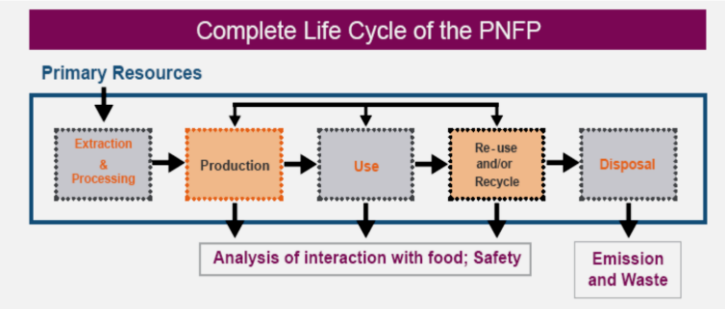
Schedule Clara Silvestre

- Presentation
- Lesson n. 1 Reasons to apply radiation and packaging technologies in food processing
- Lesson n. 2 Active packaging (nanotechnology) of food and its combination with irradiation.
- Lesson n. 3 Modified atmosphere packaging of food: diffusion concepts and evaluation of barrier properties
- Lesson n. 4 Biodegradable polymers and irradiation: Migration concepts and evaluation through food simulants
- Lesson n 5 Eco- sustainable issues: LCA, waste management



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Date: Oct. 2017

Institute of Polymers, Composites and Biomaterials (IPCB)

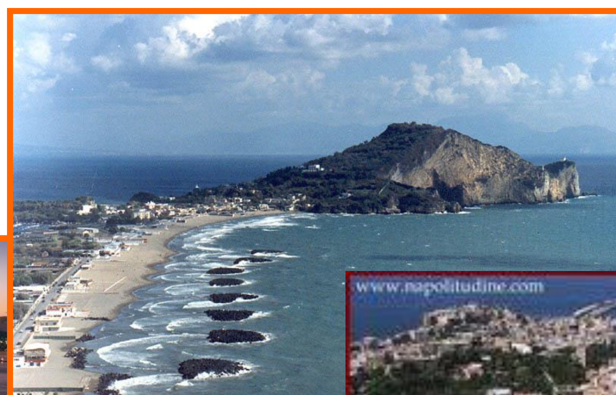
IPCB ISTITUTO PER I POLIMERI COMPOSITI E BIOMATERIALI

STAFF Pozzuoli (main section)
- **30 researchers (chemists, engineers)**
- **15 technicians**

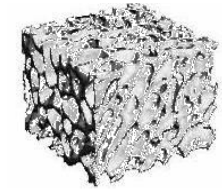
Aim

To investigate with a fundamental approach systems of high technological interest in the field of polymer-based material

Via Campi Flegrei 34
Pozzuoli (Naples) Italy



Institute of Polymers, Composites and Biomaterials (IPCB)



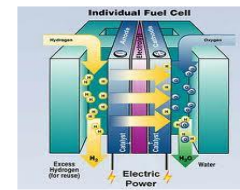
Competences

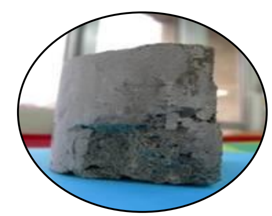
- Polymers from oil and renewable Resources
- Nanocomposites
- Blends- Ibrid materials
- Biomaterials
- Structure -processing
- Process technologies
- Synthesis and Chemical miodification of polymers

KNOWLEDGE INTEGRATION

Fields

- Health
- Transportation
- Energy
- Packaging
- Construction
- Cultural Heritage





Via Campi Flegrei 34
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STAFF Pozzuoli (main section)
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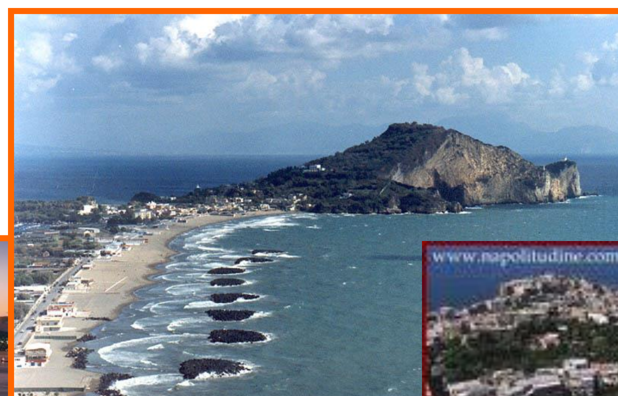
- 15 technicians

Aim

To investigate with a fundamental approach systems of high technological interest in the field of polymer-based material

Main research lines:

1. New polymeric materials for tailored applications
2. Structure-properties-processability relationships of polymers, blends, composites and nanocomposites
3. Synthesis, chemical and physical modification for the development of multifunctional thermoplastic systems, composites, blends with high tech impact


IPCB facilities 1/4

SYNTHESIS AND CHEMICAL MODIFICATION

- 200 m^2 laboratories

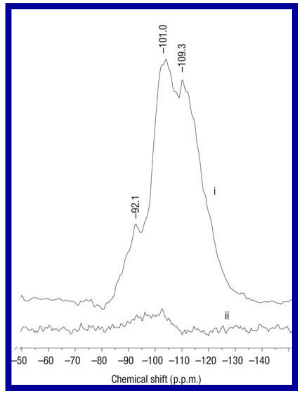
PROCESSING

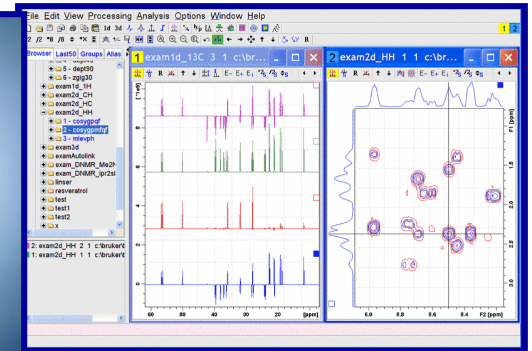
- 2 twin screw extruders + 1 microcompounder
- 1 blow extrusion line
- 1 micro-injection moulding
- 3 hot platen presses
- 2 torque rheometer Plastograph
- 1 electrospinning®

