PACKAGING Technology & Research

Midwest Dairy ASSOCIATION

Midwest DAIRY FOODS RESEARCH Center

NDC NATIONAL DAIRY COUNCIL™

# *Milk Packaging*

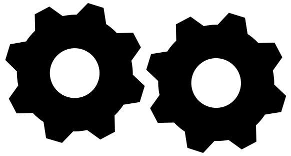
*Types of packaging material and their functionality, how they protect (or not) milk, innovations packaging for milk*

Dr. Claire Sand

July 2017

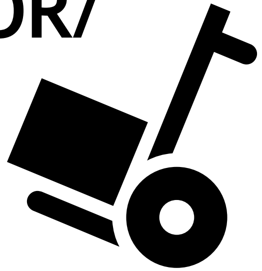
# Packaging Challenges

## MANUFACTURER



- Reduce contamination during product fill
- Assess initial microbial load
- Reduce initial microbial load
- Enable HACCP, etc
- Address chilled worker conditions

## DISTRIBUTOR/ RETAILER



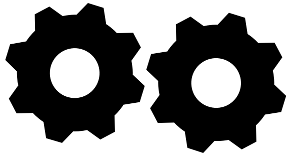
- Enable stock rotation
- Time &Temp monitoring system
- Oxygen level monitoring system
- Control temperature
- Reduce microbial load at POS

## CONSUMER/SOCIETY

- Enable safe package reuse
- Reduce consumer contamination from repeat use
- Expand time for safe product use
- Enable storage
- Portions
- Sustainability

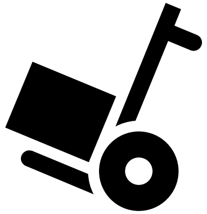
# Packaging Solutions

## BRAND/MANUFACTURER



- Manufacturing agility
- Reduce microbial contamination

## RETAILER/ CONSUMER



- Provide barrier to deliver needed shelf life
- Sustainability
- Enable distribution & retail handling
- Enhanced value and interface
- Align with demographic shifts
- Safety

# Select Roles of Packaging for Milk

- Provide a barrier
- Enable Manufacturing agility
- Enhance consumer interface
- Incorporate sustainability
- Enable Distribution and handling
- Enable safety

# Provide a barrier

# Functions of packaging barrier for milk

- Reduce lipid oxidation
- Reduce Riboflavin and Vitamin A loss
  - Light barrier
    - Reduce exposure to sunlight, fluorescent LED
  - Oxygen barrier
- Retain water
  - Provide water barrier

# Ways to achieve a barrier

- Material and polymer selection
- Polymer modification
  - Copolymers
  - Coextrusions/laminations/coatings
  - Tortuosity
  - Antimicrobials
  - Pigments

# Milk barriers - OTR

- OTR and reality
  - Temperature
  - Gradient
  - As rxn progresses
  - What barrier is needed

# OTR

- Common OTRs
  - PET – 0.22 $cc/m^2dayatm$
  - HDPE - 2.6
  - PP – 11
  - LDPE - 20
  - Paper/polymer – variable
  - Combinations paper-metal-polymer - ~0

# Light barrier

# Light barriers

- HDPE and PET with Additives:
  - Carbon black layer
  - 1.3-6.3% $TiO_2$
- Shrink sleeves



# LED provides an opportunity

- LED results in less degradation

Journal of Dairy Science
Volume 99, Issue 4, April 2016, Pages 2537-2544

Comparison of milk oxidation by exposure to LED and fluorescent light

C. Brothersen, D.J. McMahon, J. Legako, S. Martini

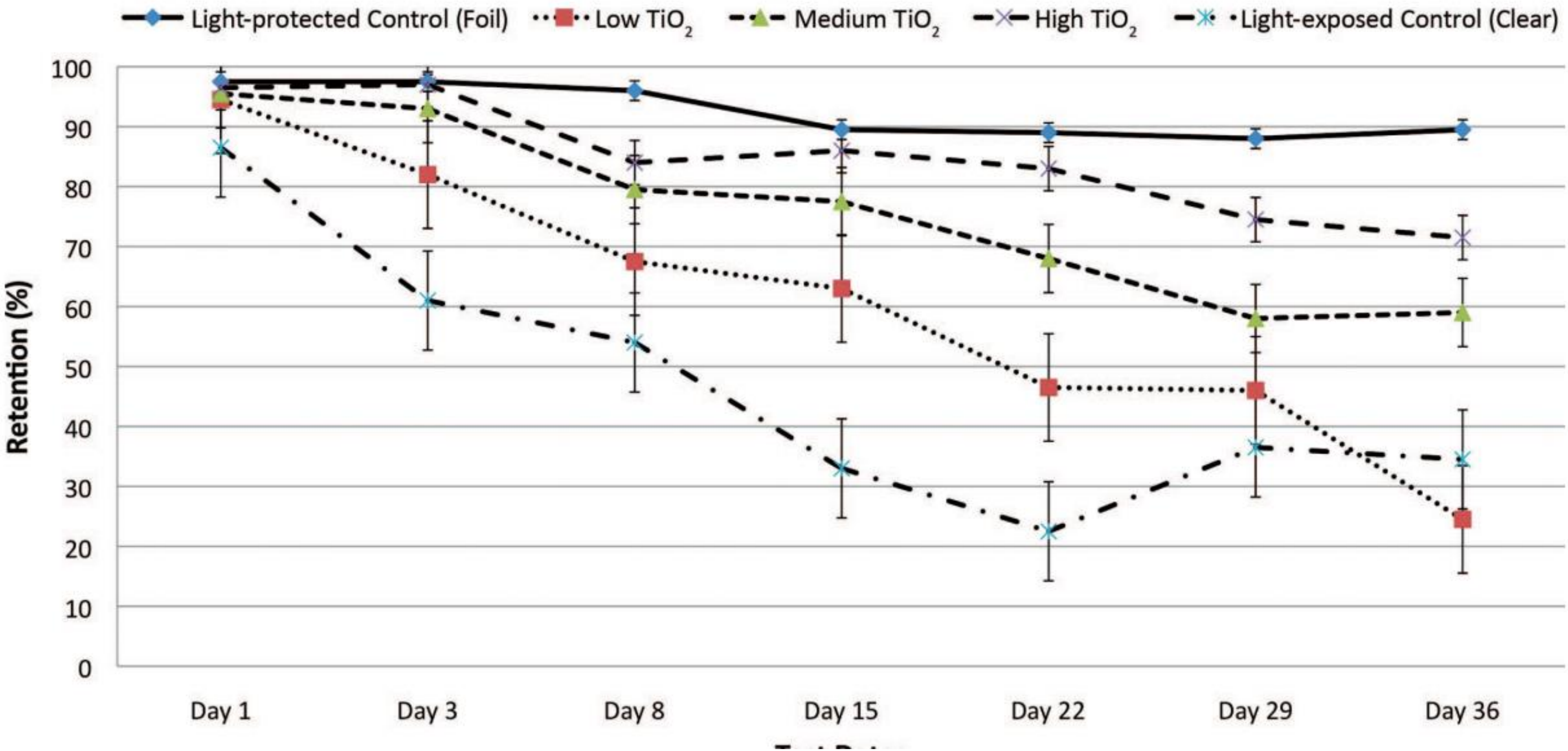
*"Products in PET exposed to LED lighting, with the higher light intensity of 1,460 lx, had higher acceptability for aftertaste (6.0 and higher) than did milk packaged in HDPE (except light-protected HDPE) under LED light."*

Journal of Dairy Science
Volume 100, Issue 1, January 2017, Pages 146-156

Retail lighting and packaging influence consumer acceptance of fluid milk

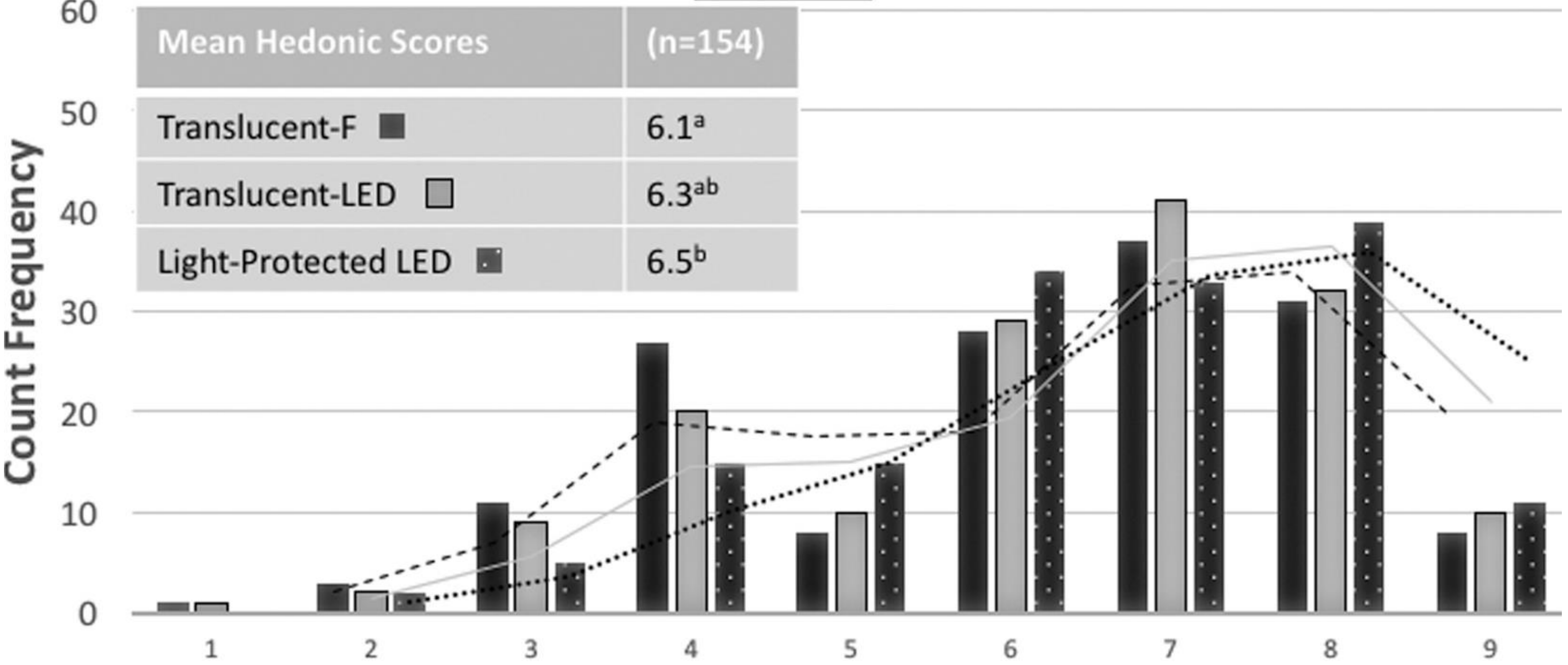
H.L. Potts, K.N. Amin, S.E. Duncan

*"LED light intensity (4,000 lx) resulted in less nutrient degradation in 1% milk than fluorescent light (2,200 lx) after 24 h of light exposure."*

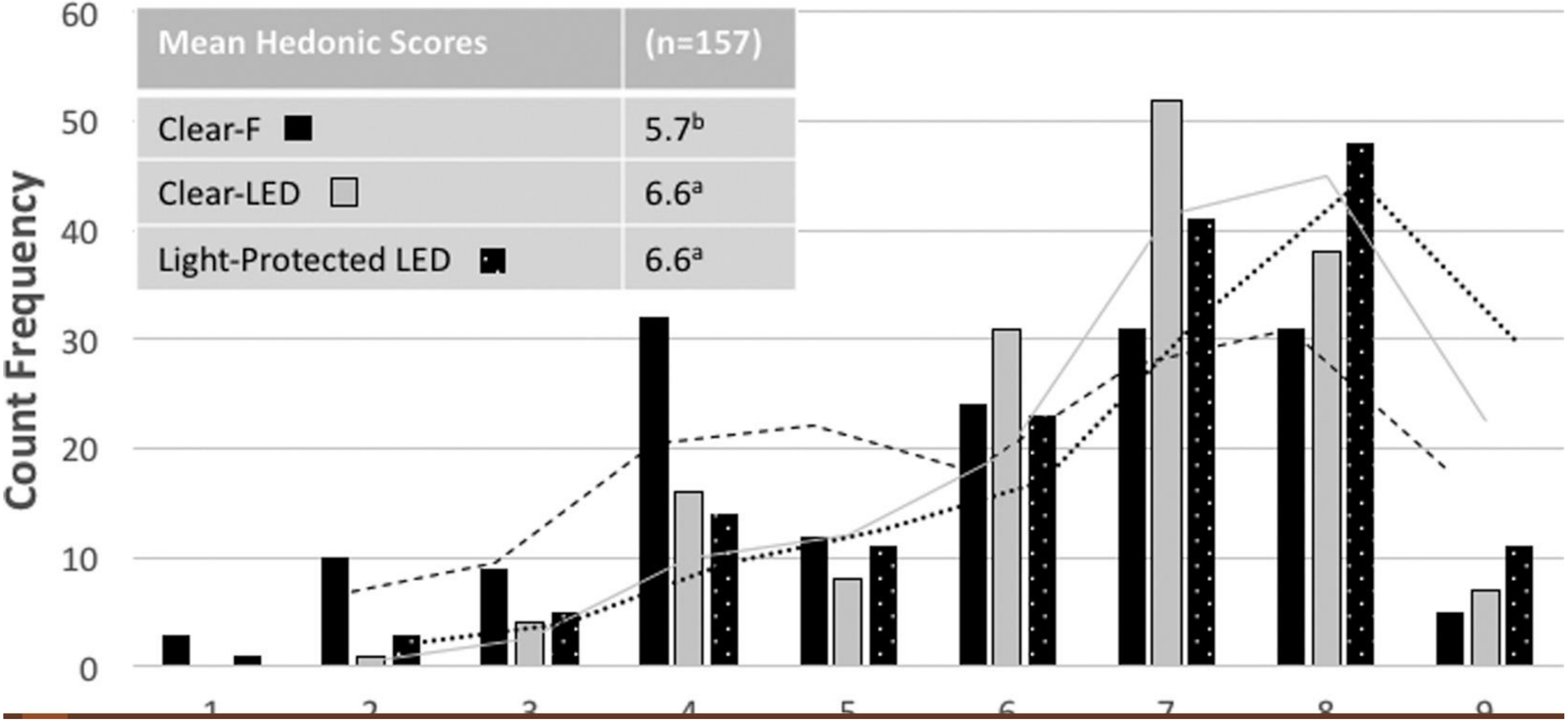

Light-protected Control (Foil)
Low $TiO_2$
Medium $TiO_2$
High $TiO_2$
Light-exposed Control (Clear)
Retention (%)
100
90
80
70
60
50
40
30
20
10
0
Day 1
Day 3
Day 8
Day 15
Day 22
Day 29
Day 36

