Potential Metalized Film Replacement via HDPE Barrier Lamination

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Agenda

- High-Barrier Food Packaging Background
- HDPE Barrier Lamination Concept
- Comparison of HDPE Barrier Lamination Structures with Current Food Packages
- Conclusions

Presentation Introduction

- Historically, packaging that required excellent barrier properties used foil
- Product development and lower costs led many barrier food packaging applications to move to metalized film
- New developments in HDPE resin design and nucleation provide significantly improved moisture barrier over traditional HDPE resins used in barrier applications
- Use of next-generation HDPE barrier products may provide sufficient product shelf life for over-engineered packages

Presentation Introduction

- Alternatively, consumer packaged goods companies may want to show their product via windows in the package
- To meet barrier requirements, these structures typically use ethylene-vinyl alcohol (EVOH) or nylon
- Use of EVOH or nylon results in a multi-layer film requiring at least five layers
- Next-generation HDPE barrier products may provide sufficient performance to allow packaging substitution in these applications

High-Barrier Food Packaging

- A major market for barrier film (metalized or non-metalized) is stand-up pouches
- 2013 United States pouch usage = 17 billion units
  - 50% growth in past five years
- Food applications represent over 60% of pouch end-uses
  - Pet food = 33%; Human food = 30%
- Forecasted 2018 US pouch demand = 24 billion units
- Growth spurred by bottle/can replacement, packaging cost reduction, and increased consumer convenience

Pouches offer significant current and future market opportunity

Source: Packaging Digest, October 31, 2013.

Typical High-Barrier Film Structures

Reverse-printed PET/oPP Film
LDPE Laminating Layer/Adhesive
Metalized PET/oPP Film
LDPE Laminating Layer/Adhesive
PE Sealant Film

Reverse-printed PET/oPP Film
LDPE Laminating Layer/Adhesive
<u>Multi-layer Film</u> PE Skin Tie-Layer EVOH or Nylon Tie-Layer PE Sealant Film

- Typical overall structure gauge = 3.0 – 5.0 mil
- Metalized structure requires two passes through lamination line
- EVOH/Nylon film requires at least 5-layer film line
- Applications – Bags/pouches for end-uses typically requiring good moisture and/or oxygen barrier

HDPE Barrier Lamination Concept

- HDPE Barrier Lamination presented by LyondellBasell at TAPPI PLACE in 2012
- Compared barrier of HDPE extrusion coating on Kraft paper with HDPE blown film laminated to Kraft paper
- Presentation showed significantly improved barrier resulted with the use of HDPE laminating film
- Study also outlined additional potential design capabilities by incorporating laminating film into structure

HDPE Barrier Lamination Structures

Reverse-printed PET/oPP Film

LDPE Laminating Layer

HDPE Laminating Film

Use same base substrate and LDPE laminating layer as current metalized film or EVOH structures

- HDPE Laminating Film uses blown film made with next-generation HDPE with excellent moisture barrier
  - Replaces metalized film and sealant layers
- May use co-extrusion technology to incorporate other materials for other packaging features
  - Sealant, toughness, O_2 barrier, etc.

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Potential Advantages for HDPE Barrier Lamination

- Lower costs
  - Material costs
  - Single-pass through extrusion coating line
- Food packaging differentiation
  - Windows (if desired) to view product
- Improved food product safety
  - Allow use of metal detectors for metal contaminants
  - Allow use of high voltage leak detection systems
- Ability to tailor film structure to enhance package
  - Use different polymers/layers for barrier (H_2O, O_2), toughness, sealing/opening, etc. as desired
- Overall structure yield advantage by eliminating metalized PET film

HDPE Barrier Lamination Sample Preparation

- Produced ABA co-ex blown films
  - Skin layers (A) were butene LLDPE
    - Primary functions were for toughness and sealant layer
  - Core layer (B) was nucleated, next-generation HDPE homopolymer
  - Used layer distributions of 15-70-15 and 30-40-30
  - 3.0-mil total gauge

- Produced extrusion lamination films on coating line
  - Used 48-gauge PET film as substrate
  - Laminated ABA co-ex films to PET with 0.5-mil LDPE
  - For subsequent charts, 15-70-15 = 48-gauge PET / 0.5-mil LDPE / 15-70-15 LLDPE-HDPE-LLDPE
  - Same sample description for 30-40-30 laminating film

