Applications of Innovative Packaging to Reduce FLW from Farm to Household

(2025/06/05)

Plastics Industry Development Center (PIDC) Presented by: Ho Hoong Yuan

Table of Contents

PIDC Introduction

Plastics Industry Development Center (PIDC):

- **Established** in 1993, by a joint initiative between the government and plastics industries.
- **Mission:** To drive economic growth by supporting and advancing the plastics industry.
- **Focus:**
  - •Addressing the unique challenges faced by local predominantly SME-based plastics sector (98% of enterprises).
  - •Providing essential resources in:
    - •Knowledge development.
    - •Internationalization.

•**Key Role:** Bridging the gap and fostering growth within the plastics industry.

Headquarters

PIDC headquarters serves well-equipped facilities, such as analytical testing laboratory, pilot plant, biomedical laboratory, biodegradable testing laboratory, etc., and a strong R&D teams with professional researchers and counsellors to provide services for the industry.

Southern Branch

PIDC southern branch specializes in product development laboratory and demonstration sites for cooperative companies and aims to explore the development of high-value-added industrial application products, assists in industrial transformation plans, and creates value-added business models.

R&D → Analysis → Verification → Training → Consultation

Global Packaging Trends

Packaging and Packaging Waste Regulation 2025/40 (PPWR)

11 February 2025

- **Prevent and reduce** packaging waste, including through more reuse and refill systems.
- Make all packaging on the EU market **recyclable in an economically viable way by 2030**.
- **Safely increase** the use of recycled plastics in packaging.
- **Decrease the use of virgin materials** in packaging and put the sector on track to **climate neutrality by 2050**.

Advancement in Packaging Technologies

Modified Atmosphere Packaging (MAP)

Extends shelf life by altering the internal atmosphere to slow spoilage.

Active Packaging

Packaging material includes antimicrobial layers, moisture regulators, oxygen scavengers and etc.

Smart Packaging

Features sensors or labels that monitor freshness, indicate temperature changes, and provide real-time data on food quality.

Other Packaging Methods

- Compostable packaging
- Edible packaging
- Recyclable mono-materials
- Upcycled materials

Global trends of Packaging Material

Biobased

PEF (polyethylene furanoate)

vs

PET (polyethylene terephthalate)

Advantages

- 100% biobased
  - synthesized from fructose or glucose
- Improved shelf life compared with PET
  - O_2 barrier 6-10x better
  - CO_2 barrier: 3–20× better
  - H_2O barrier: 2× better
- Light weight
  - 60% higher modulus and strength than PET
- Hot Fill/Hot serve
  - 12°C higher Tg than PET
- Recyclable, existing recycling system compatible with PEF

Mono

95% PP pouch laminates

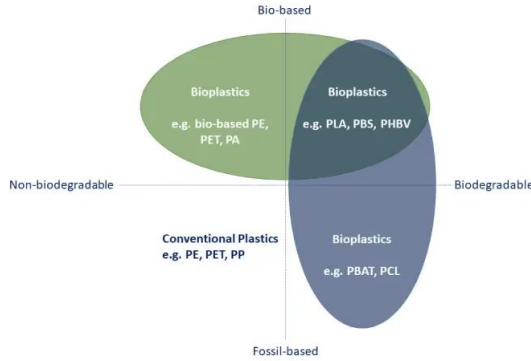
Pouch laminates is used to protect food stuff from moisture, oxygen, aromas, light etc. to extend shelf life.

For PP pouch laminates, extrusion lamination process is used to laminate PP cast and biaxially oriented polypropylene (BOPP) films, conventional pouch laminate materials contain approximately 90% PP.

Advantages

- Recyclability

Biodegradable



Algae Spirulina

Advantages:

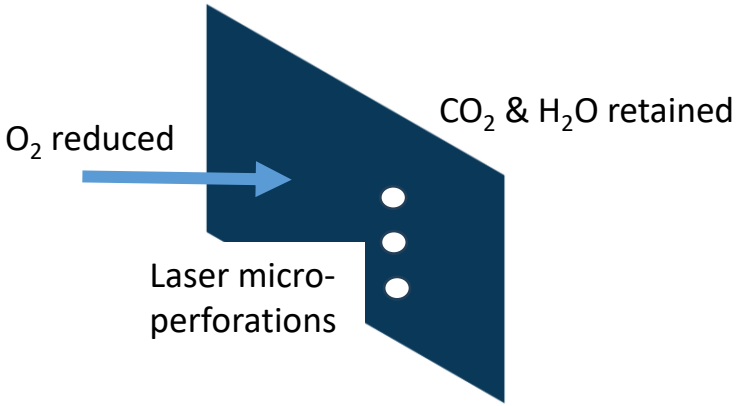
- Excellent mechanical properties
- Cultivatable on a large scale.
- Self-extinguishing, biodegradable and recyclable
- Same processing methods

Disadvantages:

- Susceptible to damage from water exposure
- Further research required

Global Trends on Packaging Technology

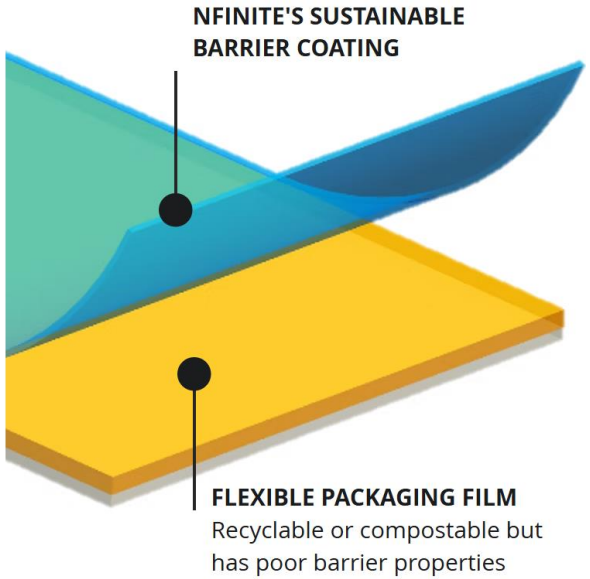
Modified Atmosphere Packaging (MAP)



Control the atmosphere inside packaging to extend shelf life, maintain product quality or enable controlled ripening processes.

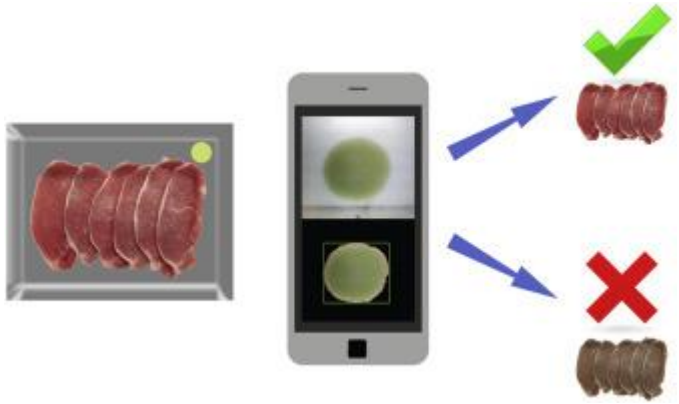
- Substitute air inside the package with a less reactive gas
- Create a controlled ventilation system within the packaging.

