Safety and Quality of Irradiated Foods

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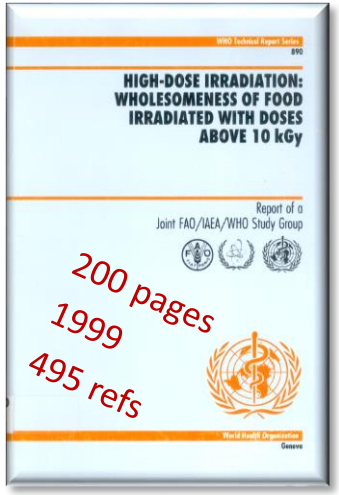
Food irradiation aims to:

Sterilises insects
Inhibits sprouting
Limits decay of fruits and vegetables
Kills parasites and bacteria that cause diseases
Kills moulds and bacteria that cause deterioration

- Increase food safety
- Increase food security (less waste)
- Improve biosecurity (quarantine) for trade
  - Replacement of chemicals
  - lightweight, plastic packaging

Effective
Penetrating
Cold process
Easy to control
Physical process
Broad spectrum for bacteria

Food irradiation should be safe if we believe:



International organizations

- FAO/WHO Joint Expert Committee (1980)
- *Codex Alimentarius (1983)*
- WHO (1992)
- WHO/FAO (1999)
- EFSA (2001)
- *Codex Alimentarius (2003)*
- EFSA (2011)

National organizations

- Food and Drug Administration (USA)
- Anses (France)
- …

Basis of radiation chemistry

Reaction (Hart, 1972)	k ($M^{-1} \times s^{-1}$)
$e^-_{aq} + e^-_{aq} \rightarrow H_2 + 2\ OH^-$	0.6×10^{10}
$e^-_{aq} + H^\bullet \rightarrow H_2 + OH^-$	2.5×10^{10}
$e^-_{aq} + OH^\bullet \rightarrow OH^-$	3.0×10^{10}
$e^-_{aq} + H_2O \rightarrow H^\bullet + OH^-$	16.0
$H^\bullet + OH^- \rightarrow e^-_{aq}$	1.8×10^{7}
$e^-_{aq} + H_3O^+ \rightarrow H^\bullet + H_2O$	2.06×10^{10}
$e^-_{aq} + H_2O_2 \rightarrow OH^\bullet + OH^-$	1.2×10^{10}

Reaction (Hart, 1972)	k ($M^{-1} \times s^{-1}$)
$e^-_{aq} + O_2 \rightarrow {}^\bullet O_2^-$	2.0×10^{10}
$H^\bullet + H^\bullet \rightarrow H_2$	2.0×10^{10}
$OH^\bullet + OH^\bullet \rightarrow H_2O_2$	0.6×10^{10}
$H^\bullet + OH^\bullet \rightarrow H_2O$	$\sim 2 \times 10^{10}$
$OH^\bullet + H_2 \rightarrow H_2O + H^\bullet$	4.5×10^{7}
$H^\bullet + H_2O_2 \rightarrow OH^\bullet + H_2O$	9.0×10^{7}
$OH^\bullet + H_2O_2 \rightarrow H_2O + HO^\bullet_2$	4.5×10^{7}
$H_3O^+ + OH^- \rightarrow 2\ H_2O$	1.43×10^{11}

H_2O_2 and H_2 are largely consumed

Low yields of production even if high dose is employed

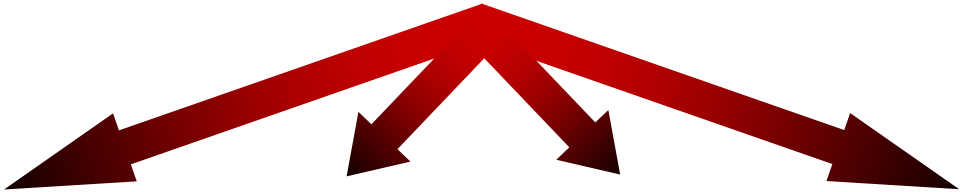
Radicals are the very first radiolysis species formed

To resume, we got : H° ; OH°

Basis of radiation chemistry

Radicals and excited species are the primary radiolytic products

They will react with the food matrix :