- Total film gauge = 4.0 mil

Blown Film Line Conditions: 6-inch die, 60-mil die gap, 3.0:1 BUR
Extrusion Coating Line Conditions: 7-inch air gap, 615ºF melt temperature, 250 feet per minute line speed, Michelman MFP888 primer

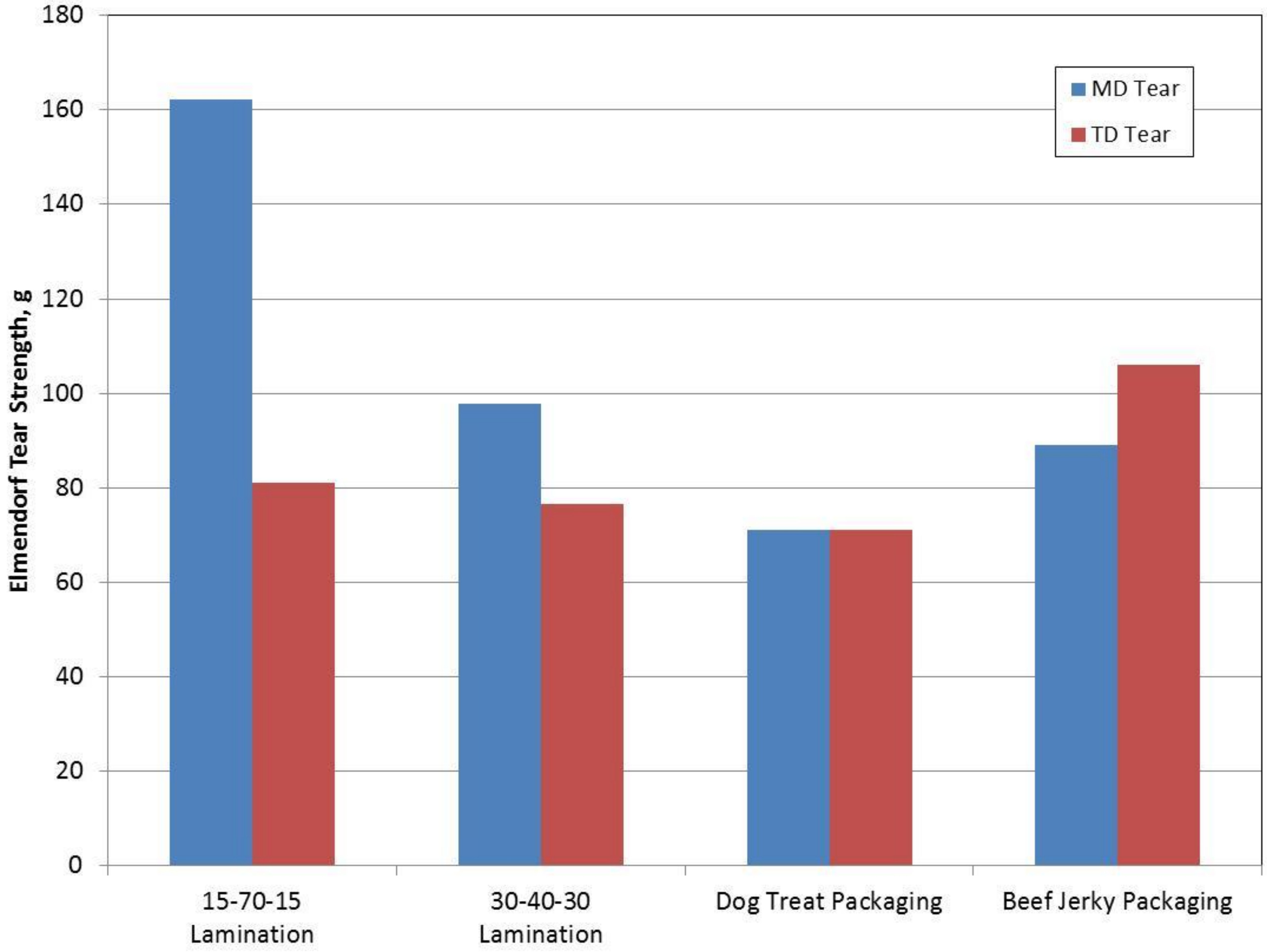
HDPE Barrier Lamination Comparison Testing

