final report

Project code: V.RMH.0027

Prepared by: Richard Tomasevic
Sealed Air Pty Limited

Date published: 27 January 2017

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Preliminary trial of several packaging concepts that extend red meat shelf-life

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

Sealed Air is one of the world's leading packaging and hygiene materials and systems providers (Refer to http://www.sealedair.com/food-care/food-care-products/fresh-red-meat) and currently a large supplier within the Australian Red Meat industry. Sealed Air globally has recently developed a number of packaging solutions for the wider food industry and this project will develop a report on several concepts and evaluate the value proposition (considering shelf life, bill of materials yields and costs and throughput and industry capability to adopt) to be made available for dissemination to Australian red meat industry – these include:

- Large Bone-in Vacuum packaged barrier bags ("Telescope") - using a vacuum seal chamber and high abuse bulk bag, pack whole or spilt lambs or 18 bulk portion beef carcass rather than current cheesecloth or sub primal vacuum/bone guard format

- Marinade on Demand (M.O.D.) Thermoform web – film and index design that allows marinade to be deposited separately and squeezed onto the meat

- Scavenger and Active barrier (S.A.B) materials – embedded film layer that aims to minimise or eliminate "confinement odours" or "residual oxygen" to maintain the desired product aroma and/or colour

The following packaging concepts address some of the primary benefits in packaging innovations include:

- Consumer lifestyle
- Cost saving and logistics efficiency
- Sustainability trends
- Convenience
- Continual improvement

Specifically, this report will:

- Describe the "Telescope, M.O.D. and S.A.B." packaging principles, trends and applications in other food and market sectors and opportunity for Australian Red Meat industry adoption (Milestone 1).
- Develop research design and implement preliminary evaluation on the above packaging concepts with Red Meat (include shelf life assay, bill of materials yields, and operational and logistics capability/throughput costs) against present mode of operation in Australia and describe value proposition and possible commercial constraints (Milestone 2b and Final report.
- List the procured packaging materials and (credit costs) laboratory assays to complete the trials (milestone 2a only).

The purpose of this research was to review new to market "active" packaging technologies to provide improved shelf life and to demonstrate a potential process design suitable for case ready, chilled exported product.

Executive Summary

There is new technology designed to absorb confinement odour for products packed under vacuum for long periods in barrier shrink bags which can suit meat exports with the additives added into the sealant layer. A successful additive mix has been developed for poultry and there appears strong market interest in Australia to create an additive blend that will work on lamb. Another special “active” additive can be added to the outside layer of the barrier film. Sealed Air have had success with extending shelf-life on various products like guacamole, as well as holding the colour of cheese and smallgoods products to the end of its shelf life but more work needs to be done to see if shelf life of lamb and beef can be extended.

Active packaging systems extend the shelf life of food products by extending product quality and increasing safety, protecting against intentional and unintentional contamination, and enhancing the convenience of food processing, distribution, retailing, and consumption. Active packaging systems achieve this by including constituents intentionally added to enhance the performance of the packaging. Active packaging technologies have a number of applications, several of which have been commercialised and used in the food industry. A number of published reports (www.sgs.com/foodsafety) describe the role individual active packaging technologies play in extending the shelf life of packaged foods. However, it is worth noting that combinations of hurdles, in this case a combination of multiple active packaging technologies are required in most, if not all cases, to guarantee the safety and preservation of food.

Applications for active packaging technologies include:

- Antimicrobial packaging
- Carbon dioxide scavenging
- Moisture scavenging
- Oxygen scavenging

Increases in product shelf life can provide greater chilled market access both domestically and export for value added fresh red meat products and reduce the clearances and dump markdown rates of spoilt products. Whilst preservatives and additives can address this, selecting the correct packaging format significantly determines available substrates for microbial growth and final product shelf life. In turn, the last 20 years has seen significant increased adoption of Modified Atmosphere Packaging formats whereby CO2 and O2 gas ratios are designed to optimise meat colour and inhibit microbial growth. Likewise, the use of O2 scavenger sachets, typically containing silica have been inserted into vacuum packaged meats and pasta in particular to consume residual O2, albeit despite long held concerns for consumers to wrongly ingest as part of the product.

Sealed Air Global packaging have developed Cryovac® Freshness Plus® range - a family of active packaging technologies specifically designed to maximize freshness, flavour and product colour while reducing confinement odours. Currently no Australian meat processor uses or has assessed the feasibility of Freshness Plus® packaging range. Overseas customers who have adopted these technologies have included Hormel ready meals, Foster Farms and Nestle Buitoni fresh pasta – appendix 1: Sealed Air brochure. A study to determine if these materials do improve the product quality for the life of fresh red meat is

required and will represent an advance to the Ageless™ sachets – the first and still commonly used oxygen absorber (http://ageless.mgc-a.com/applications/food/).

The available Sealed Air technologies are:

1. Oxygen Scavenging (OS) films are designed for lidding onto Modified Atmosphere Packages (MAP). The film rapidly scavenges residual oxygen left in the package headspace after the packaging process or oxygen that migrates out of the product after the packaging step. The invisible scavenger is inside the film and is activated with a patented UV triggering unit which is integrated with packaging equipment. The OS film helps reduce or eliminate oxidative deterioration of colour, flavour and nutrients while preventing growth of aerobic microbes like mould. These are proposed to be commercially viable for “Preservative Free” and organically sourced products.

2. Active Barrier materials are designed for vacuum packaged products or packages with minimal headspace. The active barrier materials contain oxygen scavenging components that actively trap oxygen migrating into the film. This provides a higher level of protection against oxygen verses passive barrier materials. This film is ideal for oxygen sensitive products and products with a long shelf life. Film does not require an activation step.

3. Odour Scavenging materials are designed to minimise or eliminate “confinement odours” and maintain the desired product aroma. A variety of odours can be generated in fresh or process foods which are associated with a reduction in freshness and quality. Cryovac® odour scavenging materials remove odours from the package and keep the product fresher, longer. No film activation required. This material is being used by Koch Foods for boneless skinless chicken breasts, Foster Farms for turkey luncheon meats and a national pork processor for pork back ribs and spareribs.

The current work demonstrated a range of packaging options to deliver product and shelf-life enhancements for export lamb. The results show that only one portion of lamb had acceptable quality and microbiology. It is proposed that this result was due to one side being semi-crust froze which means it didn't release any drip. This result re-affirms the need to have mechanisms in place to reduce or even eliminate drip in the packaging. To this end, there are some interventions proposed by Sealed Air to reduce and/or eliminate drip in the bag.

A commercial trial was (voluntarily) undertaken by a lamb processor. The processor air freighted some telescope lambs after our trials to customers and after receiving positive feedback, the processor presented telescope lamb samples at the Gulfoods stand in the Middle East. Positive feedback was received at the tradeshow. The processor is currently considering to conduct further commercial trials to validate the shelf-life and quality of bone-in lamb product. Subsequently the processor has sent samples via airfreight in December to the Middle East the day after the trial was packed off and the feedback from the customer was very positive with no issues raised with shelf-life or quality of product. This result potentially demonstrates the commercial application of the use of telescope packaging options in lamb export products.

Table of Contents

1 Background

1.1 Introduction

There is a growing demand by consumers for meat and meat products perceived as tender, nutritious, healthy and safe (Grunert & Valli, 2001). Meat quality and safety properties are highly dependent on the applied packaging materials and technologies.

The fundamental reasons for packaging fresh and processed meat products are to prevent contamination, delay spoilage, permit some enzymatic activity to improve tenderness, reduce weight loss, and retain colour and aroma (Brody,1997; Mondry,1996). Based on this, current meat packaging practices range from overwrap packaging for short-term chilled storage and/or retail display, to vacuum packaging, bulk-gas flushing or modified atmosphere packaging (MAP) systems for long-term chilled storage, each with different attributes and applications (Kerry, O'Grady, & Hogan, 2006; McMillin, 2008).

Recently, a series of new packaging technologies and materials have been developed including active packaging, intelligent packaging, edible coatings/films, biodegradable packaging, and nanomaterial packaging, as described in some very comprehensive reviews (Arvanitoyannis & Stratakos, 2012; Ghaani, Cozzolino, Castelli, & Farris, 2016; Kapetanakou & Skandamis, 2016; Kerry et al., 2006; Lee, Lee, Choi, & Hur, 2015; Maisanaba et al., 2016; Realini & Marcos, 2014; Sun & Holley, 2012). These technologies and materials have the potential to ensure food quality and safety, prolong shelf life, reduce environmental impact and increase the attractiveness of the packaged product to retailers and consumers.

