



Final report

A horizon scan of Sustainable Red Meat Packaging: what's new, innovative, and ready to market

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Abstract

With the global focus on sustainability and the ongoing challenges regarding the environmental impact of red meat consumption, the intent of this review was to deliver a horizon scan of red meat packaging. The project was tasked with identifying innovative solutions new to market, industry leading solutions commercially applied in international markets, and to provide the Australian red meat industry with valuable tools to further define their packaging strategy as consumer focus on the environment continues.

The work addresses the following points:

- The project was undertaken to support the growth of the Australian red meat industry through access to new or innovative packaging solutions for red meat, with the potential to support the industry's sustainability credentials.
- The project was undertaken to provide a concise global overview of sustainable red meat packaging to support the industry.
- The project was delivered through desk top reviews and strategic engagement with red meat processors, packaging manufacturers, and retailers. Further input was given with industry experience across packaging and ESG.
- Key results from the work include the changing direction or evolution of sustainability in packaging towards a circular economy.
- Key benefits from the study delivered include an overview of key markets versus Australian applications, an overview of the evolution in best practice for packaging sustainability, and a high-level overview of new or developing solutions.

The research and engagement were considered sufficient for a high-level review. The tables and figures throughout the report summarise the key points of the research with links to further information as relevant.

Note: in 2016, MLA commissioned Ernst & Young to complete a series of industry interviews and marketplace reviews with a "sustainable packaging value chain opportunities in the Australian red meat industry" report compiled. Whilst this report did not directly build upon those outcomes, the authors recommend it still remains relevant reading for wider industry some 5 years.

See: <https://www.mla.com.au/research-and-development/reports/2016/sustainable-packaging-value-chain-opportunities-in-the-australian-red-meat-industry/>

Executive summary

Background

Sustainability considerations are changing the way consumers and end users view pre-packaged meat into retail or foodservice. Overpackaged or the use of unsustainable materials for food packaging are major threats to the growth of many brands in today's consumer-led environment, whilst innovative sustainable solutions are driving growth opportunities.

The ability for businesses and brand owners to demonstrate compassion and focus on the environment through their packaging solutions is a critical component in achieving growth. In addition, as a major contributor to the Australian economy, it is critical to maintain the industry leading brand position of Australian red meat and its clean, green, and safe image.

As Australian retailers commit to challenging sustainability commitments and timeframes, the pace and need for change will continue to accelerate. An understanding of global best practice and early insights into innovations that are close to commercialisation will assist the timely delivery of sustainable red meat packaging solutions.

This project provides a comprehensive overview of global insights into advances in red meat packaging that will give the Australian red meat industry tools to make future investment and packaging solutions decisions with a stronger sustainability lens.

Objectives

The objectives of this review were to identify and provide further recommendations within the scope of improved sustainability perceptions, based upon:

Objective	Achieved
Advances in packaging that are commercially available.	Yes – a range of formats and material variations were identified.
New patents registered of relevance.	Search completed – no relevant patents identified.
Opportunities for improvement of the Australian red meat sector with regards to packaging.	Yes – 9 recommendations.
New developments nearing commercialisation.	Yes – advances in digital watermarking and associated plastics sorting technologies, advanced chemical recycling technologies, recyclable barrier films and trays.

Methodology

The project focussed on red meat packaging in retail and foodservice using publicly available information, surveyed retailer / wholesaler / packaging manufacturer / meat processors, websites, free-to-access patent platforms, academic journals, and start-up hubs. For added context, five packaging / film manufacturers and one meat processor were interviewed, and seven retailer's stores were visited.

Packaging formats were scored for sustainability and grouped according to their fit to a circular economy and their compliance with upcoming national packaging targets.

Results/key findings

- Packaging with reduced and / or non-petrochemical based plastic alternatives are available or on shelf, however complete elimination of plastic is not feasible under the current consumption model which requires a robust shelf-life performance. Certain retailers have introduced bring-your-own or deposit scheme containers for meat counter services.
- For the continued use of plastic to be sustainable, it requires a complete system to collect and reprocess it into materials that can be used again for food packaging. This is developing but limited.
- Rapid progress is being made on the Australian market by the large retailers in line with government packaging targets for 2025. The amount of plastic used is being reduced, chemicals considered harmful to the environment are being removed, and some fibre-based materials are being introduced.
- Materials are being designed with recyclability and reusability embedded for example, recyclable plastic trays containing mono materials and recyclable plastic trays containing recycled plastic are available.
- Advanced recycling technologies are piloting, biopolymers are being tested and effective labelling-collection-sorting schemes are having some effect.
- Some notable formats include a corrugated paperboard and plastic film which delivers up to 80% reduction in plastic, a flow-wrap format for mince which typically saves up to 70% plastic, multipacks for steaks and other cuts.