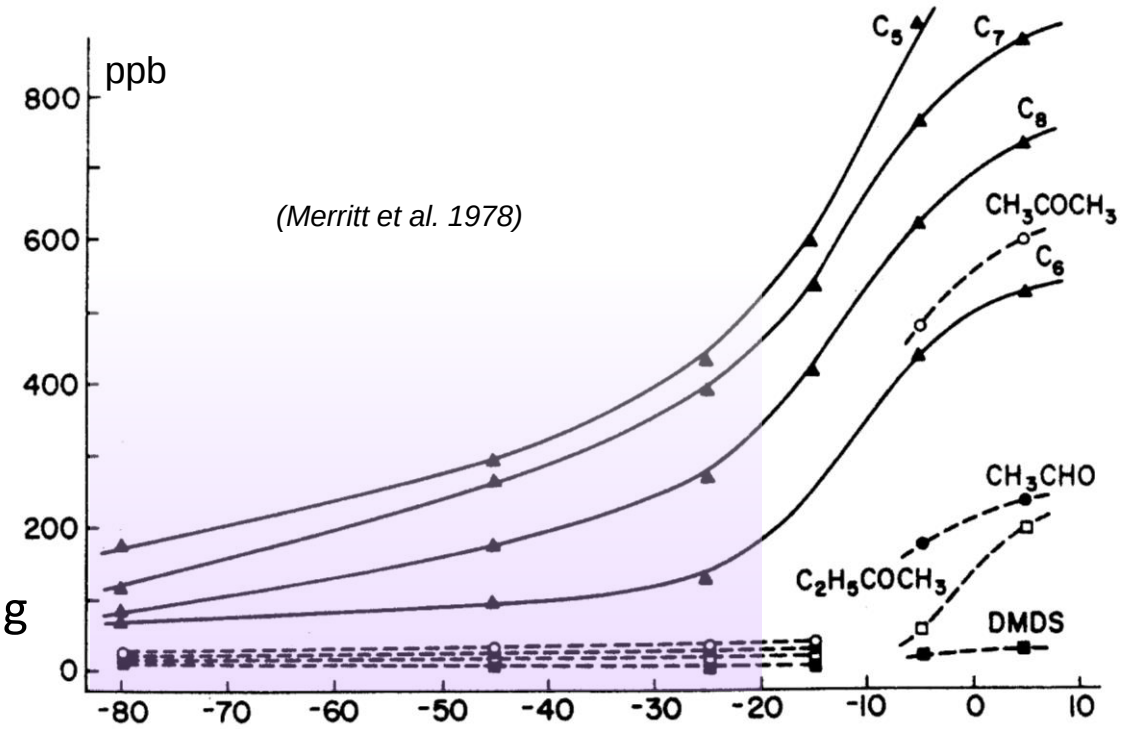
Lipids **Glucids** **Proteins** **DNA**

Radiolytic products were created!

Proteins

Chemical changes following irradiation at low temperature are much less than at ambiant temperature or chilled.

High dose irradiation treatments should be performed at subfreezing temperatures (and in anoxic conditions)

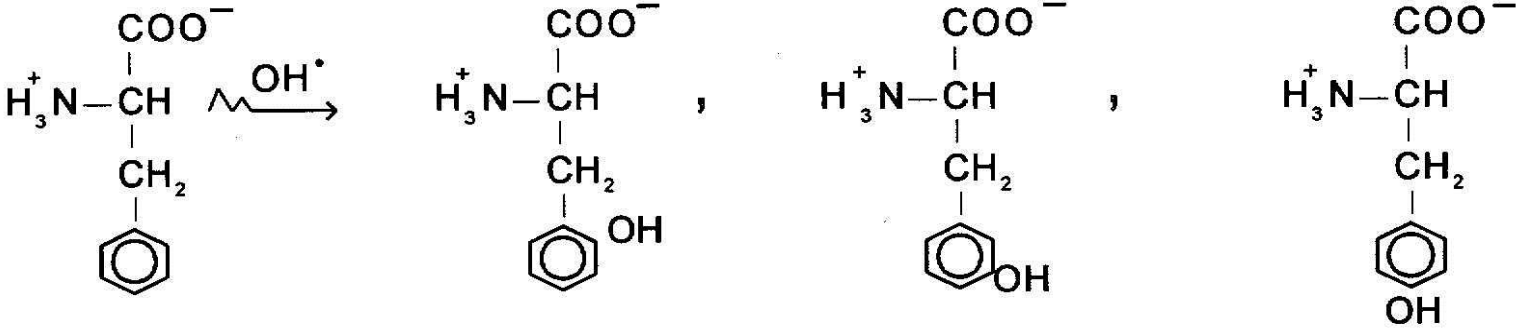


The amount of various radiolysis products formed in beef as function of temperature

Radiolytic products were created!

In 1983 Simic et al claimed that O-tyrosine was an URP…… But later (1990) he recovered this compound in non irradiated foods.

(Solar, 1985)



phenylalanine

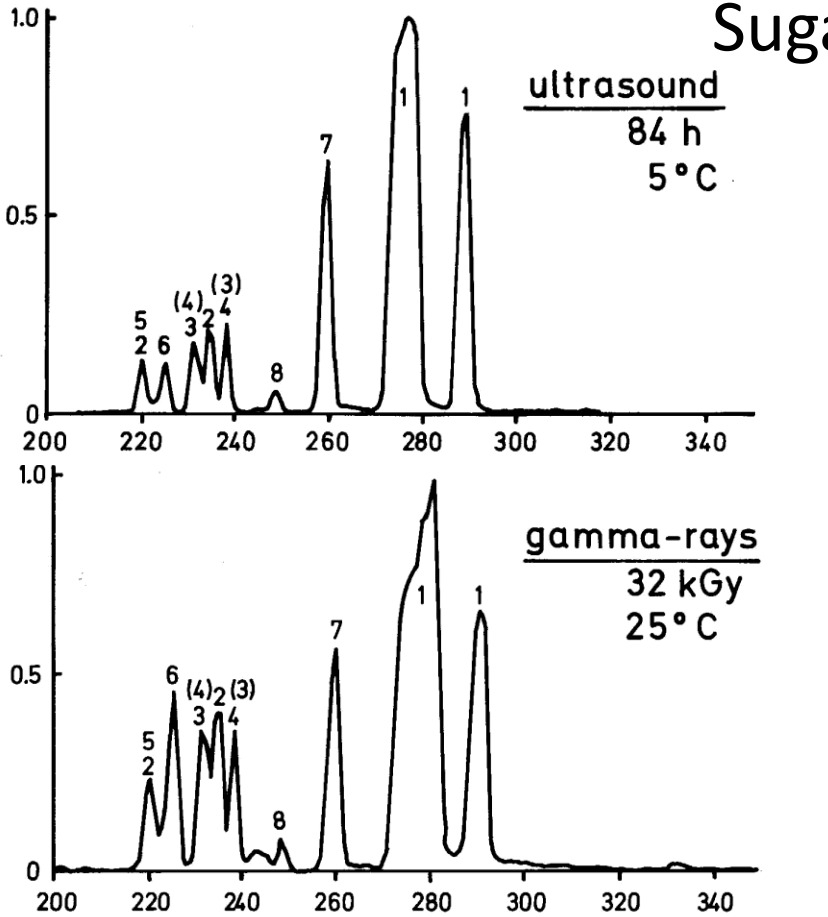
o-tyrosine (50 %)