However, only a limited number of these technologies are relevant to meat and meat products and there are only limited reviews in this application area (Arvanitoyannis & Stratakos, 2012; Coma, 2008; Kerry et al., 2006; Quintavalla & Vicini, 2002; Realini & Marcos, 2014; Sun & Holley, 2012). The Australian red meat industry is the world's largest exporter of beef (20% of total world exports) and sheep meats (36% of total world exports) (FAOSTAT, 2013). Red meat production is also the No. 2 economic contributor to Australian farm and fisheries food production industry after grains, with a value about 13.3 billion Australian dollars in the 2012e2013 financial year (DAFF, 2014). Therefore, research and application of appropriate packaging technology is critical to the meat industry. This review examines the active and intelligent packaging systems currently being used for meat and meat products, and assessed new and emerging technologies that may have potential for commercial use in the future. The internationally registered patents in the last 15 years are also discussed.

Active packaging in the meat industry active packaging is an innovative packaging technology that allows the product and its environment to interact to extend the product shelf life and/or to ensure its microbial safety, while maintaining the quality of the packed food (Ahvenainen, 2003). In the United States, the term “active packaging” generally describes any packaging system that protects food from contamination or degradation by creating a barrier to outside conditions while interacting with the internal environment to control the atmosphere within the package (Ettinger, 2002). Based on the European Union Guidance to the Commission Regulation (EUGCR) No 450/2009 (EU, 2009), active packaging is a type of food packaging with an extra function, in addition to that of providing a protective barrier against external influence. The packaging absorbs food derived chemicals from the food or

the environment within the packaging surrounding the food; or it releases substances into the food or the environment surrounding the food such as preservatives, antioxidants, and flavourings (EU, 2009). The most important active packaging systems applied to meat and meat products are antimicrobial, antioxidant, and carbon dioxide emitting/generating packaging.

Sealed Air is one of the world's leading packaging and hygiene materials and systems providers (Refer to http://www.sealedair.com/food-care/food-care-products/fresh-red-meat) and currently a large supplier within the Australian Red Meat industry. Sealed Air globally has recently developed a number of packaging solutions for the wider food industry.

1.2 Purpose

The purpose of the study was to evaluate if shelf life can be extended for several packaging solutions that are new to Australian Red Meat Industry developed by Sealed Air. On a limited scale, these proof of concepts were presented to wider industry as possible enabling technologies that can improve and maintain red meat quality and permit increased market access and penetration via packaging solutions that can be adopted and customised from learnings from other food sectors and/or markets.

1.3 Description

A number of emerging trends have been seen within the Australian Red Meat industry during the last few years whereby packaging innovations may represent possible solutions to grow red meat demand – with perhaps the two key considerations being:

- Increased exporting of whole carcasses and larger bulk primals portions being further processed offshore

- Operational, logistical and merchandising excellence demand to reduce wastage impost

- Increase merchandising of retail ready products and expectation of "fresh" produce – despite larger market area but with no confinement odours, "cherry red" meat colour and if value added, preference for "natural" value added products, particularly sauces and flavours infused or marinated on products, limiting the use of additives and wanting to "see fresh" product and choose to add "sauce" components separately not "hidden" within the pack (and the label)

1.4 Scope of the project

This project was designed to validate several active packaging concepts to enhance the value and profitability to the red meat industry. Specifically these include:

- Large Bone-in Vacuum packaged barrier bags ("Telescope") - using a vacuum seal chamber and high abuse bulk bag, pack whole or spilt lambs or 18 bulk portion beef carcass rather than current cheesecloth or sub-primal vacuum/bone-guard format.

- Marinade on Demand (M.O.D.) Thermoform web – film and index design that allows marinade to be deposited separately and squeezed onto the meat.

- Scavenger and Active barrier (S.A.B.) materials – embedded film layer that aims to minimise or eliminate “confinement odours” or “residual oxygen” to maintain the desired product aroma and/or colour.

2 Project Objectives

The objectives of the project were to:

- Describe the “telescope, M.O.D. and S.A.B” packaging principles, trends and applications in other food and market sectors and opportunity for Australian Red Meat industry adoption.

- Develop research design and implement preliminary evaluation on the above packaging concepts with Red Meat (include shelf life assay, bill of materials yields, and operational and logistics capability/throughput costs) against present mode of operation in Australia and describe value proposition and possible commercial constraints.

3 Methodology

The following trial process was applied. Refer to the sampling plan (See Appendix 1 – Trial Sampling Plan).

3.1 Trial Design for Large Bone-in Vacuum packaged barrier bags (“Telescope”)

- Packaging treatments x 3 cuts (lamb side; lamb shoulder; lamb rack) x 4 sampling interval (+ initial)
- Packaging
    - 200 x B4680GP CB20X39HVY PEUT P SN733G 550 x 990mm
    - 200 x B4680GP with oxygen scavenging added
    - 200 x B4680GP with odour scavenging added
- Freight
- Meat – TBC (Lamb - sourced from Cedar Meats, Brooklyn or Frewstal or Midfield, Warrnambool Vic)
- Symbio Alliance Lab Assays – sampling intervals (day 0, 25, 50, 75, 100)
    - Total Plate Count and Coliforms

3.2 Trial Design for M.O.D

- 1 packaging treatments x 3 cuts (raw beef; cooked pulled beef; raw lamb) x 4 sampling interval (+ initial)
- Roll each of Top and Bottom Web (Onpac)
- Meat – TBC (Lamb – as per [A] & [B] trial; beef from Top Cut or ACC)
- Symbio Alliance Lab Assays – sampling intervals (day 0, 7, 14, 21, 28)
- Total Plate Count and Coliforms

The research schedule applied was as follows:

1	**Detailed design and agreed scope of work. -** Sealed Air to submit to MLA a brief overview of [a) Telescope; b) M.O.D.; and c) S.A.B] applications, trends, principles and opportunity for Australian Red Meat Industry adoption Sealed Air to submit experimental design to MLA of meat / packaging treatment effects investigated and the location, timing, assays, source of materials and activities plan for where research will be completed.
2	**Trials.** Sealed Air to procure materials and complete the trials and report findings to MLA of the proof of concepts (includes summary of observations, photos, yields, costs, material specification, assays).
3	**Final Report.** a) *Commercial in confidence* - Sealed Air to submit Final Report of completed tasks and key findings. This is to include commercial value proposition compared to present mode of operation for these proof of concepts and any commercial constraints currently within the Australian Red Meat Industry that may limit uptake. b) *Industry sanitised* – Sealed Air to submit Final Report to MLA showcasing proof of concepts that can be made disseminated to wider industry

4 Results

4.1 Microbiological & Product Quality

The microbiological results from 74 days storage are shown in Table 1.

TVC counts were shown to be acceptable and as you might expect from lamb primals. However, the Enterobacteriacea results were shown to be unacceptable. Typically counts in the range of <100/cm2 are generally considered to be acceptable. These results were from the intestines and therefore you might expect the carcase to be not as clean as it could be. It is proposed the reason for the higher than expected carcase counts is related to the drip which enables spread of bacteria over the carcass. This reinforces that the need to remove or absorb the drip from the carcass to make this a viable option.

The carcass identified as Side 5a had acceptable TVC and Enterobacteria count due to it being semi frozen. These results reaffirm the commercial possibility of reducing the storage temperature even further than the trial temperatures applied.

The results showed that telescope lamb stored at 74 days on the full and side lamb carcass failed. The confinement odour was shocking and after 30mins it improved but didn't completely dissipate. It is proposed the problem is the amount of drip still left in the chest cavity (see Photo 1). Absorbent pads used in the full carcases (3 x 300ml) and the sides (1 x 300ml) weren't enough to absorb all of the drip. Some shank caps were full of drip. Excessive leakers were experienced in the Active barrier and Active/Odour barrier which was made with BXPLUS 85um gauge. TBG in 180um gauge were acceptable (See Photos 2 & 3).

Photo 1: Lamb product assessed after being stored for 74 days in Telescope barrier bag.

If the trials were to be repeated in the future, it is recommended that full (2) and half (2) carcasses were validated using:

- 5 x 300ml soaker pads in the full carcass and cotton bone-guard on the shank to replace the plastic shank caps.
- 2 x 300ml soaker pads on each carcass sides and cotton bone-guard on the shank to replace the plastic shank caps.

It is proposed to only use TBG B4680 as the BXPLUS with active and odour scavenging showed no difference in performance when it came to the confinement odour. With this specification in mind, it is recommended to have the toughest bone in bag possible for commercial applications.

The results show that only one piece passed which was a side. It is proposed that this result was due to one side being semi-crust froze which means it didn't release any drip. This result re-affirms the need to have mechanisms in place to reduce or even eliminate drip in the packaging. To this end, there are some interventions proposed by Sealed Air to reduce and/or eliminate drip in the bag.

Photo 2: Lamb product assessed after being stored for 74 days in Telescope barrier bag.

Photo 3: Lamb product assessed after being stored for 74 days in Telescope barrier bag.

