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Active and Intelligent Packaging Systems to Enhance Safety and Shelf-life of Meat

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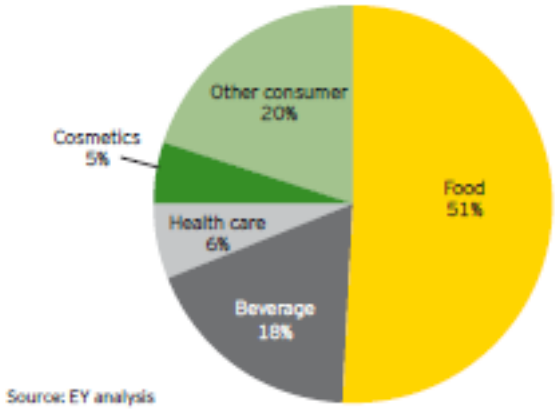
Canada

What we will talk about today

- Introduction: market, purpose, definitions, trends…
- Active packaging in meat industry: concepts, applications and innovations
- Intelligent packaging in meat industry: concept, application and innovation
- Take home…

Global packaging Market

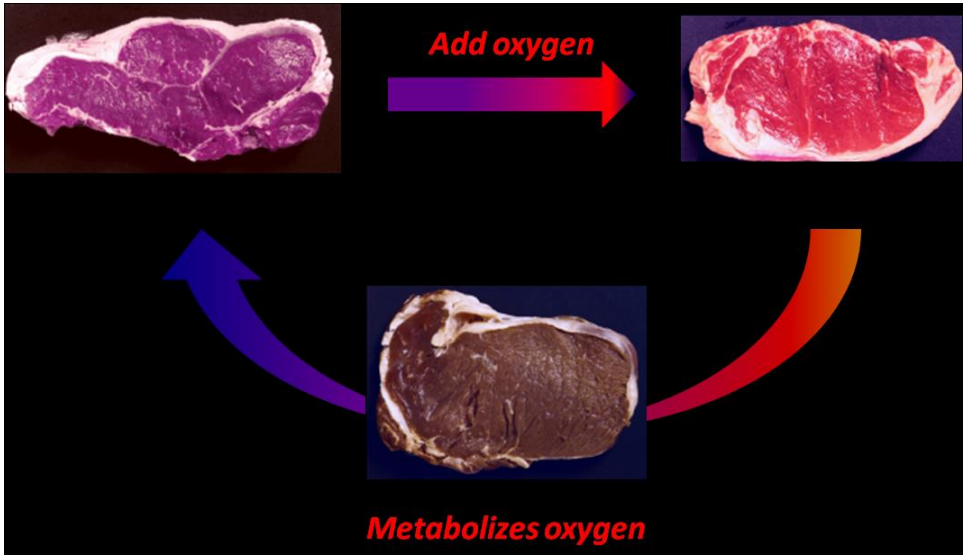


- 2012- $799 bn
- 2014- $812 bn
- 2015- $839 bn
- 2020- $997 bn

- Active & intelligent packaging
- 2021- $24.65 bn
  - US: $3.6bn
  - Japan: $2.36 bn
  - UK: $1.27 bn

Factors limiting the case life of meat

- Oxidation: Oxygen and light
- Moisture loss
- Compartmentalized odour/flavour
- Growth of spoilage and pathogenic bacteria



Functions of packaging

- Packaging should protect the product from contamination and prevent it from spoilage and at the same time should
  - Extend shelf-life
  - Facilitate distribution and display
  - Provide the consumer with greater ease of use and time-saving convenience
  - Communicate with the consumer as a marketing tool

Definitions

- **Active packaging technologies**
  - "changes the condition of the packed food to extend shelf-life or to improve safety or sensory properties, while maintaining the quality of packaged foods"

- **Intelligent packaging technologies**
  - "systems which monitor the condition of packaged foods to give information about quality of the packaged food during transport and storage"

Source: Ahvenainen, R. (2003). Active and intelligent packaging: an introduction. In R. Ahvenainen (Ed.), Novel food packaging techniques (pp. 5–21). Cambridge, UK: Woodhead Publishing Ltd..

Active and Intelligent Packaging

Active Packaging	Intelligent Packaging
Oxygen-scavenging packaging	Time-temperature integrator
Moisture-scavenging packaging	Freshness indicator
CO_2 control packaging	Gas permeation control packaging
Edible/biodegradable packaging	Radio-frequency packaging
Antimicrobial packaging	Shock/vibration abuse indicator

Active packaging

- “changes the condition of the packed food to extend shelf-life or to improve safety or sensory properties, while maintaining the quality of packaged foods”

- “Involves some physical, chemical or biological actions for altering the interactions between the package, the product and the package headspace to reach the desired outcome”

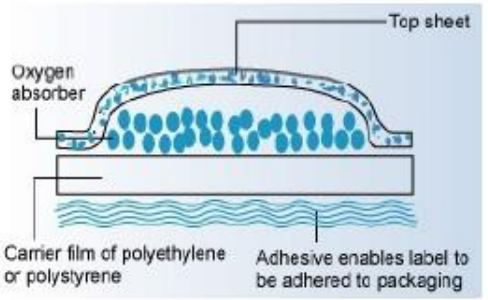
Source: Ahvenainen, R. (2003). Active and intelligent packaging: an introduction. In R. Ahvenainen (Ed.), Novel food packaging techniques (pp. 5–21). Cambridge, UK: Woodhead Publishing Ltd..

