

PACKAGING TECHNOLOGY & RESEARCH

INTELLIGENT PACKAGING –
WHY & WHERE INNOVATION
IS HAPPENING NOW &
IN THE FUTURE

Nov 2023



Dr. Claire Sand thinks “all food packaging all the time”



Claire’s mission is to enable a more sustainable food system with science and value chain innovations that more sustainably increases food shelf life and prevents food waste

- 35+ years of food packaging experience
- Ranks innovative packaging science and value chain solutions to extend shelf life
- Generates implementation roadmaps and aligns business cases
- IFT Fellow, Riester-Davis-Brody life-time achievement in food packaging award recipient
- PhD in Food Science and Nutrition at University of Minnesota
- MS and BS in Packaging at Michigan State University

Owner



Adjunct Professor



Monthly Columnist



Current Leadership & Editorial Boards



Recent Awards



Riester-Davis-Brody
Food Packaging
Lifetime
Achievement Award



IFT Fellow



**Future of
Food Packaging**



**Active
Packaging**



**Intelligent
Packaging**



**Value Chain
Drivers**



Material Science



**Process & Package
Interactions**



**Migration
Complexities**



**Global Research
Institutes**



Food Waste



**Consumer
Research on
Sustainability**



**More
Sustainable
Packaging**

**Our solutions are
tailored to client needs**

More Sustainable Packaging

We help clients achieve more sustainable packaging with packaging solutions that are Rational, Defensible, and Achievable.

CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Increase Shelf Life & Prevent Food Waste

PTR's science-based packaging solutions increase food shelf life and prevent food waste.

CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Food Packaging Innovations

PTR helps businesses identify and enact meaningful packaging innovations that meet business goals.

CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Food Package Optimization & Problem-Solving

We fine-tune food packaging using material science, deep value chain, and cost-savings experience.

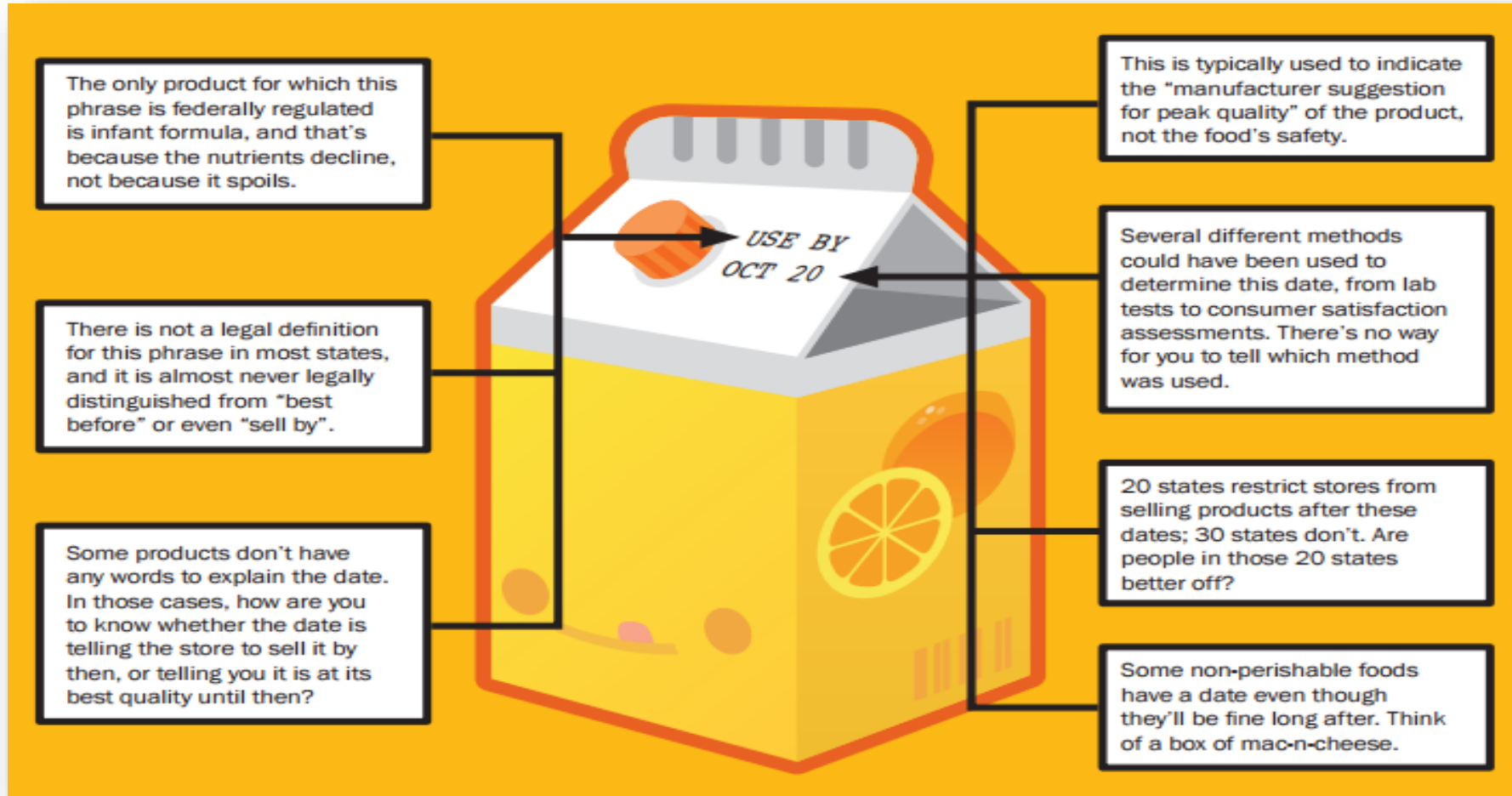
CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Expert Witness

Dr. Claire Sand is a food packaging expert with 35+ years in industry and 18+ cases as an Expert Witness.