m-tyrosine (14%)

p-tyrosine (30 %)

Radiolytic products were created!

Similar reactions products are formed after radiolysis and ultrasound treatment on carbohydrates but also on proteins and DNA



Heusinger, 1987

Radiolytic products were created!

DNA

Radiation dose to inactivate 90% of some pathogenic micro-organism

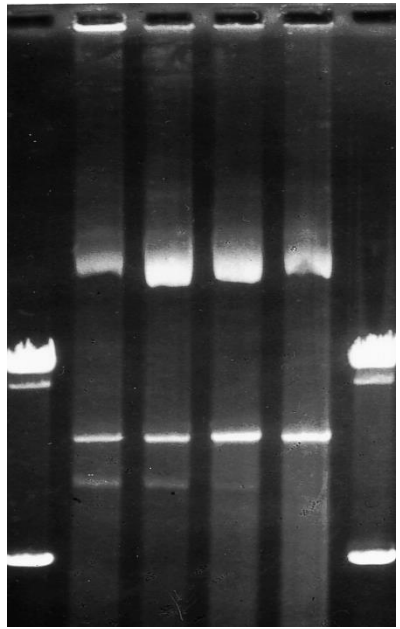
Organism	**Substrate**	**Temp. °C**	**D_{10} (kGy)**
Aeromonas hydrophila	in beef	2	0.14 - 0.19
Campylobacter jejuni	in turkey	0 - 5	0.19
E.Coli 0157 : H 7	in beef	5	0.27
Listeria monocytogenes	in chicken	2 - 4	0.77
Salmonella spp.	in chicken	2	0.38 - 0.77
Staphylococcus aureus	in chicken	0	0. 36

Radiolytic products were created!

DNA

Beef liver DNA extract

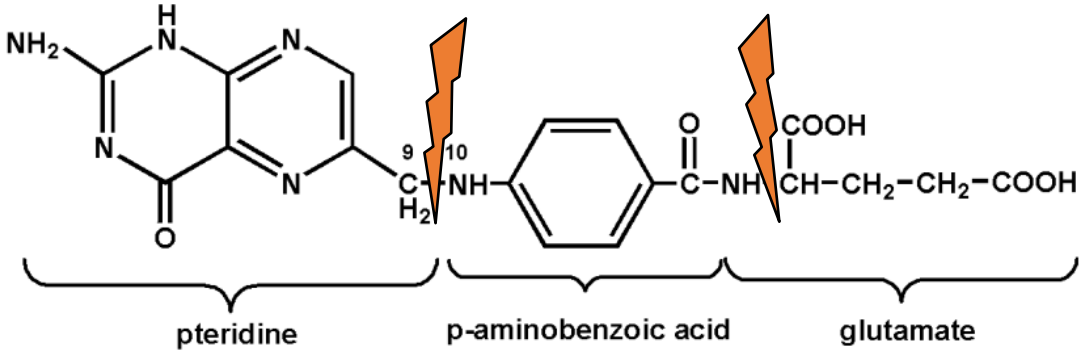
16 000 bp



M. Bergaentzlé et al., 1994, Food Sci. Technol. Today, 8, 111-113
E. Marchioni et al., 1996, Detection Methods for Irradiated Foods - Current Status, 355-366

Radiolytic products were created!