Active Packaging



Spatial Atomic Layer Deposition (SALD) technology lays down one atomic layer at a time, producing nano coatings that are uniform, pinhole-free and ultrathin.

Smart Packaging



Freshness sensors monitor changes in bacterial count, gases correlated with spoilage, inherent color change and etc.

Example: A colorimetric sensor monitors pork loin freshness within packaging by detecting CO_2 levels, indicating bacterial growth. Color changes, analyzed via a smartphone app, correlate to contamination.

Case Examples

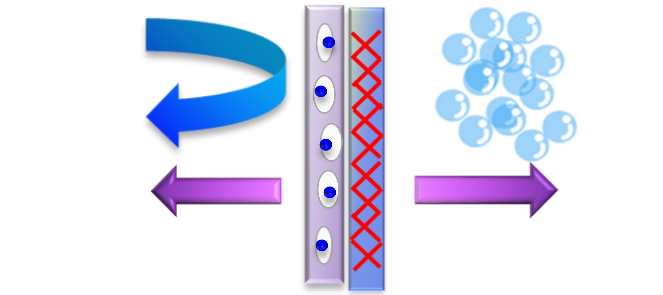
Projects by PIDC

Breathable Waterproof Bag for Fruit Bagging

Problems Encountered

Pests	Sun exposure	Diseases	Pesticide
			

Crop Bagging → Solution



- Environmental barrier
- Regulate sunlight
- Pest & disease protection

Field Trials

Common Bagging

Material properties

- Pore size > 100 μm
- Air permeability > 2,000 g/(m^2•24h)
- Water pressure resistance <2,000 mm-H_2O
- Cheap/easy to break, poor protection

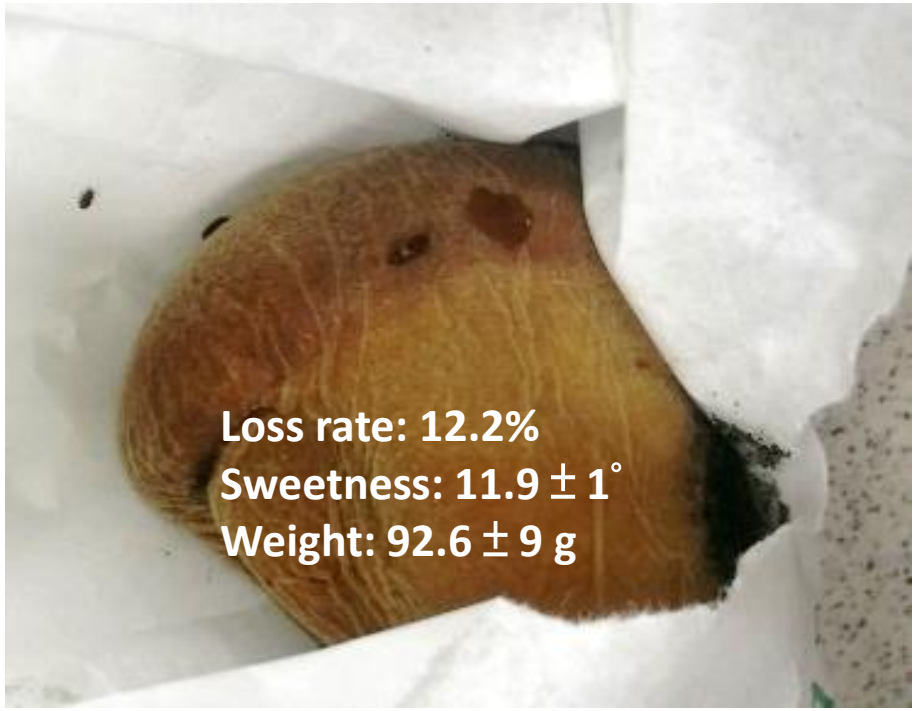
Breathable Waterproof Bagging

Material properties

- Pore size < 10μm
- Air permeability>2,000 g/(m^2•24h)
- Water pressure resistance>2,000 mm-H_2O
- Breathable and waterproof, durable and unbreakable

Breathable Waterproof Bag for Fruit Bagging Example

Paper Bag



Breathable Waterproof Bag

Note: Loss rate: peach damage amount/total peach production

- Breathable waterproof bag can repel oriental fruit flies, thus reducing losses from insect pests, with a loss rate of only 6.5%
- Paper bags are thin and easily attacked by oriental fruit flies, causing fruit drop, resulting in a 12.2% loss rate.

Fresher Green Bag

product | collection | separate | packaging | processing | storage | transportation

Farmer/Farmer Alliance

Agricultural Product Marketing Company

wholesalers | retailer | consumer

Distributors

Food spoiled due to:

1. **physiologic** function-**Fresh vegetable's photosynthesis**
2. **microorganism** activity-**Spoiled by microorganism**
3. **physical changes**
4. **chemical changes**

Solutions:

- Moisture control
- Bacterial control
- Atmosphere control

Patented Technology

Ethylene adsorption Technology

- Physical Ethylene Adsorption
- Chemically Fix ($C_2H_4 + X + H_2O \rightarrow C_2H_6O_2 + X'$)

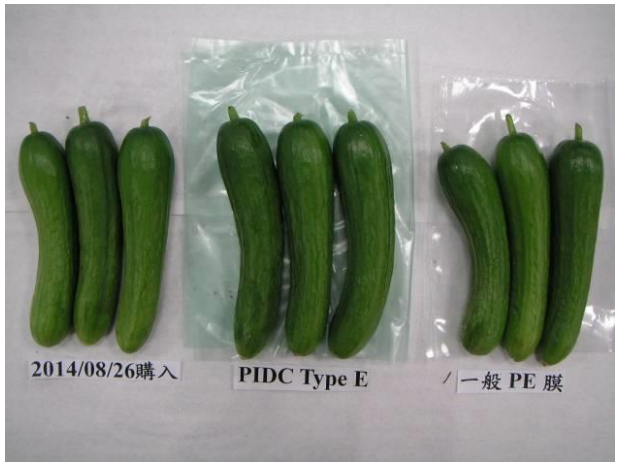
+ **Temperature & Humidity Control Technology**