CLIENTS: ATTORNEYS WORKING ON FOOD AND BEVERAGE, PACKAGING & LABELING OR PATENT & INTELLECTUAL PROPERTY LITIGATION AND LAWSUITS

We have needed intelligent packaging for a long time



We have had intelligent packaging for a long time

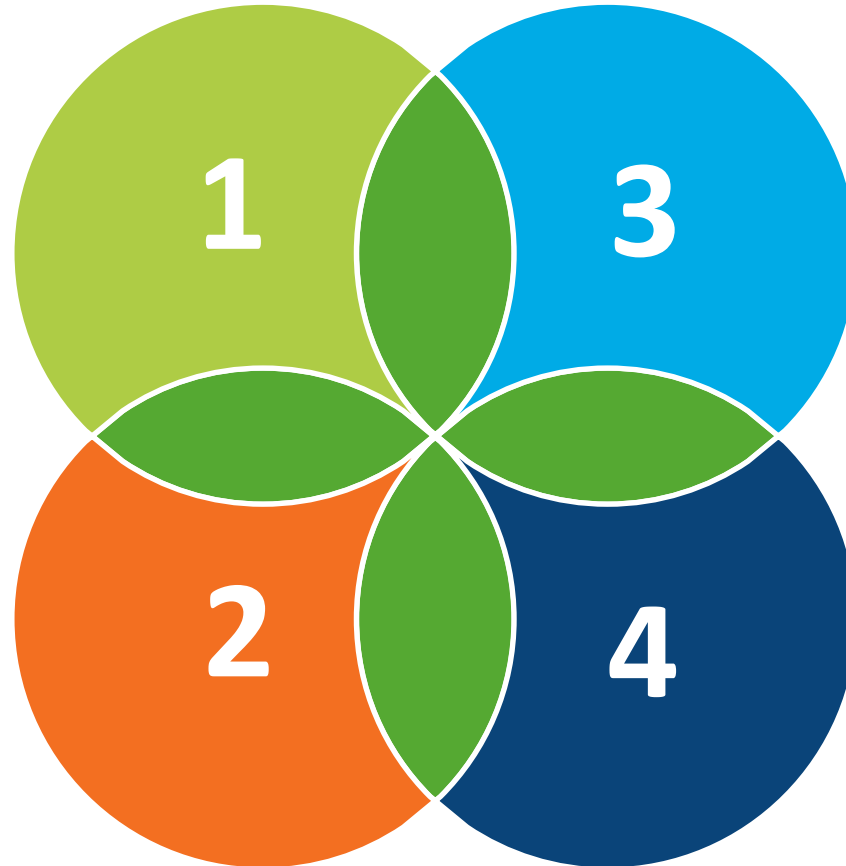


Key Takeaways

The Value Chain is moving intelligent packaging forward

Intelligent packaging technology is advancing

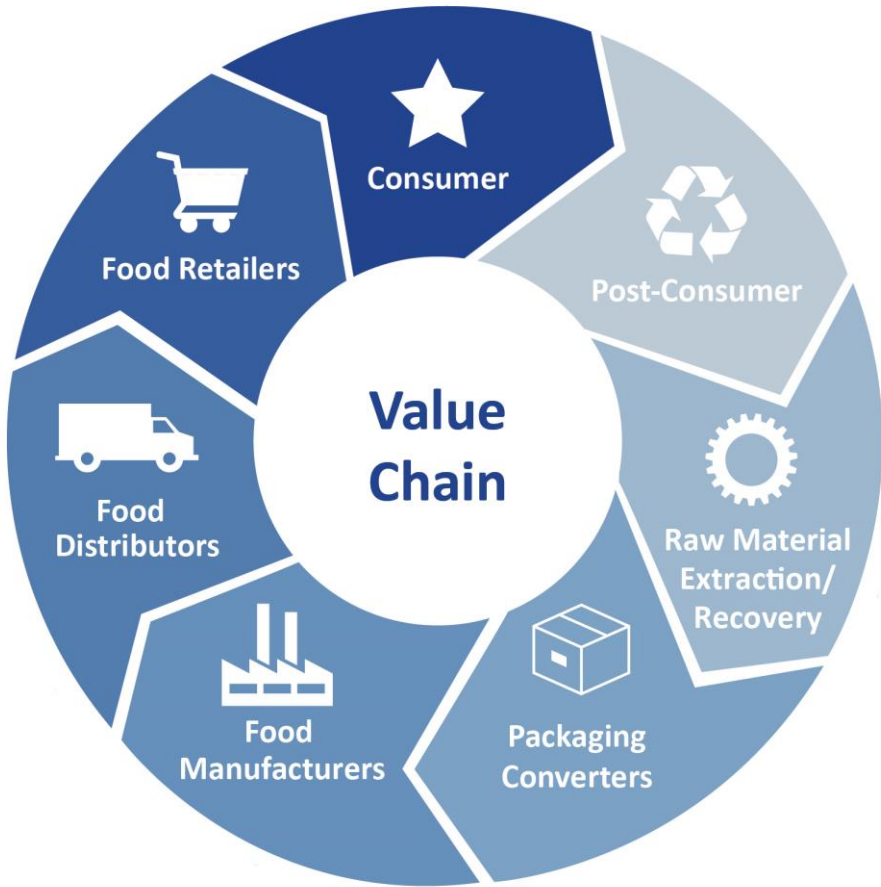
- Effective kinetic modeling
- Indicator technology
- Shifts underway



Future is bright for Intelligent Packaging

Q&A

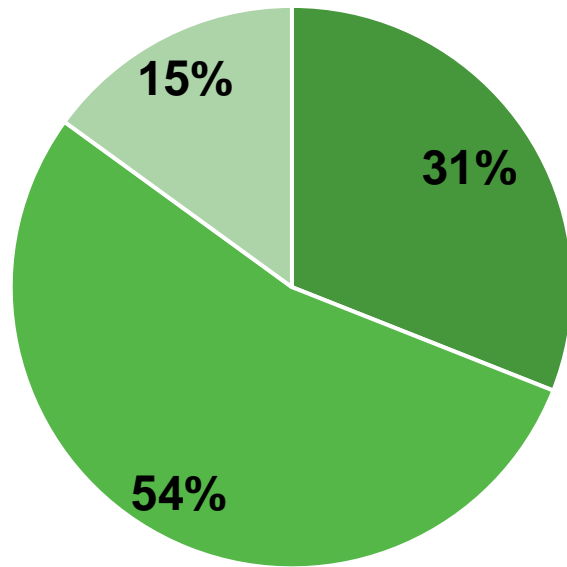
The Value chain makes the business case



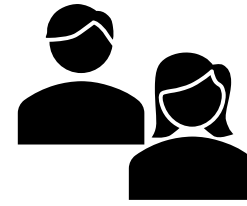
- Food Safety
- New Value chain Drivers build on old drivers of
 - Consumers
 - Retailers & QSRs
 - Brands
 - Post-Consumer Waste handling - Sustainability

Would pay \$1 for a Freshness Indicator on Beef packaging

How much more would you pay for an indicator?