Active packaging of meat

- Oxygen scavengers
- CO_2 scavengers and emitters
- Moisture control
- Gas barrier and gas permeable films for MAP
- Antimicrobial packaging

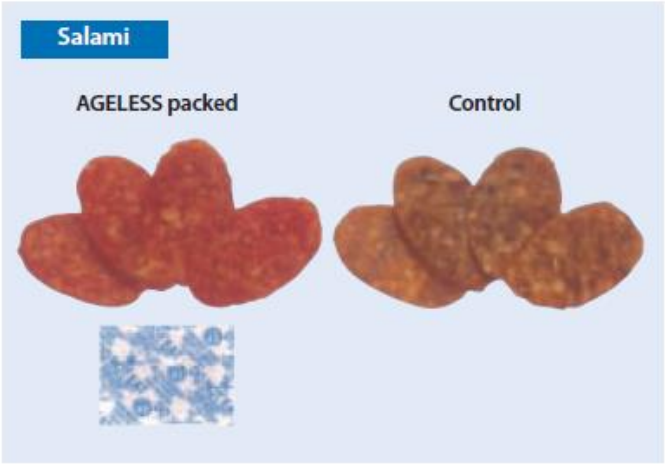
Oxygen scavenging systems

- High O_2 levels in food packages may facilitate microbial growth, development of off flavours and off odours and colour changes
- Oxygen scavenging systems provide an alternative to vacuum or gas flush technologies for improving product quality and shelf life
- Oxygen scavenging systems utilise one or more of the following concepts: oxidation of iron powder, ascorbic acid, enzymatic (glucose oxidase or alcohol oxidase)



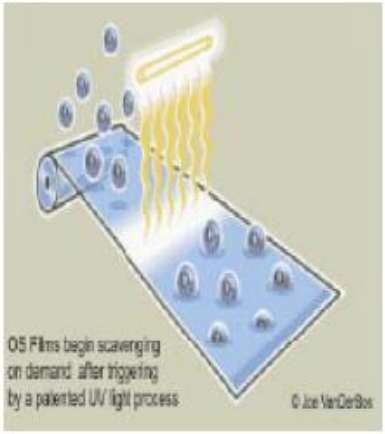
Oxygen scavengers (sachets)

- Oxygen scavengers can prevent growth of moulds and aerobic bacteria and oxidative damage of muscle pigments and flavours
- Commercial example
  - Ageless® (Mitsubishi Gas Chemical Co.)
  - FreshPax® (Multisorb Technologies Inc.)
  - ATCO® (Emco Packaging Systems)
  - Oxysorb® (Pillsburg Co.)
  - O-Busters® (Dessicare Inc.)



Oxygen scavenging films

- Oxygen scavenger layer extruded into multilayer films (PE, POE and PP)
- Cryovac OS2000® polymer-based O_2 scavenging film
- Oxygen scavenging compound incorporated into a polymer for use as a layer in a laminated packaging film
- Prevents light induced oxidation
- Eliminates the formation of oxidative by-products and protects nutrients, colour and flavour



CO_2 generators

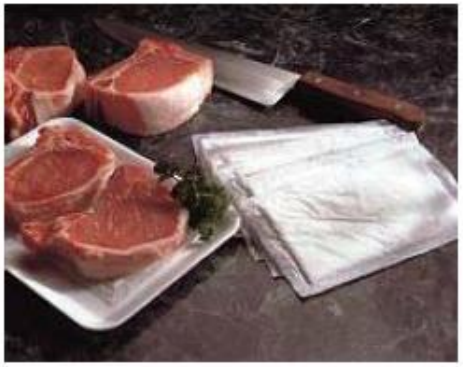
- The function of CO_2 within a packaging environment is to suppress microbial growth
- Since permeability of CO_2 higher than O_2 in most plastic films, it must be continuously produced to maintain the desired concentration within the package
- CO_2 levels at 10-80% are desired for meat and poultry products in order to inhibit surface microbial growth and extend shelf life
- CO_2 generators can be used in conjunction with O_2 scavengers

CO_2 generators

- Commercial examples
  - Ageless® G (Mitsubishi Gas Chemical Co.)
  - FreshPax® M (Multisorb Technologies Inc.)
  - Verifrais™ package (SARL Codimer)

Moisture-absorbing and controlling systems

- Lower the water activity of the product thereby suppressing microbial growth
- Super absorbent polymer located between two layers of a micro-porous or non-woven polymer
- Enhances product appearance and freshness
- Dri-Loc® (Sealed Air Corp.)
- Toppan™ (Japan)
- Fresh-R-Pax™ (Maxwell Chase Tech.)