Table 1: Microbiological results from 74 days storage across the various packaging formats.

1	**TELESCOPE LAMB SHELF LIFE TRIALS**									
2	***Full Lamb Carcase Killed 30/11/16***				***Full Lamb Carcase***		***Half Side Carcase***		***Full Lamb Carcase***	***Half Side Carcase***
3	***Half Side Carcase***				74 days		74 days		90 days	90 days
4	***Vacuum packed carcasess will be held at 0oC +/-1oC***		Carcase		Packed Date		Packed Date		Packed Date	Packed Date
5	**24 Carcases in Total Packed (small around 15kg)**		Numbered		3 x Soaker pad 300ml		1 x Soaker pad 300ml		3 x Soaker pad 300m	1 x Soaker pad 300ml
6	**How product packed in storage**									
7					2 x Shank caps		2 x Shank caps		2 x Shank caps	2 x Shank caps
8	**ACTIVE BARRIER**									
9	The active barrier materials contain oxygen scavenging components that actively trap oxygen migrating into the film. This provides a higher level of protection against oxygen verses passive barrier materials. This film is ideal for oxygen sensitive products and products with a long shelf life. Film does not require an activation step.									
11	*Carcase internal Temperature prior to packing*	Degrees OC	13	6						
12		Full	14	5.6						
13		Full	15	5.3						
14		Full	16	5.8						
15		Half	17a	5.8						
16		Half	17b	5.8						
17		Half	18a	6.3						
18		Half	18b	6.3						
19										
20	*Take samples for PH Test prior to packing*	PH results	13	6.43						
21		Full	14	6.72						
22		Full	15	6.38						
23		Full	16	6.4						
24		Half	17a	6.41						
25		Half	17b	6.41						
26		Half	18a	6.37						
27		Half	18b	6.37						
28	*Take swabs for Total Viable Aerobic Count. (Enterobacteriaceae , Coliforms, Generic E.Coli, Lactics)*	Microbe Count TVCs/cm2			Microbe Count TVCs/cm2	Enterobacteriacea/cm2	Microbe Count TVCs/cm2	Enterobacteriacea/cm2		
29			13	405.9						
30			14	267.3	3,700,000	1,650				
31			15	145.2						
32			16	990						
33			17a	521.4						
34			17b	521.4						
35			18a	303.6						
36			18b	303.6						
37										
38	*select Marketing, QA for smell tests*	Confinement Odour	13							
39	*Alistair Sharp*		14			Failed				
40	*Colin Powell*		15			Failed				
41	*Leigh Kane*		16							
42	*Richard Tomasevic*		17a							
43			17b							
44			18a					Failed		
45			18b					Failed		
46										
47										

48	**ODOUR SCAVENGING**									
49	designed to minimize or eliminate "confinement odors" and maintain the desired product aroma. A variety of odors can be generated in fresh or process foods which are associated with a reduction in freshness and quality. Cryovac® Odor Scavenging materials remove odors from the package and keep the product fresher, longer. No film activation required.									
50										
51	*Carcase internal Temperature prior to packing*	Degrees OC	7	6.4						
52			8	6.1						
53			9	5.8						
54			10	6.1						
55			11a	6.3						
56			11b	6.3						
57			12a	5.5						
58			12b	5.5						
59										
60	*Take samples for PH Test prior to packing*	PH results	7	6.54						
61			8	6.48						
62			9	6.45						
63			10	6.45						
64			11a	6.71						
65			11b	6.71						
66			12a	6.46						
67			12b	6.46						
68	*Take swabs for Total Viable Aerobic Count. (Enterobacteriaceae , Coliforms, Generic E.Coli, Lactics)*	Microbe Count TVCs/cm2			Microbe Count TVCs/cm2	Enterobacteriacea/cm2	Microbe Count TVCs/cm2	Enterobacteriacea/cm2		
69			7	290.4	2,400,000	4,752				
70			8	201.3						
71			9	273.9						
72			10	267.3						
73			11a	297			14,000,000	5,400		
74			11b	297						
75			12a	376.2						
76			12b	376.2			36,000,000	400		
77										
78	*select Marketing, QA for smell tests*	Confinement Odour	7			Failed				
79	*Alistair Sharp*		8							
80	*Colin Powell*		9							
81	*Leigh Kane*		10			Failed				
82	*Richard Tomasevic*		11a					Failed		
83			11b							
84			12a							
85			12b					Failed		
86										
87										

88	**ACTIVE/ODOUR SCAVENGING**									
89	The Two above combined									
90	*Carcase internal Temperature prior to packing*	Degrees OC	19	6.4						
91			20	6.4						
92			21	5.5						
93			22	6.1						
94			23a	6.2						
95			23b	6.2						
96			24a	6.1						
97			24b	6.1						
98										
99	*Take samples for PH Test prior to packing*	PH results	19	6.32						
100			20	6.3						
101			21	6.39						
102			22	6.4						
103			23a	6.24						
104			23b	6.24						
105			24a	6.27						
106			24b	6.27						
107	*Take swabs for Total Viable Aerobic Count. (Enterobacteriaceae , Coliforms, Generic E.Coli, Lactics)*	Microbe Count TVCs/cm2			Microbe Count TVCs/cm2	Enterobacteriacea/cm2	Microbe Count TVCs/cm2	Enterobacteriacea/cm2		
108			19	425.7						
109			20	399.3						
110			21	924	1,900,000	825				
111			22	366.3						
112			23a	135.3						
113			23b	135.3						
114			24a	155.1						
115			24b	155.1						
116										
117	*select Marketing, QA for smell tests*	Confinement Odour	19			Leaker				
118	*Alistair Sharp*		20			Failed				
119	*Colin Powell*		21			Failed				
120	*Leigh Kane*		22							
121	*Richard Tomasevic*		23a					Leaker		
122			23b					Failed		
123			24a					Leaker		
124			24b					Leaker		
125										
126										
127										
128	**CONTROL PACKS**									
129										
130	*Carcase internal Temperature prior to packing*	Degrees OC	1	6						
131			2	6.4						
132			3	5.7						
133			4	5.5						
134			5a	5.7						
135			5b	5.7						
136			6a	6.1						

137			6b	6.1						
138										
139	*Take samples for PH Test prior to packing*	PH results	1	6.96						
140			2	6.86						
141			3	6.77						
142			4	6.89						
143			5a	6.61						
144			5b	6.61						
145			6a	6.55						
146			6b	6.55						
147	*Take swabs for Total Viable Aerobic Count. (Enterobacteriaceae , Coliforms, Generic E.Coli, Lactics)*	Microbe Count TVCs/cm2			Microbe Count TVCs/cm2	Enterobacteriacea/cm2	Microbe Count TVCs/cm2	Enterobacteriacea/cm2		
148			1	250.8						
149			2	300.3						
150			3	448.8	24,000,000	>3000				
151			4	438.9						
152			5a	709.5			100,000	80		
153			5b	709.5						
154			6a	148.5						
155			6b	148.5						
156										
157	*select Marketing, QA for smell tests*	Confinement Odour	1							
158	*Alistair Sharp*		2							
159	*Colin Powell*		3			Failed				
160	*Leigh Kane*		4			Failed				
161	*Richard Tomasevic*		5a					Passed (semi frozen)		
162			5b							
163			6a					Failed		
164			6b							
165										
166										
167										

5 Findings & Active Packaging Concepts

5.1 Cryovac® OS Systems

Cryovac® OS Films may extend the shelf life of your product by weeks or even months. The system works fast, retarding mould and bacteria growth more quickly, translating to a lower bacteria count at the sell-by or used by dates. Unlike other scavenging systems such as sachets and labels, transparent scavenger is extruded as a layer of the packaging film. Refer to Photo 4 & 5. This unique innovation doesn't change the look or feel of the package, or rely on moisture to work as an activator. Plus, with our patented UV light triggering process you can activate the oxygen removing protection just as you package your product, making this system highly effective and simple to use. In addition, two new cutting edge quality assurance systems have been put in place to quickly verify that the OS system is performing properly.