■ 0-50 cents ■ 50 cents-\$1 ■ More than \$1



- See value
- Food justice
- Food Chain of Custody
- \$ - food waste

"A visual way to see how fresh the product is."

"I am always wondering if my meat is still good."

"Would definitely help me save food."

"Help you know the freshness and prevent illness"



And the industry is ready

Retailer resistance lowering

- Labor savings
- Food waste
- Reduced unsaleables and rotating poor stock
 - @Hema, sensors linked to digital prices tags that lower \$\$\$ when food shelf life declines
- Ensure Safety and Quality

QSRs invest in food safety with Intelligent Packaging

Frozen Food Company

SITUATION

Listeria growth is undetectable below 3cfu/ml and product could contain *Listeria* due to lack of a tight cold chain

SOLUTION



Screened, ranked, and sourced intelligent packaging options to detect <3cfu/ml *Listeria monocytogenes* in prepared food



Defined value chain benefits - improved food safety and reduce labor - to build the business case for top ranked option

RESULTS

- ✓ **Eliminated risk** of *Listeria* in QSR products
- ✓ Charted **intelligent packaging as a competitive advantage**
- ✓ **Confidence** in the entire value chain that the product is safe for consumption
- ✓ Switch from a “when in doubt, throw it out” mentality that **reduced food waste by 15%**
- ✓ **Expanded sales** due to less food waste

Brands optimize production and logistics

- Save \$
 - Less unsaleables at Retail
 - Avoid fees - food waste banned in Vermont
 - Optimize preservatives
- Expand distribution
- Provide on demand information
- Increase shelf life

Post-Consumer Waste and Food handling efficiency occurs

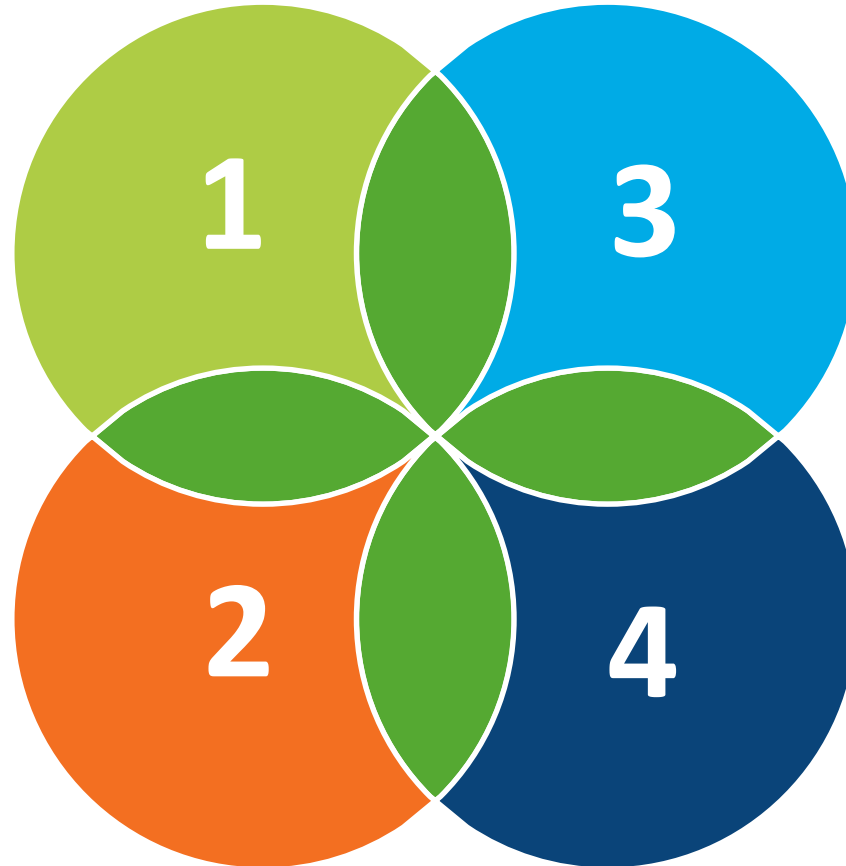
- More efficient circular economy
 - Aid in collection & sorting
 - Packaging Chain of Custody to enable use of recycalate
- Add post-consumer value to packaging
- Less landfill space - food waste
- Linked to Food Chain of Custody enables Secondary Market recovery

Key Takeaways

The Value Chain is moving intelligent packaging forward

Intelligent packaging technology is advancing

- **Effective kinetic modeling**
- **Indicator technology**
- **Shifts Underway**