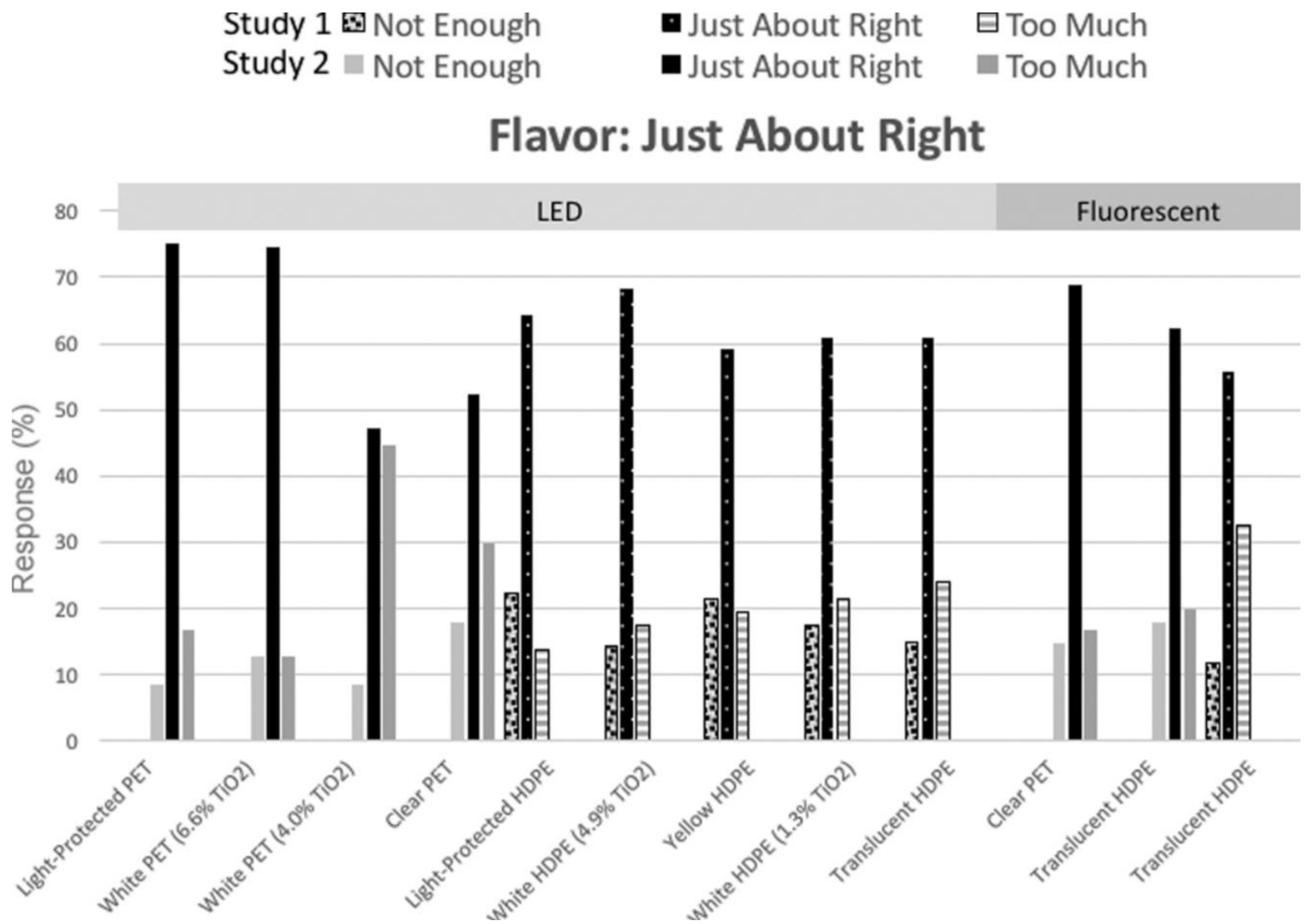
# HDPE

| Mean Hedonic Scores | (n=154) |
| --- | --- |
| Translucent-F | 6.1[a] |
| Translucent-LED | 6.3[ab] |
| Light-Protected LED | 6.5[b] |

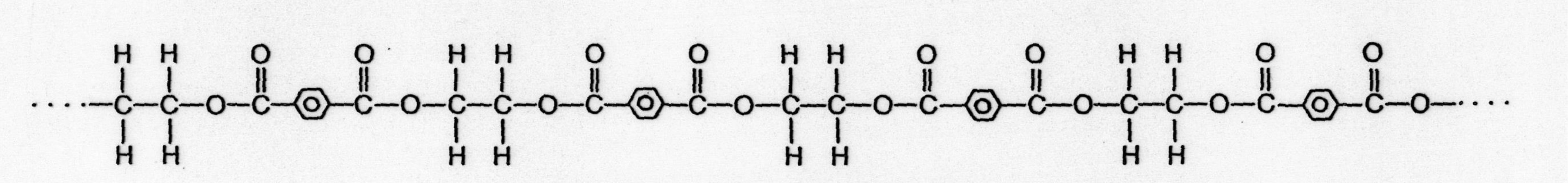


# PET


Mean Hedonic Scores
(n=157)
Clear-F
5.7b
Clear-LED
6.6a
Light-Protected LED
6.6a
Count Frequency
0
10
20
30
40
50
60
1
2
3
4
5
6
7
8
9


Study 1 Not Enough
Just About Right
Too Much
Study 2 Not Enough
Just About Right
Too Much
Flavor: Just About Right
LED
Fluorescent
Response (%)
0
10
20
30
40
50
60
70
80
Light-Protected PET
White PET (6.6% TiO2)
White PET (4.0% TiO2)
Clear PET
Light-Protected HDPE
White HDPE (4.9% TiO2)
Yellow HDPE
White HDPE (1.3% TiO2)
Translucent HDPE
Clear PET
Translucent HDPE
Translucent HDPE

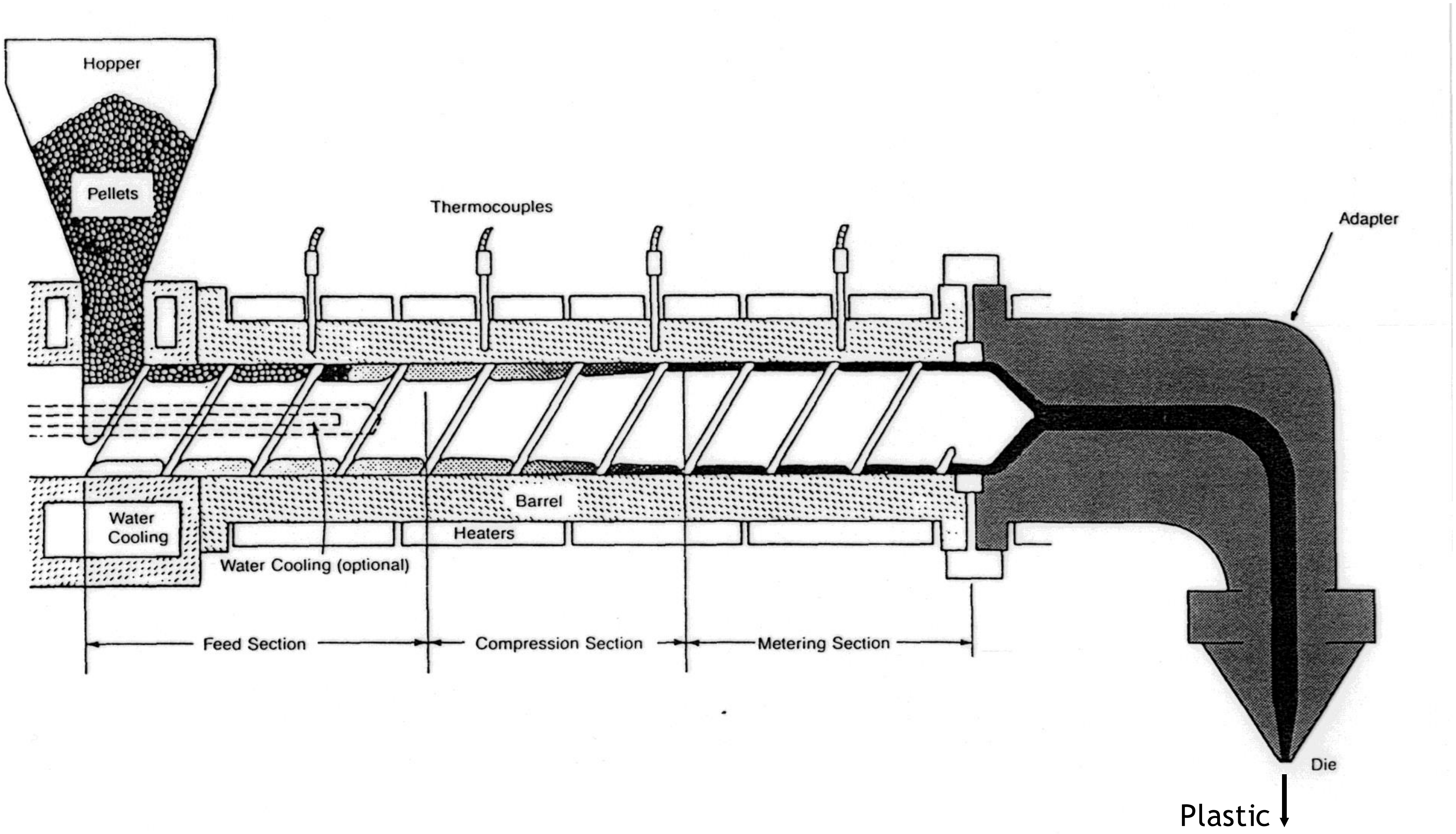
# PET



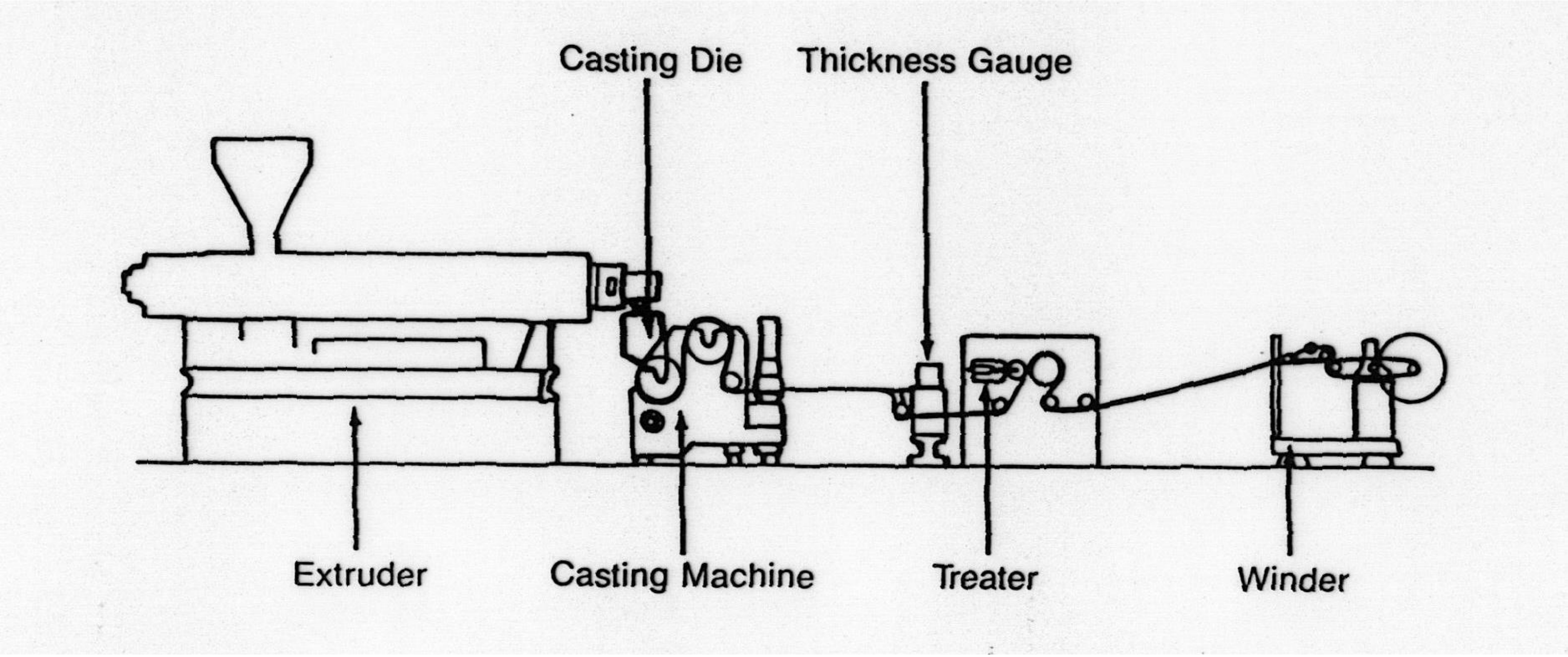
# Altering polymers

- Copolymers
- Coextrusions/laminations/coatings
- Tortuosity
- Antimicrobials
- Pigments