Photo 4: Cryovac® OS Films with transparent scavenger as a layer of the packaging film

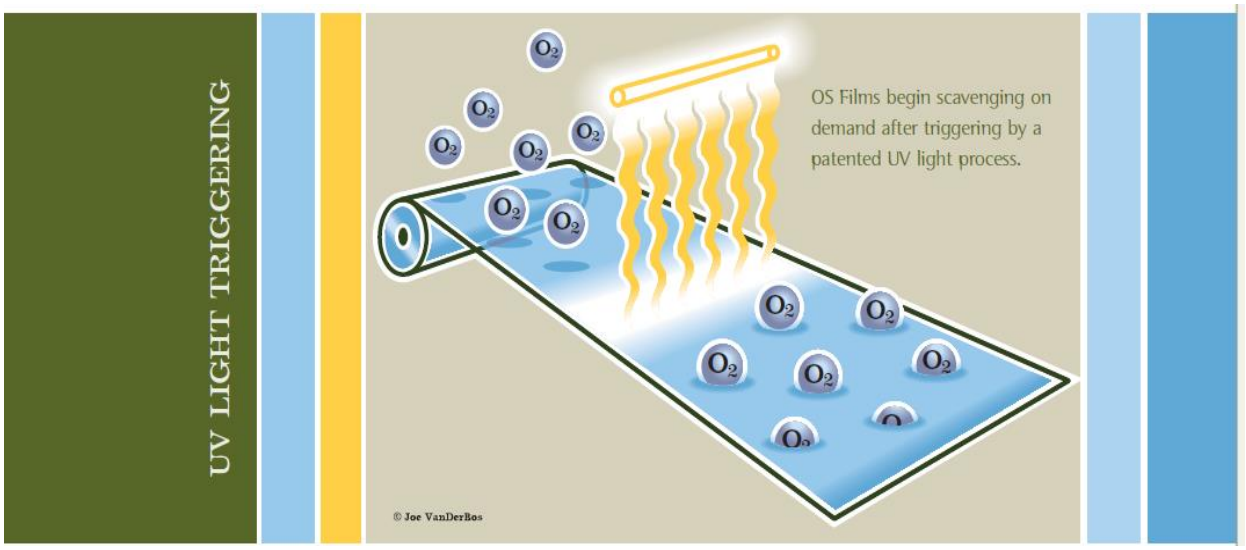


Photo 5: Cryovac® OS Films begin scavenging on demand after triggering the UV light process

Cryovac® OS Films extends shelf-life of products by weeks or months by retarding mould and bacteria growth (Shelf-life as a function of total aerobic bacteria count). Refer to Photo 6 & 7.

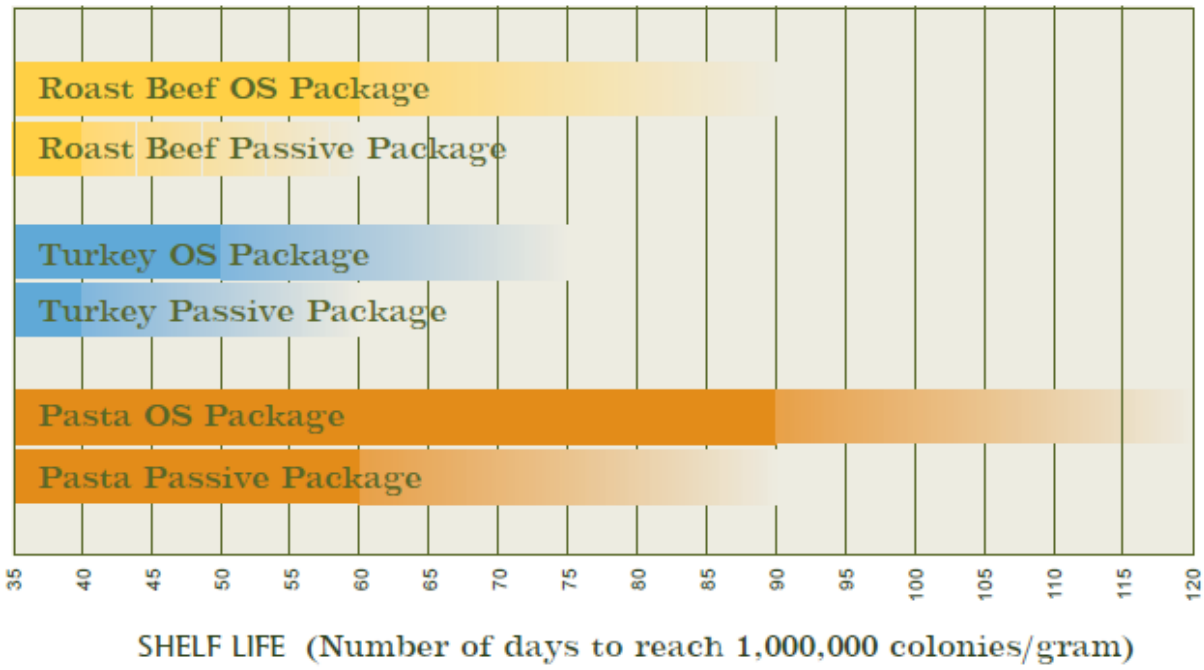


Photo 6: Shelf-life of products using Cryovac® OS Films as a function of total aerobic bacteria count.

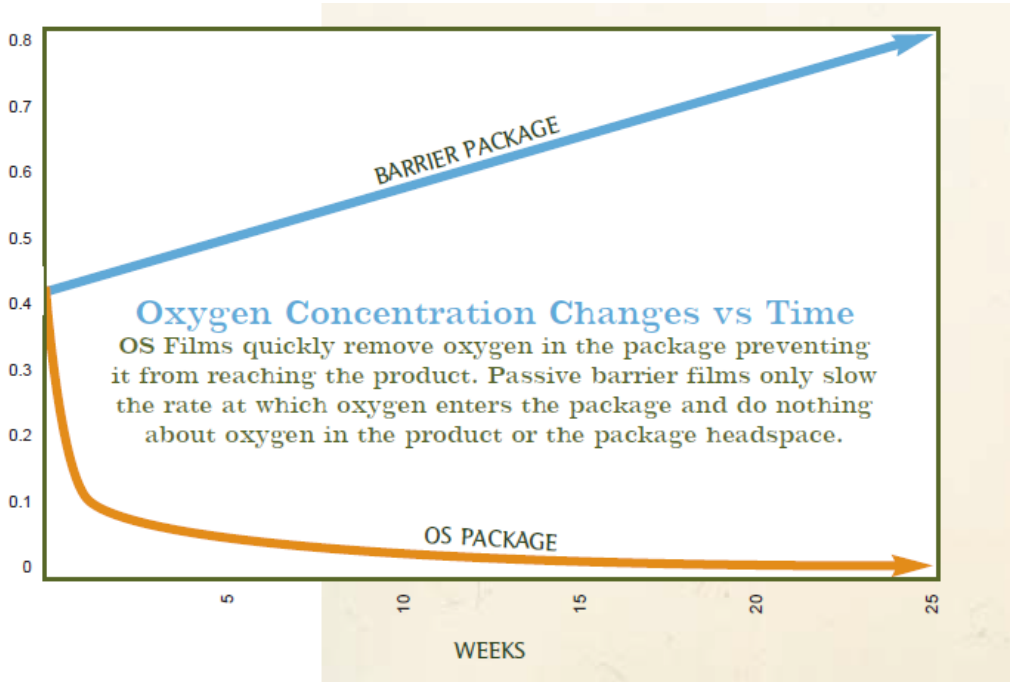


Photo 7: Oxygen concentration changes vs time using Cryovac® OS Films to help extend shelf-life of products

The benefits Cryovac® OS Films are as follows:

1) Fresher, Longer Lasting Products:

- Cryovac® OS Films protect ingredients from oxidative changes, protecting the color, flavor, aroma, and nutritional qualities of your product.
- Since OS Films retard the microbial growth, your products will last longer while maintaining their freshness.
- Faster Scavenging and Throughput:
    - Removes residual oxygen 10-20% faster than our earlier oxygen scavenging film, achieving less than .1% oxygen levels in just 3-10 days.
    - May increase packaging line speeds, especially when your packaging line throughput is limited by the line's ability to quickly remove oxygen from the package.

2) Packaging That Fits Your Needs:

- OS Films scavenging activity does not depend on your product, making it great for
- both wet and dry product applications.
- Unlimited opportunities ranging from fresh, dried, cured and cooked meat, to baked goods, fresh pasta, snack foods, nuts, and coffee.
- OS Films can be printed or pigmented, as needed.
- Cryovac® OS Films are complimented by a variety of Cryovac® flexible and semi-rigid forming webs, and barrier trays.
- Scavenging on Demand:
    - Cryovac designs its triggering systems, like the model 4104A, to activate OS Films in conjunction with your existing packaging equipment.
- Quick and Easy Scavenging Verification:
    - With Cryovac's Scavenging Verification System (SVS), you can receive positive verification
    - of scavenging in less than one hour and not more than 3 hours, decreasing the amount of production time that elapses before you know that the package is working correctly.
    - Cryovac's Dose Verification System (DVS) verifies that the film is exposed to an acceptable triggering dose of UV light.

5.2 M.O.D.

With consumers and brand owners wanting to "see" the product and to also maintain shelf life by not mixing sugar-oil-based marinades and meat, Sealed Air have developed a concept where marinade can be "squeezed" into the pack/product by the end user. This can also enable economies of scale and flexibility to promote a limited time offer of a sauce but maintain the cutting lines and production of the raw meat. This novel approach has yet to be launched in any food product globally, and it is proposed to be trialled on both raw and cooked (pulled) meats. Below illustrates the concept. Refer to Photo 8 & 9.