Antimicrobial packaging

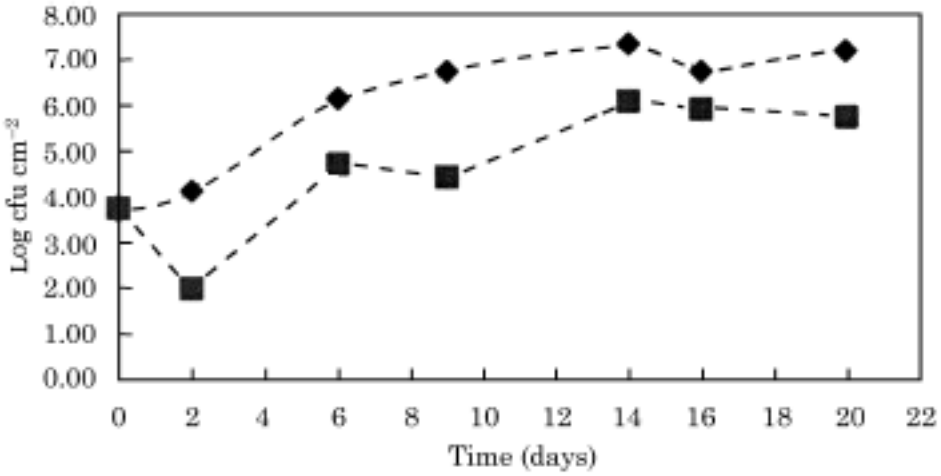
- Microbial contamination and subsequent growth reduces the shelf life of foods and increases the risk of foodborne illness
- Antimicrobial packaging is a promising form of active food packaging particularly for meat products
- Antimicrobial food packaging materials have to extend the lag phase and reduce growth rate of microorganisms

Bacteriocins

- Antibacterial peptides
  - Pediocin A, Lacticin 3147, Nisin
- Effective against G+ve foodborne pathogens and spoilage bacteria
- Incorporated into PE, PEO, alginate, zein or PVOH based bio-packaging with retention of antimicrobial activity
- Antibacterial activity enhanced in combination with organics acids and/or food grade chelators

Bacteriocins

Effect of PE base films incorporated with Nisin on spoilage of vacuum packaged raw beef



Brochothrix thermospacta population on raw beef

♦- VP; ■- VP with Nisin (PE based film with 0.1% Nisin)

Source: Siragusa et al. 1999. Food Microbiol.

Bacteriocins

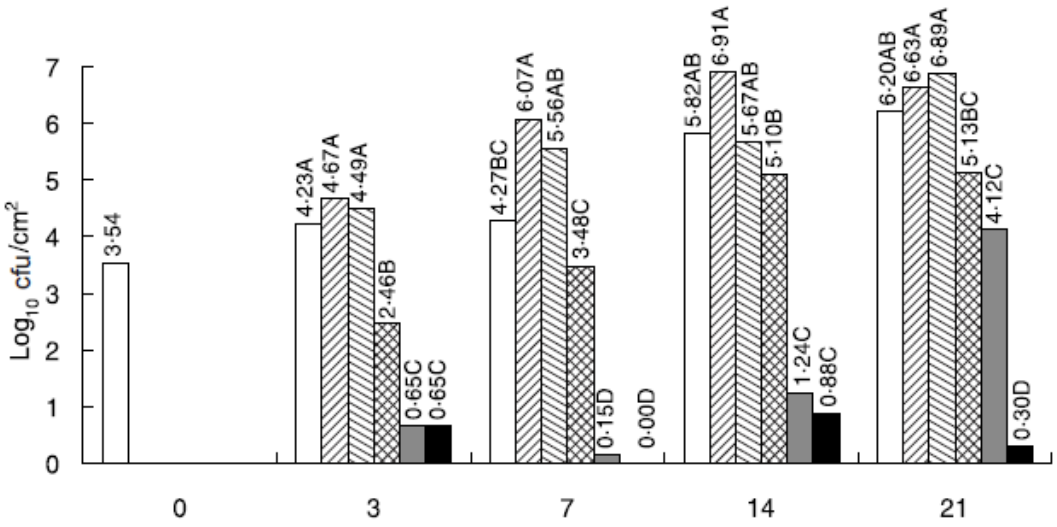
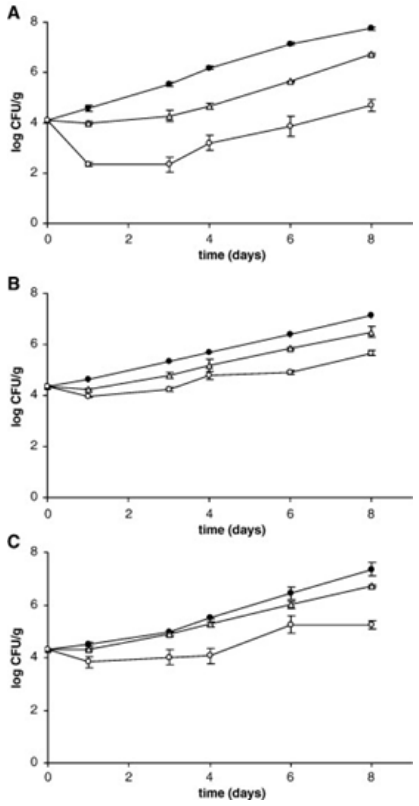


Fig. 4 Populations of *Brochothrix thermosphacta* on beef surfaces with the following treatments: untreated (□), PE (▨), PEO (▨), PE + nisin (▩), PE + nisin + EDTA (▩), and PE + PEO + nisin (■) and long-term, refrigerated (4°C), vacuum packaged storage