Extend Stay-fresh Period about **1.5 times longer**

Fresher Green Bag Results

Day 1

Day 1

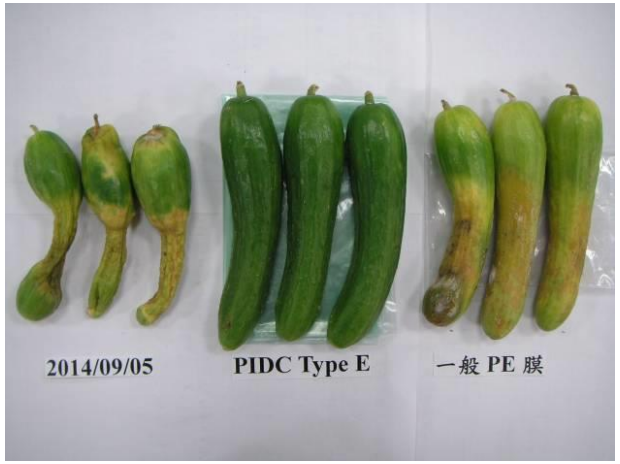


Day 1

Day 1

Day 85

Day 11



Day 9

Day 10

Fresher Green Bag Results

1st day

16th day

Fresher Green Bag Information

Patent Allocation

Packing material for preserve fruits and vegetables and producing method thereof

- R.O.C Patent Number: I-481498
- USA Patent Number: US9701818B2

Aging delaying material for fruits and vegetables and producing method thereof

- R.O.C Patent Number ：I-546021
- Japan Patent Number ：6152529
- USA Patent Number ：9877493

Comply with international food packaging standard

1. FDA of USA
2. EU-10/2011：Expanding the list of heavy metals to include aluminum for specific migration
3. EN 71-3/2003 heavy metals standard

Item(s)/ Method(s)	Result(s)	Note
1. Total Extractives Test US FDA 21 CFR 177. 1520	Tested Item: n-Hexane; Total extractives (%): 3.39; Limit (%): ≦ 5.5 Tested Item: Dimethylbenzene; Total extractives (%): 7.12; Limit (%): ≦ 11.3	

Item(s)/ Method(s)	Result(s)	Note
1. Specific Migration of Heavy Metal EU No.10/2011	0.919 g/cm^3 Limit: 0.85 ~ 1.00 g/cm^3	

Analysis Substance	Results (mg/kg)	Method Detection Limit (mg/kg)	Limit (mg/kg)
Barium (Ba)	Non-Detected	0.1	1
Cobalt (Co)	Non-Detected	0.01	0.05
Copper (Cu)	Non-Detected	0.1	5
Iron (Fe)	Non-Detected	0.1	48
Lithium (Li)	Non-Detected	0.1	0.6
Manganese (Mn)	Non-Detected	0.1	0.6
Zinc (Zn)	Non-Detected	0.1	25

2. Aromatic amine Migraton EU No.10/2011	Non-Detected Limit: ≦ 0.01 mg/kg	

Pressure Regulating Packaging for Microwave Foods

According to Stratistics MRC, the global microwave food market size was US$115.76 billion in 2023 and is expected to reach US$176.37 billion by 2030, with a compound annual growth rate of 6.2% during the forecast period.

Easy Peel Film

No easy peel film for microwave food packaging available.

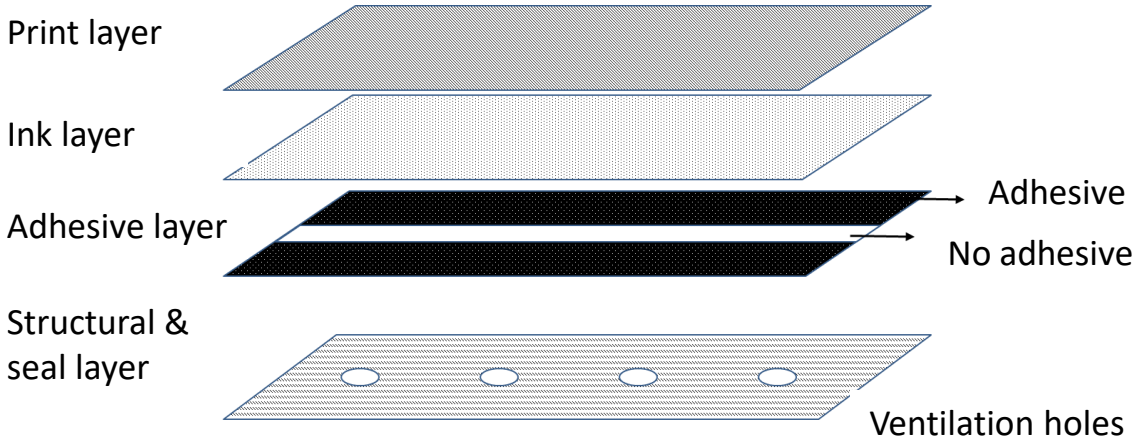
No Exhaust

Before microwave, the packaging must be opened.

Additional Exhaust

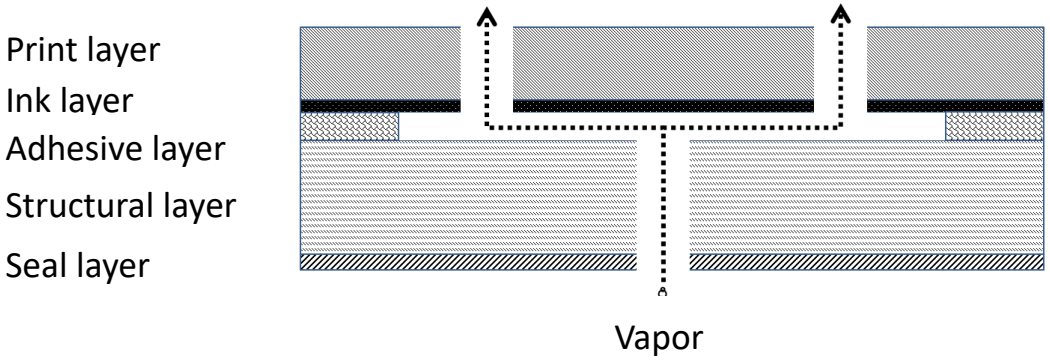
Cut opening needed for readily microwaveable products.

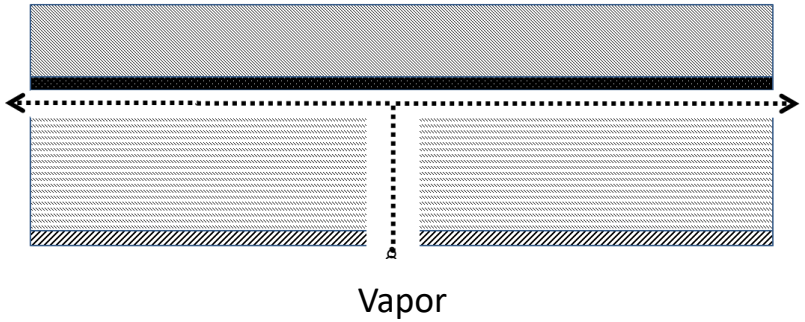
Pressure Regulating Film Design



Product advantages:

- Smooth appearance
- Small vent holes, good barrier properties
- Continuous production



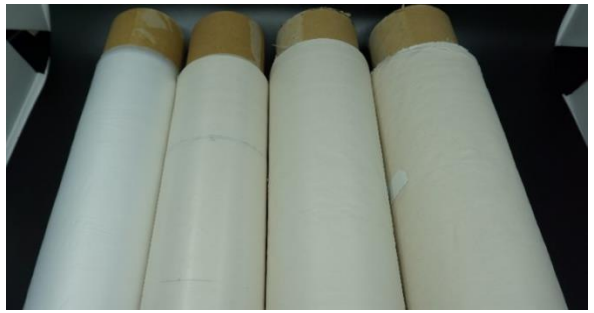


Pressure regulating sealing film exhaust path (vertical vs horizontal)

Antibacterial Packaging

Aquatic products are highly perishable due to enzymatic and microbial activity, with spoilage driven by microorganisms from the fish and secondary contamination. Preservation focuses on eliminating or inhibiting these factors through sterilization using ozone or hypochlorous acid, or by **slowing down microbial growth** and enzymatic reactions with low-temperature methods like refrigeration and freezing, thereby extending shelf life.