Photo 8: Marinade on demand concept

Photo 9. Application of the Marinade on Demand Concept

It is proposed that Sealed Air will make premade pouches on an OnPac vertical form fill seal equipment to pack sauces and hand seal. Sauces will be selected and purchased from the retailer such as Hickory BBQ to showcase the concept. Considered will be the cost to make a prototype tooling that can provide limited packs.

The benefits of Marinade on demand are:

- Reduce plant costs
- Inline system allows for continuous run of product with a 5-10 minute flavour change
- Wash down and tumbling process is eliminated, saving both time and money
- End user benefits by reducing waste – exactly the right amount of marinade for every product, every time
- Product is marinated in a sealed environment, eliminating the need to dirty pans And that's not all.

When you choose a Cryovac® packaging system, you get more than proven and consistent automated loading and packaging equipment. You get more than state-of-the-art packaging materials like case ready and active packaging technologies, Simple Steps® easy meal prep products, and Flavour MarkTM shelf-stable pouches. And more than scientists, engineers, and applications specialists who create solutions that fit your needs, or technical service specialists to help keep you up and running.

The Marinade on Demand process is as follows (refer to Photos 10 & 11).

Photo 10: Marinade on demand concept

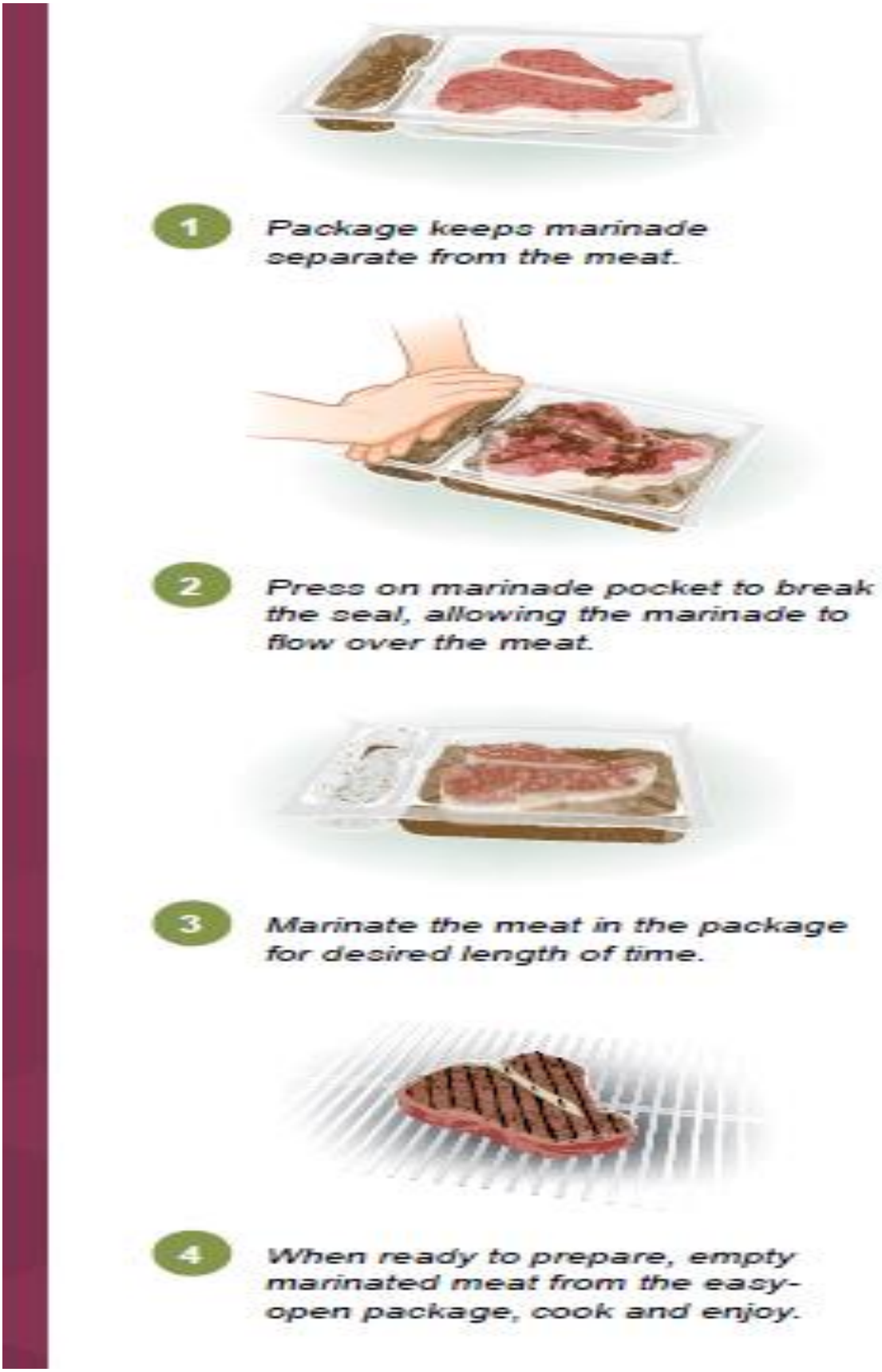


Photo 11: Process of Marinade on Demand

Now fresh meat and poultry can go from plain to deliciously flavoured with an endless array of any restaurant quality marinade in mere minutes. The secret is that the marinade is housed separately from the product, so you choose when to introduce the marinade. It is proposed that you don't have to worry about acid and tenderisers jeopardising product quality because the meat was marinated for too long.

You can also control the quality of marinade used for a consistent product time after time and from cook to cook. So start offering value-added, higher quality products customers are demanding. Get your hands on the new Cryovac Marinade on Demand. It opens up a world of new flavour possibilities.

5.3 Telescope Barrier Bag

Whole and side (half) lambs represent an ideal product to "telescope" and pack in a seal through bone guard patched bag with a reported two million lamb carcasses air-freighted chilled to the Middle East with typically only cheesecloth the "packaging material" and shelf life limited.

It is understood that the average cost difference between airfreight and sea freight and secondary packaging materials is > $1.00 per kg. For the Middle East, the average carcass weight is around 17kg which indicates that if shelf life of this product can be extended and removed or at least reduce the confinement odour, the Australian Lamb industry could capture on $17.00 per carcass. The end user would also have a better eating experience as the product has had a chance to age (in accordance with minimum 5 day Lamb MSA protocols). Shown below are the early bag concept 500 x 990mm prototype of telescope lamb.

Lamb racks and Boneless shoulders are products that Sealed Air are often advised by Australian processors and brand owners that experience confinement odour when exported to USA for example and therefore a combination of S.A.B. and telescope materials will be considered as part of the trials.

Photo 12 shows an early bag concept prototype of telescope lamb.

Photo 12a.b. Early bag concept (500 x 990mm) prototype of telescope lamb.

5.4 Cryovac Freshness Plus™

Sealed Air
CRYOVAC
Food Packaging Solutions

Cryovac® Freshness Plus® films
put state-of-the-art
active packaging technologies to work for you.

Cryovac® Active Barrier

Enhanced Oxygen Protection

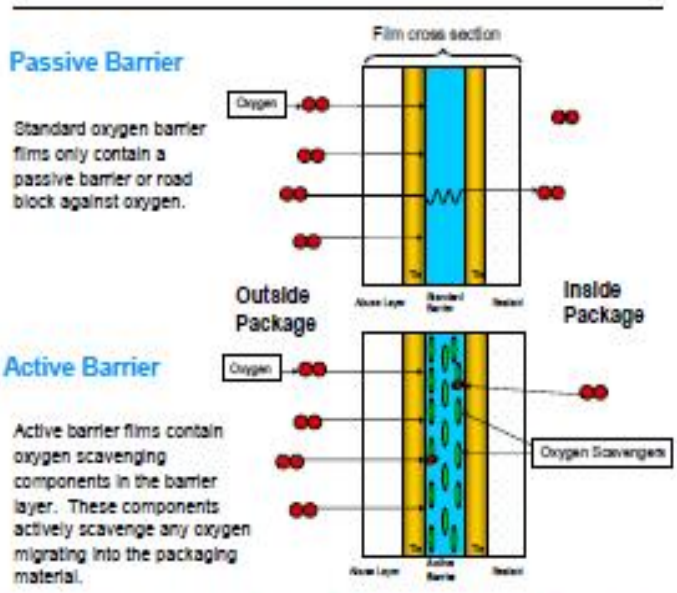
- Active oxygen barrier layer
- Oxygen scavenging polymer built into the film
- Clear co-extruded materials
- No activation required for scavenging component
- Equally effective with wet or dry products
- Invisible scavenger protects product freshness
- For vacuum packaged products or packages with minimal headspace