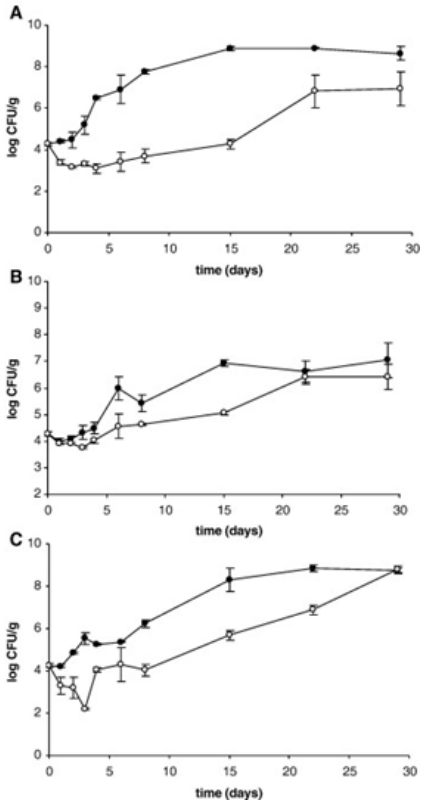
Source: Cutter et al. 2001. Letters Appl. Microbiol.

Bacteriocins

I



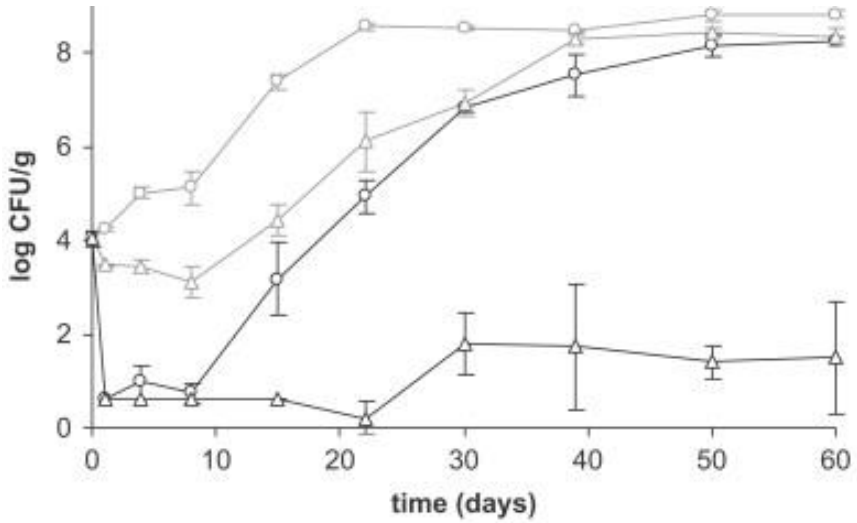
II



Growth of *L. monocytogenes* in sliced cooked ham air-packed (I) and vacuum packed (II) with alginate (A), zein (B), and polyvinyl alcohol (C) films containing 200 AU/cm^2 of enterocins (△), 2000 AU/cm^2 of enterocins (○), and control (●) stored at 6 ° C.

Source: Marcos et al. 2007. Int. J. Food Microbiol.

Bacteriocins



Growth of *L. monocytogenes* in sliced cooked ham vacuum packed with control alginate films (○), and alginate films containing 2000 AU/cm^2 of enterocins (△), submitted (black line) or not (grey line) to HPP and stored at 6 ° C.

Source: Marcos et al. 2008. Food Microbiol.

Edible/biodegradable packaging

- Chitosan, exhibit antifungal and antibacterial activity
  - GRAS status
  - Limited activity against G-Ve
  - Incorporation of organic acids enhance antimicrobial spectrum
  - Sausage casings: Chitosan-Carnosin, Chitosan-Sulphite
- Cellulose derivatives, Hydroxy propyl methyl cellulose (HPMC)
  - Sausage casings: HPMC-Organic acid-Nisin-EDTA

Spices and essential oils

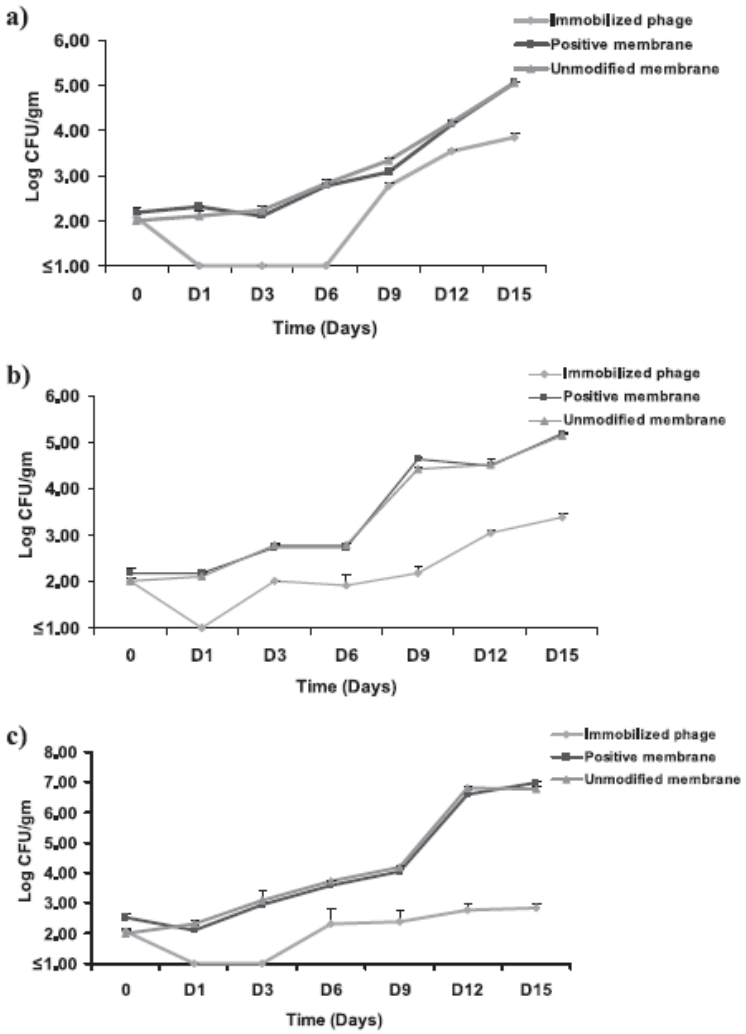
- Rich in phenolic compounds
- Incorporation into edible films are particularly interesting
- Seydium and Sarikus, 2006. Food Res. Int.
  - Whey protein based films incorporated with oregano or garlic essential oil effective against both G-ve and G+ve bacteria
- Ha et al. 2001.Packag. Technol. Sci.
  - Grapefruit seed extract incorporated by co-extrusion process in multilayered PE films
  - Reduced aerobic and coliform bacteria on fresh beef at 3°C for up to 18 days.
- Film containing Amexol (commercial of Rosemary extract concentrate) using three-layer PP material
  - Extend shelf life of beef steaks
  - Improved freshness (redness)