Gentian grouper



Composite membrane

Discarded oyster, shrimp and crab shells

Antibacterial packaging

Cold packing

Fishing product packaging

Chitosan

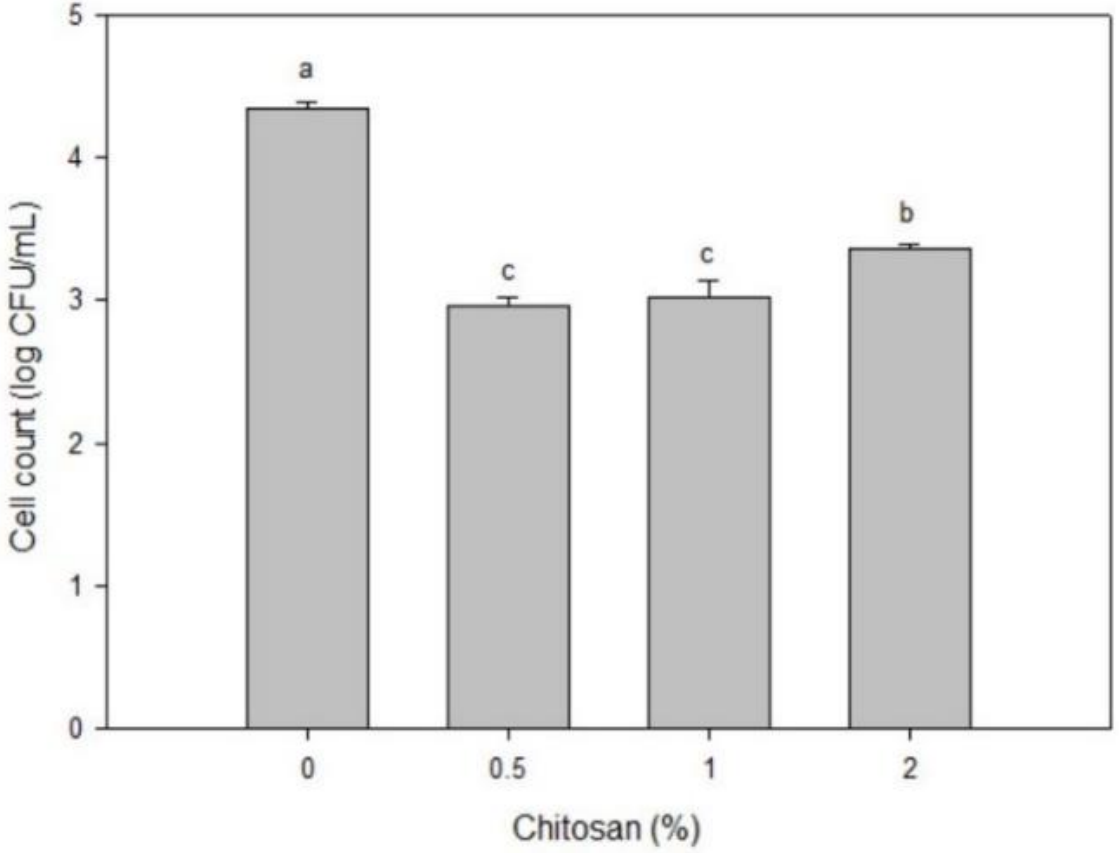
- Has antibacterial properties and inhibitory effects on fungi.

Nisin

- A natural antimicrobial peptide and a food biological preservative.

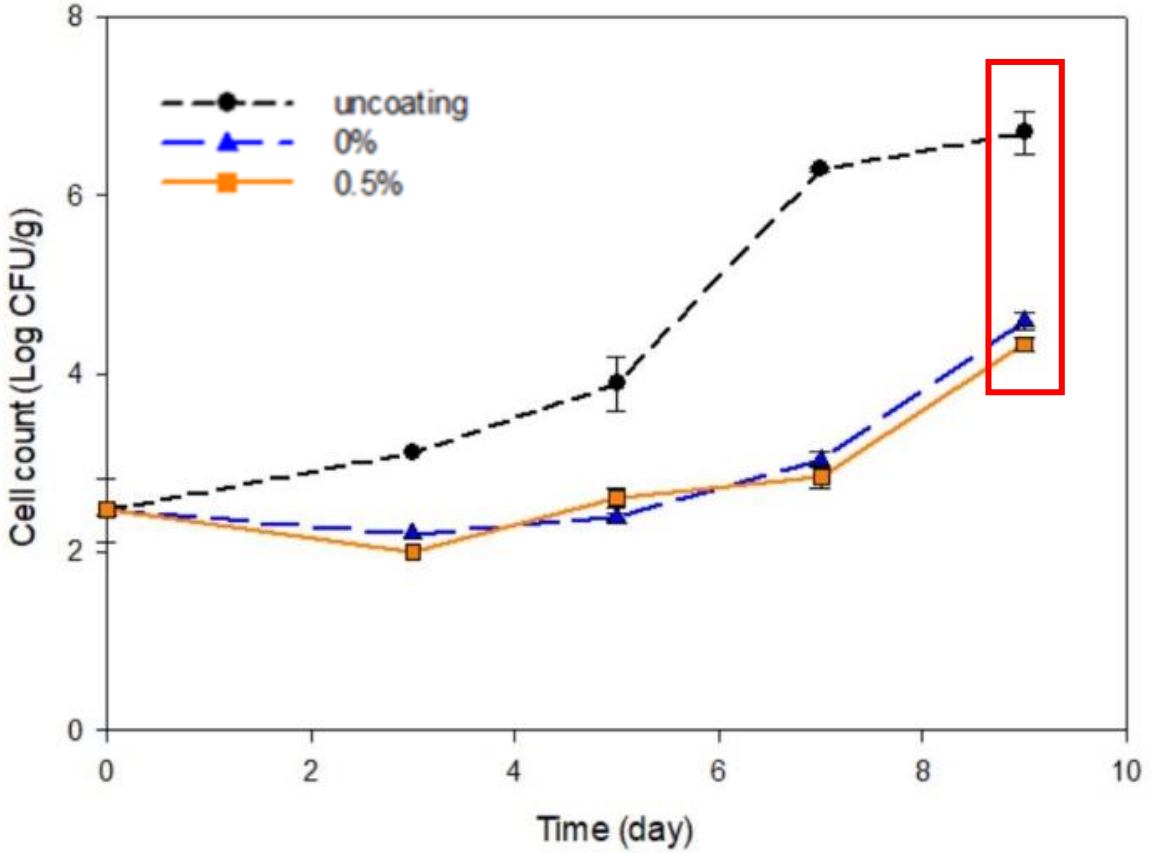
Antibacterial Packaging Results-Chitosan

Staphylococcus aureus



Measurement of antibacterial activity on plastics and other non-porous surfaces (CNS 15823).