Synergistic with High Pressure Processing (HPP) & Post-pasteurization treatments

- After post-packaging destruction of microorganisms the next primary reduction in quality comes from negative oxidation reactions
- The Active Barrier technology can impede damaging oxidation reactions
- The combination of Active Barrier protection and post-packaging lethality treatments can improve product safety, shelf life and allow for cleaner labels or not preservatives

Sustainability Benefits

- Improving sustainability through packaging solutions to reduce food waste
- Negative oxidation reactions can breakdown product nutrients, in addition to color and flavor compounds decreasing shelf life
- Oxidation reactions can cause undesirable browning color development



Freshness Plus® Active Barrier

The benefits of Cryovac Freshness Plus™ materials are:

How Freshness Plus™ Makes a Difference	Sealed Air CRYOVAC
Reduce Shrink	Customer was able to reduce retail shrink caused by mold growth and eliminate a retail reimbursement program saving an estimated $1MM / year.
Expand Distribution	Customer extended their shelf life and product quality while on retail display to expand their product distribution from regional to national, thus increasing their sales significantly.
Improve Production Efficiencies	Processor extended the product shelf life allowing manufacturing to make longer production runs and fill orders from inventory verses being force to produce to order.
Increase Customer Satisfaction	Company was able to remove the oxygen scavenging sachet that created regular customer complaints and maintain product quality and shelf life without adding cost to the package.
Create Product Visibility	One customer moved out of foil to provide product visibility to the end user while providing the necessary oxygen protection with no compromise in product quality.
Achieve 'Clean Label'	One bakery processor was able to get an acceptable shelf life with a reduced preservative formulation, allowing then "clean labels" for a major retailer.
Improve Product Quality	Customer was able to improve quality of product and reduce oxidative degradation by removing dissolved oxygen from their product..
Improve Perceived Freshness	Eliminated the periodic problems with confinement odor in a processed poultry product using the odor scavenging material, which greatly improved perceived freshness by consumers.
Reduce Food Waste	Food that is wasted requires ten times more energy and materials to produce than the packaging used to protect it. Reductions in shrink at retail and foodservice with increases in product shelf life help reduce food waste and eliminate downstream product waste.

- Customer was able to reduce retail shrink caused by mould growth and eliminate a retail reimbursement program saving an estimated $1MM / year.
- Customer extended their shelf life and product quality while on retail display to expand their product distribution from regional to national, thus increasing their sales significantly.
- Processor extended the product shelf life allowing manufacturing to make longer production runs and fill orders from inventory verses being force to produce to order.
- Company was able to remove the oxygen scavenging sachet that created regular customer complaints and maintain product quality and shelf life without adding cost to the package.

- One customer moved out of foil to provide product visibility to the end user while providing the necessary oxygen protection with no compromise in product quality.
- One bakery processor was able to get an acceptable shelf life with a reduced preservative formulation, allowing then “clean labels” for a major retailer.
- Customer was able to improve quality of product and reduce oxidative degradation by removing dissolved oxygen from their product.
- Eliminated the periodic problems with confinement odour in a processed poultry product using the odour scavenging material, which greatly improved perceived freshness by consumers.
- Food that is wasted requires ten times more energy and materials to produce than the packaging used to protect it. Reductions in shrink at retail and foodservice with increases in product shelf life help reduce food waste and eliminate downstream product waste.

5.4.1 Cryovac OS Films – Rapid Headspace

Cryovac OS Films using rapid headspace technology allows the quality of food products to be extended through oxygen-absorbing packaging, not formations; thereby slowing aerobic microbial growth and oxidative deterioration of flavours, colour and nutrients. See Photo 13.

Photo 13. Cryovac OS Films using rapid headspace technology extending the quality of food products.

The benefits of Cryovac OS Films using rapid headspace technology:

- Minimizes or eliminates the need for preservatives for "cleaner" label options
- Longer shelf life enables processors to increase sales through new, wider or different distribution channels
- Protects against light-catalyzed oxidation so products can be displayed in clear packages
- The scavenging polymer is invisible to metal detectors allowing processors to use metal detection systems after the packaging operation.
- Increasing product shelf life reduces costs such as spoilage allowance, end of code date write-downs, and returns
- Since scavenger is invisible, OS films do not alter the look of the package, and offer shoppers a clear view of the product inside.
- Faster packaging rates can potential be achieved because higher initial oxygen concentrations can be removed by the film

5.4.2 Active Packaging – Freshness Plus Odour Scavenging

6 Key findings & Conclusions

The current work demonstrated a range of packaging options to deliver product and shelf-life enhancements for export lamb. The results show that only one portion of lamb had acceptable quality and microbiology. It is proposed that this result was due to one side being semi-crust froze which means it didn't release any drip. This result re-affirms the need to have mechanisms in place to reduce or even eliminate drip in the packaging. To this end, there are some interventions proposed by Sealed Air to reduce and/or eliminate drip in the bag.

Active and intelligent packaging offer great opportunities for enhancing meat safety, quality, and convenience, and consequently decrease the number of retailer and consumer complaints. Some important factors such as legislation concerns (e.g. migration of active substances from packaging materials, labelling), economics and consumers' preferences should be considered to successfully implement antimicrobial and intelligent packaging solutions in the meat industry.

7 Recommendations & Commercial implications

7.1.1 Commercial trial

A commercial trial was (voluntarily) undertaken by a processor. The processor air freighted some telescope lambs after our trials to customers and after receiving positive feedback, the processor presented telescope lamb samples at the Gulfoods stand in the Middle East. Positive feedback was received at the tradeshow. The processor is currently considering to conduct ongoing commercial trials to validate the shelf-life and quality of bone-in lamb product. Subsequently the processor has sent samples via airfreight in December to the Middle East the day after the trial was packed off and the feedback from the customer was very positive with no issues raised with shelf-life or quality of product. This result potentially demonstrates the commercial application of the use of telescope packaging options in lamb export products.

7.1.2 Adoption of outcomes

Once the report has been finalised by the Consultant it will be posted on MLA's website in a form acceptable to the Consultant and MLA will seek industry interest and may consider future MDC adoption proposals.

It is acknowledged that company specific feasibility would need to be undertaken in a commercial mode beyond this project to validate any "market ready" packaging designs – this would include understanding the value along the supply chain for :

- Reduced shrink (shelf life extension, lower markdowns and clearances/dumps, energy and downstream waste savings)
- Expanded distribution / market development
- Improved production efficiencies (economies of scale / production scheduling)

- Combination of new packaging format and post-packaging lethality treatments can improve product safety and environmental / sustainability benefits and modifications to current Predicted eating quality Meat Standards Australia (MSA) pathways

Sealed Air will own the following background IP:

- Cryovac VS96 chamber and loading machine and associated Thermoformer design and top and bottow web materials;
- B4680GP Seal Through Patch barrier bags
- Cryovac® Freshness Plus® Active packaging materials
- Sealed Air Marinade on Demand® materials

7.1.3 Recommendations

MLA has requested Sealed Air to demonstrate other red meat applications. Emerging opportunities for this project were preliminary concepts are shown below are in the Sealed Air suite of materials.

If trialled again, it is recommended that two full and two half carcasses were validated using:

- 5 x 300ml soaker pads in the full carcass and cotton bone-guard on the shank to replace the plastic shank caps.
- 2 x 300ml soaker pads on each carcass sides and cotton bone-guard on the shank to replace the plastic shank caps.

It is proposed to only use TBG B4680 as the BXPLUS with active and odour scavenging showed no difference in performance when it came to the confinement odour. With this specification in mind, it is recommended to have the toughest bone in bag possible for commercial applications.

Ongoing work is proposed by Sealed Air to demonstrate other red meat applications.