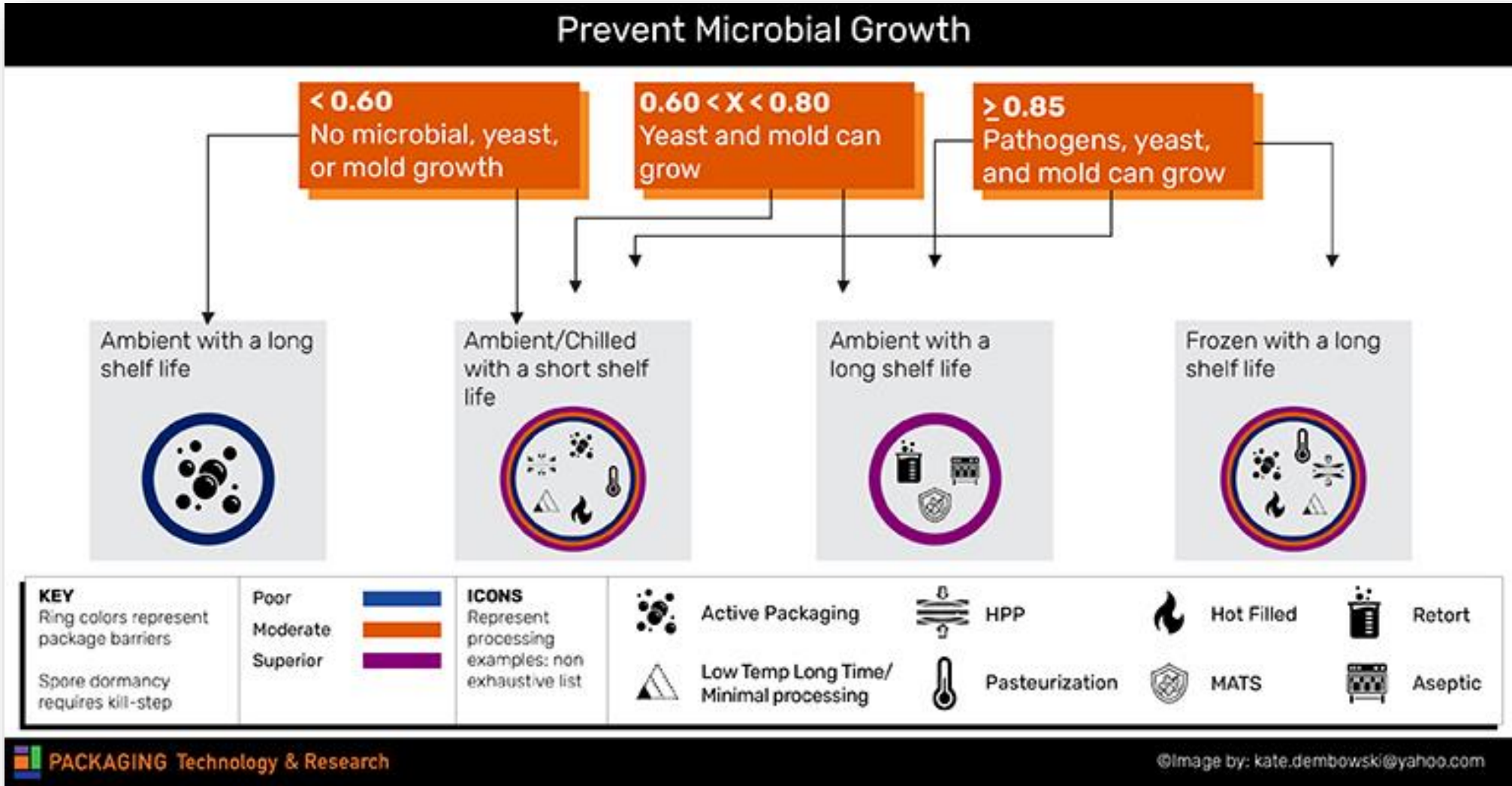
Future is bright for Intelligent Packaging

Q&A

Technology continues to advance

- More options exist
- Costs lowered
- Shifted from time and temperature monitors to matching kinetics of degradative reactions
- Shifting from sensing degradation to acting to preserve food

Modeling degradation kinetics is product and package specific



Modeling degradation kinetics is refined

Response function

$$F(X) = kt = k_{l_{ref}} \exp\left(\frac{-E_{a_l}}{R} \left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right) t$$

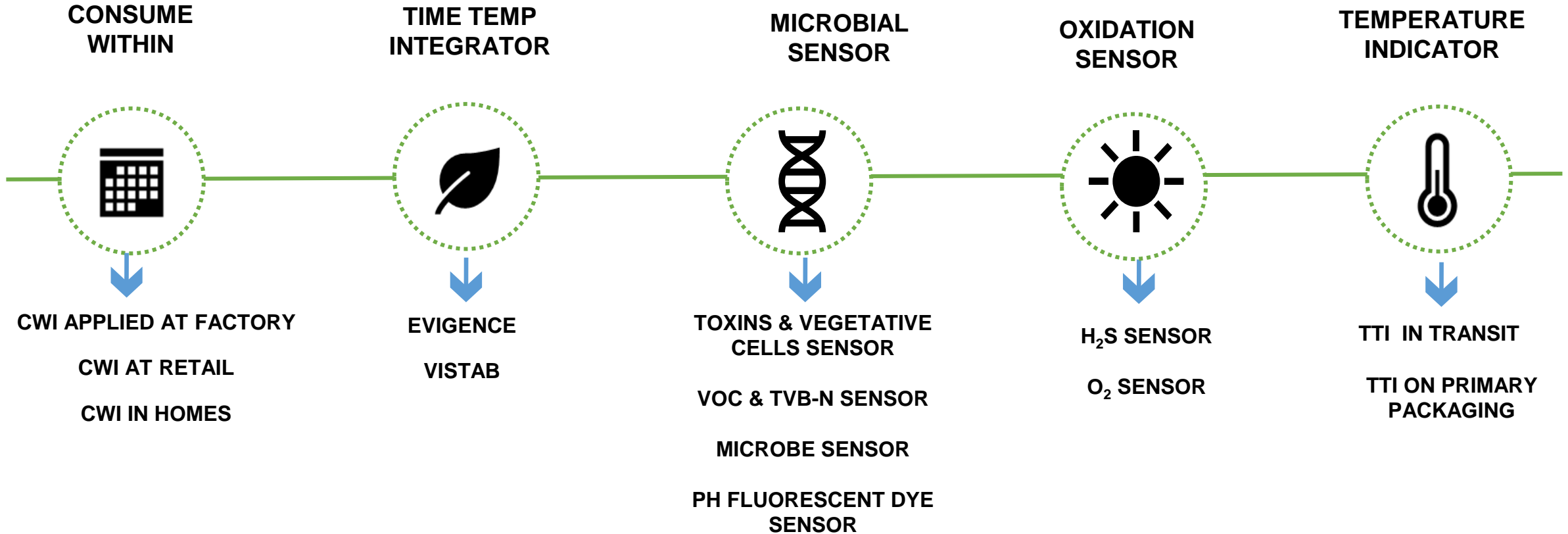
For variable temperature distribution

$$F(X)_t = \int_0^t k[T(t)] dt = k_{l_{ref}} \int_0^t \exp\left(\frac{-E_{a_l}}{R} \left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right) dt$$

Using effective temperature

$$F(X)_t = k_{l_{ref}} \exp\left(\frac{-E_{a_l}}{R} \left(\frac{1}{T_{eff}} - \frac{1}{T_{ref}}\right)\right) t$$

Intelligent Packaging Technology I Overview



Intelligent Packaging Technology I Overview

RESPONSIVE PACKAGING

1

- Responsive Packaging senses, communicates, and then acts to extend the shelf life
- Sensors sense stimuli and then release compounds to retard degradative reactions
- Responses are be tailored for internal or external stimuli such as light, temperature, O₂, microbial growth, or moisture

