
  - immunotoxic ? – link to growth retardation ?

Ochtratoxin



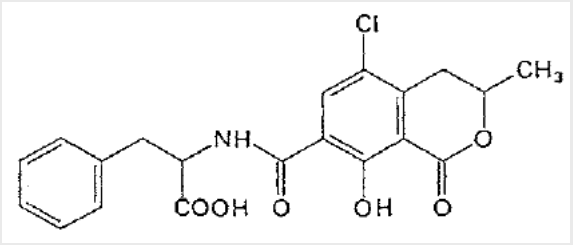
- small group of toxins
  - ochratoxin A (OTA)
- *Aspergillus*
  - *A ochraceus* (typical for warmer climates)
- *Penicillium*
  - *A verrucosum* (typical for colder climates)

Ochtratoxin - foods



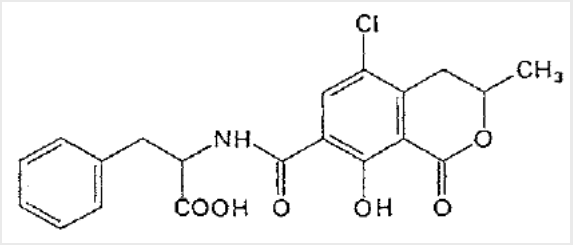
- cereals including derived products
- coffee
- dried fruits
- wine
- cocoa
- nuts
- meat (pork and poultry) due to transfer from contaminated feed
- typical concentration below 50 ppb, but ppm cases reported

Ochtratoxin - toxicity



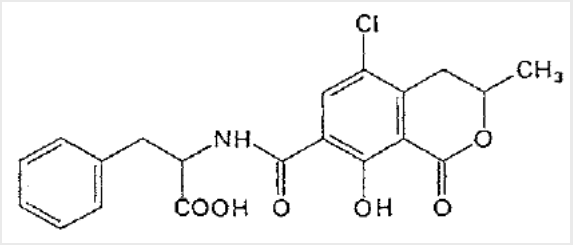
- nephrotoxicity
- genotoxic and probably carcinogenic
- teratogenic
- immunotoxic
- coffee
- dried fruits
- wine
- cocoa
- nuts
- meat (pork and poultry) due to transfer from contaminated feed
- typical concentration below 50 ppb, but ppm cases

Ochtratoxin – control options



- typically considered as storage fungi
- pre-harvest measures limited
- control of moisture content during storage (a_w below 0.8)
- cleaning of storage facilities and equipment
- fumigation to prevent mould infestation
- monitoring raw material quality

Ochtratoxin – control options



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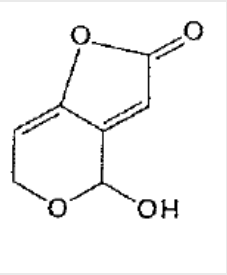
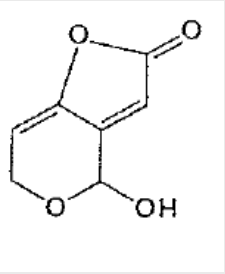
Patulin



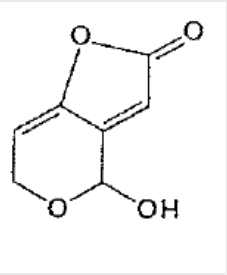
- polyketide lactone
- small molecule
- reactive
- *Penicillinium, Aspergillus, Byssochlamys*

Patulin - foods



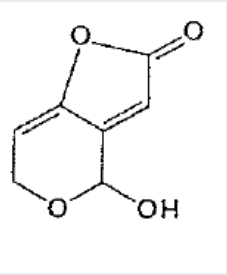
- typically on fruit
  - juices, purees, concentrates
- in europe : typically on apples
  - blue rot

Patulin - toxicity



- no convincing evidence of carcinogenicity
- teratogenic
- immunosuppresive
- enzyme inhibition
- GSH depletion – oxidative stress

Patulin – control measures



- relative stable in acidic environment
- degradation by vitamin C
- pre-harvest
  - avoid tissue damage
- post-harvest control of moulded apples
- patulin production during (ULO) storage
  - especially in stressed conditions : low oxygen, low temperature