Dr Clara Silvestre

SOLID STATE NMR SPECTROSCOPY

4mm probe for solids





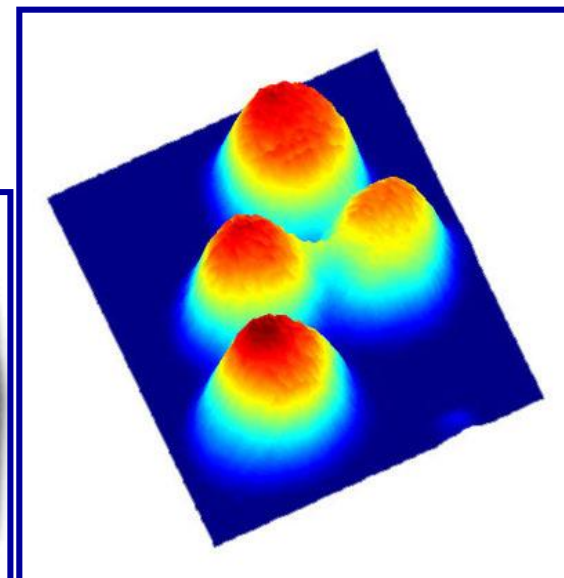
VIBRATIONAL SPECTROSCOPY

2 FTIR spectrometers

1 FTIR microscope

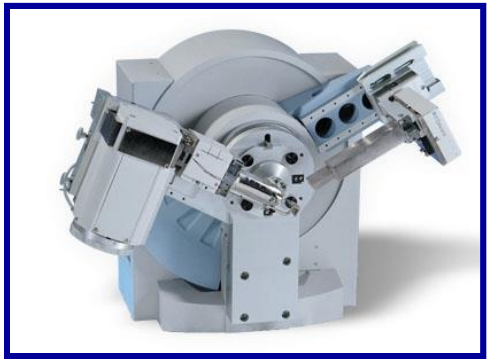
1 Raman spectrometer

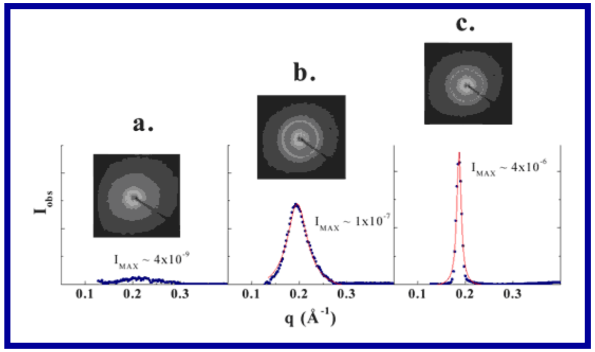
1 confocal Raman microscope



X-RAY Scattering :

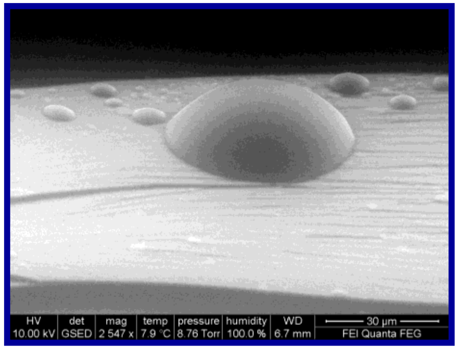
1 Wide-angle X-Ray Diffractometer (WAXD)
1 Small-angle X-Ray Diffractometer (SAXD)

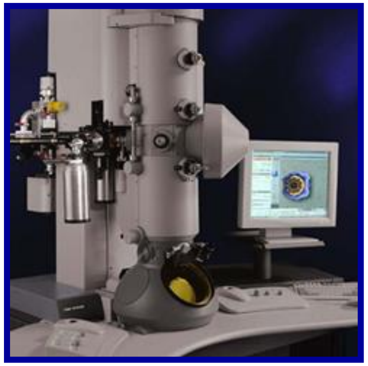


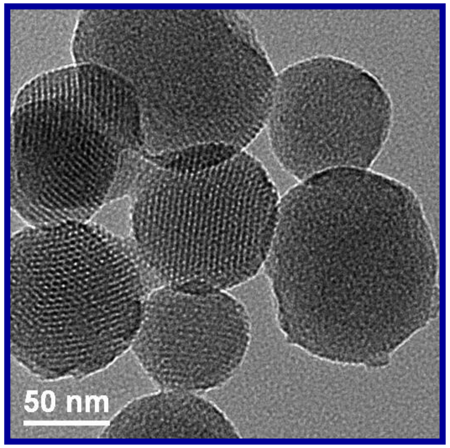


OPTICAL AND ELECTRON MICROSCOPY

1 environmental scanning electron microscope (FEG-ESEM) equipped with EDS microanalysis
1 transmission electron microscope (TEM)
1 atomic force microscope (AFM)
2 optical microscopes

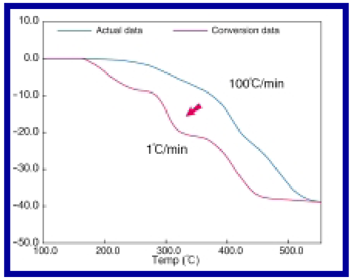






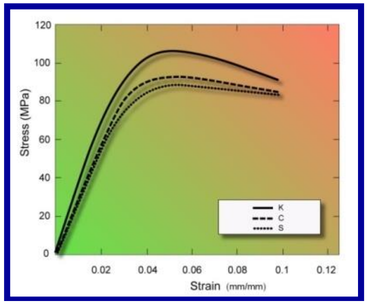
THERMAL AND THERMO-MECHANICAL ANALYSIS

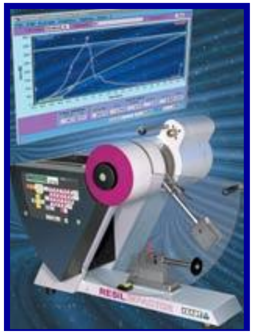
- **1 differential scanning calorimeter (DSC)**
- **2 modulated differential scanning calorimeters (MDSC)**
- **2 thermo-gravimetrical and differential thermal analysers (TG/DTA)**
- **2 dynamic-mechanical analysers (DMA)**

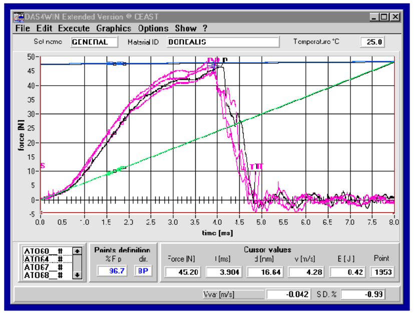


MECHANICAL ANALYSIS

- **2 Instron dinamometers**
  - tensile, flexural, compression tests; temperature control
- **2 instrumented Charpy pendulum for impact tests**







Dr Clara Silvestre

CURRICULUM VITAE

Name Clara Maria Immacolata Silvestre clara.silvestre@ipcb.cnr.it Italian Senior Researcher of CNR –IPCB

Main activities/ responsibilities

Coordinator/Responsible of national, international and FP projects and infrasctructure . To mention:

- Horizon 2020-MSCA-RISE-2016 *Multifunctional Graphene-based Nanocomposites with Robust Electromagnetic and Thermal Properties for 3D-printing Application* (Graphene 3D)
- FP7 Eranet Susfood *Improved and resource efficiency throughout the post-harvest chain of fresh-cut fruits and vegetables* 2014 -2017 (CEREAL)
- Erasmus+ Cooperation and Innovation for Good Practices "*Joint innovative training and teaching/learning program in enhancing development and transfer knowledge of application of ionizing radiation in materials processing*, 2014-2017
- Cost Action FA0904 "*Ecosustainable food Packaging based on polymer nanotechnology*" www.costfa0904.eu, 2010-2014 ;
- IAEA Coordinated Research Project (CRP) F22063 "*Combining radiation technologies and packaging nanotechnology to contribute ensuring worldwide food quality, quantity and safety* 2013-2017
- FP7 - *Setting up research-intensive clusters across the EU on characterization of polymer nanostructure*- NaPolyNet- www.napolynet.eu 2008-2011
- FP6 "*Strenghtening the role of women scientists in Nano-Science"- WomenInNano 2005-2008;*
- *International bilateral Joint Projects*: CNR Italy /BAS Bulgaria since 2004; CNR Italy /CNRS France 2010-2011; MIUR Italy/Quebec 2014/2017,
- Supervisor laboratories at IPCBCNR Atomic Force Optical Microscopy laboratories , XRay lab