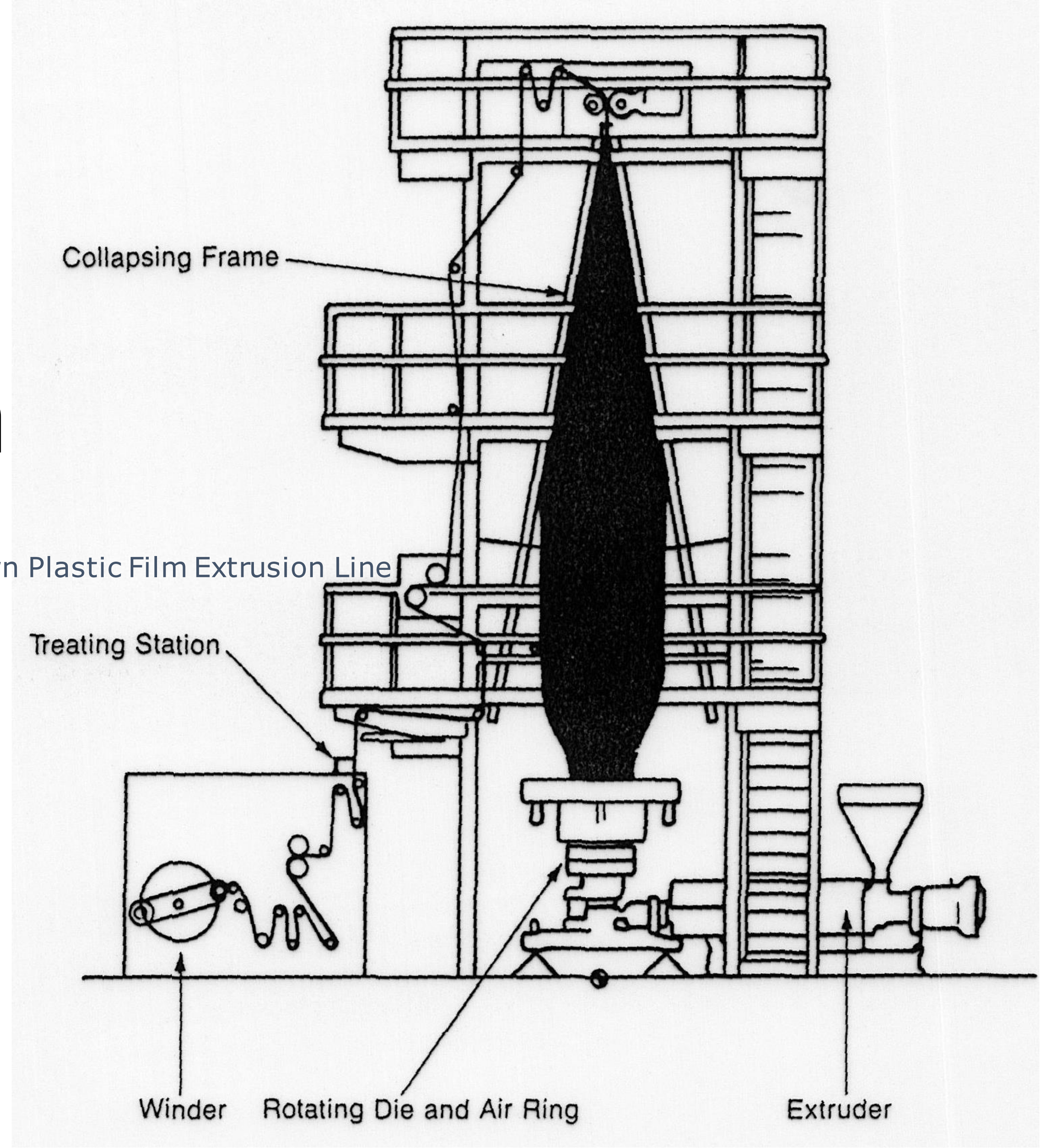
# Plastics Extrusion



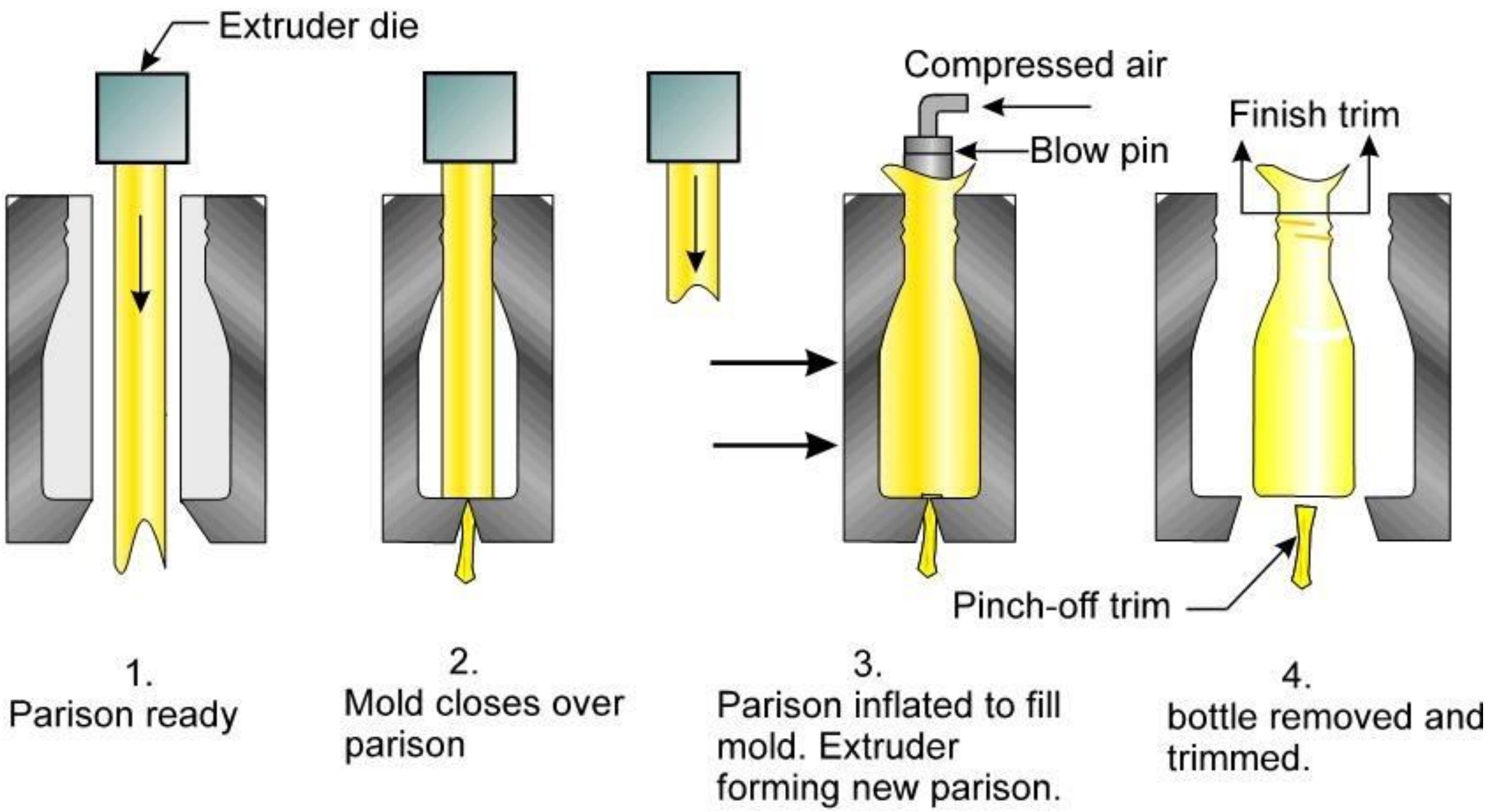
# Cast Plastic Film/Sheet Extrusion Line



# Blown Plastic Film Extrusion Line




Blown Plastic Film Extrusion Line


Extruder die
Compressed air
Blow pin
Finish trim
Pinch-off trim
1.
Parison ready
2.
Mold closes over parison
3.
Parison inflated to fill mold. Extruder forming new parison.
4.
bottle removed and trimmed.

# Coextrusions/laminations/coatings

- Adding further oxygen barriers
  - EVOH
  - PVDC
  - Nylon
- SiOx
- Metallizing

# Add Tortuosity

Polymer-Clay composites

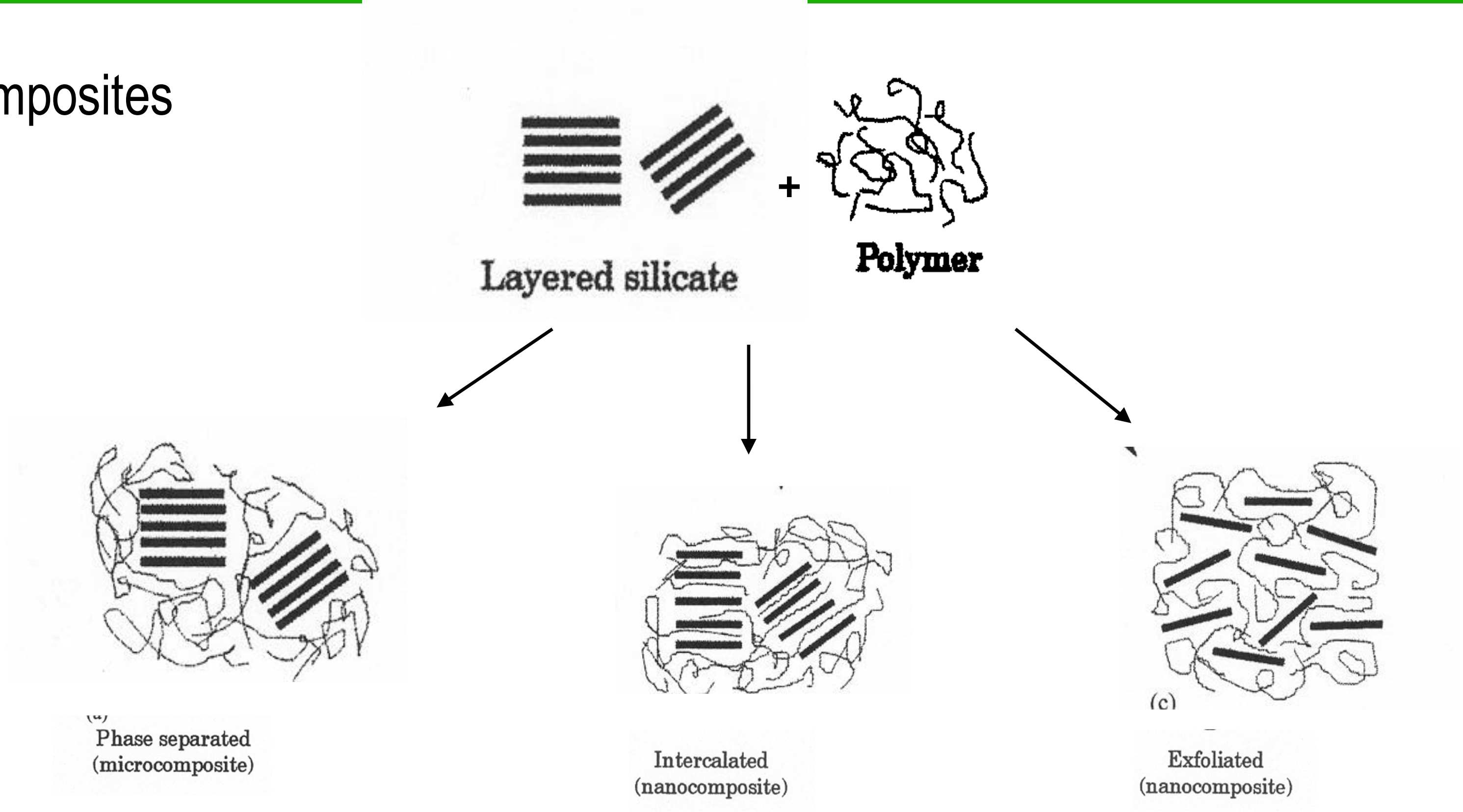
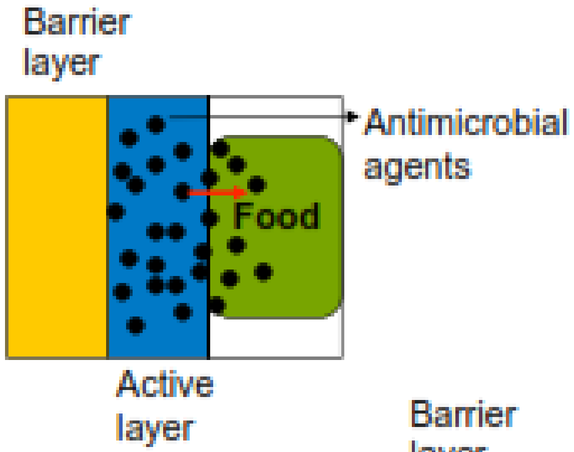