Vitamins

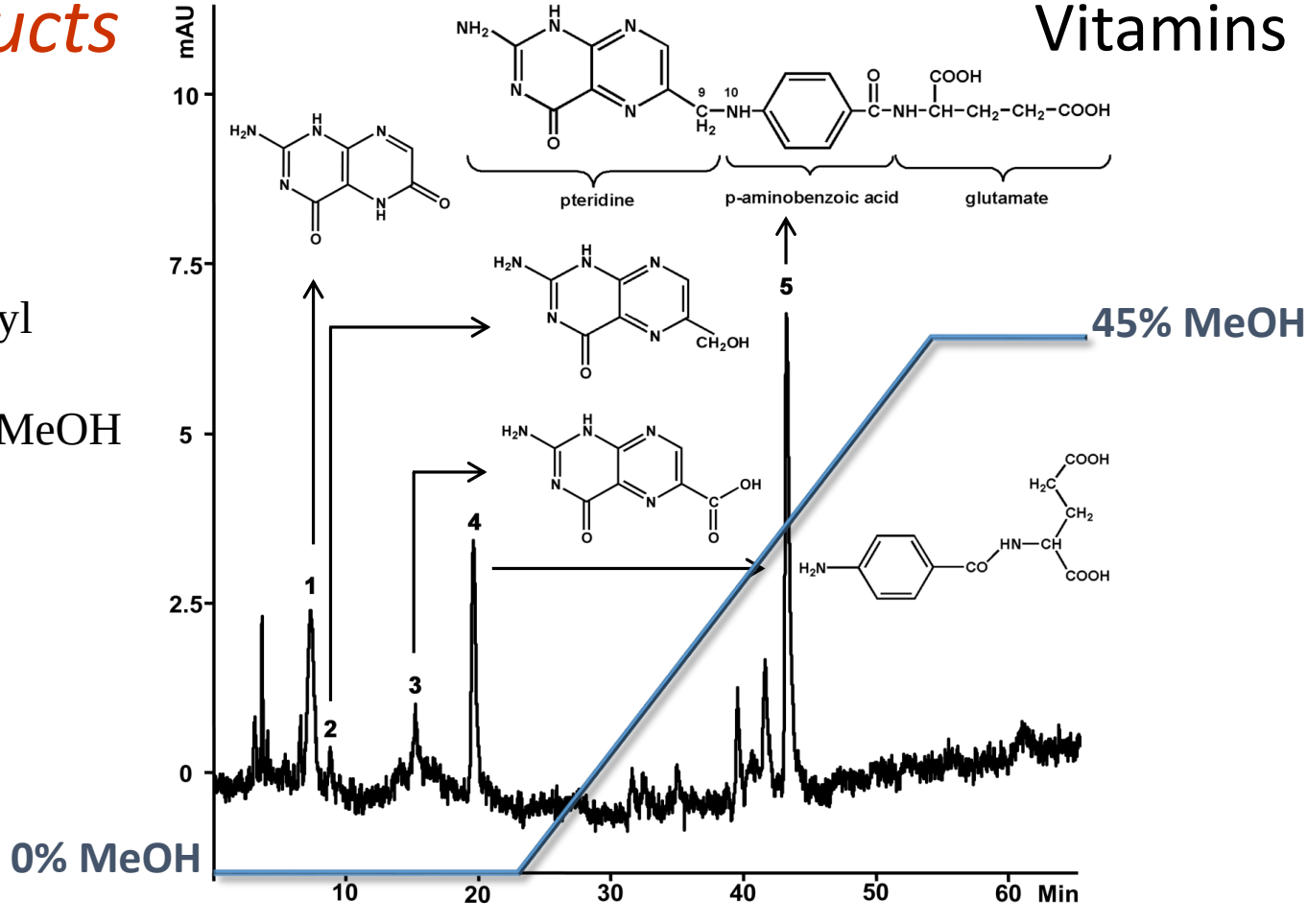


Folic acid

Radiolytic products were created!