Research activity

- Determination and control of physical and structural factors devoted to design and realize innovative eco-sustainable polymer systems for application in the area packaging, membranes, fire resistant textiles and biomaterials ; Correlation among molecular characteristic, morphology and structure and physical mechanical properties of polymer based systems (homopolymers, copolymers, polymer blends, nanocomposites);

Publications

- 180 Papers published on international scientific journals and books.14 Monographs/Book Chapters on science and technology of polymer based materials; Over 200 Communications at international meetings 3 Patents.
- Editor of the 5 books with ISBN. : C. Silvestre and S.Cimmino eds "Ecosustainable Polymer Nanomaterials for Food ckaging"CRC Press 2013

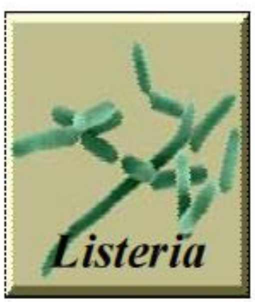
Lesson n1: Reasons to apply irradiation and new packaging technologies in food processing

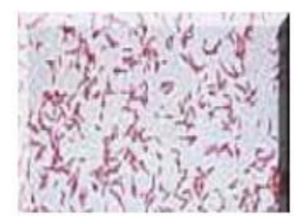
- Presentation
- Health, ethical, environmental, economic, issues
- Food irradiation
  - History
  - Function
- Food packaging
  - History
  - Function
- Challenges

Health ISSUES

The Center for Disease Control and Prevention (CDC) estimates that **48 million people/year** get sick and 3000 deaths due to **foodborne diseases** (USA)

Therefore, controlling of food pathogens in food products is very important




Campylobacter

Health/Economic ISSUES

- Lately the World Health Organization (WHO-2011) has underlined that because of growing global trade the world population has become more vulnerable to outbreaks of disease caused by contaminated food.
- The food poisoning outbreaks cause immense economic burden due to food recalls and medical treatment costs. **The post-process contamination caused by product mishandling and faulty packaging is reported to be responsible for about 2/3 of all microbiologically related recalls in USA**
- .Food industry and reseacrh ares searching new solutions to contribute to solve these problems.

Ethical ISSUES

Recent reports by FAO (2009, 2011 and 2013) state that :

- **Food availability, abundance and safety are under threat and that by 2050 global production of safe and nutritious food must increase by 70% to feed the growing world population.**

9 Billion in 2050, FAO

- **A huge amount of food (~ 40% -1.3 billion tons/year) is lost between the stages**
- **of production and consumption.**

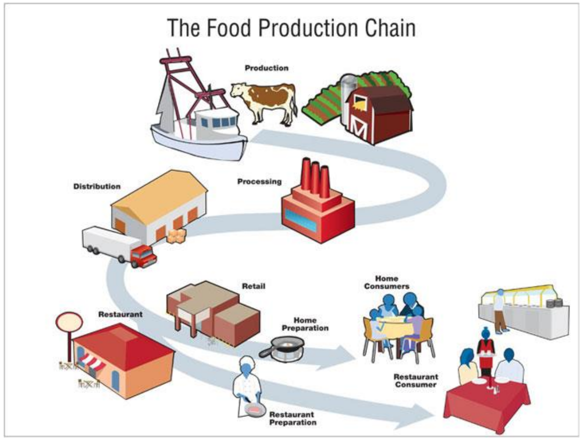
Efforts are being made to increase food productivity and several methodologies for increasing food production are presently identified and applied:

- mechanization,
- irrigation,
- use of fertilizers,
- improved crop varieties,
- control of weeds and insects,
- new varieties of farm animals
- infrastructure development.

Ethical/Economic issues

Improving yield is only one aspect of increasing food supply. It is equally important to conserve and protect what is produced. Huge amount of food (~ 40% -1.3billion tons/year) is lost and wasted between the stages of production and consumption.

During the journey from producer to consumer, if food products (plants and animals) are not handled and packed with care they are prone to contamination with pathogenic microorganisms, **causing additional food loss along with highly worrying safety risks.**



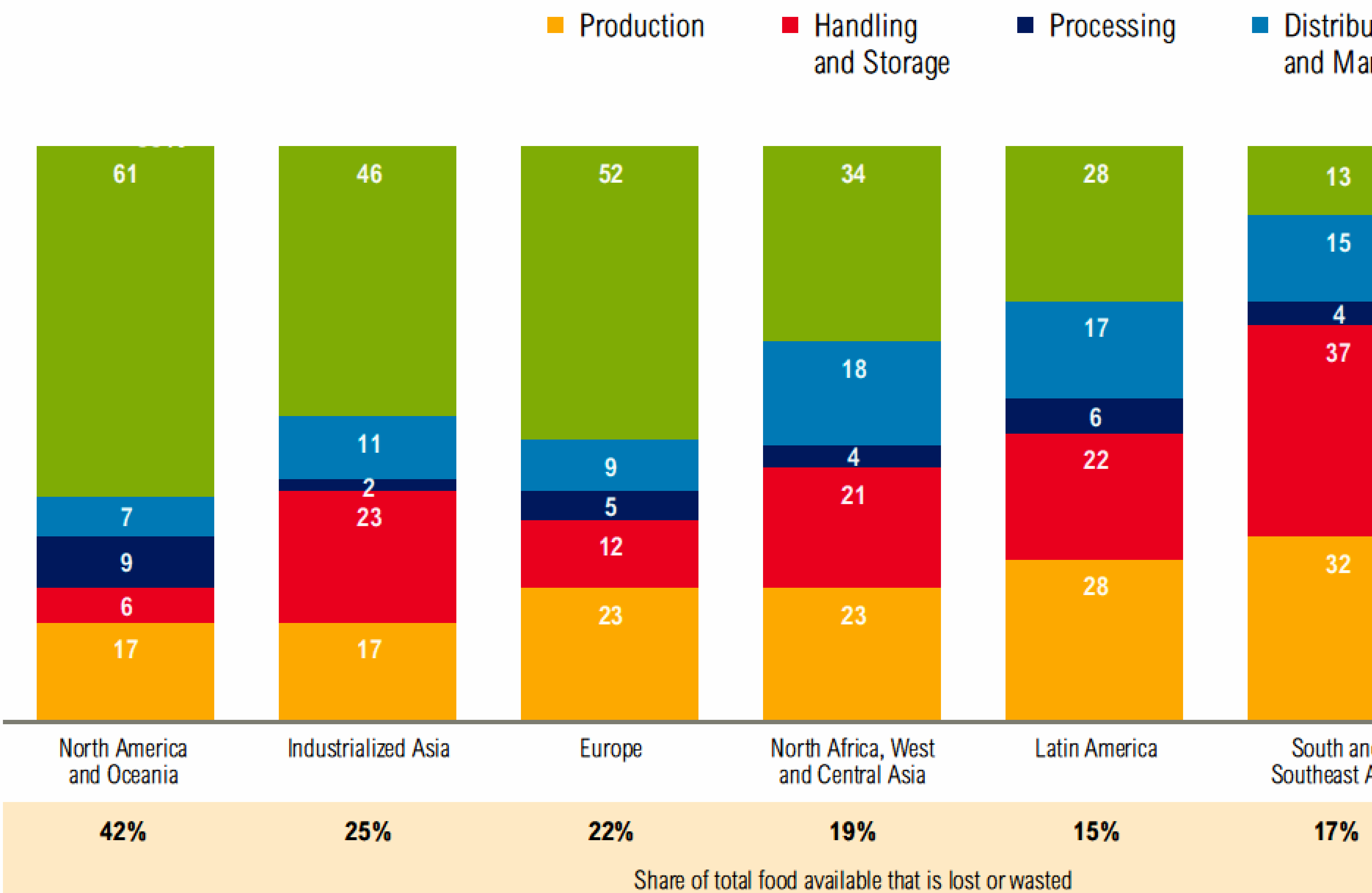
Food Loss and Waste definition

“**Food loss and waste = Food wastage** ” refers to the edible parts of plants and animals that are produced or harvested for human consumption but that are not ultimately consumed by people.