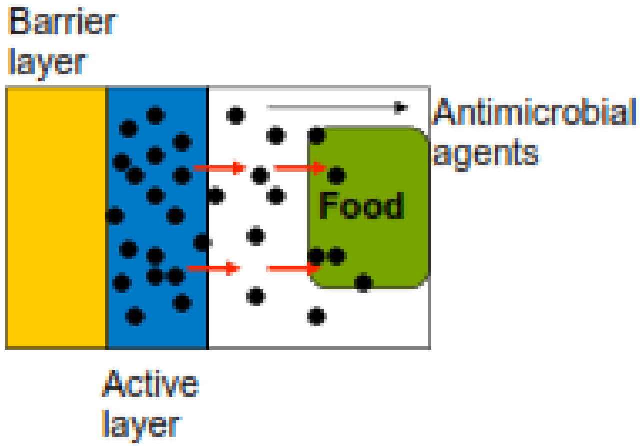

*Fig. 4, Alexandre & Dubois, Mater. Sci. Eng.. 28(2000) 1-63*

# Employ Antimicrobials or oxygen scavengers

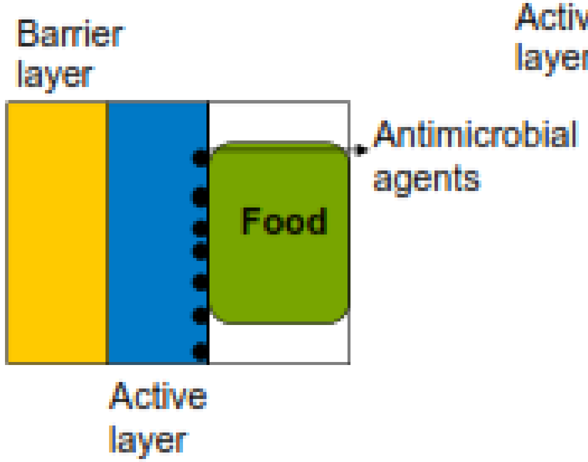
within a structure




through headspace

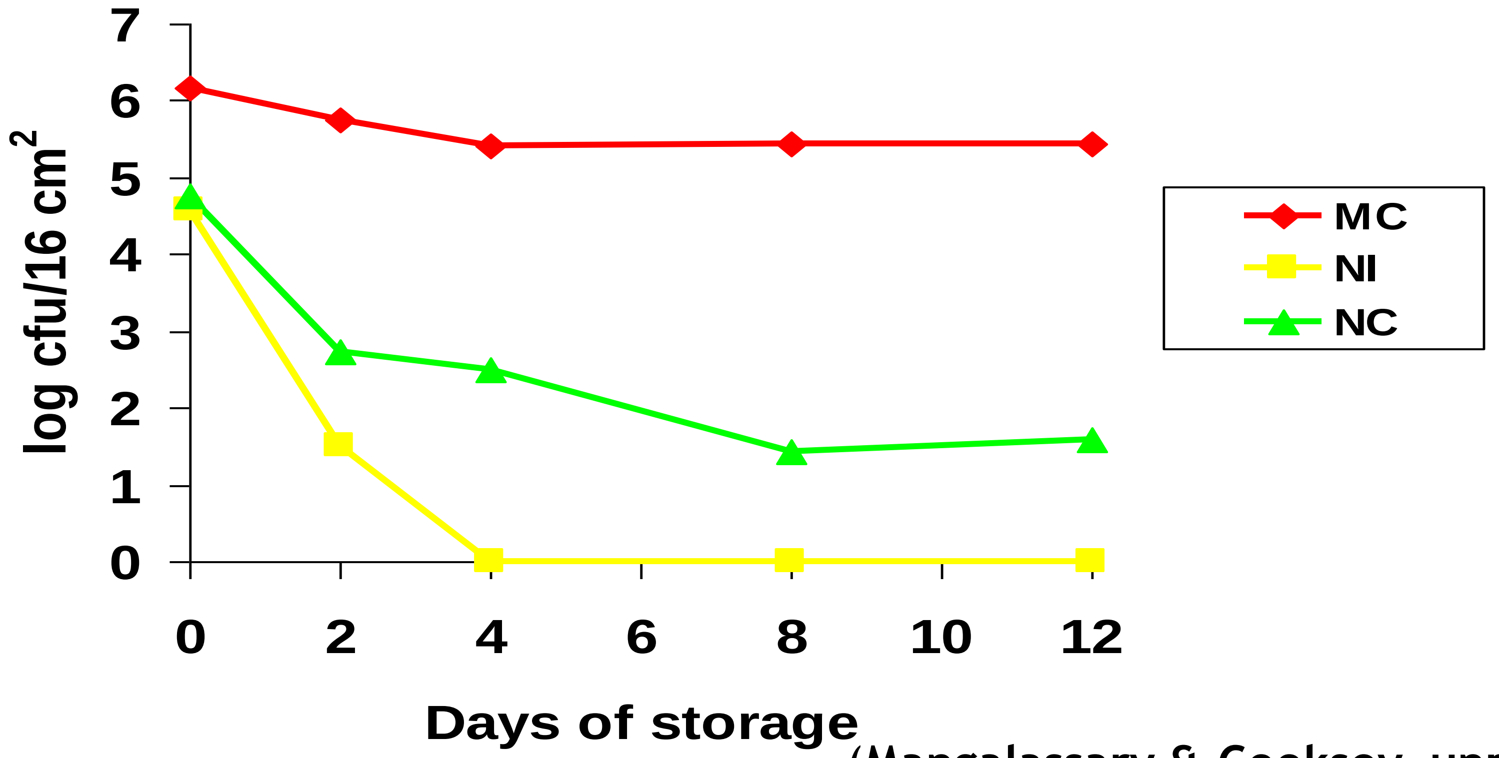



as a coating



# Coatings work best

- Nisin coated vs incorporated to the polymer matrix




(Mangalassary & Cooksey, unpublished data)

# Antimicrobial Options

Regulatory

- FDA
  - Most are GRAS
- EU
  - Defined amounts allowed

**Table 6—List of permitted food additives that could be used as antimicrobial agents in packaging materials.**

| Additive | Code Assigned by Legislative Authority Australia/New Zealand[1] | Europe[2] | U.S.A.[3] |
|---|---|---|---|
| Acetic acid | 260 | E260 | GRAS |
| Benzoic acid | 210 | E210 | GRAS |
| Butylated hydroxyanisole (BHA) | 320 | E320 | GRAS |
| Butylated hydroxytoluene (BHT) | 321 | E321 | GRAS |
| Carvacrol | | | FA |
| Citral | | | GRAS |
| Citric acid | 330 | E330 | GRAS |
| *p*-Cresol | | | FA |
| EDTA | | | FA |
| Estragole (methyl chavicol) | | | GRAS |
| Ethanol | | E1510 | GRAS |
| Ethyl paraben | | E214 | GRAS |
| Eugenol | | | GRAS |
| Geraniol | | | GRAS |
| Glucose oxidase | 1102 | | GRAS |
| Hexamethylenetetramine (HMT) | | E239 | |
| Konjac glucomannan | | E425 | GRAS |
| Lactic acid | 270 | E270 | GRAS |
| Lauric acid | | | FA |
| Linalool | | | GRAS |
| Lysozyme | 1105 | E1105 | GRAS |
| Malic acid | 296 | E296 | GRAS |
| Methyl paraben | 218 | E218 | |
| Natamycin | 235 | E235 | FA |
| Nisin | 234 | E234 | GRAS |
| Phosphoric acid | 338 | E338 | GRAS |
| Polyphosphate | | E452 | GRAS |
| Potassium sorbate | 202 | E202 | GRAS |
| Propionic acid | 280 | E280 | GRAS |
| Propyl paraben | 216 | E216 | GRAS |
| Sodium benzoate | 211 | E211 | GRAS |
| Sorbic acid | 200 | E200 | GRAS |
| Succinic acid | | E363 | GRAS |
| Sulfur dioxide | 220 | E220 | GRAS |
| Tartaric acid | 334 | E334 | GRAS |
| Tertiary butylhydroquinone (TBHQ) | 319 | | FA |
| α-Terpineol | | | FA |
| Thymol | | | FA |

# Factors Effecting Efficacy of Antimicrobials

1. **FOOD PROCESSING CONDITIONS**
   - Food pH, and stability after pH changes
   - Inactivation by food enzymes
   - Interaction with food additives/ingredients

2. **FOOD SHELF LIFE FACTORS**
   - Food storage temperature
   - Limited stability during food shelf life

3. **MICROBIAL FACTORS**
   - Microbial load
   - Microbial diversity and the target bacteria
   - Microbial interactions in the food system
   - Physiological stage (growing, resting, starving or viable)

4. **BARRIERS**
   - Protection by physico-chemical barriers (microcolonies, biofilms, slime)
   - Barriers enrobing Antimicrobials

5. **DEVELOPMENT OF RESISTANCE/ADAPTATION**
   - Predicted to be an issue of concern

| Antimicrobial | Food Safety Microbes | Food Quality Microbes | Categories Tested | Packaging Materials Tested | FDA | EU | FAO/WHO | Manufacturers | Economic | Social Issues | Technology | Innovation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nisin** | Listeria (with Lysozyme); E. coli (with EDTA); Salmonella | Not assessed | Meat, cheese, seafood, perishable processed food | Cellulose and SPI, zein, WPI, LDPE, cellophane, paper, chitosan | GRAS | E234; Restrictions to cheese, eggs, puddings | Approved | Numerous | Costs are not standard and are based on desired result; concern with resistance promotoes use of other bacteriocins in tandem | Increased resistance possible; considered natural | Abundance of studies due to nisin's commercial availability | Use bacteriociins synergistically; bioengineering for increased efficacy; refine coating distribution |
| **Pediocin** | Listeria | S. aureus and B. cereus | Processed meat (ham, bologna, smoked fish) | WPI coated PP, Cellulose | GRAS | Not approved | | Minimal | Concern with resistance promotoes use of other bacteriocins in tandem | Increased resistance possible; considered natural | Limited studies | Use bacteriociins synergistically; bioengineering for increased efficacy; refine coating distribution |
| **Lacticin** | Clostridia and Listeria | S. aureus, Bacillus, Lactococcus, Lactobacillus | Cottage cheese, cheese, milk, orange juice, egg, water, ham, turkey breast, smoked salmon | Zein, WPI, Paper board with AP; PE, Pectin/PLA composite Cellophane | GRAS | Not approved | Approved by 50+ countries | Laboratories | Concern with resistance promotoes use of other bacteriocins in tandem | Increased resistance possible; considered natural | Limited understanding beyond use as additive | Use bacteriociins synergistically; bioengineering for increased efficacy; refine coating distribution |
| **Chitosan** | E. coli | S. Aureus, P. fragi, B. subtilis | Seafood | PVA, PE, carrier of other antimicrobials | GRAS | Not approved | | Multiple | Innovations and use in water quality and fuel cells may lower prices or increase demand to increase prices | Non-toxic, biodegradable, and biocompatible | Abundance of research; variability of results due to natural origin | Combining with other antimicrobials to increase spectrum; identify optimum molecular weight and polymerization |
| **Lysozyme** | Listeria; E.coli (with lactoferrin or EDTA) | S. Aureus, P. fragi, B. subtilis, L. plastarum | Tuna; sushi, raw and processed meat | Cellulose, paper, zein, SPI, PVOH, surface immobilization | GRAS | E1105; approved for cheese and beer | | Numerous chemical companies | Need to combine with lactorferrin or EDTA to inhibit E.coli | Considered natural | Abundance of research; variability of results due to natural origin | To attain both Listeria and E. coli inactivity, determine optimum EDTA or lactoferrin concentration |
| **Lactoperoxidase** | Listeria; E. coli | Yeasts, Molds | Salmon and roasted turkey, milk, cheese, vegetables | •WPI, alginate | GRAS | No approved | Recommended when adequate cooling unavailable in dairy | Numerous chemical companies | Whey derivation lowers cost | Advocacy by FAO has increased awareness | Efficacy a function of LPS, thiocyanate, and $H_2O_2$ | Activation by $H_2O_2$ |
| **Plant Extracts** | E. coli (Oregano); Listeria (Neem) | S. aureus (Grapefruit seed, green teat) | | SPI, WPI, chitosan, casein | GRAS | Approved | Approved | Numerous | Costly due to extraction | Taste preferences inhibit use; no labeling issues | Not applied beyond laboratory stages | Natural/organic platform; improving efficacy |
| **Metal ions** | E.coli , Listeria (Titanium), Ziinc, Silver, Copper); Salmonella (Zinc and nisin) | S. aureus | Meat, sliced fruit, eggs, orange juice | Glass, metal, polymers, chitosan, zein, cellulose | Defined amounts | Defined amounts | Defined amounts | Numerous | Silver most costly | Consumer familiarity; Environmental and increased resistance; Limit migration into food is paramount | Nanoparticles most effectives due to shigh surface area | Medical research applicable to food packaging |
| **Surface Treatments** | E. coli | Antifungal | Meat, produce | Paperboard, polymers | by-products would need approval | by-products would need approval | by-products would need approval | Internal | Variable | resultant additives require acceptance | Skill set within converters | Adapt processes from medical packaging; plasma activation; GRAS by-products |
| **Acids, Salts, Anhydrides** | Listeria and E.coli (Sorbic Acid); Listeria (Lauric acid and EDTA) | Yeasts, Molds | Meat, produce | Coatings on various substrates | Most are GRAS | Defined amounts allowed | Defined amounts allowed | Numerous | Variable | Consumer familiarity | Processes of inactivation are well known | Refined efficacy |
| **Chlorine Dioxide** | Listeria, Salmonella | Not Evaluated | Produce | Known permeability to $ClO_2$ | Considered a treatment | E926 under consideration | | Numerous | Systems in place lowers cost | Color issues; Connected to household disinfectant | Technology well known | Explore ability to recharge system |