8 References / Hyperlinks

The following hyperlinks are relevant to the current research:

https://sealedair.com/food-care/food-care-products/cryovac-freshness-plus-active-barrier

https://sealedair.com/food-care/food-care-products/cryovac-freshness-plus-odor-scavenging

http://www.cryovac.com/AP/EN/food-packaging-products/freshnes-plus-active-packaging.aspx

http://cryovac.com/NA/EN/food-packaging-products/marinade-on-demand.aspx

9 Appendix

9.1 Trial Plan

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	TELESCOPE LAMB SHELF LIFE TRIALS																	
2	* Full Lamb Carcass		Full Lamb Ca	Full Lamb Cas	Full Lamb Cas	Full Lamb Cas	Half Side Ca	Half Side Ca	Half Side Ca	Half Side Ca	Full Lamb Cas	Full Lamb Cas	Full Lamb Cas	Full Lamb Cas	Half Side Ca	Half Side Ca	Half Side Ca	Half Side Carc
3	* Half Side Carcass		70 days	70 days	70 days	70 days	70 days	70 days	70 days	70 days	90 days	90 days	90 days	90 days	90 days	90 days	90 days	90 days
4	* Vacuum packed carcasses will be held at 0±C +/- 1±C		Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date	Packed Date
5	* 36 Carcasses in Total Packed		Soaker pad 300m	Soaker pad 300ml	Soaker pad 300ml	Soaker pad 300m	Soaker pad 300m	Soaker pad 300ml	Soaker pad 300ml	Soaker pad 300m	Soaker pad 300ml	Soaker pad 300ml	Soaker pad 300ml	Soaker pad 300ml	Soaker pad 300m	Soaker pad 300m	Soaker pad 300m	Soaker pad 300ml
6	* Have product packed in storage																	
7																		
8			Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps	Shank caps
9	ACTIVE BARRIER																	
10	The active barrier materials contain oxygen scavenging components that actively trap oxygen migrating into the film. This provides a higher level of protection against oxygen versus passive barrier materials. This film is ideal for oxygen sensitive products and products with a long shelf life. Film does not require an activation step.																	
12	Carcass internal Temperature prior to packing	Degrees 0C																
13	MSA Compliance (weight, fat spec) MSA data collected																	
14	Take sample for PH Test prior to packing	PH results																
15	Take swab for Total Viable Aerobic Count. (Enterobacteriaceae, Coliforms, Generic E. Coli, Lactics)	Microbe Count																
16	2 Data loggers place with carcass to confirm correct	Data Loggers																
17	select Marketing, QA for smell tests	Confinement Odour																
18	Photo of lambs prior to open																	
19	Photo of lambs after opened during bloom																	
20	Amount of drip recorded, take photo																	
21																		
22	ODOUR SCAVENGING																	
23	designed to minimize or eliminate "confinement odour" and maintain the desired product aroma. A variety of odors can be generated in fresh or process foods which are associated with a reduction in freshness and quality. Cryovac® Odor Scavenging materials remove odors from the package and keep the product fresher, longer. No film																	
25	Carcass internal Temperature prior to packing	Degrees 0C																
26	MSA Compliance (weight, fat spec) MSA data collected																	
27	Take sample for PH Test prior to packing	PH results																
28	Take swab for Total Viable Aerobic Count. (Enterobacteriaceae, Coliforms, Generic E. Coli, Lactics)	Microbe Count																
29	2 Data loggers place with carcass to confirm correct	Data Loggers																
30	select Marketing, QA for smell tests	Confinement Odour																
31	Photo of lambs prior to open																	
32	Photo of lambs after opened during bloom																	
33	Amount of drip recorded, take photo																	
34																		
35	ACTIVE/ODOUR SCAVENGING																	
36	The Two above combined																	
38	Carcass internal Temperature prior to packing	Degrees 0C																
39	MSA Compliance (weight, fat spec) MSA data collected																	
40	Take sample for PH Test prior to packing	PH results																
41	Take swab for Total Viable Aerobic Count. (Enterobacteriaceae, Coliforms, Generic E. Coli, Lactics)	Microbe Count																
42	2 Data loggers place with carcass to confirm correct	Data Loggers																
43	select Marketing, QA for smell tests	Confinement Odour																
44	Photo of lambs prior to open																	
45	Photo of lambs after opened during bloom																	
46	Amount of drip recorded, take photo																	
47																		
48																		
49																		

9.2 Sealed Air Packaging Technology Brochures

9.2.1 Active Barrier Flyer

Sealed Air
CRYOVAC
Food Packaging Solutions

Cryovac® Freshness Plus® films
put state-of-the-art
active packaging technologies to work for you.

Cryovac® Active Barrier

Enhanced Oxygen Protection

- Active oxygen barrier layer
- Oxygen scavenging polymer built into the film
- Clear co-extruded materials
- No activation required for scavenging component
- Equally effective with wet or dry products
- Invisible scavenger protects product freshness
- For vacuum packaged products or packages with minimal headspace

Synergistic with High Pressure Processing (HPP) & Post-pasteurization treatments

- After post-packaging destruction of microorganisms the next primary reduction in quality comes from negative oxidation reactions
- The Active Barrier technology can impede damaging oxidation reactions
- The combination of Active Barrier protection and post-packaging lethality treatments can improve product safety, shelf life and allow for cleaner labels or not preservatives

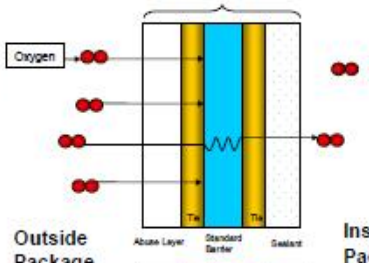
Sustainability Benefits

- Improving sustainability through packaging solutions to reduce food waste
- Negative oxidation reactions can breakdown product nutrients, in addition to color and flavor compounds decreasing shelf life
- Oxidation reactions can cause undesirable browning color development

Film cross section

Passive Barrier

Standard oxygen barrier films only contain a passive barrier or road block against oxygen.

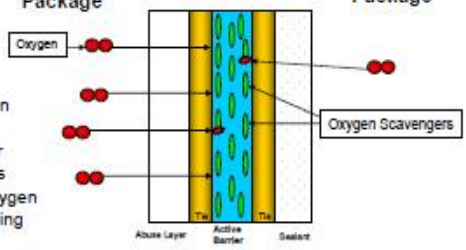


Outside Package

Inside Package

Active Barrier

Active barrier films contain oxygen scavenging components in the barrier layer. These components actively scavenge any oxygen migrating into the packaging material.



Freshness Plus® Active Barrier

9.2.2 Cryovac Freshness Plus™ Flyer

Cryovac Freshness Plus™ is a family of active packaging technologies specifically designed to maximize *freshness, flavor* and *product color* while reducing confinement odors. *Cryovac Freshness Plus*™ packaging improves the product quality for the life of the product. There are three available technologies.

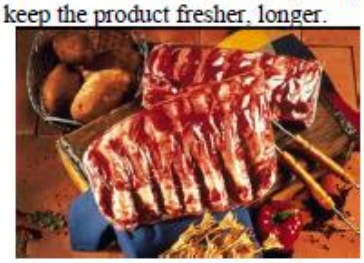
1. **Oxygen Scavenging**
2. **Active Barrier**
3. **Odor Scavenging**

1. Oxygen Scavenging (OS) films are designed for lidding onto Modified Atmosphere Packages (MAP). The film rapidly scavenges residual oxygen from the package headspace that is left over from the packaging process or migrates out of the product or diffuses into the package over the life of the product. The scavenger is inside the film and does not require moisture to scavenge. The OS film helps reduce or eliminate oxidative deterioration of color, flavor or nutrients while preventing growth of aerobic microbes (mold), as well as eliminating the need to add preservatives to the product. Perfect for Organic foods.


2. Active Barrier materials are designed for vacuum packaged products or packages with minimal headspace. The active barrier materials contain oxygen scavenging components that actively trap oxygen migrating into the film. This provides a higher level of protection against oxygen verses passive barrier materials. This film is ideal for oxygen sensitive products and products with a long shelf life. Film does not require an activation step.



3. Odor Scavenging materials are designed to minimize or eliminate "confinement odors" and maintain the desired product aroma. A variety of odors can be generated in fresh or process foods which are associated with a reduction in freshness and quality. Cryovac® Odor Scavenging materials remove odors from the package and keep the product fresher, longer.




9.2.3 Cryovac Freshness PlusR Flyer

Cryovac® Freshness Plus® is a family of active packaging technologies specifically designed to maximize *freshness, flavor* and *product color* while reducing confinement odors. *Freshness Plus®* packaging improves the product quality for the life of the product. The available technologies are:

1. **Oxygen Scavenging**
2. **Active Barrier**
3. **Odor Scavenging**

1. Oxygen Scavenging (OS) films are designed for lidding onto Modified Atmosphere Packages (MAP). The film rapidly scavenges residual oxygen left in the package headspace after the packaging process or oxygen that migrates out of the product after the packaging step. The invisible scavenger is inside the film and is activated with a patented UV triggering unit which is integrated with packaging equipment. The OS film helps reduce or eliminate oxidative deterioration of color, flavor and nutrients while preventing growth of aerobic microbes like mold. Excellent for "Preservative Free" and organically sourced products. Current customers include Hormel, Foster Farms and Nestle Buitoni fresh pasta.

2. Active Barrier materials are designed for vacuum packaged products or packages with minimal headspace. The active barrier materials contain oxygen scavenging components that actively trap oxygen migrating into the film. This provides a higher level of protection against oxygen verses passive barrier materials. This film is ideal for oxygen sensitive products and products with a long shelf life. Film does not require an activation step.