“**Food loss**” refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer. Food loss is the unintended result of an agricultural process or technical limitation in storage, infrastructure, packaging, or marketing.

“**Food waste**” refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded—either before or after it spoils. Food waste is the result of negligence or a conscious decision to throw food away.

Figure 6 | **Food Lost or Wasted By Region and Stage in Value Chain, 2009 (Percent of kcal lost and wasted)**



Environmental /Economic issues

Food wastage have many negative economic and environmental impacts.

•Economically, they represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses.

•The amount of food loss and wasted also produce millions of tons of residues every year, which in many cases are used rather inefficiently or even discarded as a waste resulting in the losses of valuable materials and creating environmental problems.

.

Impact of food wastage

•In European countries it is estimated that the per capita food waste and lost by consumers is 95-115 kg/year.

The wastage of food is unacceptable:

•For economic considerations (€600 billion/year),

•For the associated environmental footprint of such a wastage, that includes deforestation and greenhouse gas emissions, (3.3 billion tons/year of CO_2; 250 km^3 of H_2O and 1.4 billion hectares of land used in vain).

•**For ethical reasons (today nearly 1 billion people suffer hunger**

•

Food processing technologies

Emerging Technologies

- ***New packaging technology***
  - ***Improved Packaging***
  - ***Active Pakaging***
  - ***Smart Packaging***
- ***Radiation***
- ***Modified Atmoshere packaging***
- ***Biopreservatives***
- ***High pressure processing***
- ***Ultrasounds***
- ***Pulsed Electric fields***

Technologies in use

- ***Low temperatures***
- ***High ttemperatures***
- **dehydration**
- **Natural & artificial preservatives**
- **fumigation**
- **Etc ……**

Technological convergence

- A number of different innovative, current and older food processing technologies may be combined to enhance efficiency (food availability, food safety) , waste reduction, and facilitate recycling and re-use.
- Radiation technologies + Packaging technology

Technological convergence

Radiation

- Kills up to 99 per cent of pathogens
- Currently permitted by over 50 countries,
- Food treated 500,000 metric tons/year
- Not expensive: (~5c (US) per pound meat/poultry
- Endorsed as safe for foods and health (WHO/EFSA)
- Environmentally clean and efficient technology

Emerging packaging technologies

- Implements all packaging functions:
  - Containment
  - Protection
  - Preservation
  - Marketing and communication
- Increases sustainability

- **The combination of these emerging technologies is a new challenge to feed world's growing population to increase food availability and minimize food waste**

9 Billion in 2050, FAO

Relevance Actions toward European strategies

- To ensure provision of sufficient and safe food for everyone in a sustainably responsible manner to save resources (land, water, energy) and to reduce the environmental footprint of the entire food chain are relevant and timely acitivies in addressing important society's food challenges:

The relevance and timeliness is also underlined in

- The EUROPE 2020 strategy for smart, sustainable and inclusive growth which aimed to combat poverty , reduce greenhouse gases, build growth through research/ innovation education and create jobs over the next year.
- The resolution of EU and Member States (September 2015) committed to meeting the Sustainable Development Goals (SDG), that includes a target to halve per capita food wastage by 2030,
- The Road Map 2050 for a resource-efficient Europe;

Lesson n1: Reasons to apply irradiation in food processing

- Presentation
- Ethical, economic, environmental reasons
- Food irradiation: History, Influence of irradiation on food, Market
- Food packaging : History, Functions; Market
- Challenges

Food Irradiation

- Food irradiation is a promising food safety technology that can eliminate disease-causing microorganisms such as E. coli O157:H7, Campylobacter, and Salmonella from foods.
- The effects of irradiation on the food and on animals and people eating irradiated food have been studied extensively for more than 40 years. These studies show clearly that when irradiation is used as approved on foods:
  - Disease-causing microorganisms are reduced or eliminated
  - The nutritional value is essentially unchanged
  - Irradiation is a safe and effective technology that can prevent many foodborne diseases

History of Food Irradiation 1/2

- 1895 - discover of ionising radiation (Roentgen) and of the emission of radiation from with uranium, thorium, polonium, radium (Becquerel, Mary and Pierre Curie)
-
- 1905 First patent (J. Appleby) for “an improvement in foodstuff" and "their general keeping quality“” proposing treatment of food (cereal) with alfa, beta o gamma rays from radiactive substances.

- 1918 the invention of an apparatus for preserving organic materials by the use of X ray (Gillet)

- 1930 first patent of interest for an invention dealing with " Food of all kinds which are packed in containers are submitted to the action of hard X-ray to kill bacteria

Food irradiation History 2/2

- None of the inventions led to practical application as the radiation source available at that time were not powerful enough to treat food in commercial quantity

- 1950 radiation sources were strong enough for industrial exploitation:

The US Army and the US Atomic Energy Commission stimulated by the Eisenhower's initiative "Atom for food" started the development of the technology to improve safety quality of food

- **1980 Joint Expert Committee FAO/IAEA/WHO on Food Irradiation declared irradiated foods safe and wholesome for human consumption**