Benefits to industry

Alternative packaging formats and materials enables processors to reduce their plastic packaging, save costs and enhance the reputation of red meat brands.

A guide to choosing sustainable packaging can be adopted by the industry to make better decisions with a sustainability lens.

A path forward is proposed that shows how the industry can move to a fully circular economy which is a desired destination for food and packaging, reducing greenhouse gas emissions and food waste.

Future research and recommendations

Ingrain circular economy principles when choosing and developing new packaging - MLA members could be supported with awareness and training.

Build a customer engagement strategy directly or with key NGO's gaining recognition for the improvements and progressed delivered by Industry.

Adapt and implement existing packaging guidelines and develop a clear roadmap for the industry.

Join partnerships to collaborate for packaging circularity which would support MLA's sustainability goals and raise the industry's credibility.

Advocate for responsible packaging disposal - shelf-life extension reduces food waste and is enabled by high barrier plastic but the infrastructure and systems are needed to make this a success.

Partner with food waste prevention advocates to communicate about the role of packaging in limiting food waste.

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1.0 Background

Overpackaged or the use of unsustainable materials for food packaging are major threats to the growth of many brands in today's consumer-lead environment. The ability for businesses and brand owners to demonstrate compassion and focus on the environment through their packaging solutions is a critical component in achieving growth. With the global drive to centrally packed red meat to deliver an improved customer proposition, the vast displays of pre-packaged red meat have attracted adverse publicity and brand challenges with regards to sustainability and the environment. With the focus on addressing consumers' concerns and driving value or growth into the red meat sector, key stakeholders have committed significant resources to address this global challenge.

Whilst the main principles of fresh meat packaging remain constant (overwrapped, modified atmosphere packed or vacuum packed) several new materials or styles are being seen in the market which reduce the negative feedback. The aim of this study is to provide a comprehensive overview of red meat packaging across retail and food service to support the Australian red meat industry, its sustainability commitments and 2030 growth strategy.

The scope of this project, delivered as a high-level review, focuses on retail and foodservice to identify what the industry-leading best practises are to meet consumer needs, what is new / unique or being trialled, and what is approaching commercialisation via a desk top review (including patents via free-to-access platforms).

This is our report of findings resulting from websites, literature reviews, international industry experience, and direct dealings with retailers / wholesalers / meat processors and packaging suppliers.

2.0 Objectives

Our hypothesis was that sustainability is changing the way consumers and end users view pre-packaged meat into retail or foodservice. In addition, as a major contributor to the Australian economy, it is critical to maintain the industry leading brand position of Australian red meat and its clean, green, and safe image. The objective is to provide a clear overview through a project of global insights into advances in red meat packaging for retail and foodservice that will provide the Australian red meat industry with tools to make future investment and packaging solutions decisions with a stronger sustainability lens.

The objectives of this review are to identify and provide further recommendations within the scope of improved sustainability perceptions, based upon:

- Advances in packaging that are commercially available
- New Patents registered of relevance
- Opportunities for improvement of the Australian red meat sector with regards to packaging
- New developments nearing commercialisation

3.0 Methodology

3.1 Survey

3.1.1 Products in scope

The products in scope were fresh beef, lamb, and goat meat with light references to poultry, seafood, and frozen meat to check for transferrable packaging technology. All cuts and some processing, for example mince, was included.

Table 1: Products in scope

In Scope	Check for transferable technology	Out of Scope
Beef, Lamb, Goat	Burger patties	Other livestock
Whole and part Carcase	Sausage	Secondary and tertiary packaging for retail
Primal and other cuts (bone and boneless)	Offal	Butcher Stores
Processing - mince	In-store butchery	
Retail packs - all forms	Frozen	
Foodservice - primary packs	Foodservice corrugated packaging	
	Fresh Poultry	
	Fresh seafood	

3.1.2 Organisations in scope

The research comprised desktop research of different value chain players and literature reviews of online academic journals and IP search databases. Desk top research of retailers'/wholesalers' (27), meat processors' (5), and packaging and film manufacturers' (8) websites and retailers' online shops (where accessible) were included as were all organisations' available sustainable packaging commitments. Desk top research included start-up hubs, sustainability NGOs, and industry collaborations relevant in the packaging and waste space.