# Select Roles of Packaging for Milk

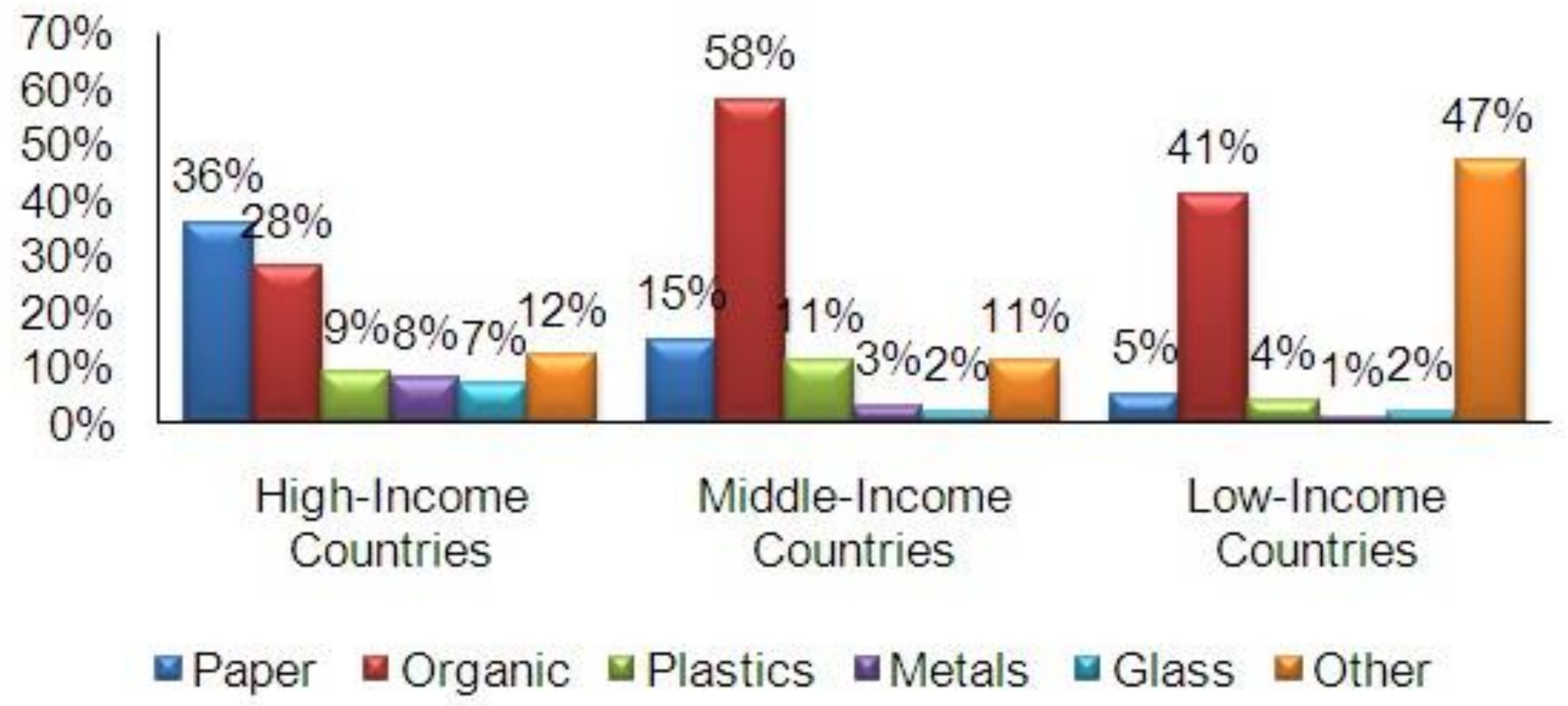
- Provide a barrier
- Enable Manufacturing agility
- Enhance consumer interface
- **Incorporate** sustainability
- Enable Distribution and handling
- Enable safety

# Incorporate sustainability

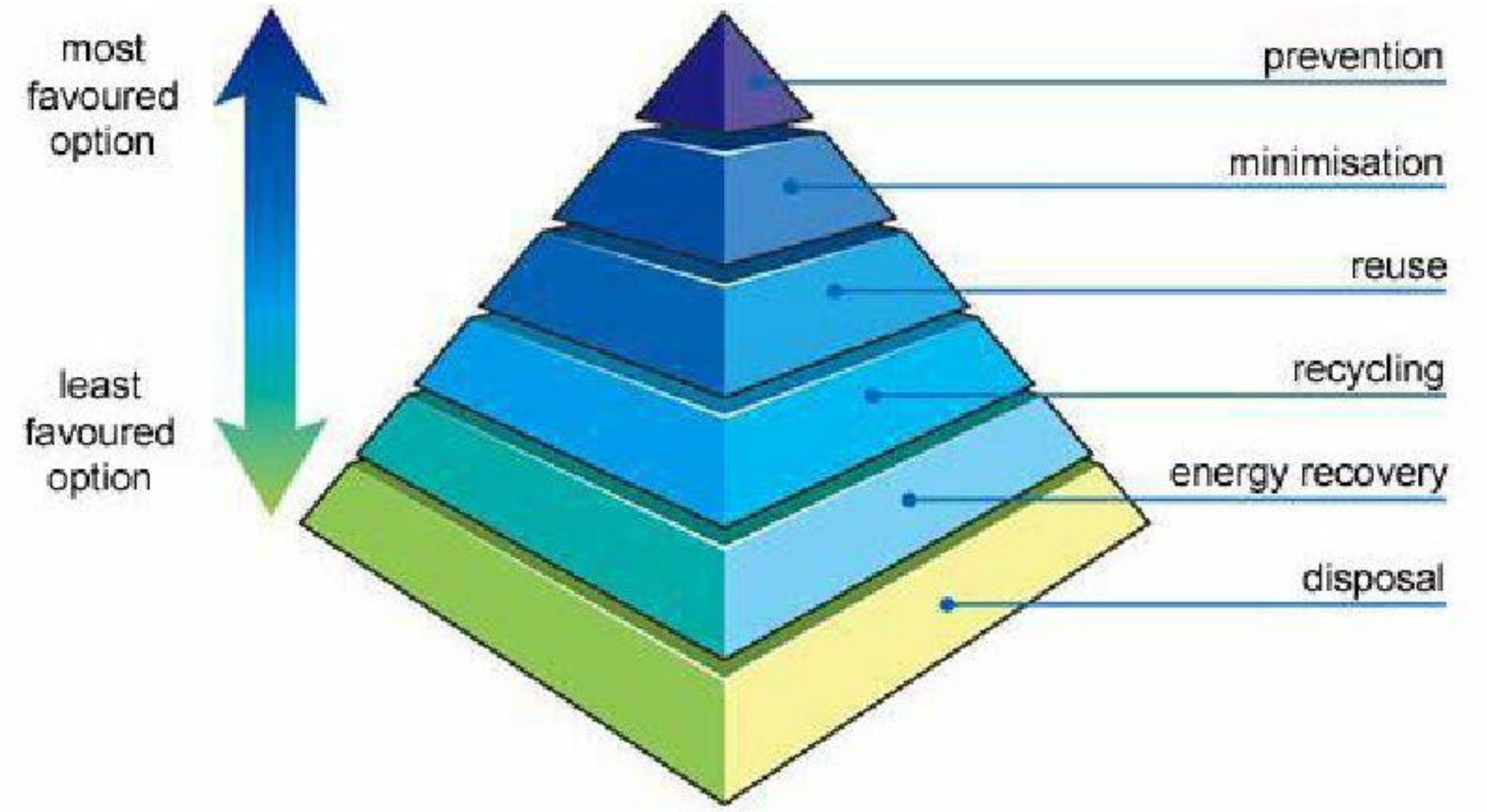
# Packaging sustainability-Competitive advantage

- Interviews from CEOs state:
  - 98 % believe that sustainability issues will be critical to the future success of their business
  - 92 % believe that companies should integrate sustainability through their supply chain; only 59% believe that their company has done so
  - 51 % cite the complexity of implementation as the most significant barrier to embedding sustainability

# Packaging & Sustainability-Packaging waste increases with income



# Sustainability is seeking a favored option



# Packaging & Sustainability-Companies react in different ways

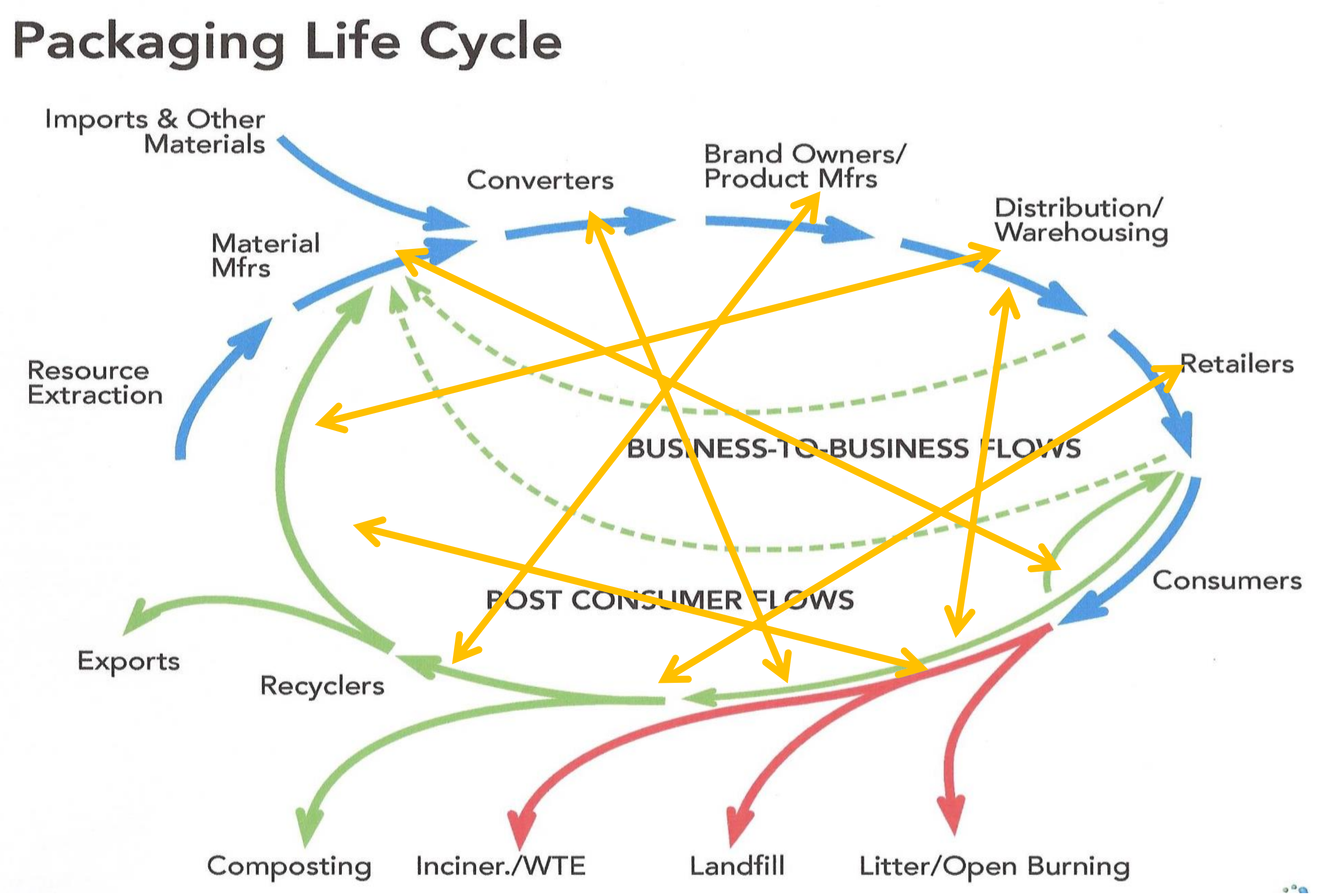
- Dannon reduced packaging waste by eliminating the plastic cap over the peel-back foil seals on yogurt cups
  - 3.6 million pounds of plastic/year
  - Copied others in industry
- SunChips
  - Compostable bag
  - Limited compost facilities
  - Noisy