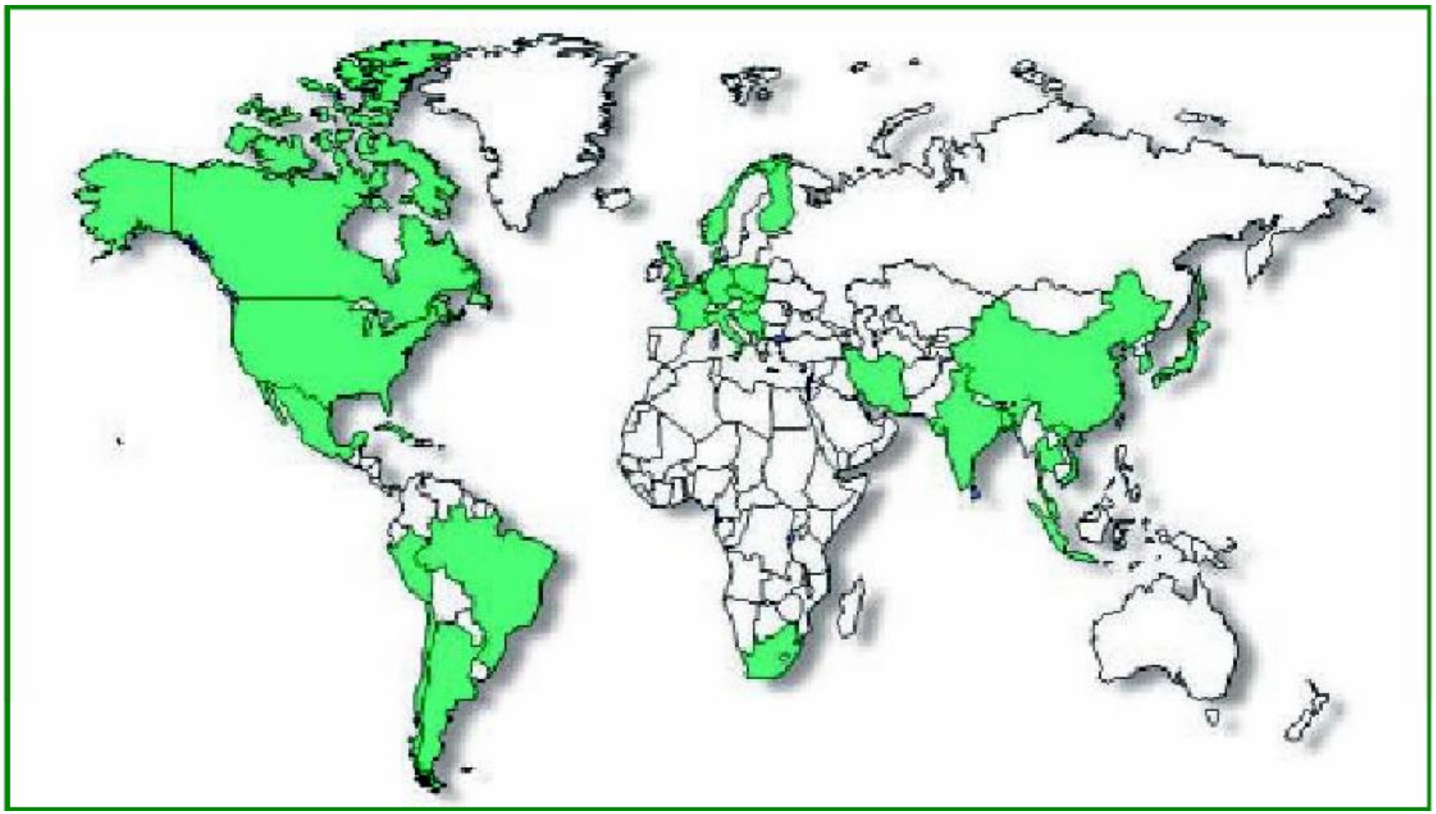
Food irradiation: actual situation

•Food processing by ionizing radiation technologies such as cobalt-60, electron beam (eBeam), and X-rays is approved in all continents and in commercial use **over 60 countries**.

•The extent of clearances in the countries is varying from almost any food in Brazil, to selected items in several EU countries, as listed by Official Journal of the European Union .

• In US between 2007 and 2013, the total volume of commodities treated by ionizing radiation increased by over 6000% from **195,000 kg in 2007 to approximately 13 million kg in 2013.**

•*World-wide Utilization of Food Irradiation*



Countries which apply food irradiation for commercial purposes

Do not yet apply food irradiation

The type of radiation used in processing materials is limited to radiations from high energy gamma rays, X-rays and accelerated electrons

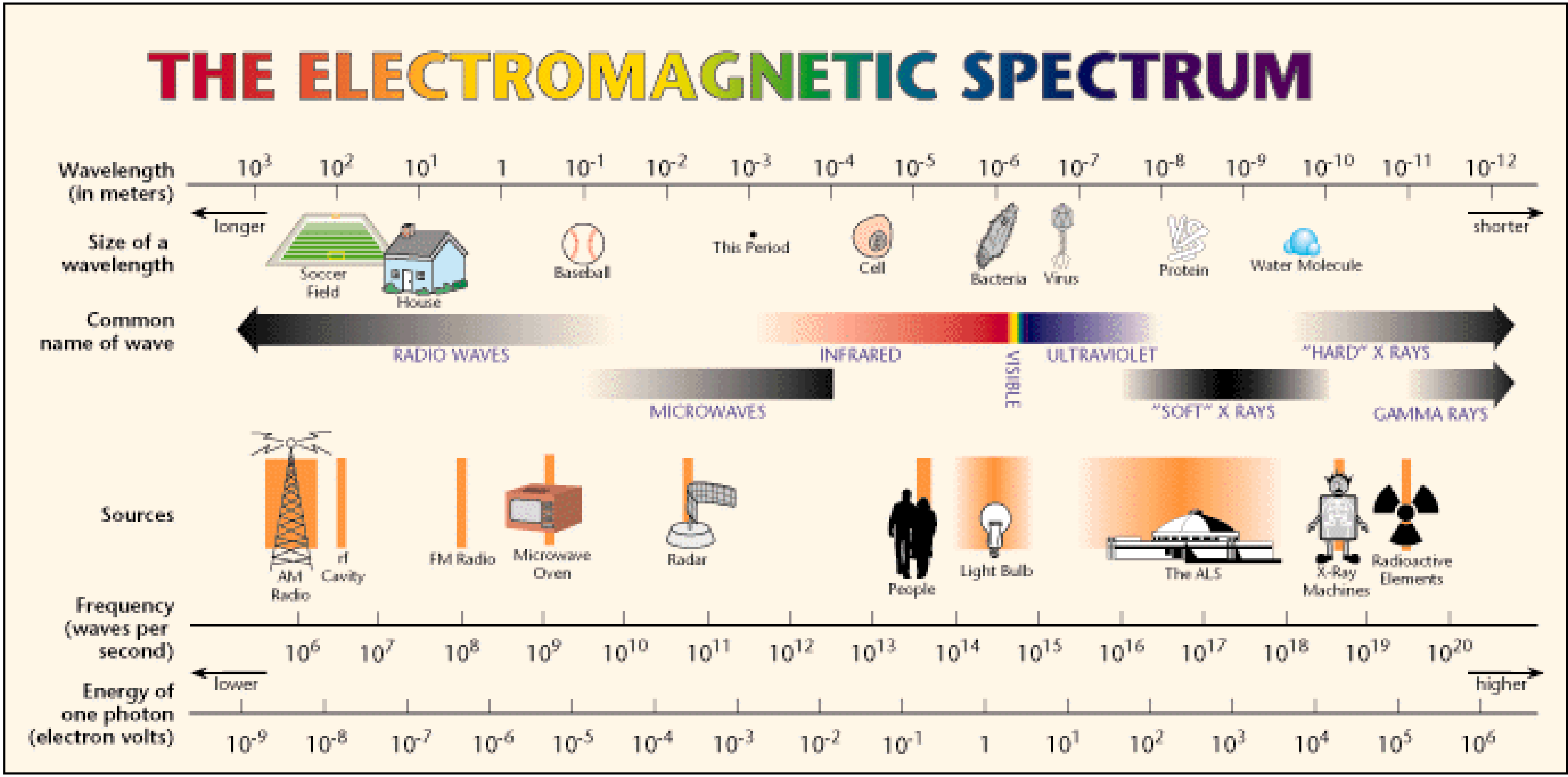


Table Units of Radiation Dose and Radioactivity

	Absorbed dose	Radioactivity
Unit	gray (Gy)	becquerel (Bq)
Definition	1 Gy = 1 J/kg	1 Bq = 1 disintegration/sec
Former unit	rad	curie (Ci)
Conversion	1 rad = 0.01 Gy	1 Ci = 3.7 X 10^{10}Bq = 37 GBq
	1 krad = 10 Gy	1 kCi = 37 TBq
	1 Mrad = 10 kGy	1 mCi = 37 PBq

Food Irradiation/doses

- Food irradiation can be broadly divided into two categories based on the doses that are employed namely, doses ≤ 1.0 kGy and doses ≤ 10 kGy.
- Doses ≤ 1.0 kGy is used **primarily for eliminating insects** and pests from fruits and vegetables and for extension of shelf-life
- doses ≤ 10 kGy **for eliminating microbial pathogens from meat and poultry products**.
- The use of doses ≤ 1.0 kGy for phytosanitary treatment of fruits and vegetables in international trade is the fastest growing market sector.
- Plastic packaging is widely used in products that undergo either the ≤ 1.0 kGy or the ≤ 10 kGy dose scenarios.