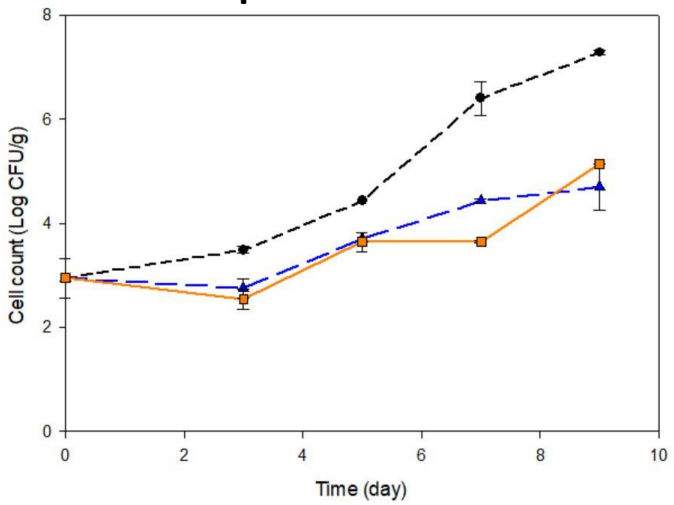
Escherichia coli



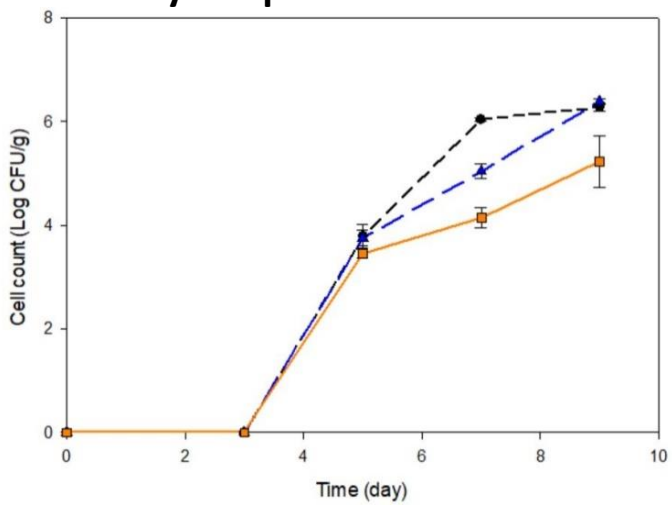
Changes in bacteria count in grouper fillets coated with 0% and 0.5% chitosan films during storage at 4 ° C.

Chitosan formula packaging material results

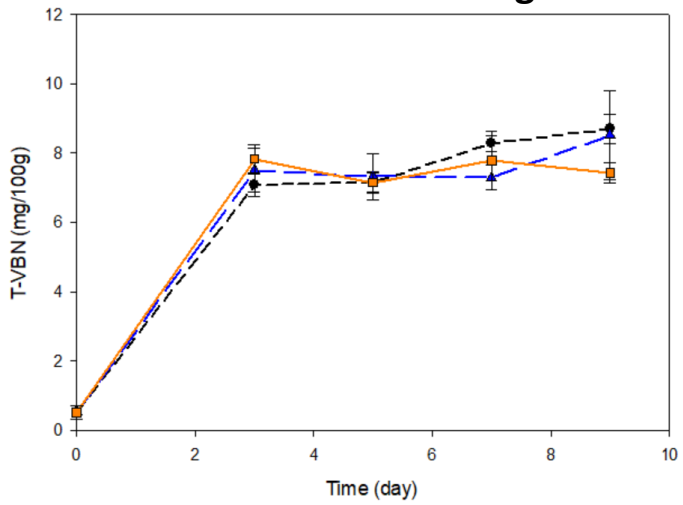
Mesophilic bacteria count



Psychrophilic bacteria count

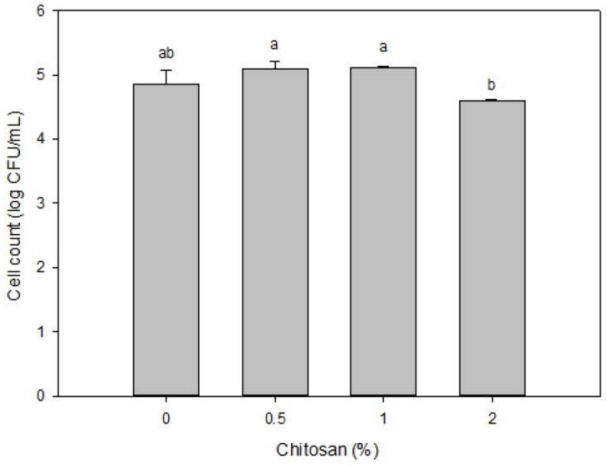


Volatile Basic Nitrogen

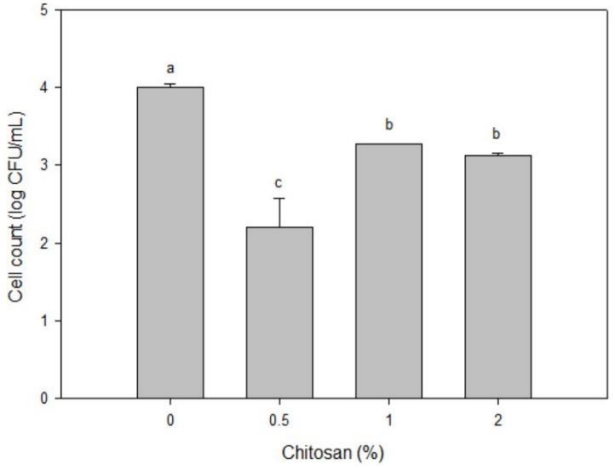


Changes in mesophilic bacterial counts, pyrolytic bacterial counts, and volatile basic nitrogen in grouper fillets coated with chitosan film during storage at 4 °C.

