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"The use of gamma irradiation for biopolymers development for food packaging application"

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Basics of requirements for food packaging and its sterilization by irradiation: Problems and Challenge

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History of food packaging

- **Inauguration of food microbiology**

  canning process, glass bottle, wooden crates

- **War I and II**

  aluminum foil, plastic (PE, PVC)

- **Development of Polypropylene, polyester, etylene vinyl alcool**

Brody et al., 2008 J. Food Sc. 73, 8, R107-115

Current global consumption of plastics

200 million tonnes/year

polyethylene terephthalate (PET)
polyvinylchloride (PVC)
polyethylene (PE)
polypropylene (PP)
polystyrene (PS)
polyamide (PA)

Function of packaging

- **Protection and preservation from the external contamination**

  retardation of deterioration, shelf life extension, quality, safety

- **Protection from environmental influence**

Migration of packaging components

plastic monomers, dimers, oligomers

antioxydant

plasticizers

dye/adhesive solvent residues

Ideal packaging

should be inert

resistant to hazards

not allow molecule transfer from or to packaging materials

Recyclable and/or biodegradable films

- Biodegradable synthetic polymers
  - Starch, cellulose, lignin
- Non biodegradable bioplastic
  - Nylon 9 types polymers
  - Polyamid 11

Performance expected

Containing and protecting the food

Could be assured

by controlling and modifying their mechanical and barrier properties

The stability should be demonstrated

when in contact with the food

Examples of biodegradable polymers

poly (lactic acid) (PLA)

polyhydroxyalkanoates (PHA)

polycaprolactone (PCL)

Improvement of biopolymers performance

Nanocomposite

Grafting

Cross-linking

Permselectivity of packaging

- Coating
- Microperforation
- Lamination
- Co-extrusion
- Blending

Barrier properties of commercial laminated or coated PET based films

Film	OTR cc/m²/day	WVTR g.mm/m²daymmHg
PET	110	15
PET/PE	0.9-1.2	0.25-0.37
PET/PVAL/PE	0.1	0.26-0.39
PET/EVOH/PE	0.06	0.13-0.27
PET/AL-met/PE	0.06-0.1	0.06-0.03
PET/SiOx	0.06	0.0024-0.06
PET/PVDC/PE	0.3	0.132
PET/Al-foil/PE	0	0

Active and Intelligent packaging

Active packaging allows to interact with food product and the environment and play a dynamic role in food protection

Examples of smart packaging

- Time-temperature indicator
- Ripeness indicator
- Biosensor
- Radio frequency identification (for tracking or tracing produce and other perishable commodities)

Decontamination of food packaging

Irradiation: Simple, good penetration, treatment done at room temperature.

Stability of the polymers should be demonstrated

Examples of polymer reactions to irradiation treatments

- Cross-linking: Polyethylene (PE);
  Polypropylene (PP);
  Polystyrene (PS)
- Chain scission: Natural polymers
- Stable polymers at doses $\leq$ 8 kGy:
  Low and high density polyethylene (LDPE,HDPE); PP
  Polyethylene terephthalate (PET);
  Poly(vinyl) chloride (PVC);

Regulations- up to 10 kGy

glassine paper

coated cellophane

wax-coated paperboard

Kraft paper

Nylon 11

multilayer PET

PVDC-VC copolymer

PS

polyetylene films

Irradiation at doses > 25 kGy

- PP and PE: low volatiles compounds
  oligomers and additives

- PET; PA; PS stable until a dose of 44 kGy

- PVC: release of HCL, many volatiles

Haji-Saeid, Sampa and Chmielewski, 2007, Rad. Phys. Chem. 76, 1535-1541.

Regulations-up to 30 kGy

Etylene-vinyl acetate

Regulation up to 60 kGy

Multilayer Polyethylene

Nylon 6

PET

PVC-VA co-polymers

Summary: Safety of irradiated polymers

- Polymers with aromatic structures like PET are more stable to irradiation
- Aldehydes and hydrocarbones are the most important migrants from the irradiated bags
- The use of stabilisers can protect the functional properties and can reduce the formation of off-odours
- Physical surface modification of polymers like grafting can improve the functional and physico-chemicals properties of packaging

Challenges

Intelligent and active packaging

Nanotechnology

Natural polymers with good functional and mechanical properties

The use of natural stabilizers or natural active compounds

Ref: Sanchez-Garcia et al., 2010, Trends in Food Science & Technology 21, 528-536

Challenges

- **Modification of the biodegradable polymers**

  Nanocomposites (Nanofibers, nanocarbon)

  enhance mechanical properties, thermal and electrical conductivity (microwavable, antistatic, intelligent packaging)
- **Grafting of natural polymers**
- **Nanoclays enhance rigidity, thermal stability and barrier properties, block UV radiation**
- **Nanoparticles permit control release and the development of active packagings**

Thank you

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