Food Irradiation Applications

Benefit	Dose (kGy)	Products
Low-dose (up to 1 kGy)		
(i) Inhibition of sprouting	0.05 - 0.15	Potatoes, onions, garlic, root ginger, yam etc.
(ii) Insect disinfestation and parasite disinfection	0.15 - 0.5	Cereals and pulses, fresh and dried fruits, dried fish and meat, fresh pork, etc.
(iii) Delay of physiological processes (e.g. ripening)	0.25 - 1.0	Fresh fruits and vegetables.
Medium-dose (1-10 kGy)		
(i) Extension of shelf-life	1.0 - 3.0	Fresh fish, strawberries, mushrooms etc.
(ii) Elimination of spoilage and pathogenic microorganisms	1.0 - 7.0	Fresh and frozen seafood, raw or frozen poultry and meat, etc.
(iii) Improving technological properties of food	2.0 - 7.0	Grapes (increasing juice yield), dehydrated vegetables (reduced cooking time), etc.
High-dose (10-50 kGy)		
(i) Industrial sterilization (in combination with mild heat)	30 - 50	Meat, poultry, seafood, prepared foods, sterilized hospital diets.
(ii)Decontamination of certain food additives and ingredients	10 - 50	Spices, enzyme preparations, natural gum, etc

•Dose level

•The doses are the result of a balanced compromise between what is necessary to obtain:

•desired effects from the treatment and what could be tolerated by the product without the occurrence side effects and sensory changes in nutrition in the treated product .

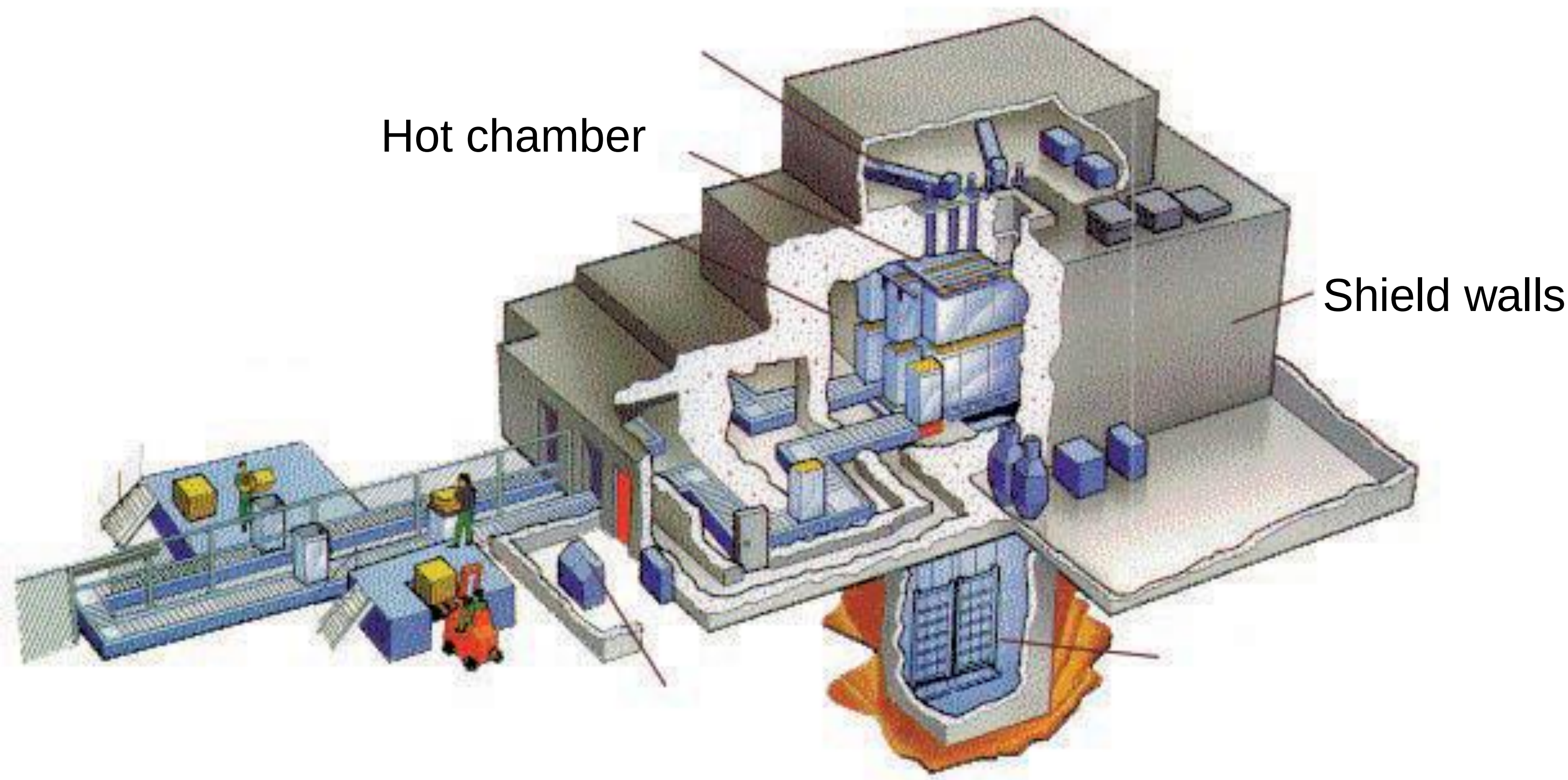
•Too high doses can alter the properties organoleptic (development of odor and / or losses color and firmness)

Radiation Sources

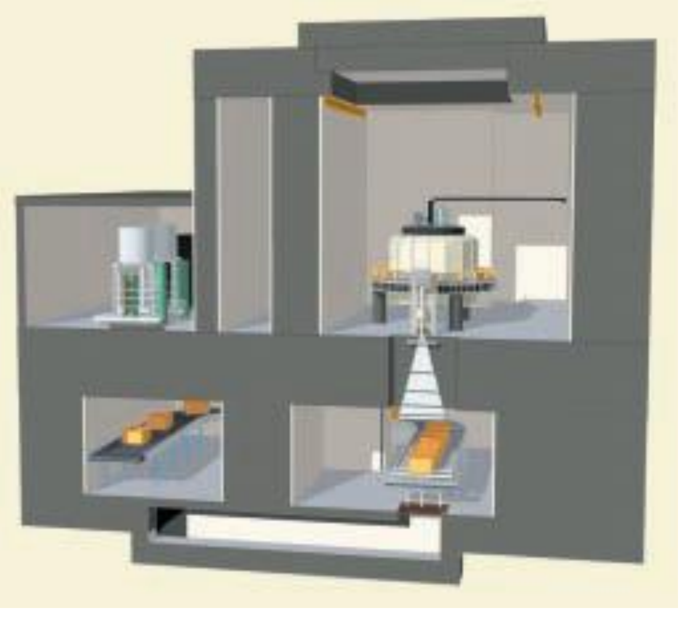
- **Radionuclide or radioactive materials that give off ionizing gamma rays**
  - **Cobalt-60**
  - **Cesium-137**
- **Machine sources of ionizing radiation**
  - **Electron beam accelerators**
  - **X-rays generators**