SENSORS THAT DEFINE SHELF LIFE

2

- Allows for supply chain, package and product formula changes because shelf life to determined in the actual supply chain and product
- Added value is in decreasing food waste and allowing flexibility with shelf life based on conditions at which the product has been exposed

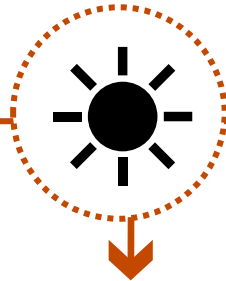
TRACK AND TRACE AND ENHANCED BRANDING

3

- QR codes have the loP/IoT low potential with changing web-based delivery to consumers and supply chain
- NFC and RFID sensors have the most potential when consumer interfaces are integrated with track and trace needed within the supply chain
- A balanced cost and benefit of the technology in between the supply chain and brand owner is needed

Increase shelf life – RESPONSIVE Packaging

OXIDATION



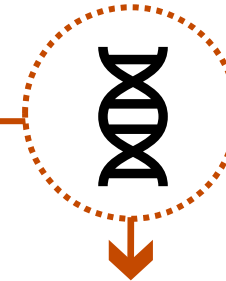
LIGHT-RESPONSIVE O₂ SCAVENGING FILMS / LINERS

HYDROGELS FOR ANTIOXIDANT RELEASE

HYDROGELS TO ADJUST CHANGING LIGHT CONDITIONS

CYCLODEXTRIN WITH REVERSIBLE INTERACTION FORMING WITH POLYMERS

MICROBIAL



TEMPERATURE-RESPONSIVE HYDROGELS

PH-RESPONSIVE HYDROGEL AND BIOACTIVE FILMS

PH AND TEMPERATURE-RESPONSIVE HYDROGELS

BIORESPONSIVE HYDROGELS

PH RESPONSIVE POLYSACCHARIDES

Increase shelf life - RESPONSIVE PACKAGING

pH SENSORS



pH-responsive hydrogel and bioactive films

pH Sensitive fluorescent dye sensor

pH responsive polysaccharides



Microbial activity is sensed and then reduced



BIOLOGICAL SENSORS

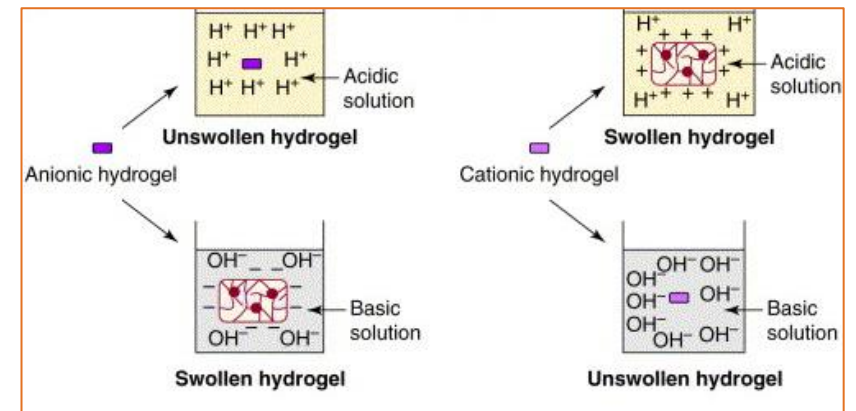
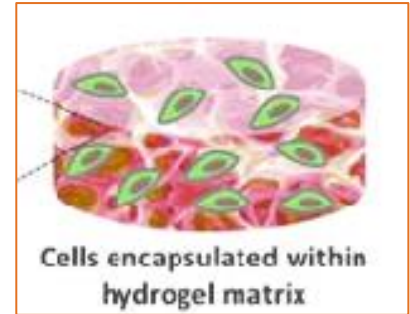


Bioresponsive hydrogels

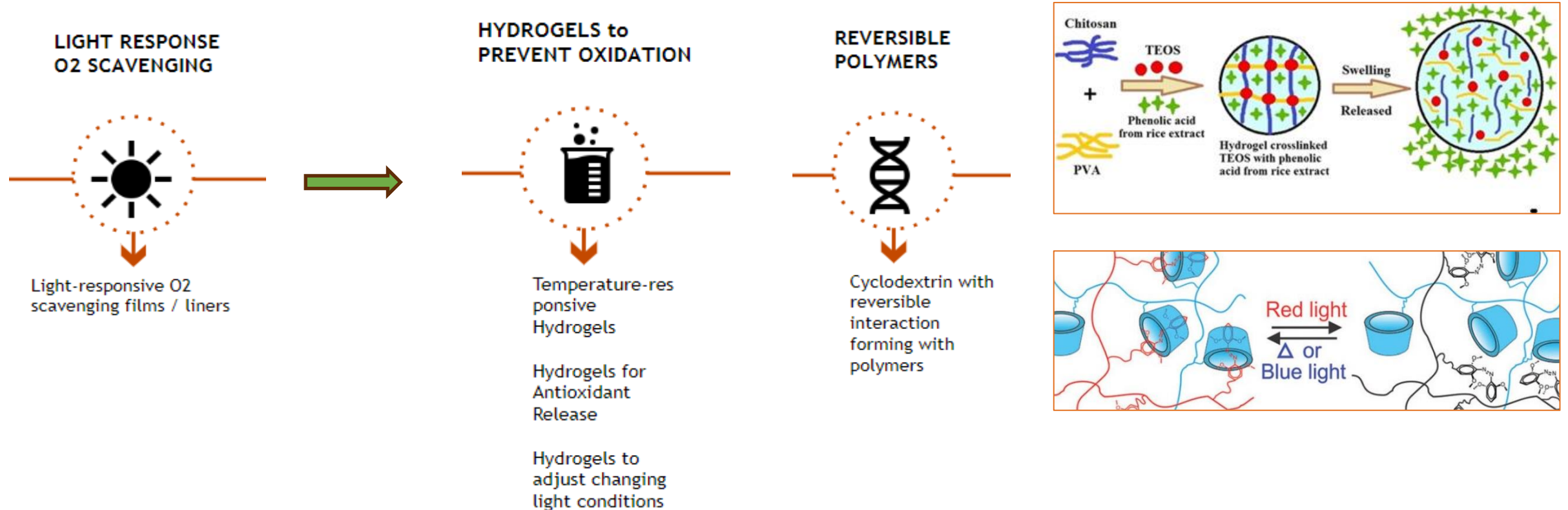
Volatile Organic Compounds (VOC); Total Volatile Basic Nitrogen (TVB-N)