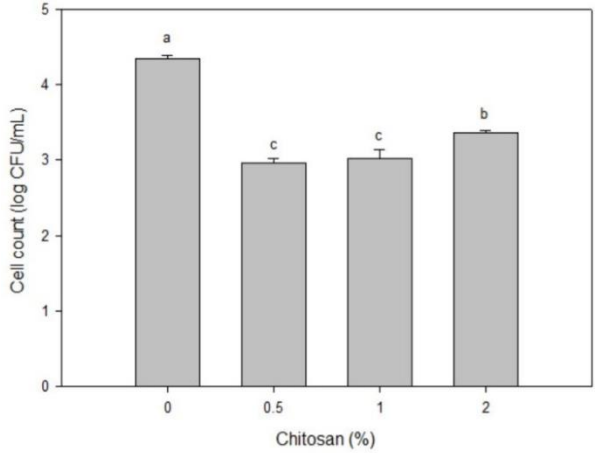
Escherichia coli



Pseudomonas fluorescens

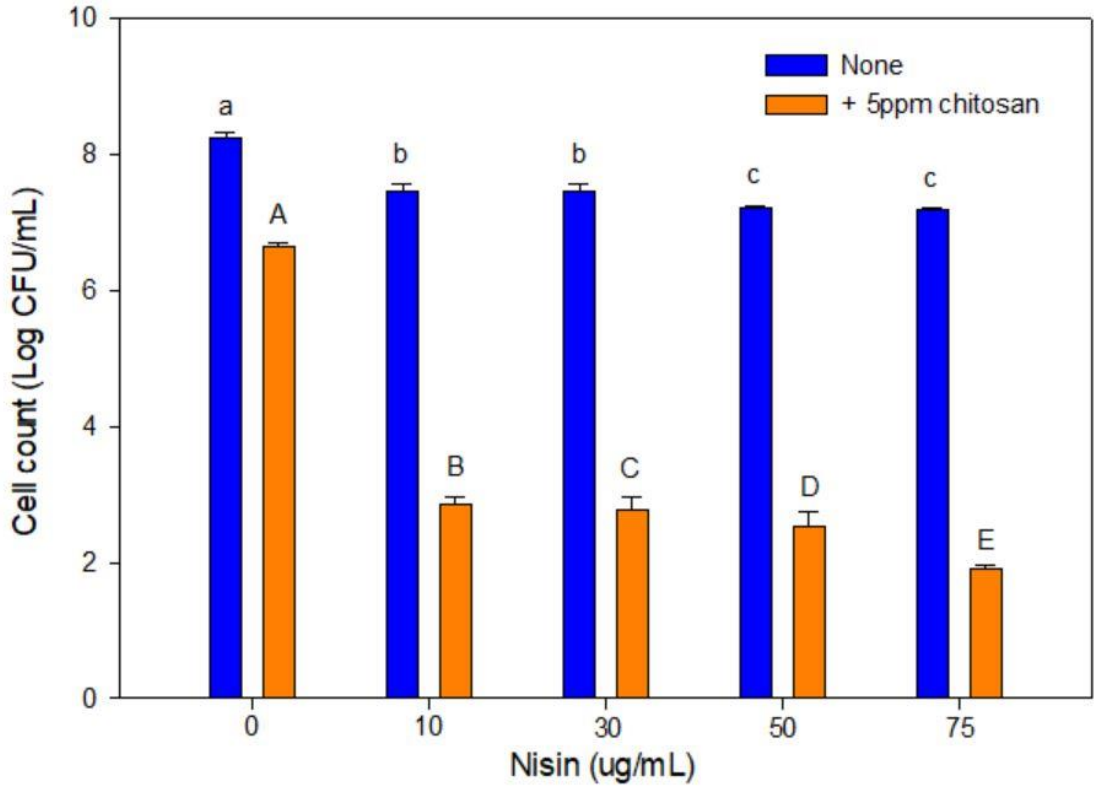


Staphylococcus aureus

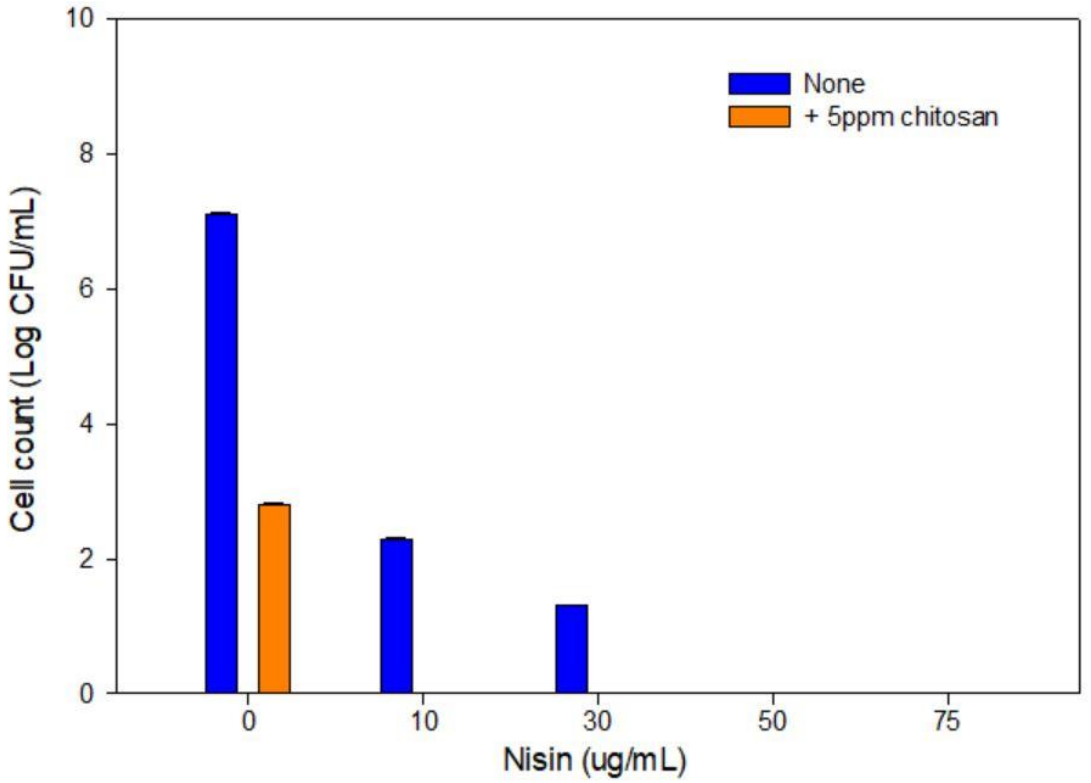


Antibacterial Packaging Results-Nisin

Escherichia coli

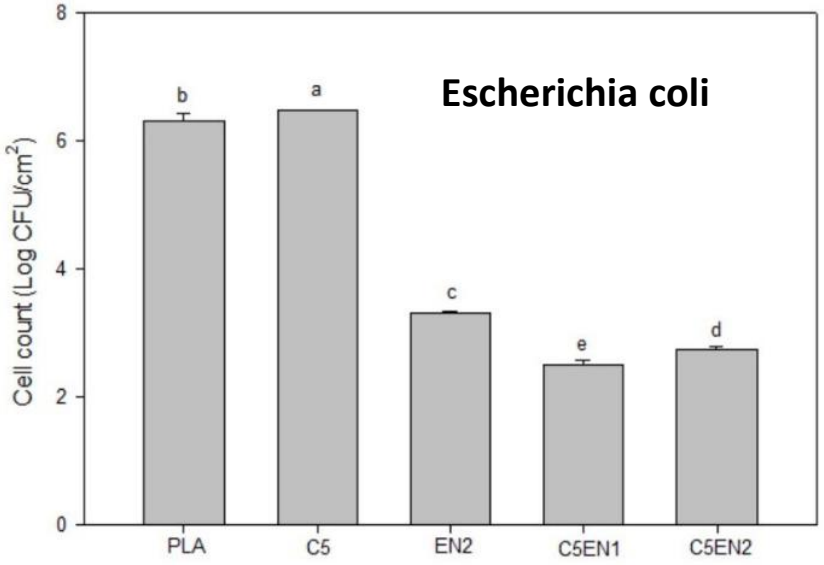


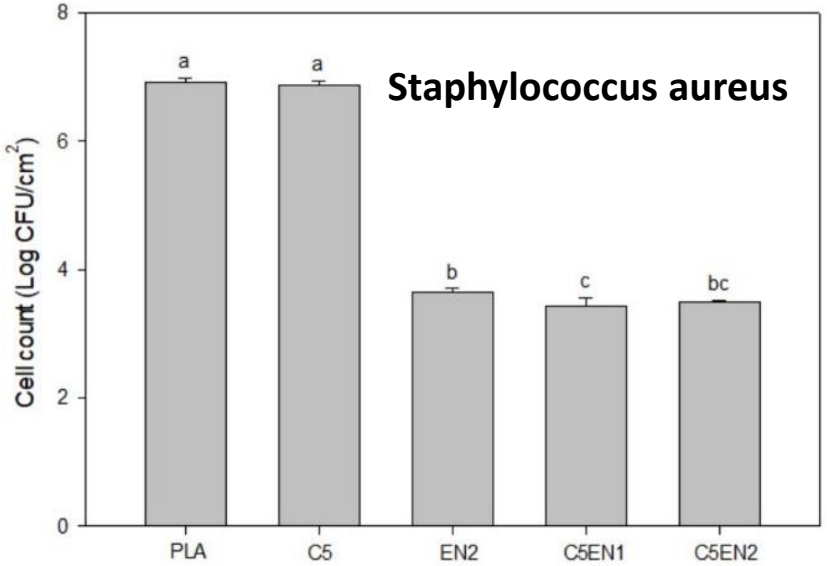
Staphylococcus aureus

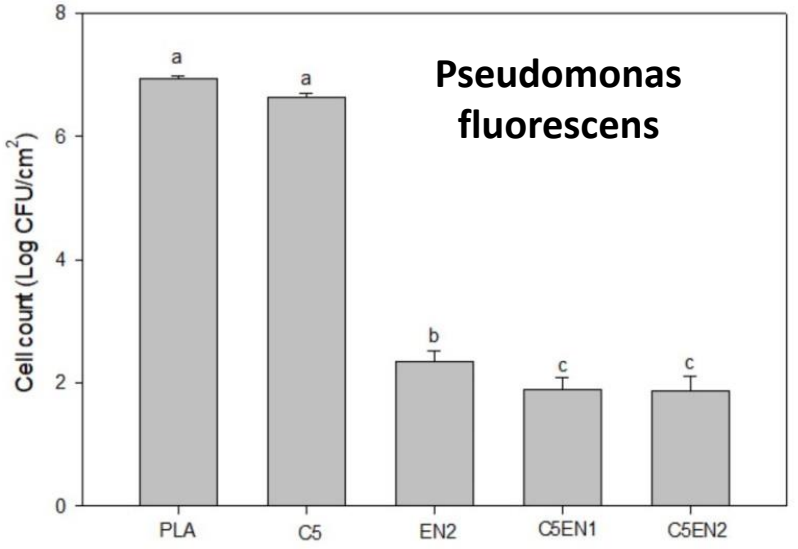


Effect of antibacterial effect with addition of chitosan to nisin

Antibacterial Packaging Results on Different Bacteria

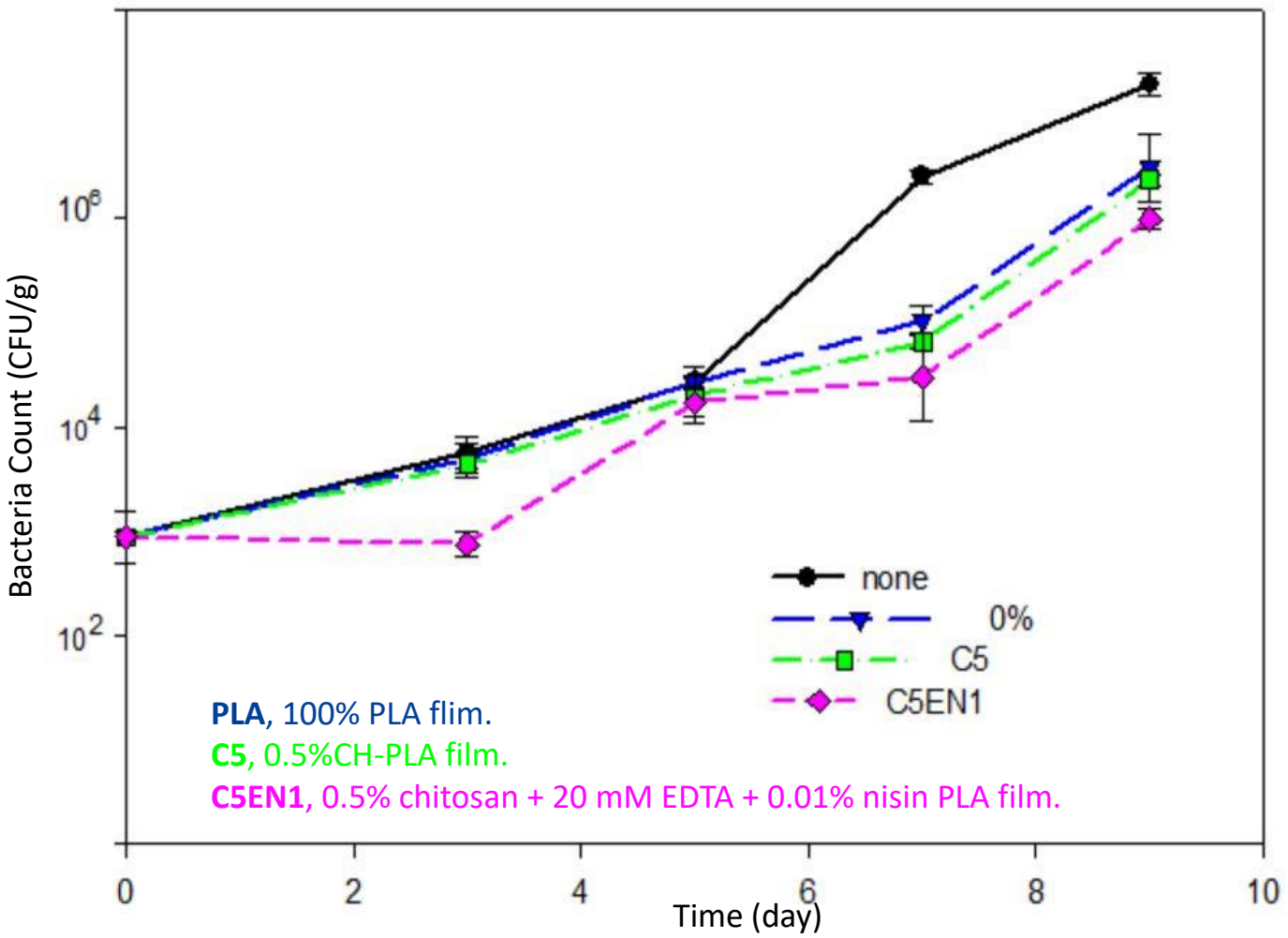






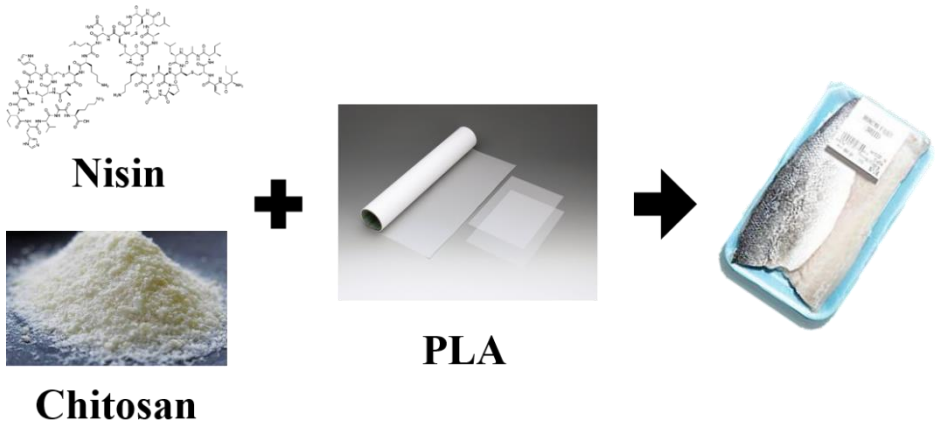
PLA, 100% PLA flim.
C5, 0.5%CH-PLA film.
EN2, 20 mM EDTA+ 0.02% nisin PLA film.
C5EN1, 0.5% chitosan + 20 mM EDTA + 0.01% nisin PLA film.
C5EN2, 0.5% chitosan + 20 mM EDTA + 0.02% nisin PLA film.

Antibacterial Packaging Results on Fish Fillet



Changes in total bacterial count for grouper fillet at 4 °C with polylactic acid plastic film (PLA), chitosan-polylactic acid plastic film (C5), chitosan-polylactic acid plastic film (C5EN1)