    The number of eBeam processing facilities has grown to 1500 worldwide and has now outnumbered gamma irradiation facilities by almost 10:1

Gamma Irradiator for food processing



Electron beam irradiator for food processing



Challenges

Irradiation of any food must satisfy three objectives

1- Adequate kill of target micro-organisms and insects

2-Retention of high quality of product

3-Avoidance of radiation-induced sensory detriment

Challenge is to ensure the simultaneous attainment of these
- ***goals***

Effects of irradiation on food 1/2

The effectiveness of the process depends on

organism's sensitivity to irradiation

temperature

amount of DNA in the target organism.:

Effects of iradiation on food 2/2

- **Parasites and insect pests**, which have large amounts of DNA, are rapidly killed by an extremely low dose of irradiation.
- It takes more irradiation to kill **bacteria**, because they have less DNA.
- **Viruses** are the smallest pathogens that have nucleic acid, and they are, in general, resistant to irradiation at doses approved for foods.
- If the food still has living cells, they will be damaged or killed just as microbes are. This is a useful effect: it can be used to prolong the shelf life vegetables because it **inhibits sprouting**

  delays ripening

Nutritional value of irradiated foods

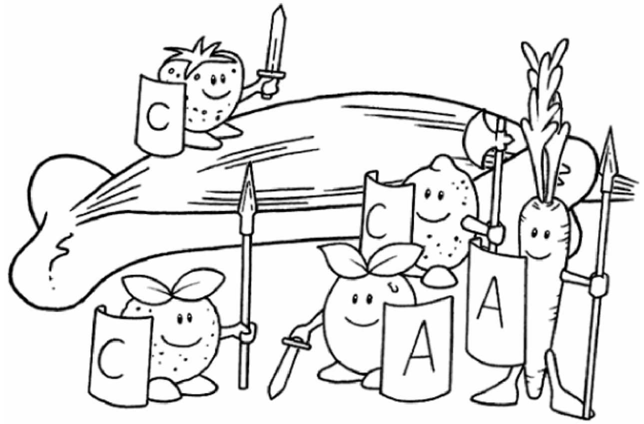
- The foods generally are not changed in nutritional value and they don't become dangerous as a result of irradiation, at the irradiation levels approved for use on foods,
- A big advantage of irradiated food, is that it is a cold process: the food is still essentially "raw", because it hasn't undergone any thermal process.
- **it does not substantially raise the temperature of the food being processed, nutrient losses are small and often significantly less than losses associated with other methods of preservation such as canning, drying and heat pasteurization.**

- **The change in nutritional value caused by irradiation depends on: irradiation dose, and type of food, packaging, and processing conditions, (temperature and time)**

- **Carbohydrates, proteins, essential amino acids, minerals, trace elements and most vitamins and fats, undergo little change during irradiation even at doses over 10 kGy.**

- **Five vitamins are recognised as being highly sensitive to irradiation: B1, C (ascorbic acid), A (retinol) and E (a-tocopherol**

***Irradiated foods* can lose 5%-80% of many *vitamins* (A, C, E, K and B complex). The amount of loss depends on the dose of *irradiation* and the length of storage ...**



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•Possible adverse effects of food irradiation on the nutritional well-being of man are of the same order of magnitude than those associated with other forms of food preservation in the doses currently allowed by the rules

Cost of food irradiation

- Irradiation is a capital-intensive technology requiring a substantial initial investment, ($1 to $5 million for irradiation facilities: radiation source (cobalt-60), hardware (irradiator, totes and conveyors, control systems, and other auxiliary equipment), radiation shield, and warehouse.
- Operating costs include salaries (for fixed and variable labor), utilities, maintenance, taxes/insurance, cobalt-60 replenishment for gamma irradiation, general utilities, and miscellaneous operating costs.

Irradiation of food and cost

- Any food processing method will add cost. Canning, freezing, pasteurization, refrigeration, fumigation, and irradiation will add cost to the food. These treatments will also bring benefits to consumers in terms of availability and quantity, storage life, convenience, and improved hygiene of the food.
- The increase in price is estimate
  - for irradiated fruits and vegetables **at 2 to 3 cents per pound**.
  - Irradiated poultry and meat products at **3 to 5 cents a pound** more than non-irradiated meat.
  - The price is likely to decline as irradiated foods become more widely available.

Irradiated foods available now

- Astronauts have eaten irradiated foods in space since the early 1970s.
- Patients with weakened immune systems are sometimes fed irradiated foods to reduce the chance of a life-threatening infection.
- In addition, irradiation is widely used to sterilize a variety of medical and household products, such as joint implants, band-aids, baby pacifiers, cosmetic ingredients, wine and bottle corks, and food packaging materials.

Food treated with irradiation and label

- Special labels are required on irradiated foods, including the international symbol of irradiation, known as a **“radura”**, and a statement indicating that the food was *treated with irradiation*
- The petals represent the food, the central circle the radiation source, and the broken circle illustrates the rays from the energy source

Labeling of Irradiated Foods

FDA has required labeling of irradiated food products since 1966

Radura logo required since 1986

Irradiated ingredients excluded

Only “First Generation” foods must be labeled

The symbol reduces acceptability of irradiated food products because of consumer association with radioactivity and lack of consumer education regarding safety and efficacy of irradiation

Consumer Acceptance

Affected by Irradiation label declaration

Tested by consumer surveys, limited market testing and retail sales

Affected by perception that irradiation equals radioactive:

72% of consumers have heard of irradiation but 30% of those think irradiated foods are radioactive (1996 survey)

Survey found that education increases acceptance

Lesson n1: Reasons to apply irradiation in food processing

- Presentation
- Ethical, economic, environmental reasons
- Food irradiation: History, Influence of irradiation on food, Market
- **Food packaging :** History, Functions, Market
- Challenges

History of packaging

- ✓ Packaging has been with humans for thousands of years in one form or the other. It dates back to when people first started moving from place to place.
- ✓ Originally, skins, leaves, and bark were used for food transport
- ✓ Four thousand years ago, sealed pottery jars were used to protect against rodents, and glass making was an important industry in Egypt.

History of modern food packaging 1810 - 2014

- Modern food packaging started in the 1810 with the invention of canning by Nicholas Appert.

  "Without this invenction starving and diseases would have distroyed the human beings"
  J. Floros Pennsylvania State University 2010

- The introduction of plastics as food packaging materials began in the nineteen thirties, assuming a continuously increasing role.

- At the end of the 20th and in this century, the innovations are related to polymer nanotechnology, modified atmshpere pa that are predicted to greatly improve properties.

- The main drivers for most of the innovations are consumer and food service needs and demands mainly related to the global and fast transport of food. It is also required sustainability.

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Packaging Functions

Technical Functions	
Containment	• Contain a product (ex: milk powder, sirup, baby food)
Transportation	• Effective movement of goods from production to consumption
Protection	• Prevent physical damage during the whole supply • Prevent tampering and theft
Preservation	• Prevent spoilage of product by being a barrier to gasses, moisture, light and volatiles • Prevent chemical and biological contaimination of the product

Packaging Functions

Marketing Functions	
Information	• Product identification and quantity • List of ingredients • Product preparation and use • Storage data and expiry date • Legal and safety requirements • Address of the responsible body • Opening instructions
Display	• Point of sale display • Branding
Communication	• Appeal to the potential customer by the use of topography, sybols, icons, color, illustrations, etc.