Enzyme-based

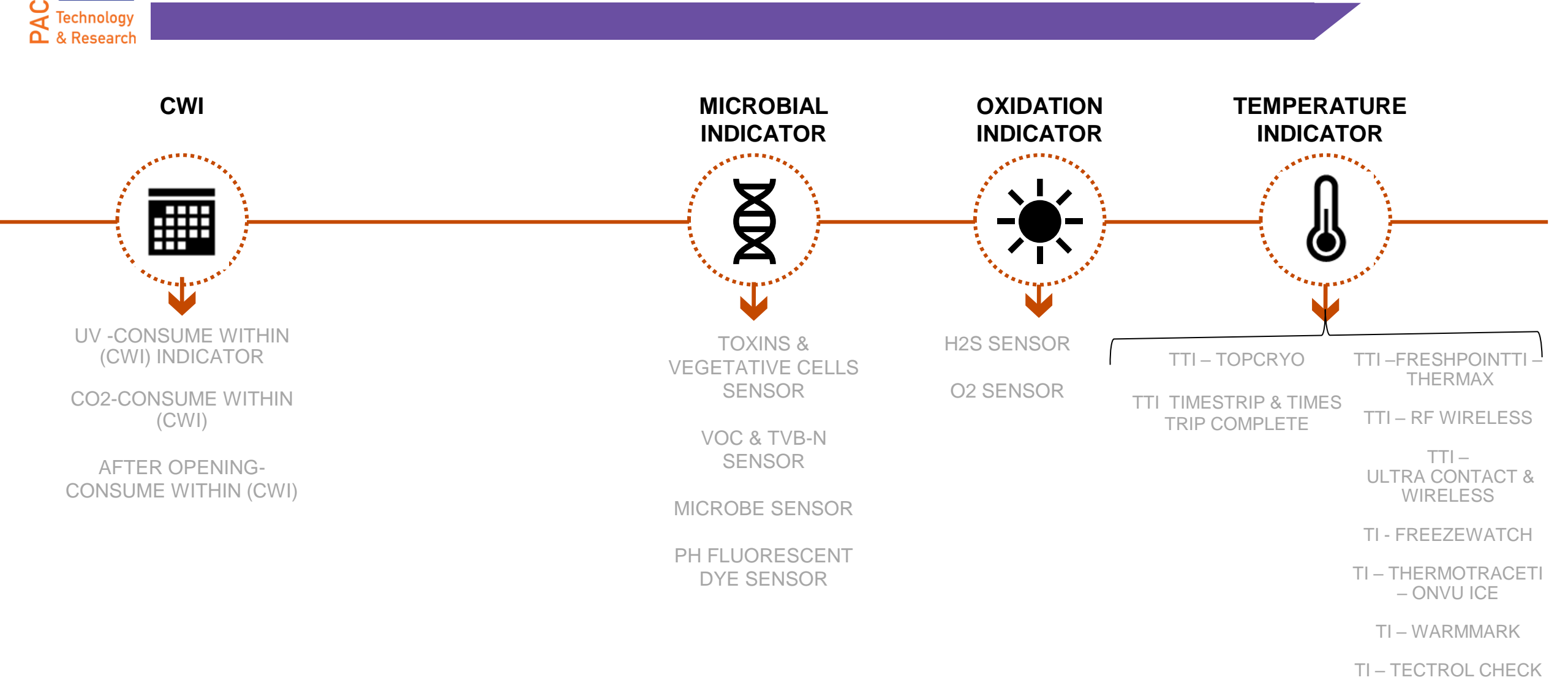
Polydiacetylene biosensor



Oxidative activity is sensed and then reduced



Sensors that define shelf life



AFTER OPENING- CONSUME WITHIN (CWI)

CWI

How it Works

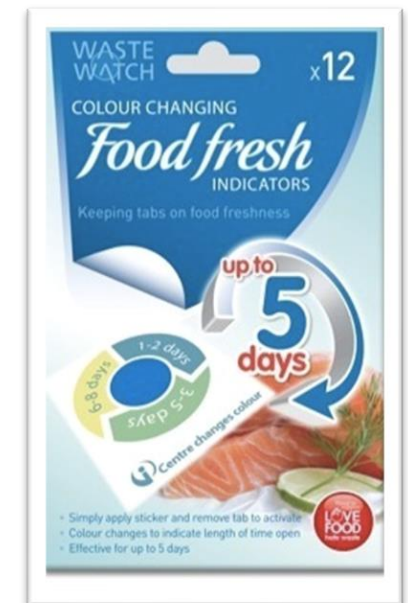
- Activates when package is opened
- Consumer activated
- Mechanism, beyond time, is undefined

Manufacturer

- NOVAS Freshness Indicators
- Insignia Technologies

Opportunity

- Ready for adoption for MAP stored deli meat, MAP and stored fresh meat
- Shelf stable foods



Sensors that define shelf life

UV- CONSUME WITHIN (CWI) INDICATOR



Original tag UV-activated After opening

CWI

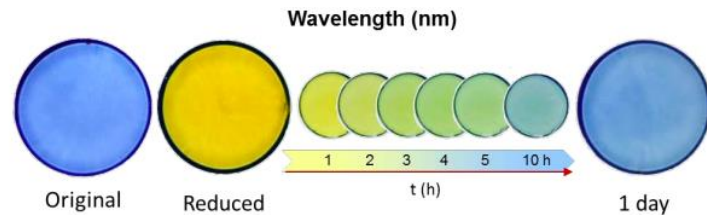
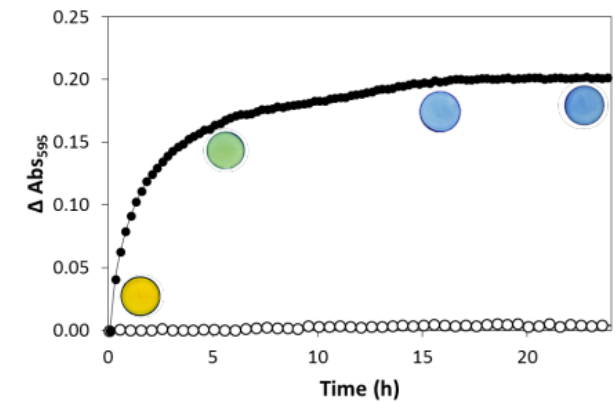