The bacterial count of **uncoated grouper fillets** exceeded the raw food standard on the **6th day**; the chitosan-polylactic acid plastic film (C5EN1) can effectively inhibit the increase of bacterial count in the first 3 days and **extend the shelf life to 9 days**.



Patent No. M663019 A long-acting sustained-release film structure

A long-acting slow-release film structure is provided. A plurality of fresh-keeping materials are sprayed onto the fresh-keeping carrier and dried, and then uniformly mixed with a plastic substrate and solidified to form the slow-release layer, thereby effectively controlling the release of the fresh-keeping materials from the long-acting slow-release film structure and slowing down the rapid precipitation of the fresh-keeping materials from the surface of the long-acting slow-release film structure.

Conclusion

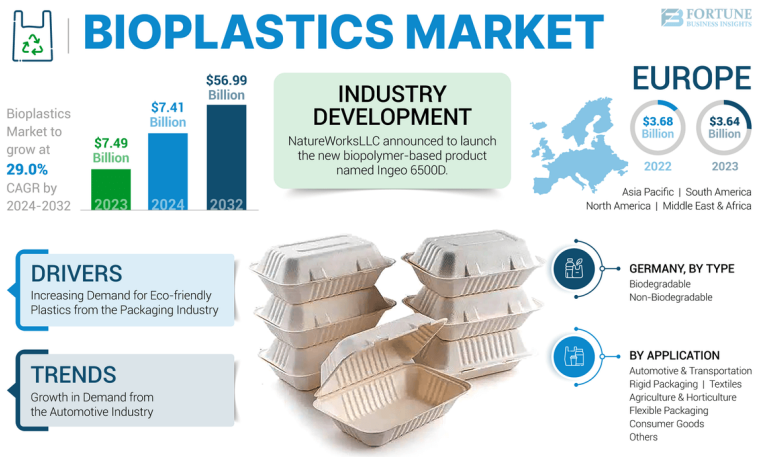
Material

Recyclable

- mono-material packaging to simplify the recycling processes.