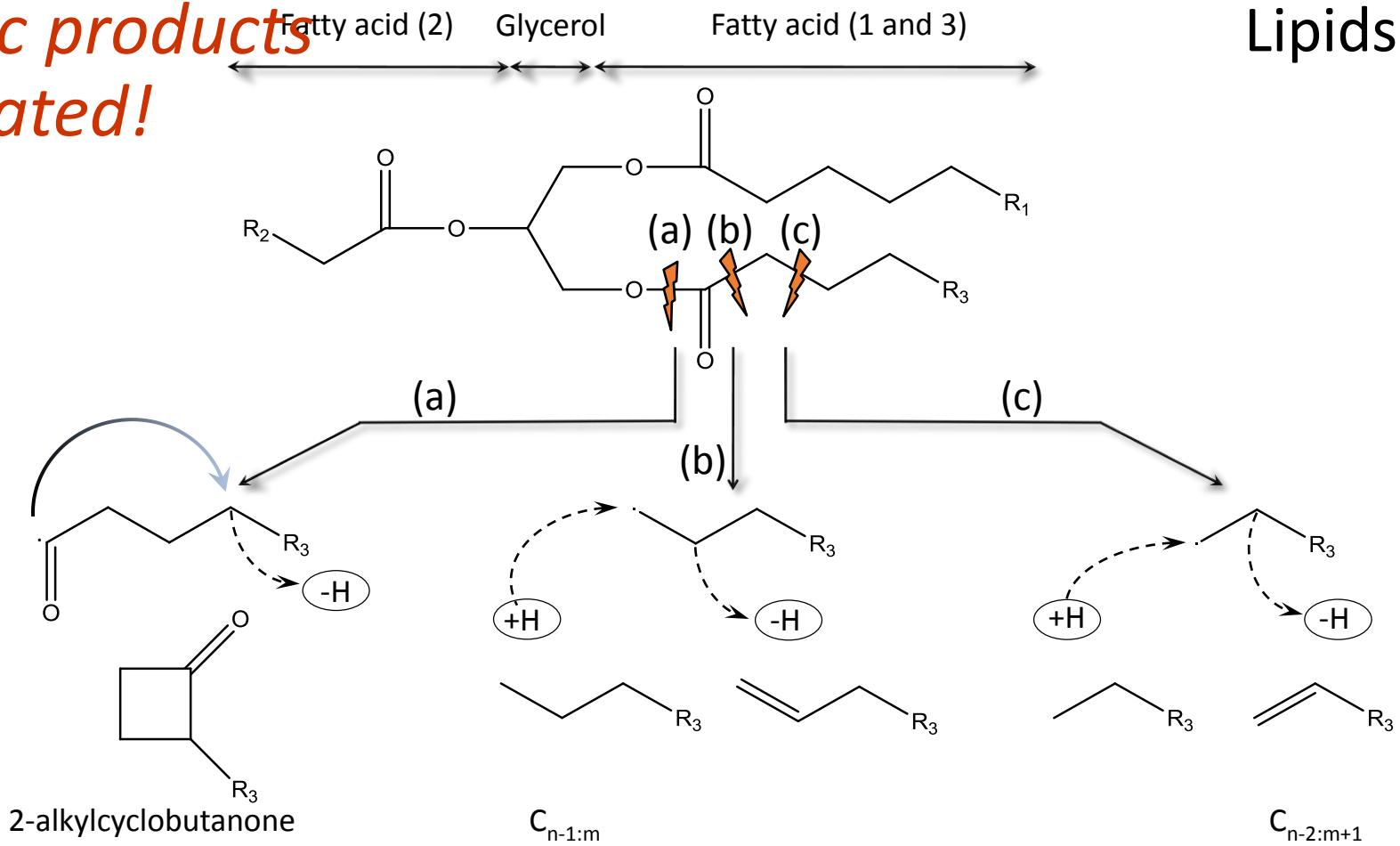
Vitamins

Detection UV 280 nm
Column: Agilent-XDB Phenyl
(250 x 4,6 mm; 5 μm)
Aqueous acetic acid (0,5%)/MeOH
1,0 mL.min^{-1}
20 μL injected

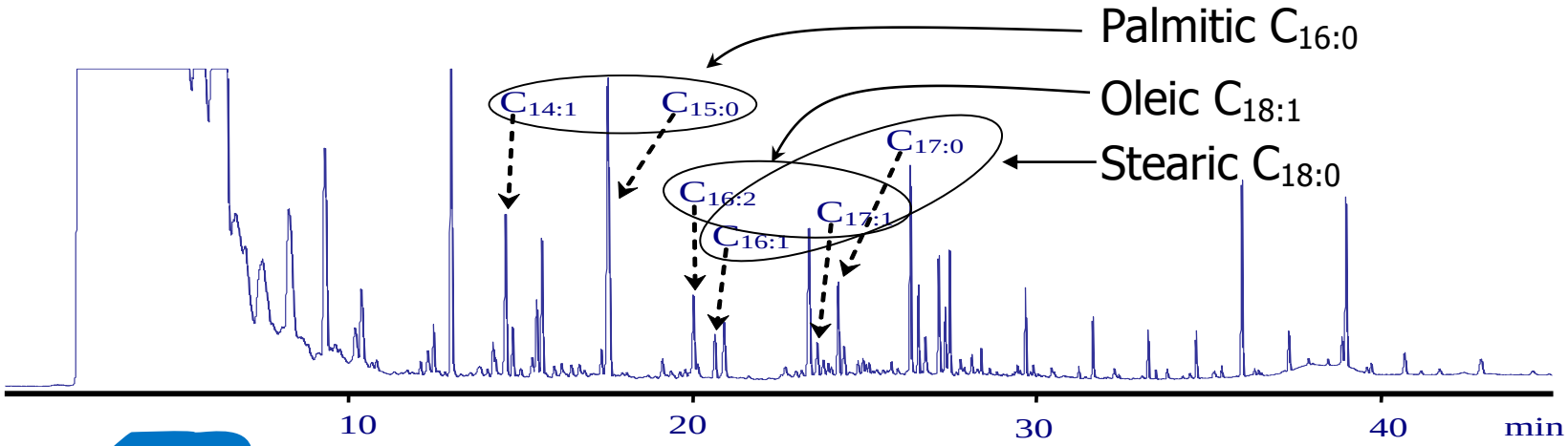


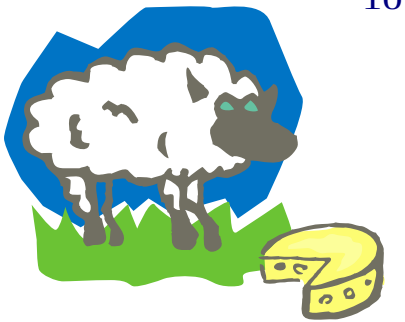
Radiolytic products were created!