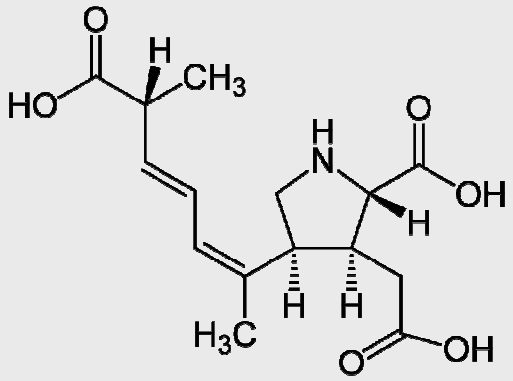
Other important mycotoxins

- trichothecenes
  - T-2 and HT-2 toxin
  - zearalenone
  - alternaria toxins

Algae toxins

Amnesic shellfish poisoning

- first reported in 1987, Canada
- domoic acid poisoning by toxic algae (toxic amino acids) – not produced by dinoflagellates but other microalgea
- typically related to bivalve molluscs (mussles, scallops, oysters, razor clams) in which toxin accumulates



Amnesic shellfish poisoning - toxicity

- neurotoxin affecting central and peripheral nervous system (acts as neurotransmitter
- nausea, vomitings, cramps, headache, diarrhoea, memory loss (selected cases)
- severe intoxication can lead to coma, disorientation, can be fatal

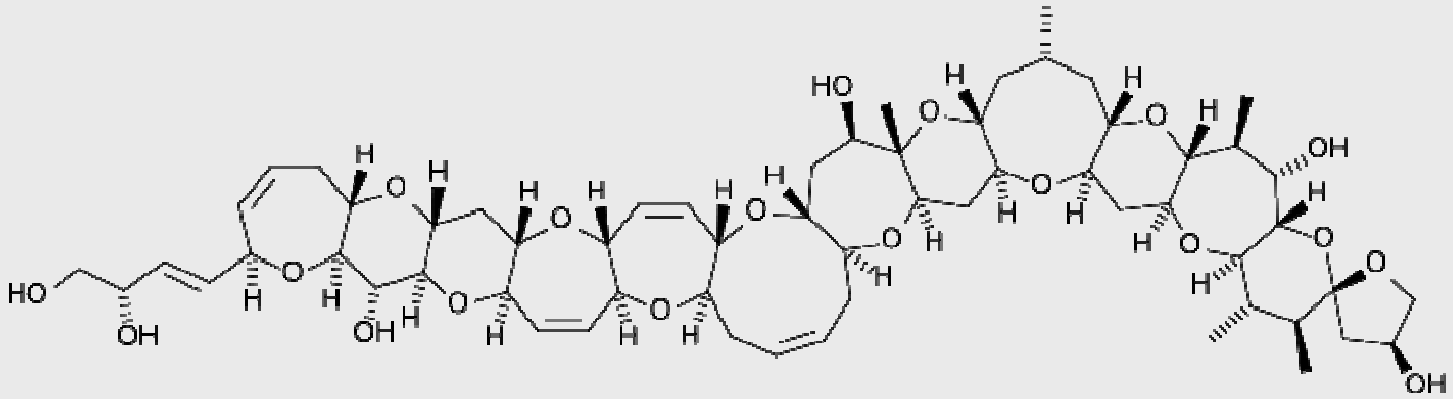
Amnesic shellfish poisoning – control options

- monitoring water quality
- testing shellfish for presence of domoic acid

Ciguatera fish poisoning

- typical for coral reef fish from tropical and subtropical waters
- commonest form of marine food poisoning
- ciguatoxins acumulate in certain fish species
- liposoluble polyether

Ciguatera fis poisoning



Ciguatera fish poisoning

- typical for coral reef fish from tropical and subtropical waters
- commonest form of marine food poisoning
- ciguatoxins accumulate in certain fish species
- liposoluble polyether
  - large carnivorous fish are potentially more toxic (bioaccumation)
- produced by dinoflagellate *Gambierdiscus toxicus*

Ciguatera fish poisoning - toxicity

- neurological, gastrointestinal and cardiovascular symptoms
  - first gastrointestinal symptoms (vomiting, nausea) (typical for Carribean)
  - tingling of lips and extremities, skin irritation (typical for Pacific)
  - hallucinations, depression, anxiety, fatigue
- very low doses are effective (up to 0.1 µg)
- increase of sodium permeability of membranes in muscle and nerve cells
- up to 10000-50000 cases each year

Ciguatera fish poisoning – control options

- detection by analysis
- avoid sensitive species
- avoid to big fishes
- avoid eating vulnerable parts of fish (liver, roe, gut)