Figure 7 – UV-vis spectra and accompanying digital images of the dark recovery of RBBR



Sensors that define shelf life

CO₂- CONSUME WITHIN (CWI)

CWI

How it Works

- Activates when CO₂ drops below certain limit Food Fresh™; <http://vanprob.com>

Opportunity

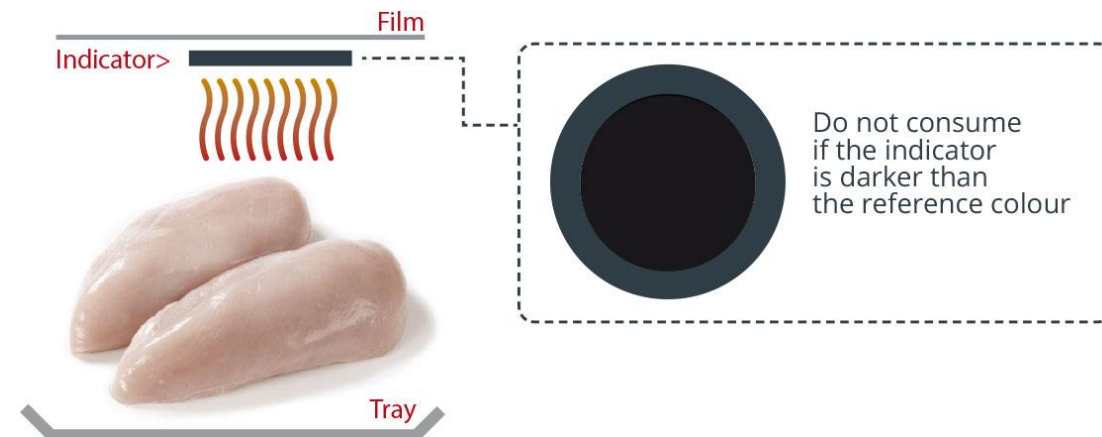
- Cost effective; after opening

Impediments

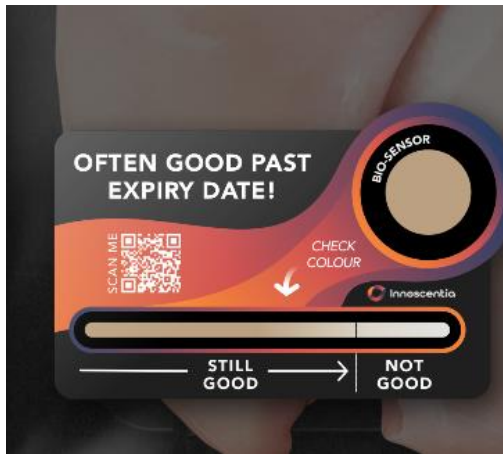
- Ready for adoption for MAP stored deli meat, MAP stored fresh meat

Where Work is Happening/Partners

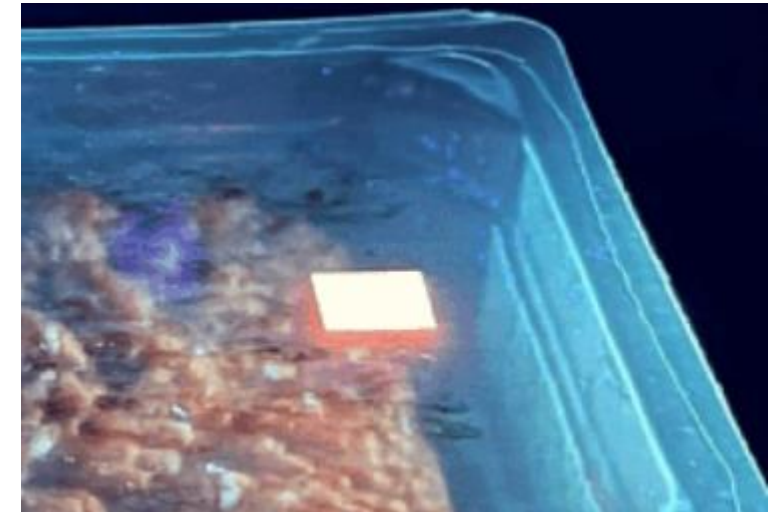
- Vanprob company, Food Fresh™ (<http://vanprob.com>)