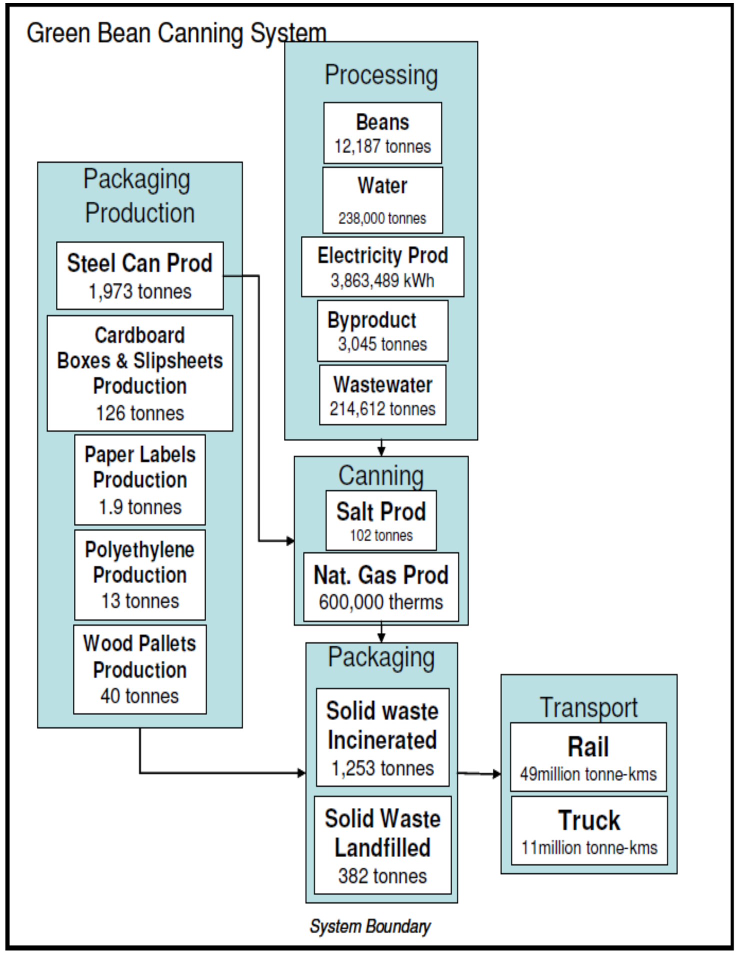
# Measuring Package Sustainability

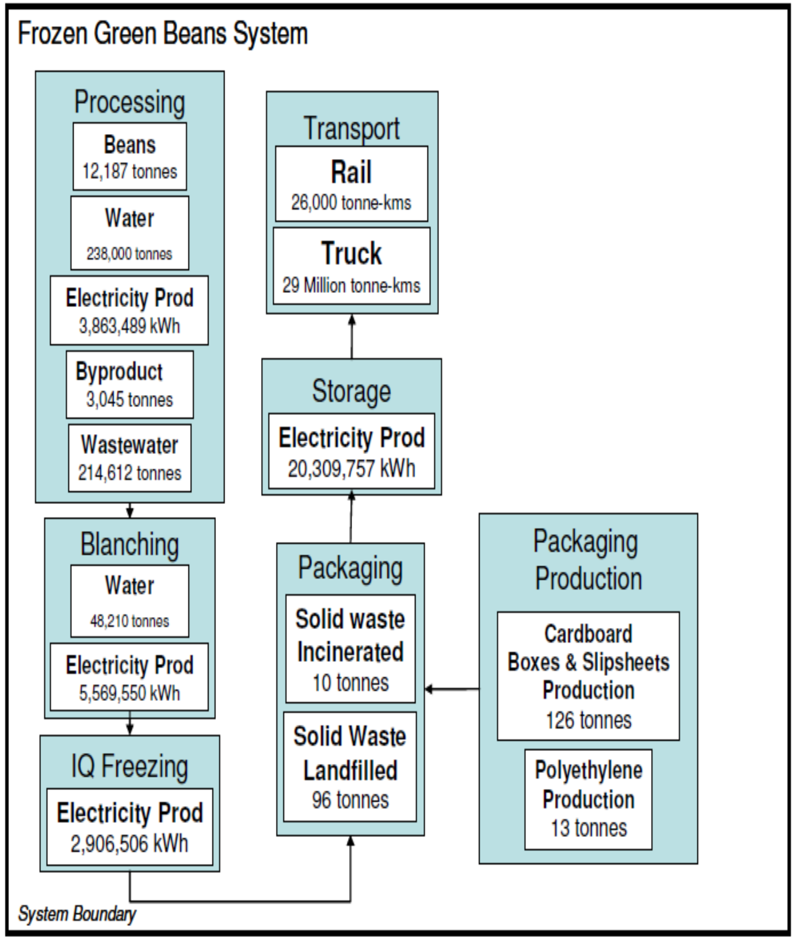
1. LCAs
2. COMPASS
3. Carbon Foot Print
4. Tesco and Wal-Mart Scorecards

# Packaging LCAs



# Packaging-LCA of Frozen and Canned Green Beans



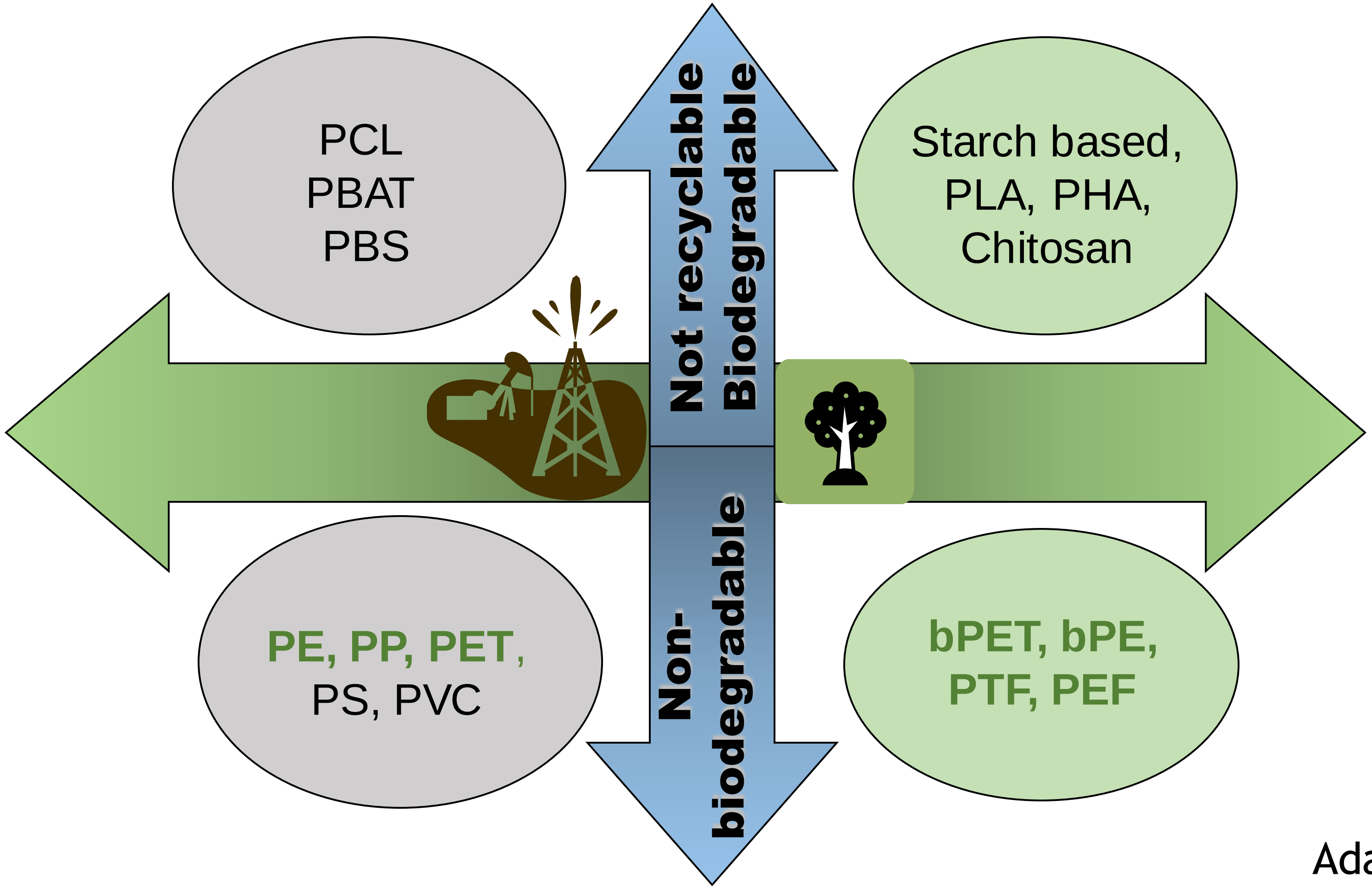
# Sustainable food packaging

- Provides packaging to protect food for total reduction of resource (energy, nutrients, etc) waste
- The future value chain links the post consumer value of packaging with raw materials
  - This moderates research to focus on raw material production-the largest energy use in packaging
  - Packaging processes are being refined to use less water and energy
  - 28% of US consumers are LOHAS
- Packaging's role is unique due to the short use of the packaging
- Packaging is also unique in that it is global since packages are made and disposed worldwide vs products being consumed or used as durable goods
  - Packaging research leads the way for regeneration of manufactured goods
    - Example-reusable packaging before reusable computers

# Sustainable food packaging

- Packaging's role in the value chain can link raw materials with post consumer environment
- Progress mirrors the future
  - Example –EU's APEAL industry initiatives provide image of potential in packaging
  - Example-KLM
  - Example-Migros exceeded Switzerland's PET recycling goal
- Future role in value chain is collaborative
- Global powerhouses (WWF, CERES, Forum for Future) are engaged

# Polymer derivation, biodegradation, recycling




PCL = Poly (e-caprolactone)
PBAT= Poly(butylene adipate-*co*-terephthalate)
PBS = Polybutylene succinate
PE = Polyethylene
bPE = Bioderived Polyethylene
PP = Polypropylene
PS = Polystyrene
PET = Polyethylenterephthalate
bPET = Bioderived Polyethylenterephthalate
PVC = Polyvinylchloride
PLA= Polylactic Acid (Polylaktate)
PHA = Polyhydroksyalkanoate
PTF = Polytrimethylene furandicarboxylate
PEF = Polyethylene furanoate

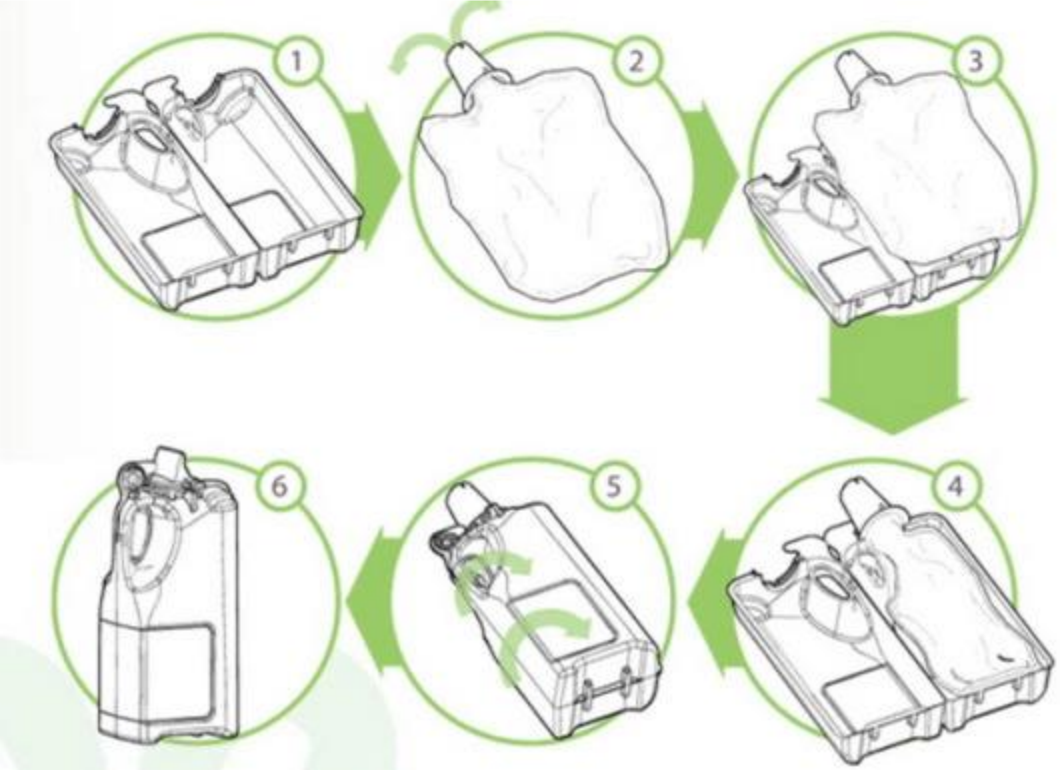
Adapted from G. Robertson

# Biomaterials - Definitions

- Biopolymer: organic material where source of the carbon is from biological resources (not-fossil resources)
- Biodegradable: Biodegradable polymers with approved biodegradability (according to EN 13432)
- Compostable: *ill defined*

# Green PE and PET

# More Sustainable choices


7th generation bottle
Consumes about 33% less energy to produce
Carbon Footprint that is 48% lower than plastic

# More Sustainable choices

Calcium Carbonate stiffens HDPE

| ENERGY | GREENHOUSE GASES | FOSSIL FUELS | CRITERIA AIR POLLUTANTS | ACIDIFICATION POTENTIAL | WATER USAGE |
|---|---|---|---|---|---|
| REDUCED COMSUMPTION 19% | REDUCED EMISSIONS 13% | REDUCED USAGE 15% | SOx REDUCED 15%<br>NOx REDUCED 13%<br>PARTICULATES REDUCED 11% | REDUCED EMISSIONS 14% | SAVED 7% |