Images of new and/or different packaging were captured alongside press releases and other literature that were used to verify the interest.

For added context, five packaging/film manufacturers and one meat processor were interviewed (via webinar, phone, or email), and seven retailers were visited.

Table 2: Companies who contributed directly and retail stores that were visited

Packaging and film manufacturers interviewed	Amcor Flexopack Select-Equip / Mondini PLANTIC Sealed Air
Meat processors interviewed	Hilton Food Group
Retailers / wholesalers visited	Auchan (France) Co-op (UK) Waitrose (UK) Coles (Aus) Woolworths (Aus)

	Aldi (Aus) Rewe (Germany)
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Table 3: Organisations who were surveyed via desktop website review

Packaging and film manufacturers			
Amcor	Australia	LINPAC (Klöckner Pentaplast)	UK/Germany
Berry Global	USA	Select-Equip/Mondini	Australia/Italy
Bolloré Group	France	Mondi Plc	UK
Flexopack	Australia	PLANTIC™	Australia/Japan
GEA	Germany	Sealed Air	Australia/USA
Meat processors			
ABP	UK	JBS	USA
Cargill	USA	Tyson	USA
Hilton Food Group	Holland		
Retailers / wholesalers			
Albert Heijn,	Netherlands	Kroger	USA
ALDI,	Australia	Le Clerc	France
ALDI Nord,	Germany	Loblaws	Canada
ALDI Sued,	Germany	Marks & Spencer	UK
Amazon/Wholefoods	USA	METRO	Germany
Auchan	France	Rewe	Germany
Axfood	Sweden	Sainsbury's	UK
BidFood	UK	Super U	France
Booker	UK	Tesco	UK
Coles	Australia	Trader Joes	USA
Compass	UK	Waitrose	UK
Co-op	UK	Wegmans	USA
HEB	USA, Mexico	Woolworths	Australia
ICA	Sweden	Woolworths	South Africa
Academic journals databases			
Google Scholar			
IP databases			
Google Patents	Freepatent online		
Espacenet	United States Patent and Trademark Office (USPTO)		
Patentscope			
Start-up hubs			
Forward Fooding	France	EIT Food	Europe
Digital Food Lab	France	StartLife	Netherlands
Industry collaborations and NGOs			
The Australian Packaging Covenant Organisation (APCO)	Australia	Ellen McArthur Foundation	Global

ANZPAC Plastics Pact (ANZPAC)	Australia, NZ	Recycling Near You	Australia
CEFLEX	Europe		

3.1.3 Interview questions

Questions were customised and defined in advance to ensure comparability in response for the different value chain players. Interview questions are detailed below.

Survey questions for retail, wholesale, foodservice, and meat processing industries:

1. What are the current red meat packaging formats? E.g., Vacuum, vacuum skin, overwrapped tray, tray with sealed lidding, shrink, thermo form fill seal, and flow wrap.
2. What are the key focus areas for improvements to pack sustainability?
3. Do you have a policy around packaging that is recyclable / renewable / compostable / has recycled content?
4. Do you receive case ready packs in bulk secondary MAP bags?
5. Who / what are the key red meat pack format drivers?
6. Roadblocks to change to current formats.
7. Do you support in-store collection for recycling?
8. Is all red meat packaging designed or specified in accordance with prescribed sustainability objectives (E.g., APCO's 10 design criteria)?
9. Do you have / when is the cut off for acceptance of non-recyclable / renewable / compostable packaging for red meat?
10. Do you have / are you involved with recycling developments around mechanical and / or chemical recycling?
11. What are your customers asking for?

Survey questions for packaging and film manufacturers:

1. What are the latest developments in red meat packaging supporting sustainability objectives?
2. New packaging formats under development for red meat (e.g., Moisture absorbing tray)?
3. Do you have packaging formats that are recyclable in recognised existing recycling streams?
4. Is film development driving towards high barrier mono materials and multilayer materials compatible with recycling streams?
5. Do you have packaging formats that are compostable or biodegradable and under what conditions / to what standard?
6. Is there innovation in areas of active and intelligent packaging?
7. Advances in packing / processing of red meat including automation and labelling (e.g., QR codes)?
8. Do you have / are you involved with recycling developments around mechanical and / or chemical recycling?
9. What are your clients / customers asking for?

3.1.4 IP Search terms

To facilitate a robust search the following meat packaging search terms were applied and as shown in Table 4.