Lipids



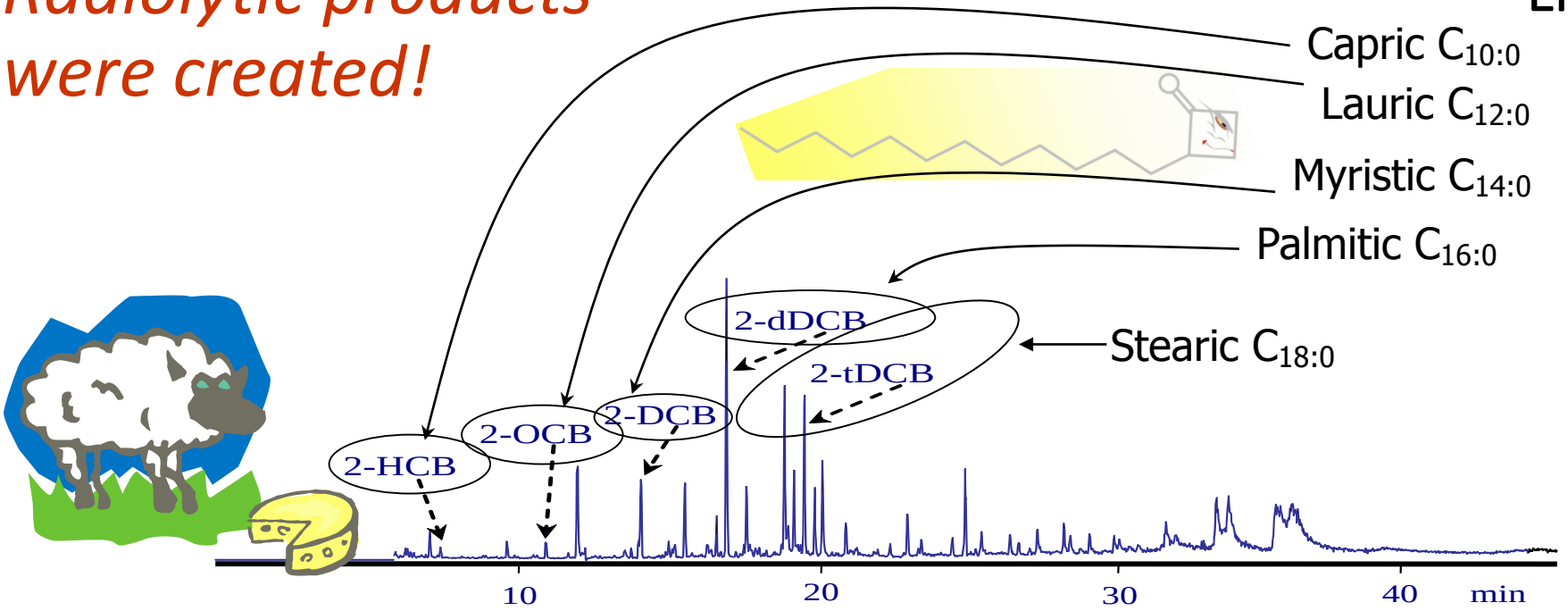
Radiolytic products were created!





Gas chromatographic analysis of volatile hydrocarbons present in a sample of cheese irradiated at 3.1 kGy
(Ndiaye et al., 1999)

Radiolytic products were created!



Gas chromatographic analysis of 2-alkylcyclobutanones in a sample of cheese irradiated at 3.1 kGy **(Ndiaye et al., 1999)**

Radiolytic products were created!

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Natural Existence of 2-Alkylcyclobutanones

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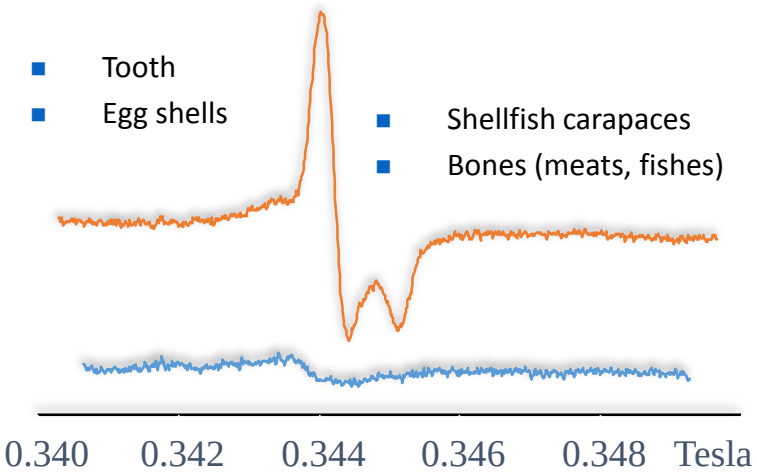
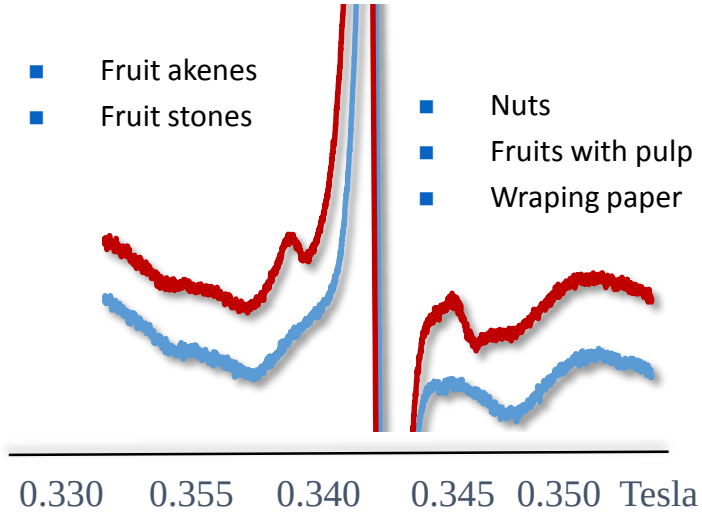
SFE-TLC-GC-MS
30 g round cashew nuts