- Purchased dog treats packaged in metalized film
- Analytical testing found packaging was 3-ply with:
  - Reverse printed PET primary substrate
  - Metalized PET film layer
  - PE-based sealant layer
- Total film gauge = 4.0 mil
- Test samples cut from packages for film testing
  - Toughness – Tear, Puncture
  - Stiffness
  - Optics
  - Food aging

HDPE Barrier Lamination Comparison Testing

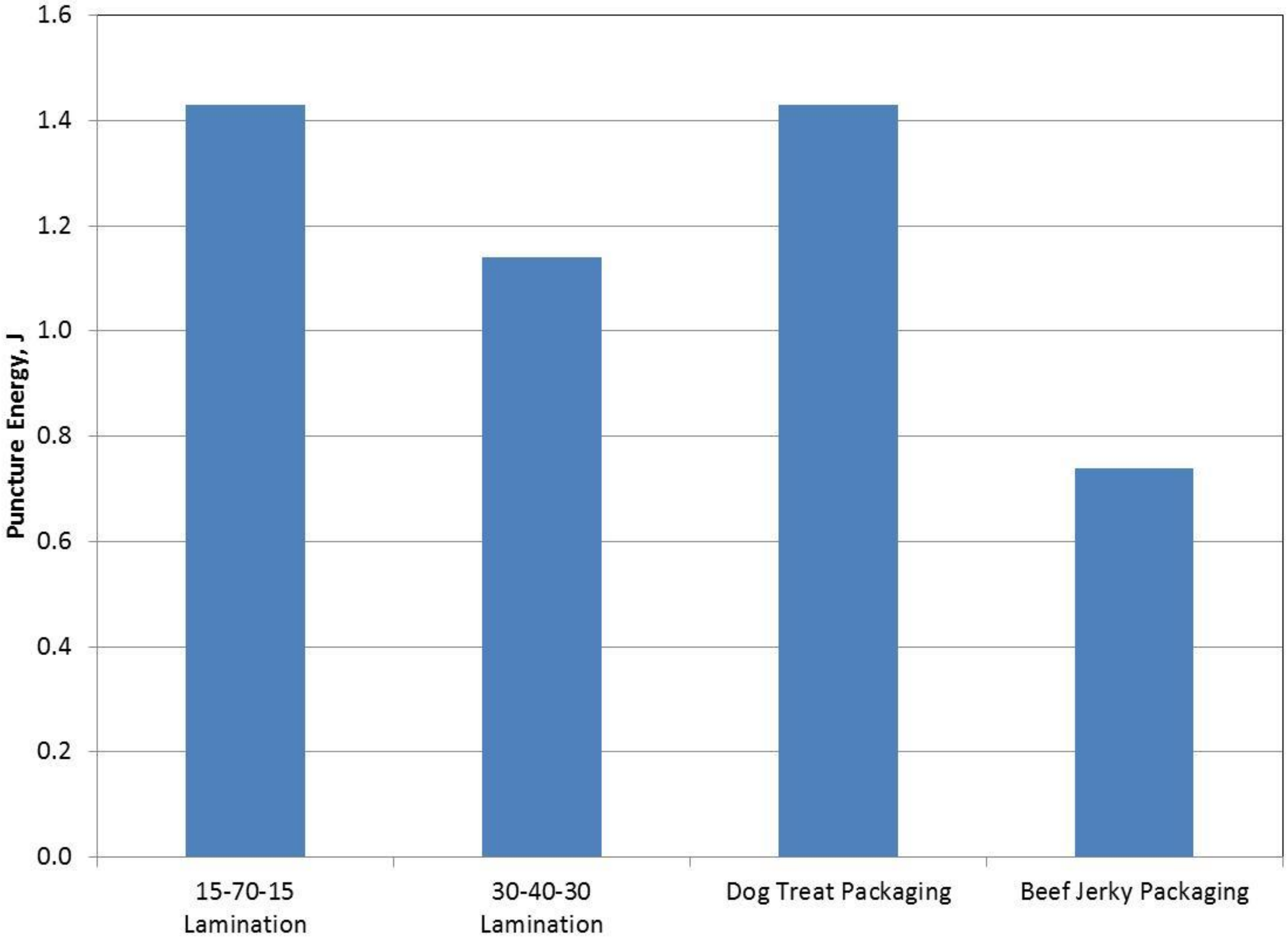
- Purchased beef jerky packaged in non-metalized structure, but known to require good barrier
- Analytical testing found film was 2-ply with:
  - Reverse printed PET primary substrate
  - 4.5-mil LLDPE-tie-EVOH-tie-LLDPE co-ex film
- Total film gauge = 5.0 mil
- Similar film testing completed as metalized film samples

