



## Active Packaging

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אירוסק - הוועידה השנתית  
**אריזה בעידן משתנה**  
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ISRAEL  
PLASTICS  
& RUBBER  
CENTER.






## Food Packaging


- Function:
  - Protection
  - Communication
  - Convenience
  - Containment



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## Active packaging vs intelligent packaging



**Active Releasing Systems**

- Antimicrobial agents
- CO<sub>2</sub>
- Antioxidants
- Flavors
- Ethylene

**Active Scavenging Systems**

- Oxygen
- CO<sub>2</sub>
- Moisture
- Ethylene
- Odor

- Time-temperature indicators (TTIs).
- Freshness indicators.
- Pathogen indicators.
- Leak Indicators (O<sub>2</sub> and CO<sub>2</sub> indicators)
- Radio frequency identification (RFID).

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## Active packaging – targets

- To preserve the quality of food during the shelf life
- Extend product shelf life
- To increase the food safety
- To decrease food loss/waste
- To reduce use of food additives



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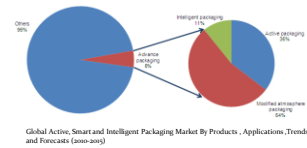
## Food waste reduction

- The United Nations Food and Agriculture Organization (FAO) estimates that about one third of all food produced in the world for human consumption every year is lost or wasted.
- That adds up to about 1.3 billion tonnes annually.
- If you are a consumer living in the U.S. or Europe, you will likely throw away 95 - 115 kg of food every year.



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## Active packaging segment



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## Types of Active Packaging

- Sachets and pads which are placed inside of packages
- Active ingredients that are incorporated directly into packaging materials



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## Applications

- Oxygen Scavengers
- Carbon Dioxide Generating System
- Ethylene Scavengers
- Flavor and Odor Absorber/Releaser
- Antioxidants
- Humidity Control
- Antimicrobial Packaging

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## IPRC Innovations in Active Packaging

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## Natural Antimicrobials



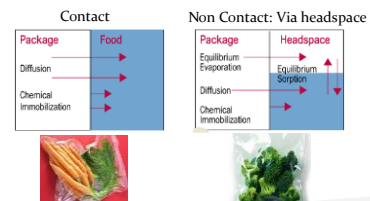
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### Natural Antimicrobial Agents

- Natural antimicrobial agents occur in nature or are isolated from microbial, plant or animal sources.
- Antimicrobial agents produced by microorganisms:
  - Bacteriocins: nisin, pediocin
  - Antibiotics: nantamycin
  - Enzymes: lysozyme
- Plant origin antimicrobial: extracts of spices (thyme, oregano, clove, cinnamon, etc.)
- Organic acids: sorbic and benzoic acids

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### Antimicrobial activity

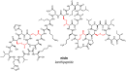


J.H. Han, The University of Manitoba, 2003

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### Bacteriocins

- Bacteriocins are antimicrobial peptides produced by bacteria which inhibit other closely related bacteria.
- Nisin is produced by fermentation of milk by "Lactococcus lactis" and is the most common bacteriocin.
- It has been approved for use as a food preservative and is recognized as GRAS by FDA.
- It is non toxic, heat stable, commercially available and already used in a variety of foods (preservative for cheese).
- Broader spectrum of antimicrobial activity



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### Anti-microbial packaging with Nisin - IPRC

'Nisin' (as Nisaplin compound) was incorporated in thermoplastics and polymer coatings used in flexible food packaging

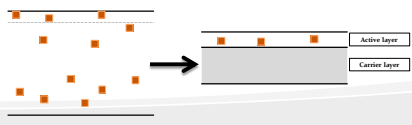


Reichenberg, Gilad & Ophir, Amos & Nir, Yifach, Nisin as an Antibacterial Substance in Active Packaging: a. Use of Ethylene Methyl Acrylate and Co-Polyamide to Enhance its Effectiveness. International Journal of Material Science, 2015.

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### Anti-microbial packaging based on Nisin - IPRC

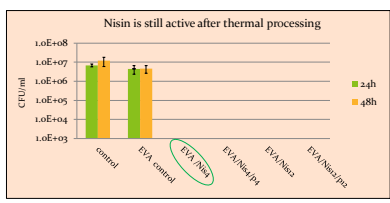
- Incorporation of Nisin in polymer blends (EVA, EMA and co-polyamide) at various ratios to control migration.
- Laminate with an outer active layer (water absorption).
- Same antibacterial activity – less amount of Nisaplin.



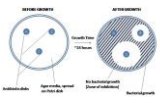
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### Antimicrobial tests results

Nisin is still active after thermal processing



Sample	24h	48h
control	~1.0E+07	~1.0E+07
EVA-control	~1.0E+07	~1.0E+07
EVA/Nisin	~1.0E+07	~1.0E+07
EVA/Nisaplin	~1.0E+07	~1.0E+07
EVA/Nisac	~1.0E+07	~1.0E+07
EVA/Nisap/pe	~1.0E+07	~1.0E+07



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### Natural Antimicrobial from plant extracts

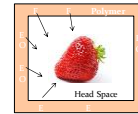
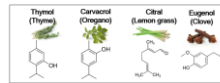
- Spices and herbs are an important source of antimicrobial agents effective against a vast spectrum of bacteria as well as yeast and fungus.
- The chemistry of the essential oils play an important role in determining their antimicrobial activity.
- The majority of the essential oils are approved as GRAS by the FDA.