Sustainable

- plant-based materials such as PLA (polylactic acid), cellulose, seaweed, and mushroom-based packaging (mycelium).



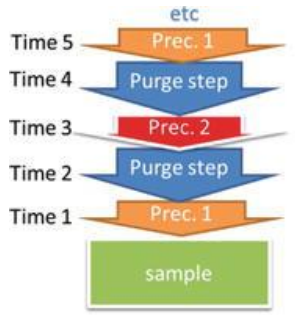
Function

Protective barrier

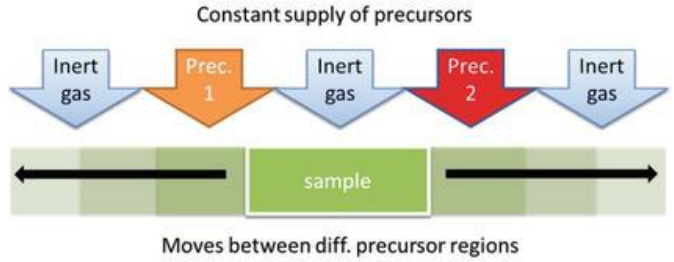
- Modified microenvironment around the developing fruit, protecting it from external stressors.

Prolonged storage

- Advanced materials and coatings developed to better protect food from oxygen, moisture, and other external factors.



Temporal ALD



Spatial ALD

Bioplastics Market Size, Growth, Share, Analysis, Report, 2032

Spatial Atomic Layer Deposition | IntechOpen

Thank you for your time.

Official Website
www.pidc.org.tw

PIDC Channel
reurl.cc/1Q5pMQ

Technology Transfer

Patent Licensing

Phone call
+886-4-2359 5900

- 3D printing and rapid tooling
- Environmental protection
- Composite materials
- Smart materials
- Membrane plastic sheets
- Rubbers and elastomers
- Food packaging materials
- Polymeric materials
- Medical devices
- Product design