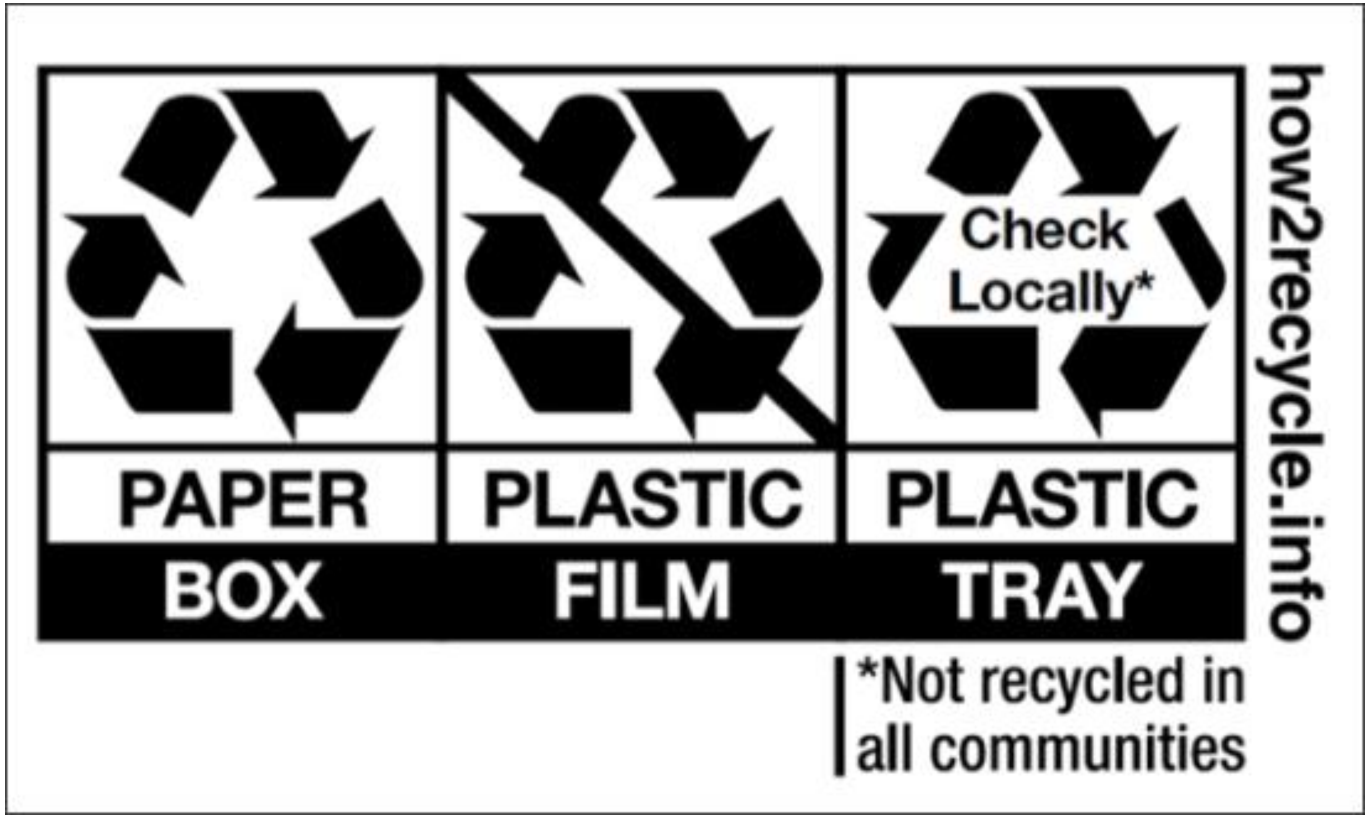



# More Sustainable choices

# Packaging & Sustainability-Value Chain derived redesign


- Improved design is stackable, eliminates need for crates
- Eliminates need to transport, return and wash crates
- Can fit 224 jugs on a pallet instead of 180
- Reduces distribution costs by ~30%
- Reduces price to consumers by ~$ 10

# Packaging & Sustainability-Value Chain derived redesign



# Sustainability-Value Chain & shared value solutions needed

**Total resource optimization-Food and nutrient vs packaging energy & waste**

**Design for Recovery**

- Paper & film-air float separation
- Steel-magnetic separation
- Aluminum-Eddy currents
- PE, PP, PET, PS- NIR and float density

**Use of Recycled and Bioderived recyclable polymers**

- rHDPE Envision
- rPET
- bPET

**Build Composting and Recycling Infrastructure**

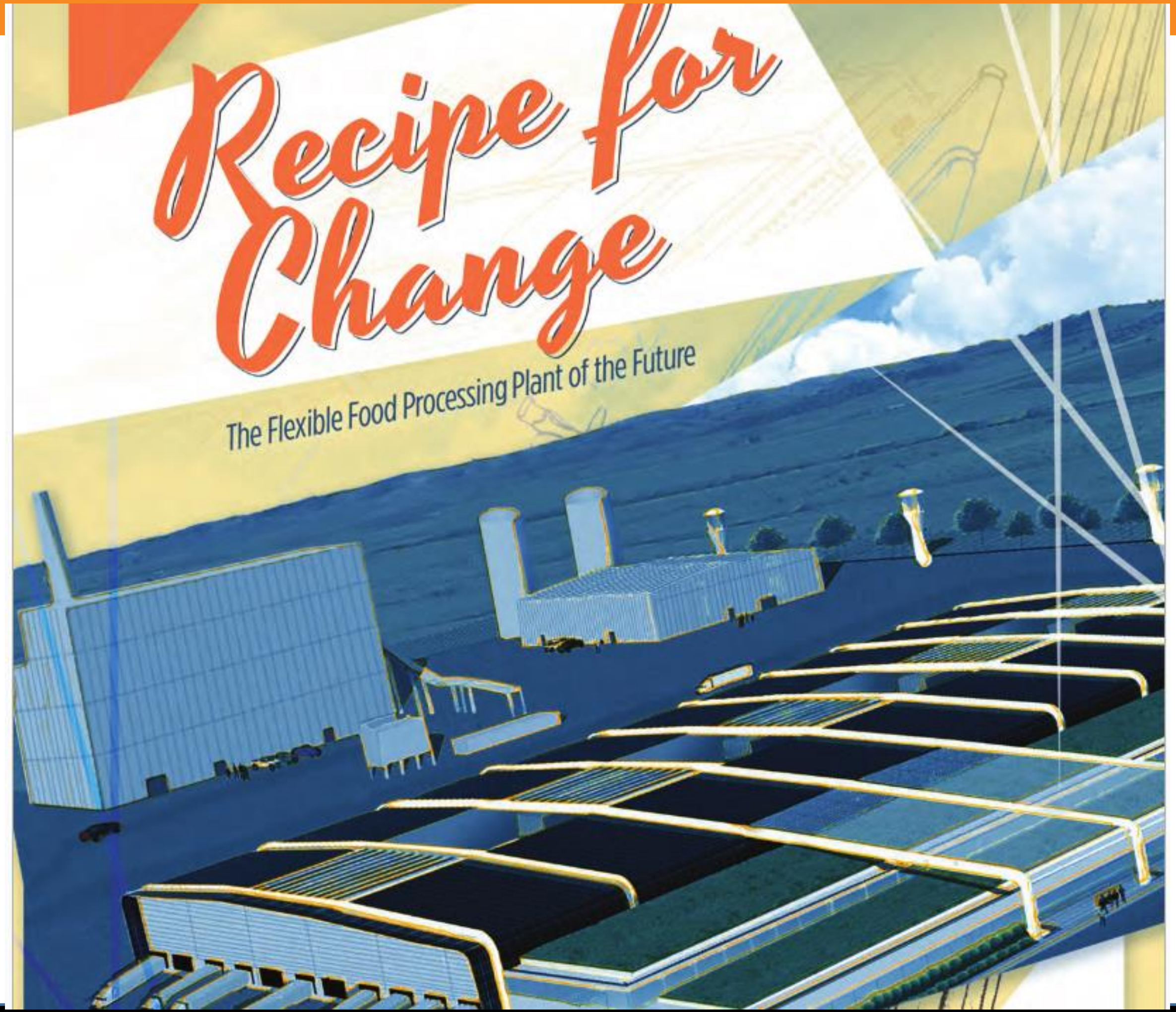
# Select Roles of Packaging for Milk

- Provide a barrier
- **Enable** Manufacturing agility
- Enhance consumer interface
- Incorporate sustainability
- Enable Distribution and handling
- Enable safety

# Enable Manufacturing agility

# Agility provides inherent opportunity

# Agility provides inherent opportunity



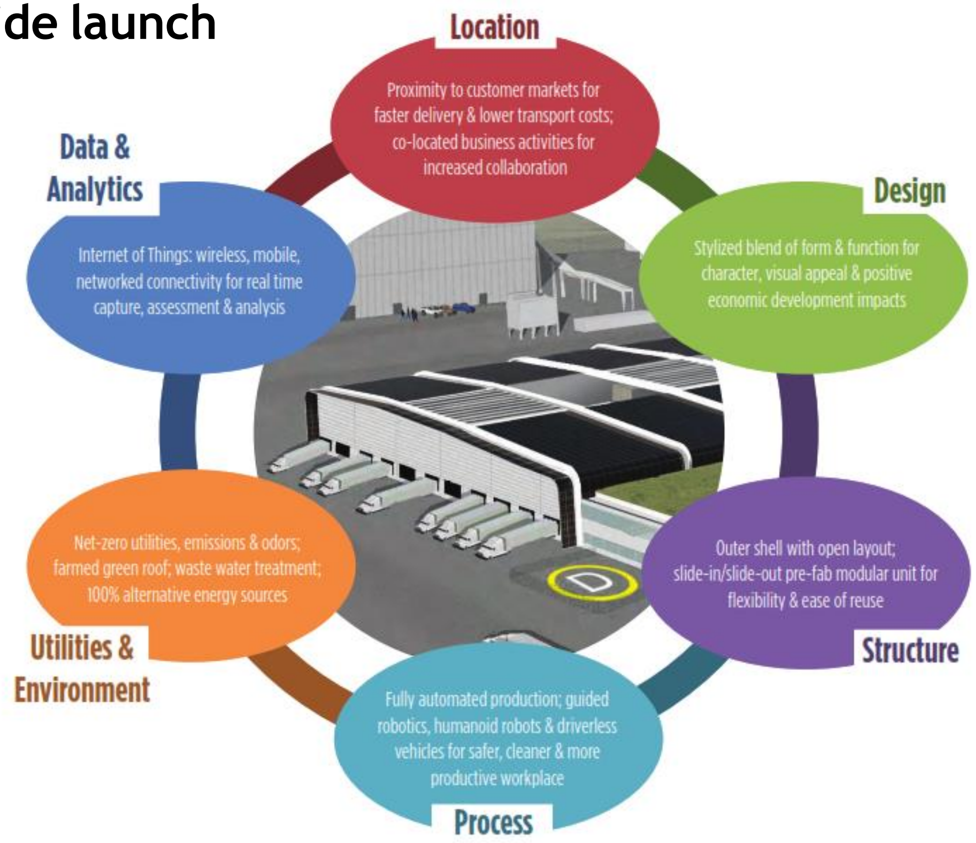
# Agility provides inherent opportunity

## THE FLEXIBLE FOOD PROCESSING PLANT OF THE FUTURE

- Architecturally significant, energy efficient building envelope with sleek design features and attractive landscaping
- Single level, open plan to facilitate modular conversion within production areas and interaction and collaboration among user groups
- Minimal use of hard-to-remove concrete
- Light-weight materials like polyurethane core-filled stainless steel
- Self-contained modular buildings-within-buildings for efficient conversion to future uses
- Modular floor drain system installed over base level floor with sub-floor in between to enable draining
- Retractable and expandable walls and roof system for module transfer and higher ceiling heights for future uses
- Maximized roof span and minimized roof-top equipment; farmed green roof
- Robotic transportation routes for material flow; 3-D printers for parts replacement
- Air filtration system for reduced risk of air-borne contaminants and elimination of biological odors
- Segregated spaces to minimize risk of cross-contamination, contain noise, and reduce downtime during a conversion process
- Sustainable on-site renewable energy, with wind, solar, battery-enabled energy storage, and maximized use of natural light
- On-site water generation and waste water treatment
- LED lighting and lighting control systems
- Centralized distribution of utilities and flexible connections
- Environmentally-benign refrigerants
- Perimeter employee amenities such as outdoor break and activity areas
- Co-located research and development, packaging for grocery shelves, marketing, offices, cold storage
- On-site rendering plant to prepare animal by-products for sale in secondary markets
- Net-zero utilities, waste, and emissions
- Internet of Things: fully networked facility connecting food safety, environment, quality, operations, inventory, process, packaging, facility monitoring and management

# Agility provides inherent opportunity

**6 weeks from idea to nationwide launch**



# Select Roles of Packaging for Milk

Provide a barrier

Enable Manufacturing agility

Enhance consumer interface

Incorporate sustainability

Enable Distribution **and** handling

Enable safety

# Enable Distribution and handling

# Supply Chain & Value Chain are needed now

Supply Chain finesse has allowed the packaging industry to evolve:

1950-1980s

- Post-war era saw efficiencies grow
- Reduced energy costs associated with distribution led to JIT and ECR

1980s and 1990s

- Supply Chain management
- Global sourcing
- Commoditization
- Strategic alliances

# Value Chain evolved to meet diverse competitive goals

1990s

- Drucker's "knowledge worker"
- Porter's Value Chain
- Grenier's organization growth

2000s

- Need more than logistics to be competitive
- TBL – people-profit-planet
- Sweet spots
- Sustainability wave for US which has existed globally

# Involve distribution and handling to innovate

Managing for new approach requires the value chain to provide-

- Shared business culture, vision, terminology, and set of practices within the value chain
- Ability to envisage how the parts add up across chain
- Ability to change internal systems
- Activities for the sake of the whole as a cooperative effort
- Dense network of contacts and trust
- Focus on team building activities


First Choice
instant full cream milk powder
First Choice
instant skim milk powder