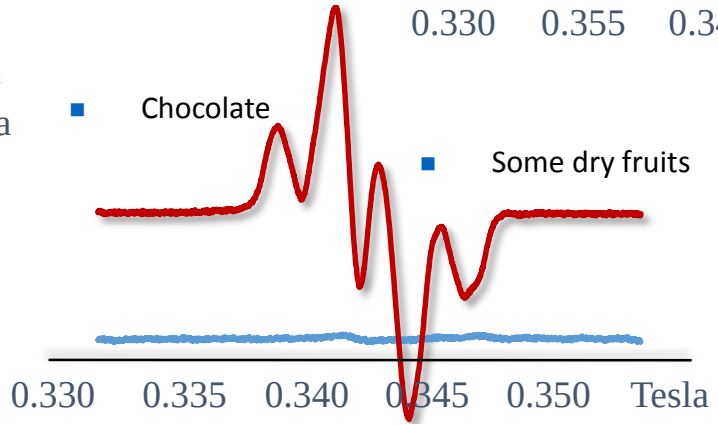
Other chemical products

- Furans
- Certain hydrocarbons
- Cholesterol oxides

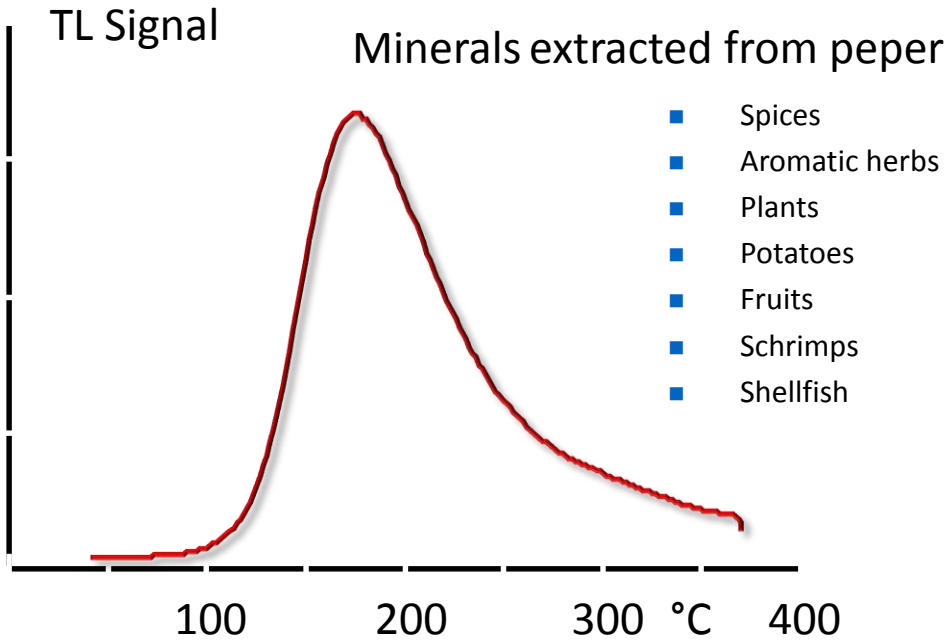
Radicals were created!







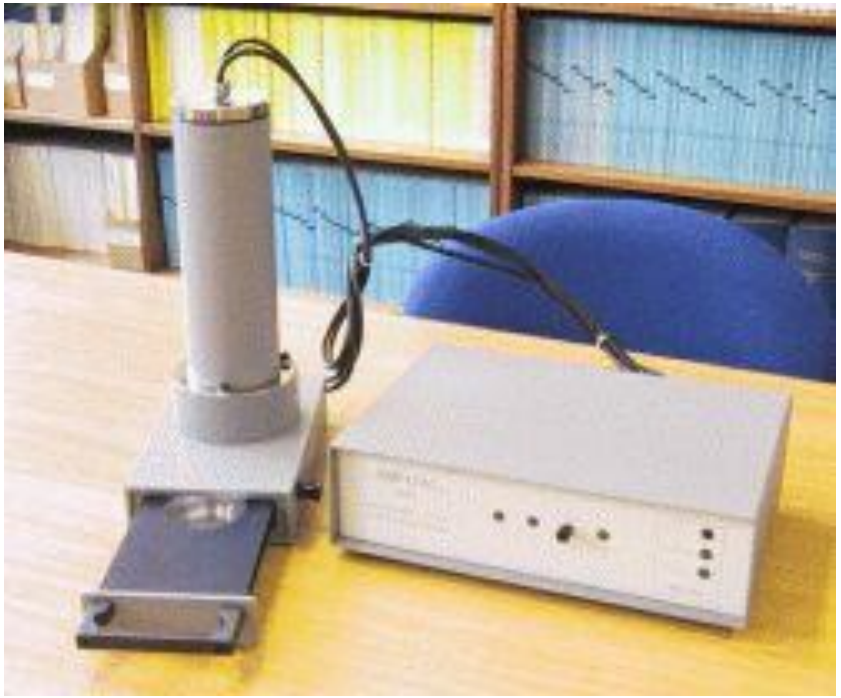
Excited species were created!



Excited species were created!