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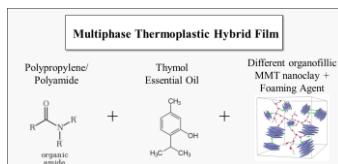
### Essential Oils as AM

- Volatile aroma compounds – challenging to introduce into the packaging material.
- Have strong smell that can affect the organoleptic properties of food products.



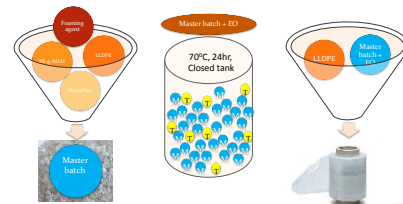
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- Development of multiphase thermoplastic hybrids system based on PP/ PA with different type and concentration of nanoclays enable to control *Thymol* EO release from the active film.



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### Experimental -Methodology



STEP 1

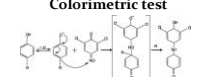
STEP 2

STEP 3


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### Experimental – characterization


**Colorimetric test**



Scheme of the proposed mechanism for the reaction of Gibbs' reagent with phenolic. (Bhuiya, 2006)




**Headspace Auto sampler GC-MS**




R. Elzail, M. Nanan, A. Peldi, A. Haberer, E. Batin, A. Dotan, and A. Ophir, "The combined effect of additives and processing on the thermal stability and controlled release of essential oils in antimicrobial films", Journal of Applied Polymer Science, Volume 111, Issue 15, (2014) 21

### Essential Oils as AM


Study the effects of EOs mixture with *Thymol* on the AM film properties




Headspace assay



Biological Tests



Biological Tests

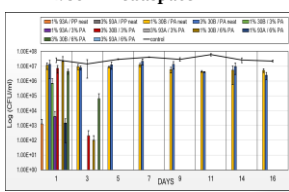


Sensorial Tests


E. Moshé, M. Nanan, A. Peldi, A. Haberer, E. Batin, A. Dotan, and A. Ophir, "Multi-phase Thermoplastic Hybrid for Controlled Release of Antimicrobial Essential Oils in Active Packaging Film", Polymers for Advanced Technologies, Springer, doi: 10.1002/pola.20111, (2016)

### Release control: Antimicrobial activity with time

**E.Coli- Headspace**





**In Vivo -44 days**



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### Gas barrier





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Oxygen barrier using whey protein based coating

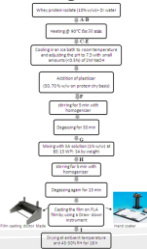


Oxygen barrier using whey protein based coating

- Whey is the yellow-green liquid that separates from the curd during manufacture of cheese and casein, about 40% of liquid whey is not utilizable.
- Can be used as coating on bio-degradable polymer films (PLA) to improve oxygen barrier.
- Development of a “whole green” multilayer film with a potential to be used as an alternative to traditional synthetic barrier polymers in the food packaging industry.

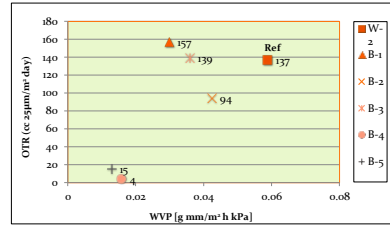


WPI-Coating Solution Development



WPI-Blends

Film	Incorporated Component
W-2 (Ref)	-
B-1	High-methoxyl pectin
B-2	PVOH
B-3	Cross-linked PVOH
B-4 (Ref)-PVOH 20% (wt/w)	-
B-5 (Ref)-Cross-linked PVOH 20% (wt/w)	-



**Oxygen Scavenger for Polyester (PET) compound and Process Technology for Sheet Extrusion and Thermoforming of Semi-rigid Active Packaging for MAP**

The diagram illustrates the application of oxygen scavengers in PET packaging. It shows a PET bottle with a scavenger layer, alongside images of various food products like vegetables and meats in packaging. A circular inset shows a cross-section of the scavenger layer with arrows indicating oxygen absorption. Text labels include 'Oxygen Scavenger', 'MAP (Modified Atmosphere Packaging)', and 'Oxygen Scavenger for PET'. A small number '29' is in the bottom right corner.

**PO/Nano-active-particle hybrids for Layer Co-extrusion Blow-molding of Bottles with Very High Water Vapor Barrier and Absorption Capability for Very Sensitive Pharmaceuticals**

The diagram shows the use of PO/Nano-active-particle hybrids in pharmaceutical packaging. It features images of various white plastic bottles, a microscopic view of the hybrid particles, and a cross-section of a bottle wall showing the layered structure. A small number '30' is in the bottom right corner.

**Technology of tie-layer-less (TLL) bi-layer HDPE/PA co-extrusion blow molding process for production of high performance rigid containers used for aggressive liquids and solvents**

The diagram depicts the TLL bi-layer HDPE/PA co-extrusion blow molding process. It includes a schematic of the extrusion process with labels for 'Die', 'HDPE', and 'PA'. Below this, there are images of various rigid plastic containers in different colors (blue, white, red) and a detailed cross-section of the container wall showing the bi-layer structure. A small number '31' is in the bottom right corner.

**THANK YOU**

The slide features the words 'THANK YOU' rendered in a colorful, 3D, bubbly font. A small number '32' is in the bottom right corner.