HDPE Barrier Lamination Comparison Testing Tear



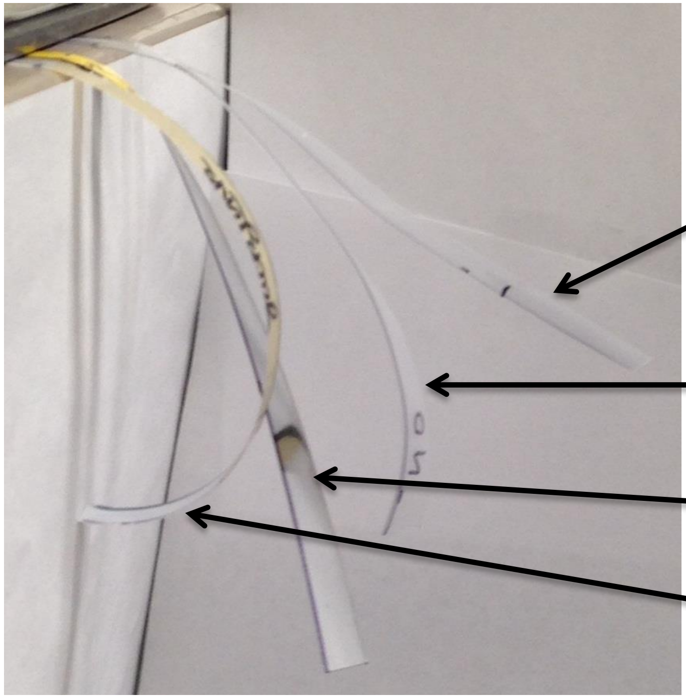
Barrier Lamination structures have comparable tear

HDPE Barrier Lamination Comparison Testing
Puncture



Barrier Lamination structures have similar or better puncture

HDPE Barrier Lamination Comparison Testing Stiffness



- Stiffness measurements are difficult for films
- To try to compare stiffness, 0.5 mm by 100 mm strips cut from packages
- Specimens allowed to overhang table (10 mm held on table)

Barrier Lamination structures appear to have higher stiffness

HDPE Barrier Lamination Comparison Testing Optics

Dog Treat | Beef Jerky

15-70-15 Lamination
(Haze = 31)

30-40-30 Lamination
(Haze = 22)

Current Package

Barrier Lamination structures may allow product to be seen (if desired)

Current Beef Jerky package haze = 33

HDPE Barrier Lamination Comparison Testing
Food Aging

- To assess potential real-world shelf-life performance, completed food-aging studies by making packages
- Cut 4-inch by 4-inch sections of film
  - Produced control samples by using metalized film structures
- Heat sealed film edges to fusion
- Filled package with food samples
  - Approximately 30 grams for dog treats
  - Approximately 20 grams for beef jerky
  - Film for packages weighed about 2 grams
  - 3 specimens per sample
- Stored samples in 23^{o}C, 50% relative humidity lab
- Weighed samples on Monday, Wednesday, and Friday