Diarrheic shellfish poisoning

- contaminated shellfish
- most common in Europe and Japan, spreading out
- several toxins may be involved – all from dinoflagellates
  - okadaic acid and dinophysistoxins (DTXs)
  - neutral toxins – pectenotoxin group (PTXs)
  - others – yessotoxin (YTX) and derivatitves
- bivalve molluscs
- seasonal toxicity – typically in summer
- fat soluble toxins which accumulate

Diarrheic shellfish poisoning - toxicity

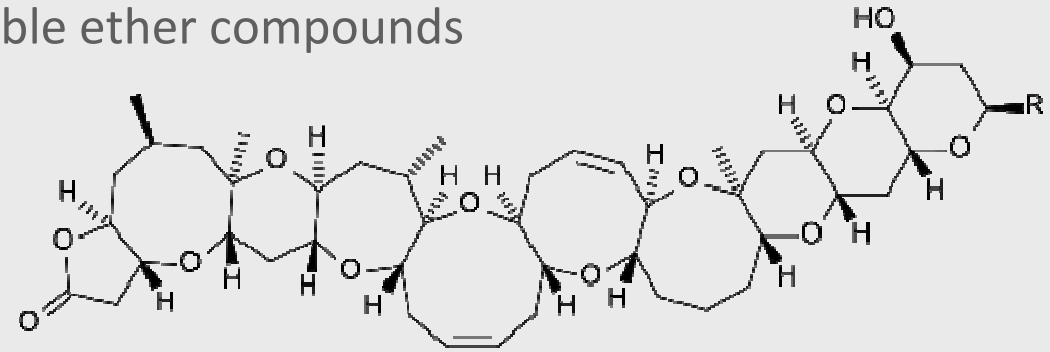
- phosphatase inhibitors
  - associated with inflamation of human gut
  - fluid loss from intestinal cell – diarrheoea
- levels expressed at OA equivalents or mouse units (mouse bioassay)
- diarrhoea, nausea, vomiting, abdominal pain

Diarrheic shellfish poisoning – control options

- monitoring marine environement and testing shellfish

Neurologic shellfish poisoning

- associated with red tides (Gulf of Mexico)
- similar as PSP but less severe
- brevetoxins
  - liposoluble ether compounds



- bivalve molluscs contaminated with dinoflagellates

Neurologic shellfish poisoning - toxicity

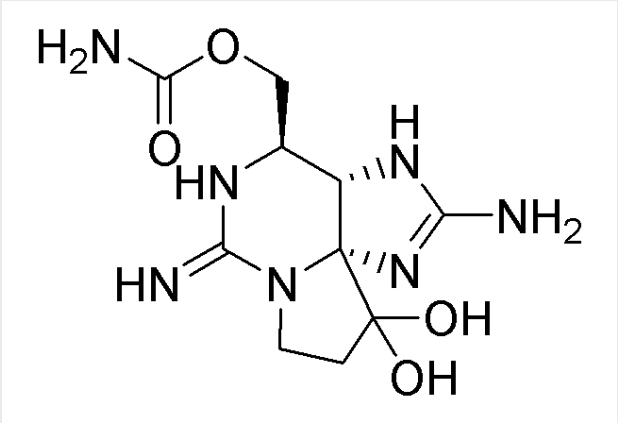
- neurotoxins affecting sodium channels
- gastrointestinal symptoms
- chills, sweating, hypotension, numbness

Neurologic shellfish poisoning – control options

- monitor marine environment
  - large fish kills (since these are vulnerable too)
  - discoloured water
- bioassays

Paralytic shellfish poisoning

- typically in temperate waters, however outbreaks are now also occurring in more southern waters
- bivalve molluscs contaminated by dinoflagellates
- at least 21 toxins are identified – all tetrahydropurines
  - saxitoxin (STX)



Paralytic shellfish poisoning – toxicity

- block the sodium channels or nerve and muscle cells
- levels up to 120-180 µg sufficient; levels above 2 mg lethal
- levels expressed as STX equivalents or mouse units
- mild cases : numbness, tingling around mouth, neck and head; pain in hand and feets and gastrointestinal symptoms; muscular weakness
- severe cases : numbness, tingling, speech loss, dizziness, motor coordination
- lethal cases due to muscle and respiratory pralysis (300/year)

Paralytic shellfish poisoning – control options

- monitoring waters
- monitoring quality of shellfish