ACTIVE PACKAGING FOR FOOD

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COST Action FP1405 Active and intelligent fibre-based packaging – innovation and market introduction

INTRODUCTION – ACTIVE PACKAGING

Active Packaging: “designed to deliberately incorporate components that would release or absorb substances into or from the packaged food or the environment surrounding the food” Regulation (EC) No 1935/2004

- Active Releasing Systems
  - Antimicrobial agent
  - CO₂
  - Antioxidant
  - Flavours
  - Ethylene

- Active Scavenging Systems
  - Oxygen
  - CO₂
  - Moisture
  - Ethylene
  - Odour

FORMS OF ACTIVE PACKAGING

Active packaging can be incorporated in different formats

- Sachets or other inserts
- Label incorporated into the packaging material
- Functional coating
- Film

POTENTIAL APPLICATIONS

Active packaging has potential to be used
- to extend the shelf life of the product (fresh produce and foods with low shelf life)
- to reduce or remove preservatives from food formulations (fresh, clean label)
- to decrease the food lost (food with short shelf lives)
- to enable to use particular types of packages (Biopackaging, flexibles, transparent window)
- to simplify processing (additional hurdles)
- to prepare and to present the food (microwave susceptors)
- to develop new products (Some products could be only possible to develop if active packaging technologies are applied to preserve the quality)

MARKET POTENTIAL

Global active packaging sales by type ($ million)

Source: Pira International Ltd.

TECHNOLOGIES
Effect of antimicrobial agents on APC (total coliform, mold and yeast counts) and total coliform counts of chicken drumsticks stored at 5°C for 6 days:

- Carvacrol EO – Retard mould growth of strawberries
- Basil leaf EO – Prevention of microbial and sensory changes of sea bass slices
- Cinnamon

For example 1% of sorbic acid into PLA films (with addition of alga fucus spiralis) can protect megrim from microbial growth – the reduction of psychrotrophs of 0.9 log CFU/g in the comparison to PE films has been observed; also lower mean values of aerobes and Enterobacteriacae were observed (Garcia-Soto et al., 2015);

- Positive antioxidant effect – better sensorial properties (external odor, gill appearance) were reported;
- Sorbic acid incorporated into PVC prevents the growth of Listeria monocytogenes on bologna slices with 7.1 logs lower population after 28 days of storage at 4°C; and 1.3 logs on Cobb black cheese after 35 days of storage (Limjareon et al., 2005).

Organic acids and their derivatives are well known preservatives for food application; can also be incorporated into packaging;

- Saturated fatty acids such as coconut and tallow oil, and unsaturated fatty acids such as rapeseed oil and sunflower oil, are also used;
- Vitamin C – well known antioxidant for dry products;
- Natural selection of foods such as asparagus, cranberries, garlic, parsley, turmeric and wakame;
- Antioxidant effect of 1% of nisin or 2% sorbic on red meat samples;

- Antimicrobial activity of lysozyme and lactoferrin (LysoZeo (A) %) incorporated into LDPE film

The efficacy of the active papers on total aerobic count in samples of veal “carpaccio” (thin slices of veal fillet, meant for consumption as raw meat):

- Papers containing lysozyme and lysozyme/lactoferrin performed the best on the microbiota in this meat samples, giving almost 1 log cycle reduction with respect to control (5.55 and 5.53 vs 6.48 log cfu/g).

ANTIMICROBIAL PACKAGING -

- Natural antimicrobial agents occur in nature or isolated from microbial, plant, or animal sources;
- Antimicrobial agents produced by microorganisms include:
  - bacteriocins such as nisin or pediocin
  - antibiotics such as natamycin
  - organic acids such as sorbic and benzoic acids
  - enzymes such as lysozyme
- Plant origin antimicrobial agents include:
  - extracts of spices such as thyme, oregano etc.
- Chitosan is a natural antimicrobial polymer obtained by deacetylation of chitin obtained commercially from shrimp and crab shell.

ANTIMICROBIAL PACKAGING - ESSENTIAL OIL

- Cinnamon EO – Retard of mould growth of bakery products (Bosch et al., 2010)
- Basil leaf EO – Prevention of microbial and sensory changes of sea bass slices (Garcia-Soto et al., 2015)
- Carvacrol EO – Retard mould growth of strawberries such as Botrytis cinerea (Campos et al., 2015)

ANTIMICROBIAL PACKAGING - SORBIC ACID

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**Antimicrobial Packaging - Nanoparticles**

- The antimicrobial films were synthesized by blending polyethylene and highly dispersed nanoscale Ag/TiO₂ powder.
- Nano-packing has long-term antibacterial activity because of the strong interaction between Ag and TiO₂.
- Nano-packing retarded the changes of pasting qualities and texture of rice.

**Oxygen Scavengers - Needs**

Oxygen scavengers can be used to remove the oxygen remaining in the headspace of packaging and thereby can prevent oxidation of food or growth of microorganisms in food, to maintain food quality and improve food safety.