HDPE Barrier Lamination Comparison Testing Food Aging

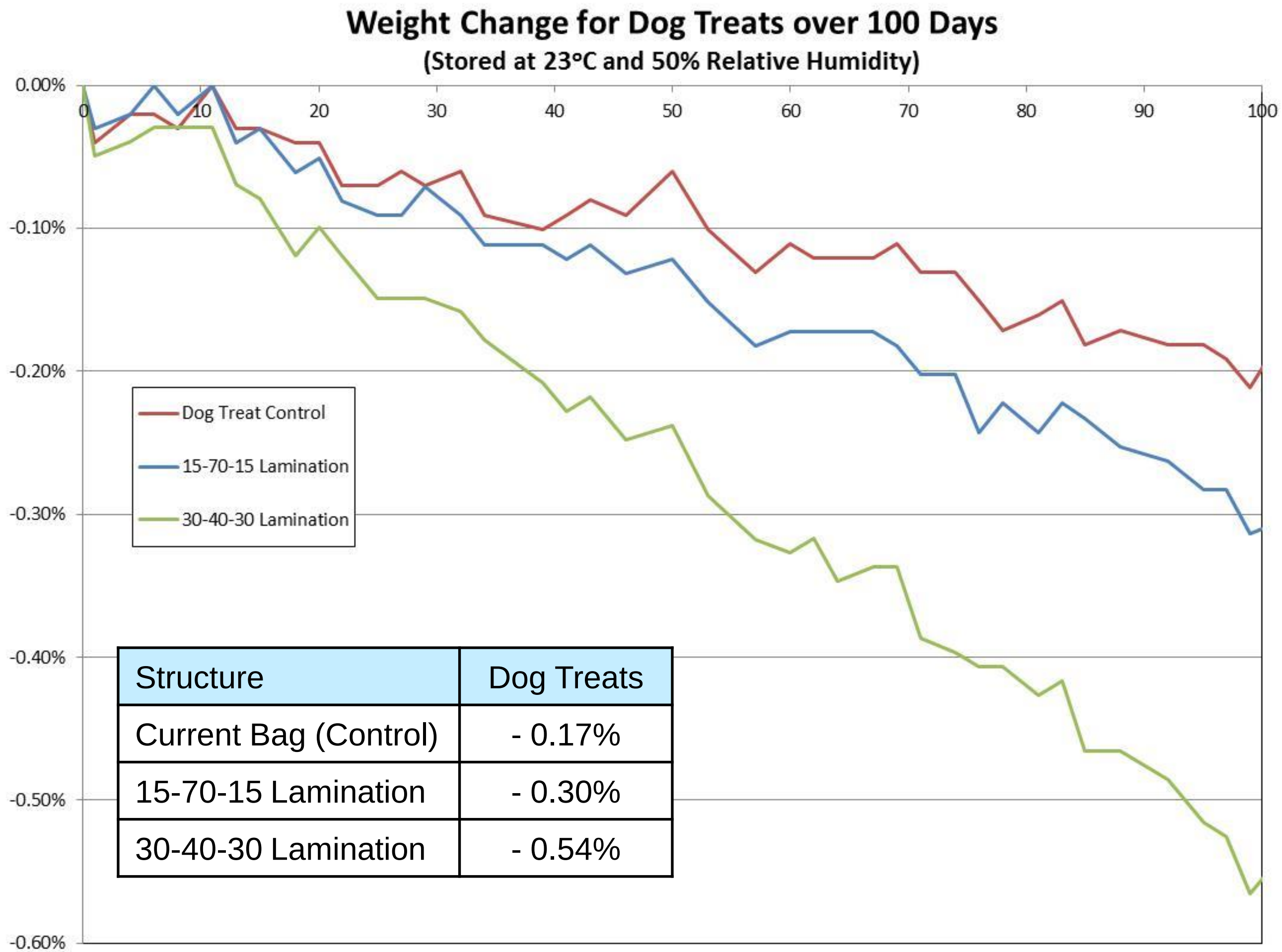
Barrier Lamination Dog Treat Sample

Barrier Lamination Beef Jerky Sample

Dog Treat Control Sample

Beef Jerky Control Sample

HDPE Barrier Lamination Comparison Testing
Food Aging – Dog Treats



Structure	Dog Treats
Current Bag (Control)	- 0.17%
15-70-15 Lamination	- 0.30%
30-40-30 Lamination	- 0.54%

Higher HDPE content leads to structures that approach the weight change of the control bag and may be sufficient for some applications