КЕФИР


0,25 л


DESNATADO
SEMIDESNATADO
INTEGRAL
Sabe
Sabidinho
90% MENOS


纯牛奶


WAKE
TOFFEE
MOCCA
CHOCOBERRY

# Refine and flex distribution and handling

- Packaging can facilitate the distribution via alternative channels (versus traditional models) to meet urban needs
  - A future value chain defined by consumer led value will optimize packaging based on global urban and rural consumers
    - Example-Medical contract packaging & Anderson's window walls & UHP
  - Optimal packaging technology focuses on post consumer disposal in urban areas (DSD)
  - Consumer specific packaging is growing
    - Kids design Legos and package
  - Packaging research on predictive restocking (beyond RFID) to make consumer and post consumer packaging seamless

# Select Roles of Packaging for Milk

Provide a barrier

Incorporate sustainability

Enable Manufacturing agility

Enable Distribution and handling

Enhance **consumer** interface

Enable safety

# Enhance consumer interface

# Enhance value for consumers-exploration

- ***Exploration*** closely links value chain entities with consumers to
  - Tell 'stories' about the packages we use to explain
    - Why it is used
    - How it was produced
    - Impact on the environment
    - Welfare of workers involved along the chain
    - Rewards accruing to the primary producers
- Commodity packaging is
  - Not able to compete on these issues
  - Disadvantaged in many premium market segments

# Enhance value for consumers-exploration

- Implementation of an exploratory platform for sustainability requires incentives

- Absorb new ideas into organization
  - Reward ideas that address how challenges could be faced
  - Enable quick clearance for external entities
  - Reward long term innovation at the expense of short term innovation

- Realign partners to achieve innovation
  - Reward new arrangements that focus on a long term innovation need
  - Reward concepts that offer opportunities to use value chain
  - Reward value chain teams that make steps toward implementation of new technology/initia


KEMPS
Root Beer Float
LowFat Milk


fresh
milk
full cream


MOLOCOW
MOLOCOW


NEW Super Safe Cap
MILK
Low Fat 1%
Organic Milk
NEW carton!
Same Milk
Better pouring


THE SPOTTED COW
STRAWBERRY MILK
VANILLA MILK
Whole Milk
CHOCOLATE MILK
Antibiotic & Hormone Free
Vitamins A & D Added


EKSTRA LETT MJØLK
LETT-MJØLK
TJUKK-MJØLK
FLØTE
SYRNET MJØLK
HEL-MJØLK

# Intelligent packaging expands brand image potential


SUPER
MILK
FRESH FROM UDDER
Nothing can be more fresh than our product that's straight from udder!
PREMIUM
PRODUCT WITH CARE
hand-tied finishing touch every bottle
NICHE
BE LOCAL, ACT LOCAL, LOOK LOCAL, WE'RE LOCAL!
We will not do like what's big company does! We will make
• Clean & simple
• Honest info
• Less info on bottle
SUPER MILK
EDUCATE
MOO's TALKING
education hang tag will give info why we are best milk in the market
FRESH
STRAIGHT FROM UDDER!
bottle shape mimics cows' udder which will definitely grasp everyone's attention.
ฟาร์มพรธารา

# Optimize packaging for different environments

- Electricity
- Urban vs rural
- Consumer group size
- Income
- etc

# Align packaging for economic reshuffling

- Packaging can enable affordable choices the 4 billion+ consumers at pyramid’s base
- Packaging needs to technically leapfrog to provide product protection and a market
- Packaging can facilitate manufacturing value added goods versus raw material exports
  - Reveals opportunity to use historically indigenous materials (eg: jute)
- Research potential in facilitating leapfrogging in technology is high

# Align for volatility

- VUCA (volatile, uncertain, complex, ambiguous) society demands agility in packaging
- By focusing on each link's value, packaging can uniquely offer this agility
  - Packaging's various finished goods phases enable faster reaction time
    - Example – skin graft packaging & disaster mgmt
  - Packaging's role is evolving within the value chain
  - Research on increasing responsiveness, core technologies (inks, tertiary packaging, labeling, GFSI, FSMA, REACH) have focused innovation on finished goods flexibility

# Select Roles of Packaging for Milk

- Provide a barrier
- Enable Manufacturing agility
- Enhance consumer interface
- Incorporate sustainability
- Enable Distribution and handling
- **Enable safety**

# Enable Safety

# Value Chain packaging solutions to food safety are focused

| | Causes/Categories | Category Z | Category Y | Category X | Catgeory W | Category V | Category U | Category T | Category S |
|---|---|---|---|---|---|---|---|---|---|
| Product Degradation Causes | Oxidation | | | | | | | | |
| | Moisture Change | | | | | | | | |
| | Microbial | | | | | | | | |
| | Browning | | | | | | | | |
| Pkg Prop. | Water resistance | | | | | | | | |
| | MVTR | | | | | | | | |
| | Antimicrobial | | | | | | | | |
| Packaging and Handling | Reduce impact of contamin. ingredients | | | | | | | | |
| | Reduce contamin. during product fill | | | | | | | | |
| | Assess initial microbial load | | | | | | | | |
| | Reduce initial microbial load | | | | | | | | |
| | Reduce cross contamin. | | | | | | | | |
| | Enable processing of some ingredients | | | | | | | | |
| | Enable HACCP | | | | | | | | |
| | Address chilled worker conditions | | | | | | | | |
| Distributio n & Retail | Time &Temp monitoring system | | | | | | | | |
| | Oxygen level monitoring system | | | | | | | | |
| | Control tempertaure | | | | | | | | |
| | Measure microbial load at POS | | | | | | | | |
| Consumer Use | Enable safe package reuse | | | | | | | | |
| | Reduce consumer contamin. from repeat use | | | | | | | | |
| | Expand time for safe product use | | | | | | | | |
| | Enable oven/MW monitoring | | | | | | | | |
| | Address eating hygiene through packaging | | | | | | | | |
| | Enable freezer storage | | | | | | | | |

# Value Chain packaging solutions focus innovation

| | | |
|---|---|---|
| Package Chemical | **Needs/Categories** | Package Properties Technology Solutions for Category X |
| | Grease resistance | |
| | Water resistance | |
| | OTR/MVTR | |
| | Antimicrobial | |
| Handling & Packing | **Needs/Categories** | Handling and Packaging Technology Solutions for Category X |
| | Reduce impact of contamin. | |
| | Reduce contamin. during product fill | |
| | Assess initial microbial load | |
| | Reduce initial microbial load | |
| | Reduce cross contamin. | |
| | Enable processing of ingredients | |
| | Enable HACCP | |
| | Address chilled worker conditions | |
| Distribution & Retail | **Needs/Categories** | Distribution and Retail Technology Solutions for Category X |
| | Enable stock rotation | |
| | Define exact OTRs and MVTRs | |
| | Time &Temp monitoring system | |
| | Oxygen level monitoring system | |
| | Control tempertaure | |
| | Measure microbial load at POS | |
| Consumer | **Needs/Categories** | Consumer Technology Solutions for Category X |
| | Enable safe package reuse | |
| | Expand time for safe product use | |
| | Enable oven/MW monitoring | |

# Intelligent packaging can improve safety

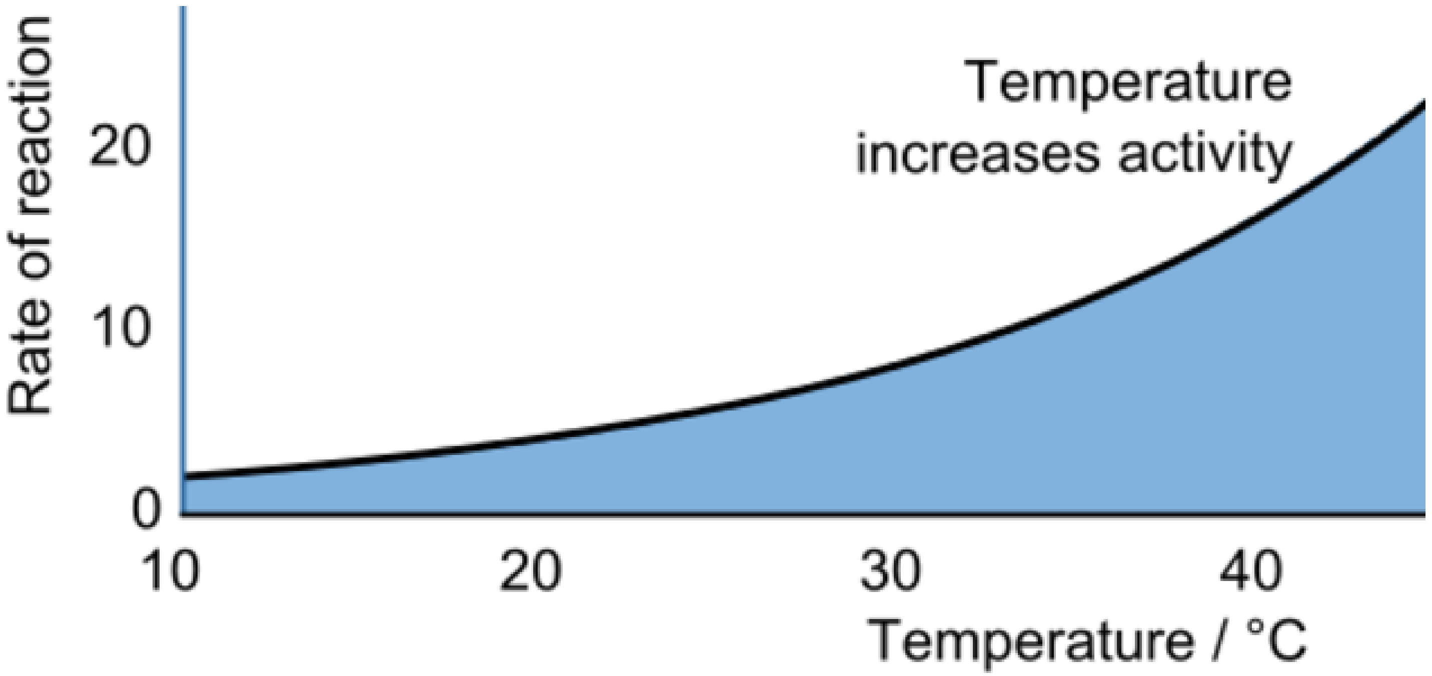
- Focus on:
  - TTI
  - Degradation sensors
  - No-Fraud assurance packaging
  - Responsive packaging

# TTIs

**TTIs are a refined proven technology**

- Remain relevant since temperature governs reaction rates and controls microbial growth

$$k = Ae^{-E_a/(RT)}$$



# Intelligent packaging-TTIs

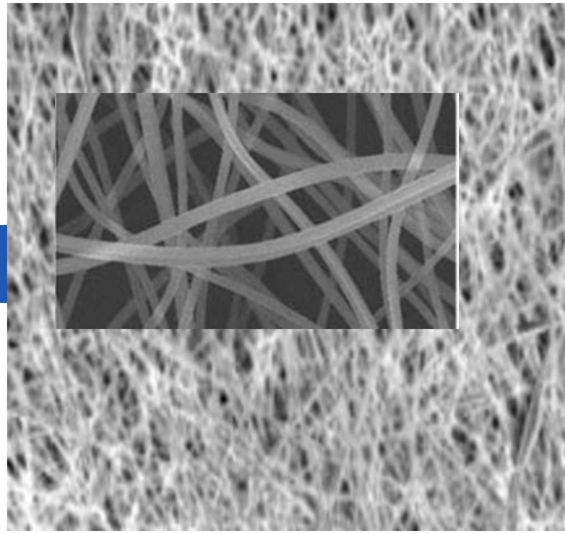
- *FreshCode*, Varcode and *Tempix*, Tempix
  - fading barcodes


- *CoolVu*
  - aluminum layer thins causing a reaction


- *FreshMeter*
  - turns from blue to gray via benzopyridine photoactivation


- *L5-8 Smart Seafood*
  - irreversible color change from the hydrolysis of triglycerides

# Degradation Sensors-Mechanisms



- High surface to volume ratio of nanofibrous membranes and electrospun sensors
- Based on surface enhanced Raman spectroscopy (SERS)
  - Measures total volatile basic nitrogen (TVBN)
  - Monitors cysteine loss via hydrogen sulfide
  - Color change indicator that activates as microbial growth increases
- Advances in wireless nanosensor networks (WNSNs)
  - Graphene printing and conductive polymers
    - enables wireless communication between nanosystems
- Incorporate antibodies (for detection) within polymer films

# Responsive Sensors

- Responsive sensors that detect then act to reduce deteriorative reactions
  - Through the release of $CO_2$, antioxidants or pH change agents
- Tremendous amount of IP in this area

# Common sensors

- Thermochromatic inks change color and reveal images when the product is at the proper temperature to eat or drink
- NFC *OpenSense* package sensor is tapped with a smartphone
- Polymark fluorescence based detection for sorting food-contact PET

# Intelligent Packaging-status

- TTIs continue to be the standard
- For optimum safety, focus on degradation sensors in 1-3 years
- Assess branding and authenticity link to balance costs
- For nutritional waste reduction and safety, focus on responsive sensors in 3-5 years

# Select Roles of Packaging for Milk

Provide a barrier

Enable Manufacturing agility

Enhance consumer interface

Incorporate sustainability

Enable Distribution and handling

Enable safety

# Milk Packaging – some takeaways

- LED (low intensity) and PET, with a better O2 barrier, offer opportunity for increased shelf life
- Sustainable packaging choices and milk shelf life need alignment
- Distribution and handling improvements are possible
- Increased manufacturing agility opens doors
- Enhanced consumer interface reduces commoditization
- Intelligent packaging offers brand and safety benefits
- Value chain solutions are essential

Food science and packaging expertise

- Coaching
- Consulting
- Technology
- Strategy

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