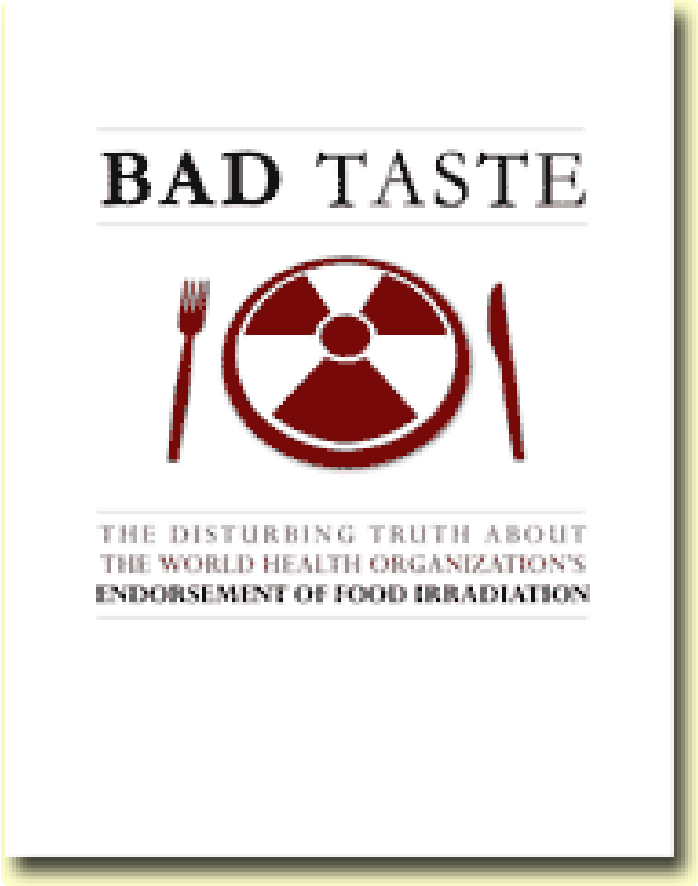
Special apparatus have been developped to detect these excited species in food

Here a PSL reader



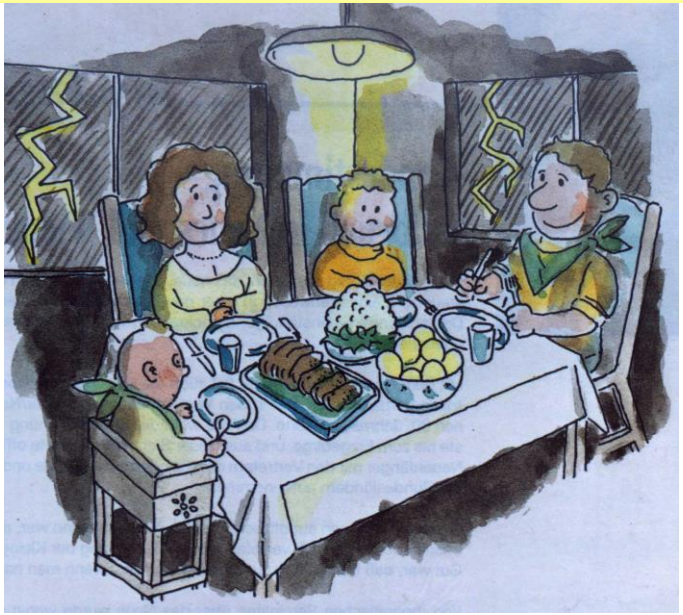

IONISOS
NON AUX ALIMENTS IRRADIES

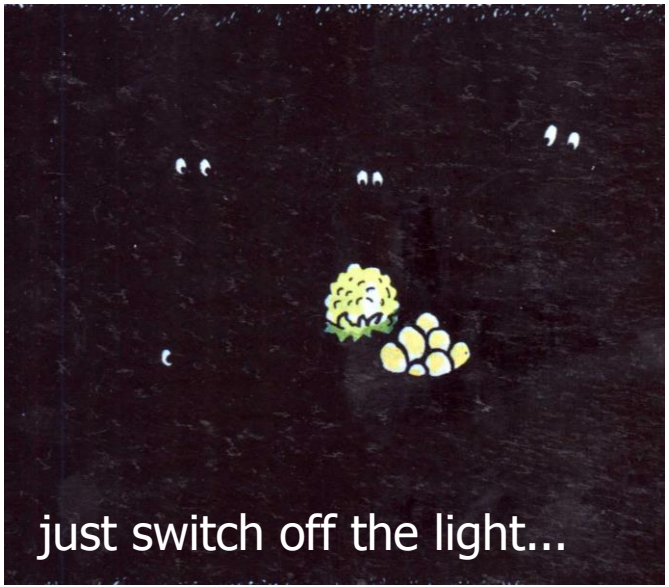

radiation leaks and accidents
radioactive waste
unhealthy food


BAD TASTE
THE DISTURBING TRUTH ABOUT
THE WORLD HEALTH ORGANIZATION'S
ENDORSEMENT OF FOOD IRRADIATION

Muito obrigado pela atenção

How to detect irradiated food ?





(Der Fachberater, 1995)

Radiolytic products were created!

2-ACBs production yield : 1.6 nmole / mole fatty acid / kGy

Toxicity tests realized with very high concentrations of 2-ACBs

Toxicity tests realized with highly pure standard compounds

***In vivo* toxicity tests realized with 2-ACBs in the drinking fluid. No matrix effect was studied**

***In vivo* toxicity tests realized with rodens**

Very few metabolic studies were done (excretion, biodistribution, metabolism)