Packaging Functions

Marketing Functions	
Promotion	• Promotional information • Free extra product or free token • New product • Product features and benefits
Convenience	• Product handling and serving for the packaging handlers and users • Portioning
Wastage	• Information abaut the use, reuse, or recycling and proper disposal of the packaging material •End of life

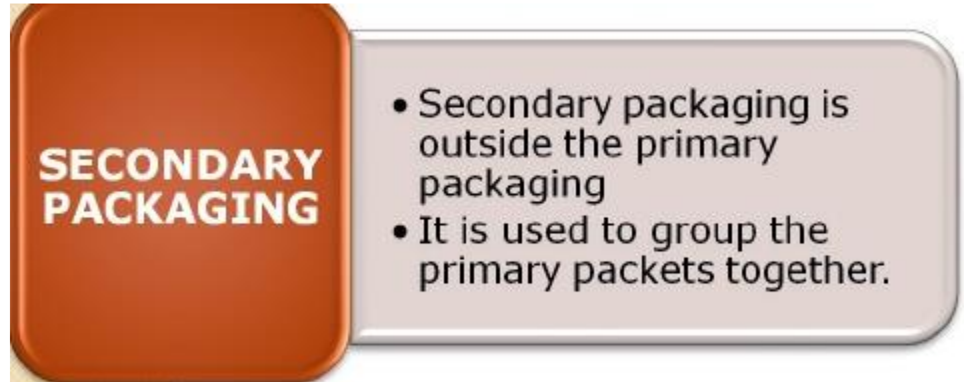
Packaging may be looked at as several different types

"Primary packaging is the material that first envelops the product and holds it

The properties of the product (form, dimensions and consistency) dictate the main priorities of primary packaging.

- The most important function is to protect and preserve the product from damage, external interference or contamination, spoiling and chemical imbalances.
- Ease of handling and shelving is a further aspect of primary packaging to be considered, so as to ensure the product can be easily handled by consumers.
- The examples of primary packaging are as limitless as the range of available consumer products.

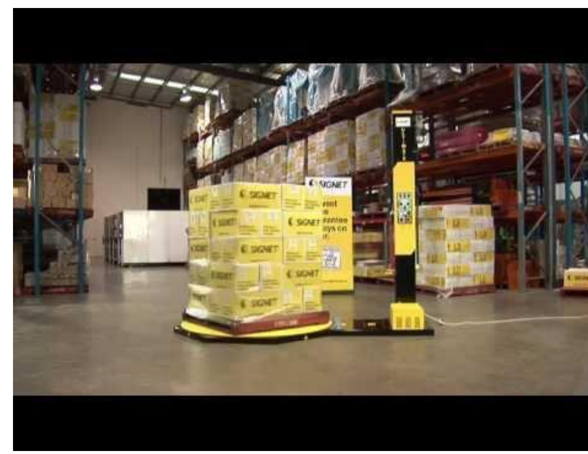
Secondary packaging



- *Secondary packaging* is intended to protect not only the product, but also the primary *packaging*, which often is the *packaging* most visible to the consumer in retail displays.
- The most common examples of *secondary packaging* include cardboard cartons, cardboard boxes and cardboard/plastic crates.

Tertiary or **transport packaging**

- **Tertiary** or transport **packaging** is that which is used to facilitate handling and transport of a number of secondary packs in order to prevent handling and transport damage.



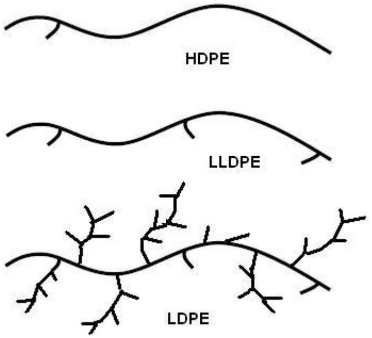
Numbers for Plastic Packaging

- Food packaging market: 440 billion $
- Food industry uses 65% of all packaging placed on the market
- 40% of total packaging is made of plastic
- High growth rate of the market of plastic packaging: 7%

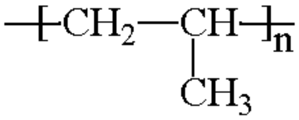
The most used plastics in the packaging are

• **PE (polyethylene ietilene)**: polymers characterized by a low vapor permeability , but high oxygen , high mechanical requirements , flexibility in the processing , non-toxicity . That of polyethylene is definitely the family of polymers most used in modern packaging , especially in the food industry , both in the form of rigid and flexible packaging .

$$\left[CH_2 - CH_2 \right]_n$$

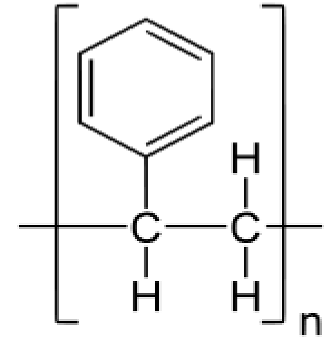


- **PP (polypropylene)** : it is a polymer particularly lightweight , non-toxic , waterproof and with a good transparency , resistant to corrosion chemistry. Permeable to oxygen . Wide use in the production of packaging for foodstuff

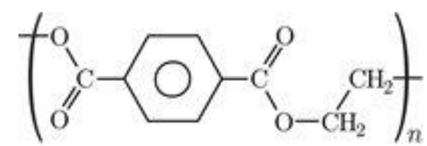


PP PP 05 PP

• PS (polystyrene) : is mainly used for protective packaging , especially for its aesthetic qualities , ease of decoration, the good transparency . Odorless and slightly water-permeable , polystyrene is characterized , however, by high fragility , rapid aging and a low resistance to he



- **PET (polyethylene terephthalate) : introduced to the market in the '50s , has found applications in the field of synthetic fibers initially to then enter in the packaging industry , through the production of bottles for beverages in general and transparent containers . PET is available in three different forms : A- PET , transparent but with little heat resistance ; C-PET , is resistant to freezing down to -40 ° C , that the heating in the oven (up to a temperature of 200 degrees centigrade), odorless, tasteless , hygienic and barrier properties to water, oxygen and carbon dioxide ; the biaxially oriented PET , the more rigid of the other , with high resistance and particularly suitable for the bottling of carbonated beverages .**



01
PET

Plastic Packaging Processing

- Initial transformation
  - Blown/cast extrusion
  - Injection molding
  - Injection blown
- Thermoforming
- Lamination
- Printing and Finishing

What do packaging producers desire ?

1) Thinner/lighter structures with enhanced properties (…and of course cheaper resins)
2) A monolayer film that will combine all properties required for packing an specific product
3) No big change in the processing machines
4) Low costs

Erasmus+ Schedule
Clara Silvestre

- Presentation
- Lesson n. 1 Reasons
- Lesson n. 2 Active packaging and nanotechnology and irradiation
- Lesson n. 3 Modified atmosphere packaging and irradiation
- Lesson n. 4 Biodegradable polymers and irradiation
- Lesson n 5 Selected characterization methodologies and practical examples

Emerging Technologies in Food processing: Benefits V Risks

Benefits:

- Increased shelf life
- Improved taste
- Higher nutritive value
- Increased security/safety
- Increased sustainability

Risks:

- Migration into food: Main concern
- Accumulation in the Environment

To make the Balance

Correct information
Regulations