Bacteriophages


http://en.wikipedia.org/wiki/File:Phage.jpg

- Viruses of bacteria
- Antimicrobial agent
  - Medicine: Phage therapy
  - Biocontrol: Food safety
- Modified cellulose membrane (AEM 2011)
- Incorporation of phage into whey protein films (Food Hydrocolloids 2014)
- Incorporation of phages in cellulose acetate film (LWT-FS&T 2015)
- Paper impregnated with bacteriophage (IJFM 2016)
- Encapsulated bacteriophage applied to paper (IJFM 2016)

Bacteriophages

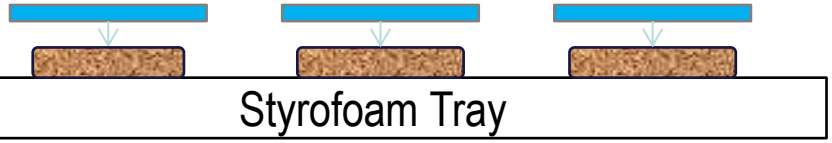


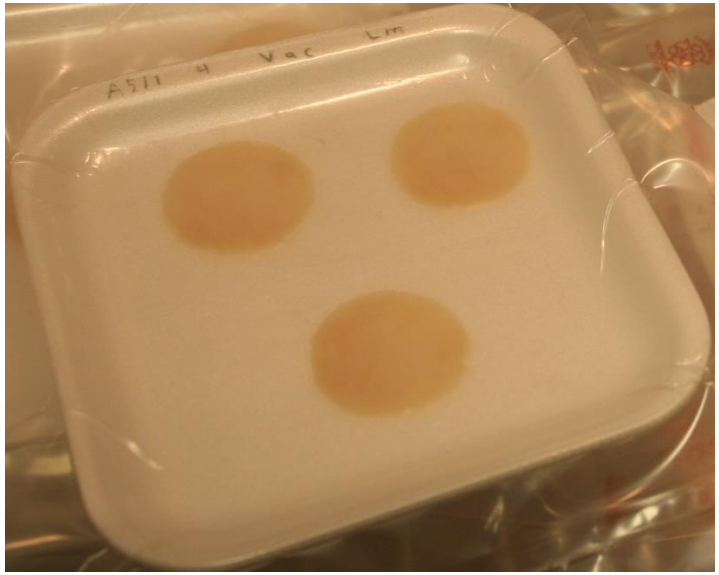
Effect of immobilized Listeria phage cocktail on growth of *L. monocytogenes* on oven-roasted turkey breast incubated at 4°C under aerobic (a), MAP (b), and Vacuum (c).

Source: Anany et al. 2011. Appl. Environ. Microbiol.