3. Odor Scavenging materials are designed to minimize or eliminate "confinement odors" and maintain the desired product aroma. A variety of odors can be generated in fresh or process foods which are associated with a reduction in freshness and quality. Cryovac® Odor Scavenging materials remove odors from the package and keep the product fresher, longer. No film activation required. This material is being used by Koch Foods for boneless skinless chicken breasts, Foster Farms for turkey luncheon meats and a national pork processor for pork back ribs and spareribs.


9.2.4 Scavenging Initiation System Model (4212 Oxygen) Flyer

Sealed Air CRYOVAC Model 4212 Food Packaging Systems

Sealed Air
CRYOVAC®
Performance Packaging Systems

Model 4212 Oxygen Scavenging Initiation System

Revolutionary oxygen scavenging system designed for Cryovac® OS Films.

The Cryovac® Model 4212 Scavenging Initiation System (SIS) is a patented process specifically designed to trigger the oxygen scavenging capabilities of Cryovac® OS (oxygen scavenging) Films. OS Films are passed through the Model 4212 system, activating the unique oxygen scavenging performance of the film. Residual oxygen is effectively removed from the package atmosphere, allowing food manufacturers to deliver fresher products to customers. The system is designed to be used with existing packaging lines.

Unique UV Triggering.

The Cryovac® Model 4212 Scavenging Initiation Systems exposes the OS Film to 254nm wavelength germicidal ultraviolet light. Web tension and temperature is controlled within the triggering section. Web tensions are also controlled by the inventory section as the film enters the packaging line. This new design significantly improves web handling and print registration control.

Smart Dose Control

Once the optimum triggering dose is set for the customer's product and conditions, the 4212 will automatically adjust the amount of UV light exposure that the OS Film receives. The lamps are never shut off, giving customers the maximum useful life available from the lamps, minimizing maintenance costs. The lamps are expected to provide approximately 7000 hours of service.

Other Features

The SIS 4212 system housings and bases are all constructed of 304 stainless steel. The control panel is NEMA4, and the equipment is spray compatible for sanitation purposes. Inside the Model 4212 systems is a single light cassette containing 12 lamps. The lamps are separated from the packaging film by a polymer window that allows the maximum amount of UV light to reach and trigger the OS Film.

The Cryovac® Model 4212 SIS is an add-on accessory. The system is typically added above or behind the existing packaging lines. Bases are designed and fabricated to fit the triggering system to the existing packaging line and the physical constraints of the packaging room. The equipment is also interlocked with the packaging line's control system to improve the ease of operating the Model 4212 and to insure proper triggering of the OS Film.

In stop and start situations, the Cryovac® Model 4212 systems are designed to minimize the amount of film in the equipment. In planned shutdown modes, only 4 feet of triggered film remains in the 4212 unit after operations are stopped. In most instances, OS film may be used for up to 30 minutes after being triggered, minimizing film waste.

As with all Cryovac packaging systems, Cryovac will support customers with outstanding technical service and support personnel.

Highlights

- **Triggers invisible scavenger on command.**
- **Customizable to existing machine requirements.**
- **Spray wash down sanitation compatible**
- **Automatic dose control**
- **Tension control for print registration**
- **Minimizes film inventory and waste**

9.2.5 Active Packaging - Benefits & Applications

Benefits and Applications

Oxygen Scavenging Films – designed for Modified Atmosphere Packaging

Benefit	Application
Mold Protection:	Fresh pasta Preservative-free bakery Cheese
Color Protection:	Pepperoni Salami Ham slices Smoke pork chops Jerky meat Corned beef Sliced roast beef Cooked bacon
Ingredient Protection: (Antioxidants, Fat and Oil, and oxygen sensitive Vitamins)	High fat foods "Trans fat" free products Vitamin and/or healthy oil fortified foods

Active Barrier Films – designed for vacuum packaged products and packages with minimal headspace

Benefit	Application
Color / Flavor Protection:	Pepperoni Salami Ham slices Smoke pork chops Luncheon meats Brats / franks / semi-dried meats Nuts, Peanut Butter, High Fat Foods Portion pack (jelly, peanut butter, condiments) Dairy
Color / Mold Protection:	Cheese Jerky meat Processed fruits Tomato products
Ingredient Protection: (Antioxidants, Fat and Oil, and oxygen sensitive Vitamins)	High fat foods "Trans fat" free products Vitamin and/or healthy oil fortified foods

Odor Scavenging Films– minimizes or eliminates "confinement odors" maintaining desirable aroma

Benefit	Application
Aroma Protection:	Processed meats* Luncheon meats* Cheese Salami Brats / franks Ribs and bone-in fresh pork Fresh beef steaks * Especially poultry based

9.3 Publications

Below is a publication related to the current research:

Trends in Food Science & Technology 61 (2017) 60–71

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: http://www.journals.elsevier.com/trends-in-food-science-and-technology

Review

Active and intelligent packaging in meat industry

Zhongxiang Fang [a, *], Yanyun Zhao [b], Robyn D. Warner [a], Stuart K. Johnson [c]

[a] Faculty of Veterinary and Agricultural Sciences, The University of Melbourne, Parkville, VIC, 3010, Australia
[b] Department of Food Science and Technology, Oregon State University, Corvallis, OR, 97331, USA
[c] School of Public Health, Curtin Health Innovation Research Institute, Curtin University, Perth, WA, 6845, Australia

ARTICLE INFO

Article history:
Received 12 September 2016
Received in revised form
6 December 2016
Accepted 3 January 2017
Available online 12 January 2017

Keywords:
Meat industry
Packaging
Active packaging
Intelligent packaging
Patent

ABSTRACT

Background: Microbial contamination and lipid and protein oxidation are major concerns for meat and meat products in terms of food safety and quality deterioration. The meat quality and safety properties are highly dependent on packaging materials and technologies.

Scope and approach: To achieve longer shelf life, active packaging and intelligent packaging have been developed to change the conditions of the package, impart information, monitor the product supply chain, and provide anti-counterfeit functionality. This will effectively enhance food safety and quality and consequently increase the product value, convenience, and consumer satisfactions. This review analyzes the recent developments in active and intelligent packaging in the meat industry, in both research and commercial domains. The global patents and future research trends are also discussed.

Key findings and conclusions: Active and intelligent packaging offer great opportunities for enhancing meat safety, quality and convenience, and consequently decrease the number of retailer and consumer complaints. Some important factors such as legislation concerns (e.g. migration of active substances from packaging materials, labelling), economics and consumers' preferences should be considered to successfully implement antimicrobial and intelligent packaging solutions in the meat industry.

1. Introduction

There is a growing demand by consumers for meat and meat products perceived as tender, nutritious, healthy and safe (Grunert & Valli, 2001). Meat quality and safety properties are highly dependent on the applied packaging materials and technologies. The fundamental reasons for packaging fresh and processed meat products are to prevent contamination, delay spoilage, permit some enzymatic activity to improve tenderness, reduce weight loss, and retain colour and aroma (Brody, 1997; Mondry, 1996). Based on this, current meat packaging practices range from overwrap packaging for short-term chilled storage and/or retail display, to vacuum packaging, bulk-gas flushing or modified atmosphere packaging (MAP) systems for long-term chilled storage, each with different attributes and applications (Kerry, O'Grady, & Hogan, 2006; McMillin, 2008).

Recently, a series of new packaging technologies and materials have been developed including active packaging, intelligent packaging, edible coatings/films, biodegradable packaging, and nanomaterial packaging, as described in some very comprehensive reviews (Arvanitoyannis & Stratakos, 2012; Ghaani, Cozzolino, Castelli, & Farris, 2016; Kapetanakou & Skandamis, 2016; Kerry et al., 2006; Lee, Lee, Choi, & Hur, 2015; Maisanaba et al., 2016; Realini & Marcos, 2014; Sun & Holley, 2012). These technologies and materials have the potential to ensure food quality and safety, prolong shelf life, reduce environmental impact and increase the attractiveness of the packaged product to retailers and consumers. However, only a limited number of these technologies are relevant to meat and meat products and there are only limited reviews in this application area (Arvanitoyannis & Stratakos, 2012; Coma, 2008; Kerry et al., 2006; Quintavalla & Vicini, 2002; Realini & Marcos, 2014; Sun & Holley, 2012). The Australian red meat industry is the world's largest exporter of beef (20% of total world exports) and sheep meats (36% of total world exports) (FAOSTAT, 2013). Red meat production is also the No. 2 economic contributor to Australia's farm and fisheries food production industry after grains, with a value about 13.3 billion Australian dollars in the 2012–2013 financial year (DAFF, 2014). Therefore, research and application of appropriate packaging technology is critical to the meat industry. This review examines the active and intelligent packaging systems currently being used for meat and meat

* Corresponding author.
E-mail address: ZhongxiangF@unimelb.edu.au (Z. Fang).

http://dx.doi.org/10.1016/j.tifs.2017.01.002
0924-2244/