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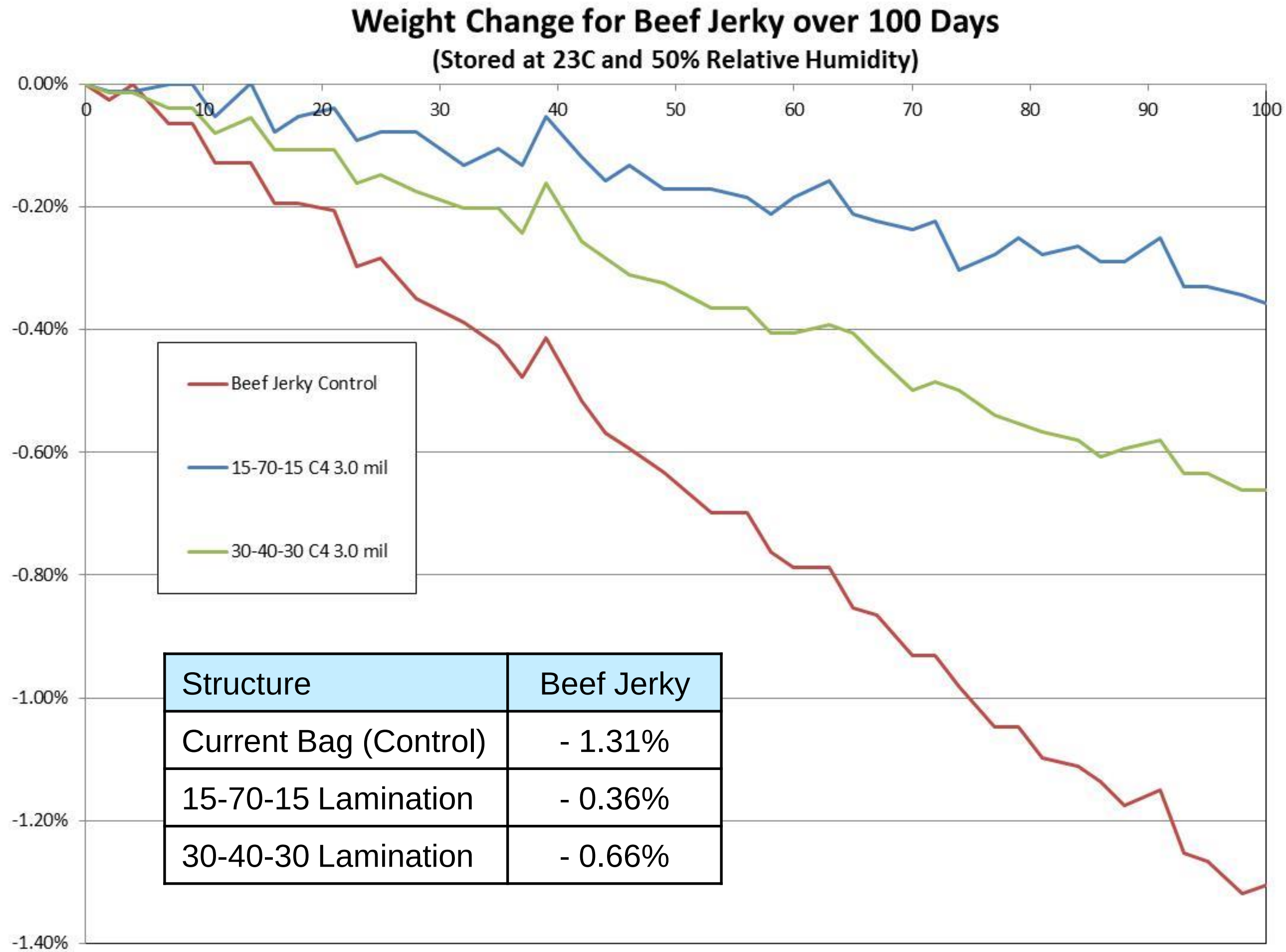
HDPE Barrier Lamination Comparison Testing
Food Aging – Beef Jerky



Structure	Beef Jerky
Current Bag (Control)	- 1.31%
15-70-15 Lamination	- 0.36%
30-40-30 Lamination	- 0.66%

Barrier lamination structures appear to show significantly less weight change over time than current package

Results Summary

+ indicates improved performance for lamination
- indicates better performance by existing structure

15-70-15 Lamination	Dog Treat	Beef Jerky
Tear	++	+ (MD) / - (TD)
Puncture	=	++
Stiffness	++	++
Haze	+++	=
Food Aging	-	++

30-40-30 Lamination	Dog Treat	Beef Jerky
Tear	+	= (MD) / - (TD)
Puncture	=	++
Stiffness	++	+
Haze	+++	+
Food Aging	--	+

While food aging may not be equivalent, is it good enough for over-engineered packages or for actual supply chain cycle?

Conclusions

- New lamination structures may be closing food freshness gap
- Over-engineered packages may be able to move to polyolefin-based lamination film structures
- Laminating film composition affects performance
- New non-metalized structures may offer other benefits
- Additional structure and material optimization may lead to further improvements in performance and costs

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