Aerobic deli bag or oxygen impermeable barrier bag

Coated PLA packaging square
Sliced cooked turkey breast

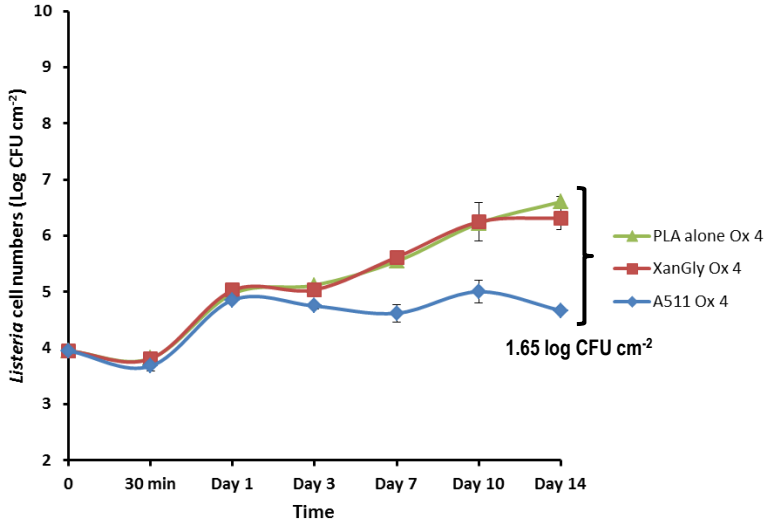




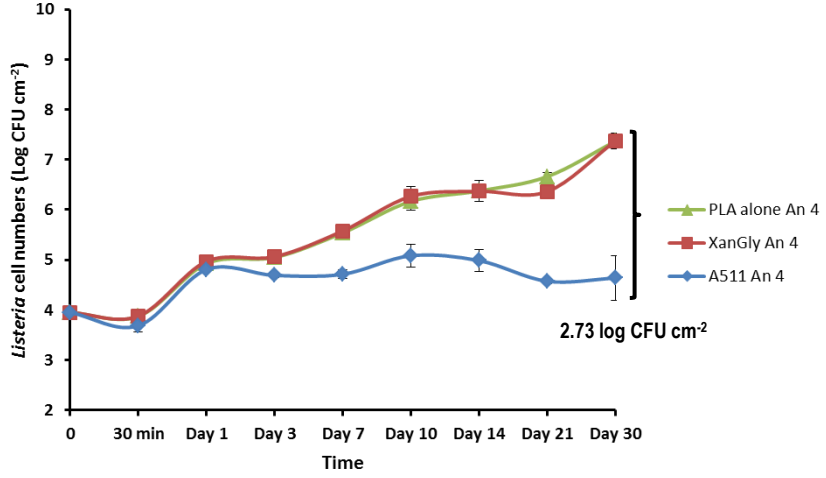
Samples of sliced turkey vacuum packed with phage coated PLA

Listeria monocytogenes cell numbers inoculated on sliced cooked turkey breasts packaged with PLA films with different coating and stored at 4° C under aerobic (A) and anaerobic (B) conditions

A

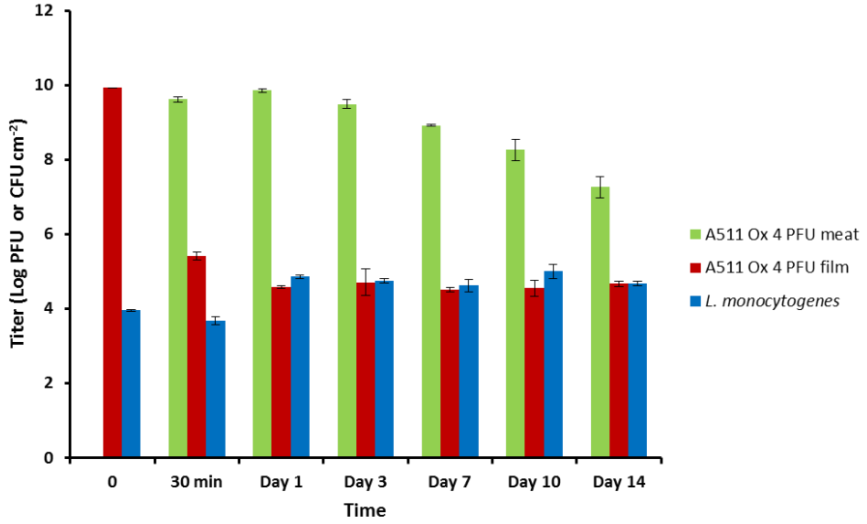


B

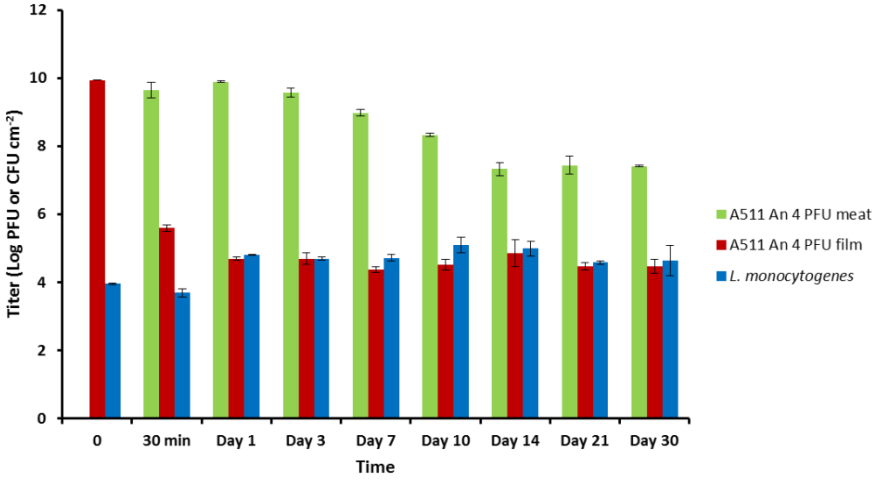


Phage titers and *L. monocytogenes* cell numbers on PLA films and sliced cooked turkey breasts stored at 4° C under aerobic (A) and anaerobic (B) conditions