Table 4: IP Search terms

Term	Google Patents	Espacenet	Patent scope	Freepatent online	USPTO
Meat and 'recyclable packaging'	0	0	0	0	0
Meat and 'Compostable tray'	0	0	0	0	0
Meat and 'biopolymer packaging'	0	0	0	0	0
Meat and 'sustainable packaging'	0	0	0	0	0
Meat and 'plant-based plastic'	0	0	0	0	0
Meat and 'vacuum pack'	0	0	0	0	0
Meat and Biofilm	0	0	0	0	0
Meat and 'vacuum skin pack'	0	0	0	0	0
Meat and 'skin pack'	0	0	0	0	0
Meat and 'compostable packaging'	+	+	+	+	0
Meat and 'plant-based plastic'	0	0	0	0	0

0 = nothing of relevance + = potential

3.2 Sustainability assessment of surveyed packaging

High level functionality and sustainability criteria were used to assess the packaging materials. The materials were then grouped according to their status as part of linear, recycling, or circular economy.

For functionality, MLA criteria were used and updated. For sustainability, the APCO sustainable packaging guidelines principles were used. Formats were scored 1-3, where 3 = best and 1 = worst. The grouping was used to map the different formats.

Table 5: Sustainability assessment criteria

Fitness for purpose	Sustainability
Traceability	Design for recovery
Food safety	Optimise material efficiency
Quality	Design to reduce product waste
Rated shelf life	Eliminate hazardous materials
Physical protection	Use recycled materials
Market needs/appearance (retail)	Use renewable materials
Ease of use (retail)	Design to minimise litter
Ease of use (consumer)	Design for transport efficiency
Cost	Design for accessibility
	Provide consumer information on sustainability

Adapted from MLA (2016) and APCO Sustainable Packaging Guidelines (2020).

3.3 Implementation support

Websites of government, NGOs and trade organisations were reviewed to search for supporting technologies or tools. A summary with links to further reading is included in the results Section 4.8, Table 12.

4.0 Results

4.1 Consumption of meat and packaging

The global pandemic has left its mark on consumer needs and purchasing behaviours with more consumers looking for products that are deemed 'trustworthy, healthy and of a high quality'. Despite the undoubted long term economic effects of COVID-19, Australia's meat sector remains strong thanks to its reputation for high quality red meat, both at home and abroad. Australia is one of the world's largest consumers of beef, and consumption is expected to rise (MLA 2020).

As red meat consumption rises, so will the amount of packaging that is required, unless the way packaging is designed and disposed changes. red meat plastic packaging is an estimated 2% of the total packaging used in Australia (Besley et al. 2016). Australians used 3.5 million tonnes of plastic in 2018 to 2019 of which around 60% was imported and 84% of plastic used is sent to landfill with only 13% being recycled (DAWE 2021).

However, when Australian consumers were asked what behaviours were most helpful for the environment, 76% said recycling regularly and 21% said decreasing meat consumption (ARL and APCO 2021).

Packaging protects and preserves food, and plastic plays a key role in extending the shelf life of red meat, helping to reduce food waste. But plastic is under scrutiny for its role in littering the environment and endangering wildlife and ecosystems, with 130,000 tonnes of plastic leaking into the marine environment every year (DAWE 2021). Certain chemicals in plastic are either being phased out or undergoing observation to prevent them from polluting the air when incinerated or contaminating the soil when degrading in landfill.

Plastic packaging that goes to landfill deprives the economy of an important resource that could be recycled back into packaging or other useful materials. Australia is missing out on an estimated \$419 million of economic value each year by not recovering all PET and HDPE (DAWE 2021). Up until 2018 when it banned imported waste, China processed almost a half of global exports of wastepaper, metals, and plastic. Exporting countries including Australia have had to very quickly change how they manage their waste. This has resulted in several technologies coming to the market quicker than might otherwise have happened.

4.2 Drivers of change in meat packaging

4.2.1 Non-Governmental Organisations

Globally, the Ellen MacArthur Foundation and UN Environment Programme partnership has been instrumental in driving improvements in packaging design to prevent packaging waste and contribute to a circular economy, which contributes to global sustainability goals, namely SDG 12 - sustainable consumption (SDG Compass n.d.) Forward thinking brands have signed up to report their progress annually (Ellen MacArthur Foundation 2020). Numerous organisations have evolved their local or sector-based approaches in response to the principles developed by the foundation, for example WRAP UK, CEFLEX, Association of Plastics Recyclers (APR), Terracycle, The Consumer Goods Forum (CGF) and the ANZPAC Plastics Pact.