**Oxygen Scavengers - Available Technologies**

- **Indoorganic scavengers**
  - oxidizable metal powders, e.g. iron, zinc
  - sulphite
  - Dithionite (sodium hyposulfite)
  - photosensitive dyes

- **Low- and high-molecular organic scavengers**
  - ascorbate (vitamin C)
  - polyethylene copolymers (aliphatic or cyclic)
  - unsaturated oils and fats

- **Catalytic systems**
  - Pd-catalyst, Pt-catalyst
  - Enzyme-based system, e.g. glucose

**Ethylene Absorbers - Need**

- Ethylene-Ripening hormone
  - accelerates senescence and softening
  - increases chlorophyll degradation
  - reduces shelf life of fresh and minimally processed fruits and vegetables

**Ethylene Absorbers - Available Technologies**

- A sachet containing potassium permanganate
  - oxidizes or inactivates ethylene
- The use of finely dispersed minerals (zeolite, active carbon, pumice etc.)
  - to absorb ethylene
ETHYLENE ABSORBERS -

- LDPE films with 8% Tazet masterbatch was produced and applied for broccoli florets.
- Tazet masterbatch is an inorganic product containing 50% of various aluminosilicate minerals (zeolite).
- LDPE bags including zeolite prolonged storability of broccoli florets up to 20 days, however, this period was only 5 days in unpackaged broccoli.
- Extension of shelf-life by establishing equilibrium atmosphere and higher sensory quality (Esturk et al 2014).

MOISTURE SCAVENGERS – NEED

- Are the most important for:
  - dry products;
  - products, where the moisture balance is the crucial factor for keeping the quality;

Necessary in respiration of horticultural products
Changes of temperature can influence on moisture distribution in food
Excessive moisture in packaging can have negative impact on food products quality:
  - promoting of microbial growth (especially fungi);
  - chemical changes of biochemical composition;
  - changes of texture;
  - colour, taste, and colour changes – sensoric quality;

MOISTURE SCAVENGERS – ACTIVE FUNCTION / AVAILABLE TECHNOLOGIES

- Most popular: sachets and absorbing pads
- Pads/blankets made of porous materials, such as polymers (PP, PE), cellulose, combined with superabsorbent polymers/minerals/salts:
  - polyacrylate salts, carboxymethylcellulose, starch copolymers, silica/silicates;
- Sachets are filled with desiccants: silica gel, clays, molecular sieves (zeolite, sodium, potassium, calcium alumina silicate), humectant salts (sodium chloride, magnesium chloride, calcium sulfate), calcium oxide;
- Others: combination of hydrophilic substances with packaging materials

CO2 EMITTERS – NEEDS

- CO2 is a commonly used packaging gas for fresh foods such as fish and meat in modified atmosphere packaging (MAP)
- CO2 dissolves in the products and the proliferation of some bacteria (Gram negative) is reduced leading to improved product quality and increased shelf-life.
- However: Standard MAP requires a high gas to product volume ratio; 3 times as much gas as product for an optimal effect. High amounts of CO2 may cause package collapse.

CO2 EMITTERS – ACTIVE FUNCTION / AVAILABLE TECHNOLOGIES

- Ferrous carbonate based
- Sodium bicarbonate and citric acid:
  \[
  C_6H_8O_7 (aq) + 3NaHCO_3 (aq) \rightarrow 3CO_2 (g) + 3H_2O (l) + Na_3C_6H_5O_7 (aq) \\
  \text{H}^+ (aq) + \text{HCO}_3^-(aq) \rightarrow \text{CO}_2 (g) + \text{H}_2O (l)
  \]
- Combined CO2 releasing/O2 absorbing system
  - Sodium bicarbonate and ascorbic acid
**CO₂ Emitters**

- Study of impact of CO₂ emitter on shelf life and drip loss of chicken filets in MAP.
- Lab type emitter: Citric acid and sodium bicarbonate in a ratio adjusted to product pH.

**ANTIOXIDANT RELEASERS - NEEDS**

Incorporation of antioxidant substances in food packaging systems to prevent oxidative processes and to extend the shelf life of food products.

- Oxidation
- Discoloration and rancidity
- Degraded appearance and nutritional value
- Impaired sensory qualities
- Reduced shelf life

**ANTIOXIDANT RELEASERS - ACTIVE FUNCTION / AVAILABLE TECHNOLOGIES**

Active function can be obtained with:

- Synthetic antioxidants: e.g. BHT, BHA, EDTA
- Natural antioxidants:
  - Compounds: e.g. citric acid, ascorbic acid, catechins, tocopherols, thymol, carvacrol, resveratrol, quercetin
  - Plant extracts: e.g. green tea, oregano, rosemary
  - Essential oils: e.g. rosemary, oregano, cinnamon
  - By-products: e.g. beet root residue, brewery residual waste

**ANTIOXIDANT RELEASERS - ANTIOXIDANT STARTCH-LLDPE FILMS (MELT BLENDING+EXTRUSION)**

- Citric acid: concentrations of 0.15-0.75%
- Antioxidant packaging prevented lipid oxidation of fresh ground beef and contributed to color preservation

**THANK YOU FOR YOUR ATTENTION**