A



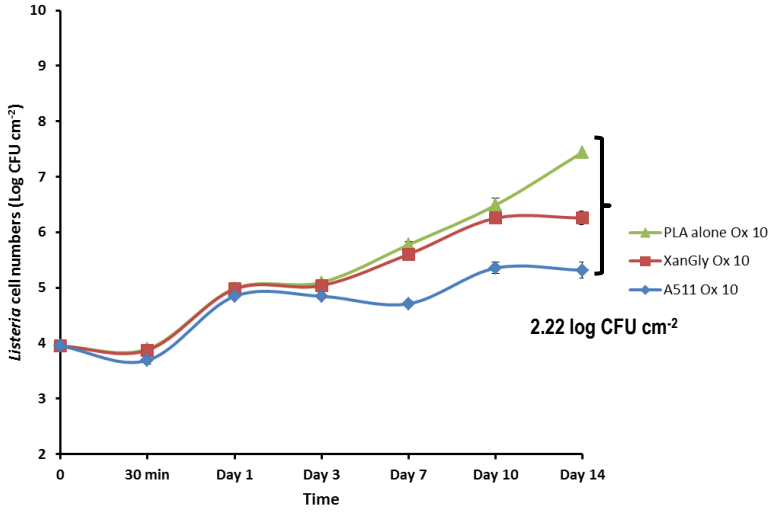
B



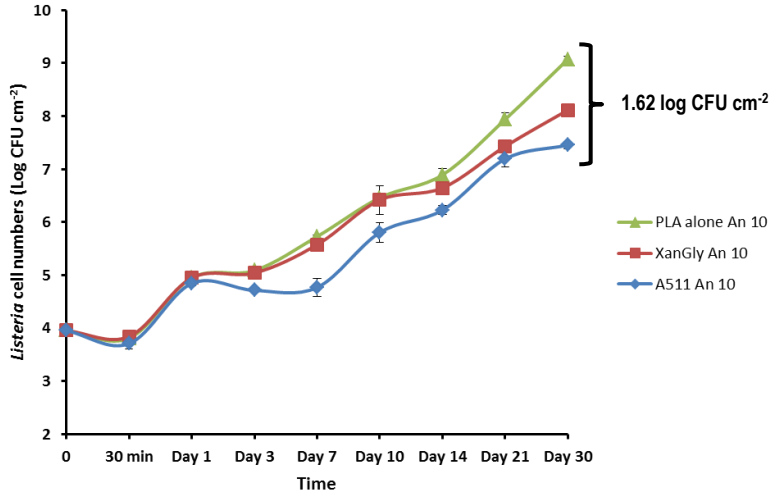
Source: Radford et al. Food Microbiol. Under review.

Listeria monocytogenes cell numbers inoculated on sliced cooked turkey breasts packaged with PLA films with different coating and stored at 10° C under aerobic (A) and anaerobic (B) conditions

A



B



Phage titers and *L. monocytogenes* cell numbers on PLA films and sliced cooked turkey breasts stored at 10° C under aerobic (A) and anaerobic (B) conditions

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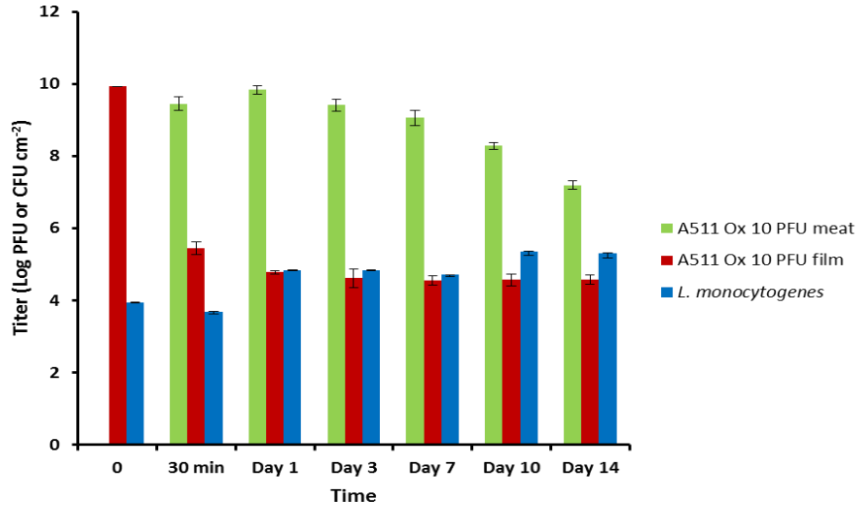
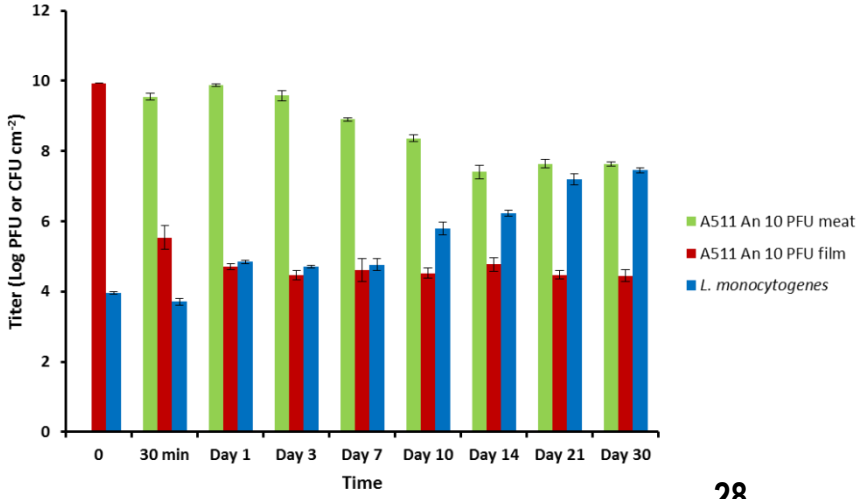


B



Source: Radford et al. Food Microbiol. Under review.