VOC & TVB-N SENSOR MICROBIAL



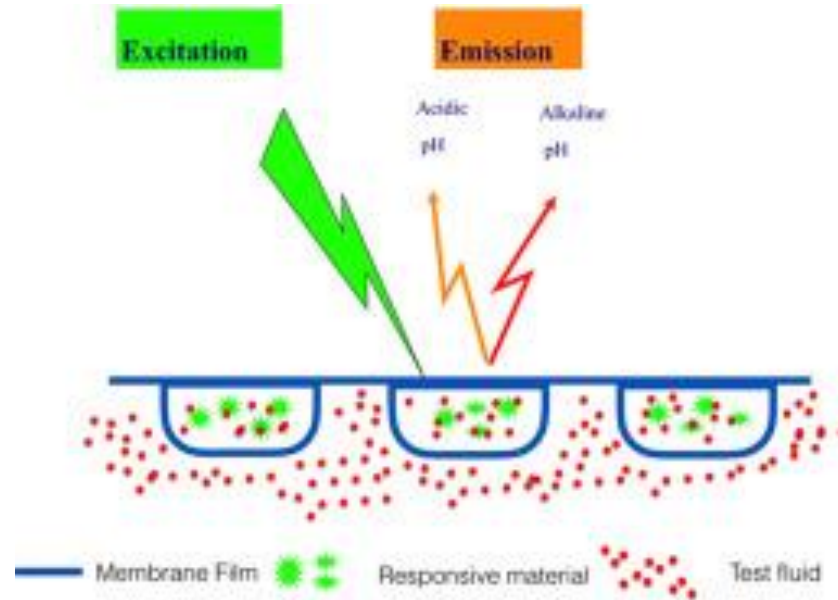
Innoscentia



Senoptica

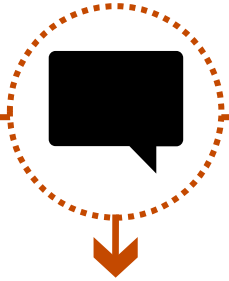
TOXINS & VEGETATIVE CELLS SENSOR

MICROBIAL



Enables brands to consumer communication

TRACK & TRACE ENHANCE BRANDING



QR CODE

NFC SPEEDTAP

NFC-THINAIRE SMART
SOURCE

NFC OPENSENSE

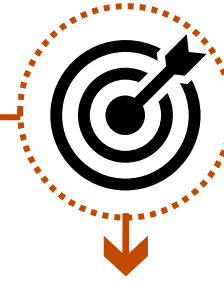
TRACK & TRACE



DUALWING

PASSIVE UHF RFID

BRANDING



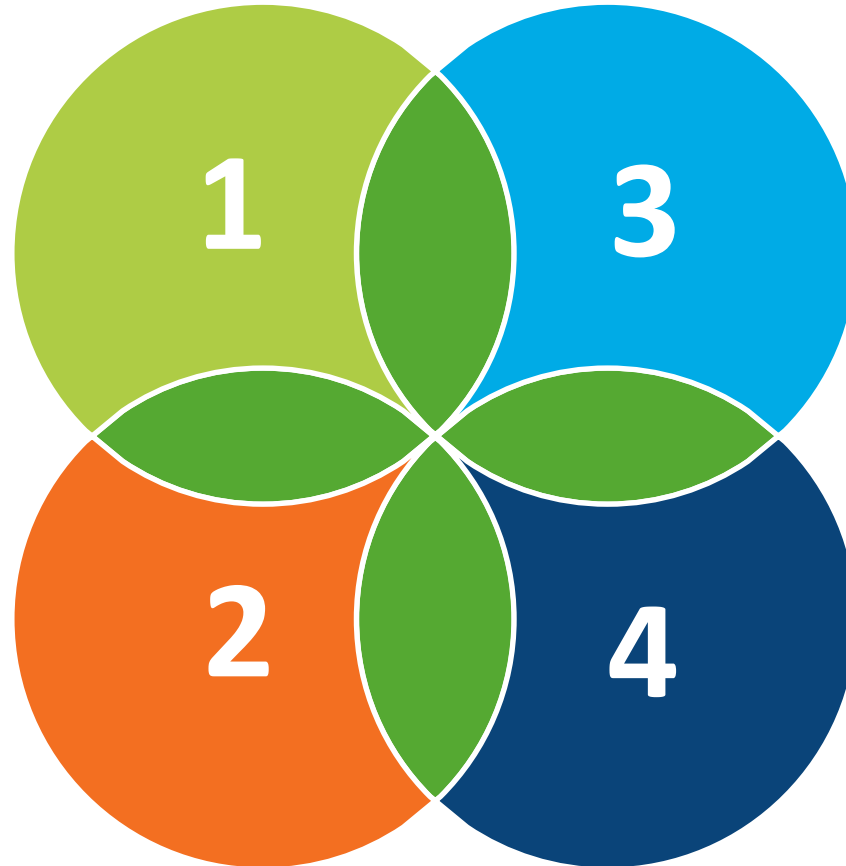
CONSUMER DIRECTED

Key Takeaways

The Value Chain is moving intelligent packaging forward

Intelligent packaging technology is advancing

- Effective kinetic modeling
- Indicator technology
- Shifts Underway

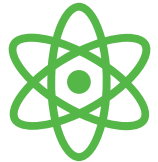


Future is bright for Intelligent Packaging

Q&A



Bayesian decision making



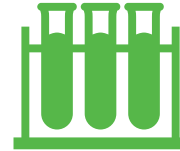
Energy

- Printed batteries



Responsive Science

- Active packaging linkage to release preservatives
- Chlorine dioxide, ZnO, ethanol



Material science

- Paperboard substrate to detect and act



Reading

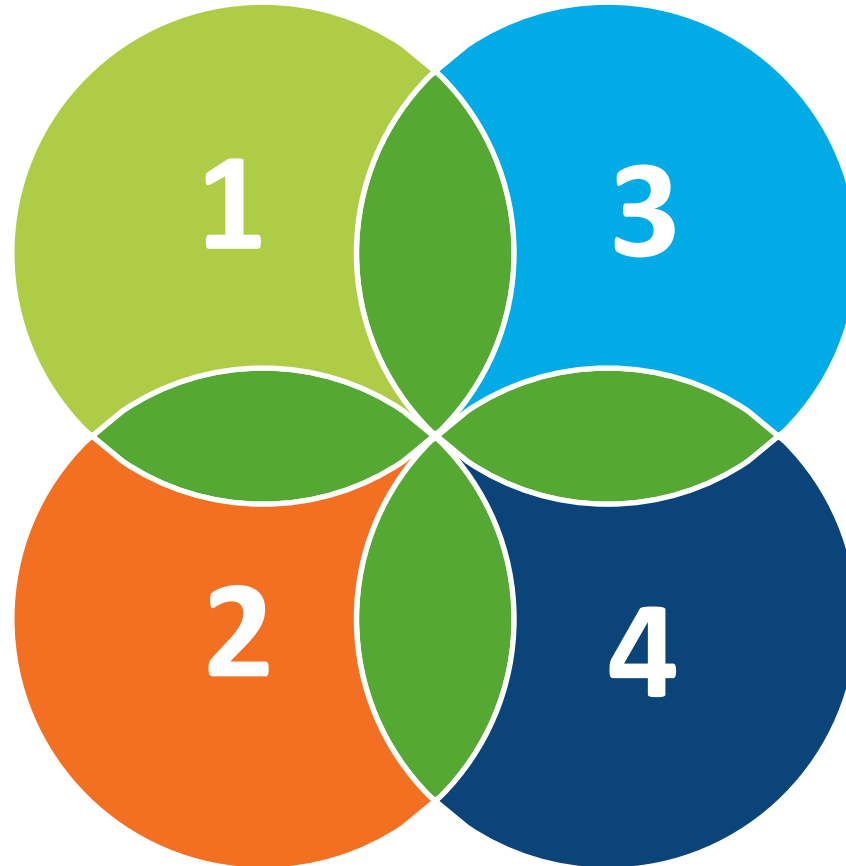
- Reading package shelf life via phone sensors
- Reactive inks

Key Takeaways

The Value Chain is moving intelligent packaging forward

Intelligent packaging technology is advancing

- Effective kinetic modeling
- Indicator technology
- Shifts Underway



Future is bright for Intelligent Packaging

Q&A

Thank you



Dr. Claire Sand

Founder & Owner



**Reach out to connect for
a virtual coffee**