Intelligent packaging

- **Intelligent packaging technologies**
  - "systems which monitor the condition of packaged foods to give information about quality of the packaged food during transport and storage"
- Intelligent packaging has the ability to:
  - Track the product
  - Sense the environment inside or outside of the package
  - Inform the manufacturer, retailer and consumer
- Applications
  - Pack integrity
  - Safety/quality indicators
  - Traceability/anti-theft devices
  - Product authenticity

Intelligent packaging

- Sensors
  - Gas sensors
  - Fluorescence based oxygen sensors
  - Biosensors
- Indicators
  - Integrity indicators
  - Freshness indicators
  - Time temperature indicators
- RFID tags

Intelligent packaging

- Gas sensors
  - Devices that respond reversibly and quantitatively to presence of a gaseous analyte by changing the physical parameters of the sensor and are monitored by an external device.
  - Destructive analysis of packages
  - New optical and optochemical sensing technologies are currently being developed
- Fluorescent oxygen sensors

Bio-sensor: The Food Sentinel System™

- The biosensor is capable of continuous detection of pathogens in food packages
- Specific pathogen antibody is attached to a membrane forming part of the barcode
- The presence of the contaminating bacteria will cause the formation of a localized dark bar, rending the barcode unreadable upon scanning

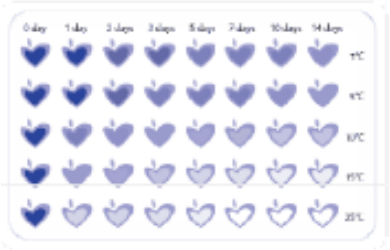
Indicators

- Use oxygen sensitive dyes; colour changes from white to blue I the presence of a leakage

- Ageless Eye indicating tablets verify that all the oxygen has been absorbed from the package
- Oxygen indicator is blue in normal atmosphere and pink when concentration of O_2 is below 1%

Time temperature indicator

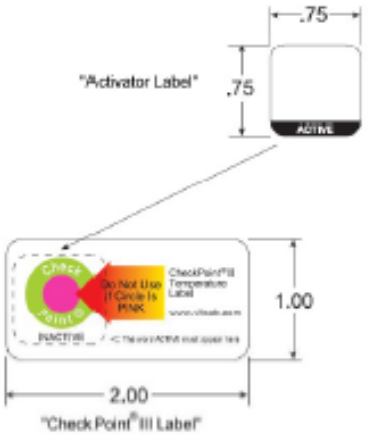
- OnVu Time-Temperature Indicator
  - Allows producers, retailers and consumers to check at a glance whether perishable products have been correctly transported and stored
  - OnVu relies on the properties of pigments that change colour over time and if temperature fluctuates



Time temperature indicators

- CheckPoint labels: Enzymatic TTIs
  - Warns of any time-temperature conditions which could potentially represent abusive conditions that might lead to growth of pathogens
  - Colour changes are induced by a drop in pH resulting from the controlled enzymatic hydrolysis of lipid substrate
  - pH drop results in a colour change from

    dark green to bright yellow

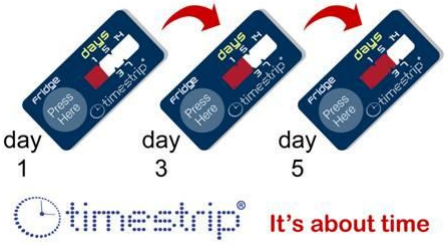


SensorQ™: Senses spoilage in fresh meat

- Detects foodborne bacteriological levels right inside the package
- When inside of the quality “Q” label is tangerine orange, the product is fresh. When the bacteria count in the package builds to a critical level, the orange turns to tan to indicate spoilage

TIMESTRIP® : Expiry date indicator

- Single-use, disposable smart label
- Automatically monitor lapsed time: from under 1 day to 6 months
- Works by capillary action, tinted liquid migrates through a microporous material at a consistent rate
- Provides a simple and safe way of monitoring food freshness



Take home- Active packaging

- Active packaging is useful for extending the shelf life of fresh, cooked and other meat products
- Commercially, there is a widespread use of oxygen scavengers in pre-packed cooked sliced meat products
- Antimicrobial packaging is gaining interest from researchers and industry due to its potential for providing quality and safety benefits

Take home- Intelligent packaging

- A variety of indicators are of interest to the meat packaging chain, such as TTI (cold chain management), freshness and leakage indicators
- Intelligent packaging offers considerable potential as a market tool and the establishment of brand differentiation for meat products

Drivers in packaging innovation

- Increase in consumer demand for ready-prepared foods
- Changes in retail and distribution practices associated with globalization
- Stricter requirements regarding consumer health and safety
- Shelf-life extension
- Cost efficiency
- Environmental issues: reduction, recycling, biodegradability
- Request for fewer or no food additives/preservatives

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Thank you!

Canada