In Australia, the Australian Packaging Covenant Organisation (APCO), a not for profit, is set up to address the environmental impact of packaging and to lead the development of a circular economy for packaging. APCO facilitates the delivery of Australia's 2025 National Packaging Targets (APCO) working with businesses to build a national sustainable packaging ecosystem. Companies signed up to the covenant must submit an action plan for improvement and report annually on achievements.

Planet Ark is an Australian NGO focussed on awareness and education about recycling. They developed the Australasian Recycling Label based on evidence from the Packaging Recycling Evaluation Portal (PREP) which was commissioned by APCO. The label helps consumers to dispose of packaging correctly which is a crucial part of a sustainable packaging ecosystem, along with design to reduce packaging and ensure more of it is collected and recycled.

The MLA aims for producers to be carbon neutral by 2030 (MLA n.d.), and while packaging is not included in this goal it would be pertinent to link targets and ensure packaging is also carbon neutral and sustainable.

4.2.2 Legislation

The National Plastics plan outlines a route towards achieving the National Packaging Targets for industry by 2025 (DAWE 2021).

Working with the Australian Government, APCO developed a regulatory framework with national sustainability targets for packaging (APCO, n.d.). The work is based on the Ellen MacArthur Foundation guidance (Ellen MacArthur Foundation, n.d.). By 2025, the APCO targets require a move from the linear cradle-to-grave use of packaging ('make-take-waste'), towards a circular system where waste is designed out at product conception and where:

- 100% of all packaging is reusable, recyclable, or compostable.
- 70% of plastic packaging is recycled or composted.
- 50% average recycled content is included in packaging (revised from 30% in 2020).
- Problematic and unnecessary single-use plastic packaging is phased out through design, innovation, or the introduction of alternatives.

While producers are not legally responsible for the management of packaging waste, those above a certain turnover must sign up to the covenant or be subject to the National Environment Protection Measure (NEPM), which authorises local governments to recover the cost of waste management from the brand owner's consumer packaging (Lorax EPI, 2021).

Extended Producer Responsibility regulations make businesses producing waste cover the cost of managing it. The effect is to incentivise good environmental design and prevent packaging waste. EPR developing around the world and is established in Europe with a plastic levy being implemented at different speeds. In the UK, a plastic tax will be introduced in April 2022 (GOV.UK, 2021). EPR is expected in Australia in 2025, and when importing countries have plastic taxes this will affect Australian exports that do not contain 30% recycled content, most likely including packaged red meat. Compliance to the National Packaging Targets would negate this tax. EPR will impact on packaging companies, the meat industry, and retailers.

Figure 1: Evolving EPR landscape. reproduced with permission.



4.2.3 Consumers

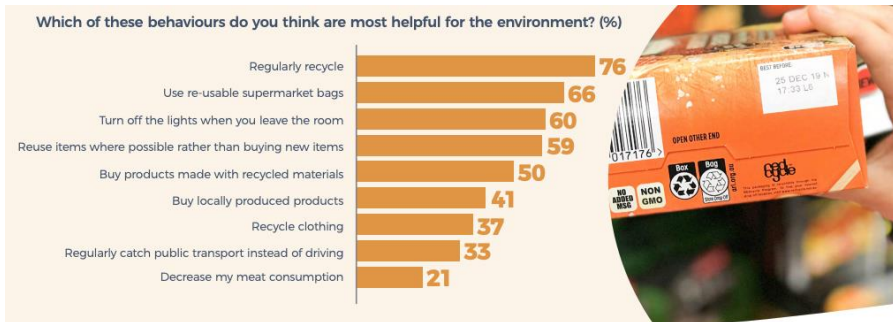
According to Google Trends cited by the Economist (2021), searches for sustainable products have increased every year (Fig 2), and in Australia 87% of consumers said they are more likely to purchase products that are ethically and sustainably produced (CouriersPlease, 2020).

Figure 2: Searches for sustainable products (The Economist, 2021)



In 2021, Australian consumers consider recycling to be the most helpful behaviour for the environment (APCO and Planet Ark, 2021). However, it is not easy to know what products can be recycled, nor how to do it in a way that does not impact the environment (Keys H. 2020). Organisations such as APCO and Planet Ark are working with industry and government to improve the situation.

Figure 3: Behaviours that consumers think are most helpful for the environment (APCO and Planet Ark 2021).



Consumer perception is largely driven by the NGO activities, traditional and social media communicators. But COVID-19 has brought marked changes in purchasing behaviour and perceptions where many consumers look for products that they trust and have an increased focus on health, hygiene and quality (MLA 2020). They also have an eye on packaging, having spent more time at home preparing meals and realising the amount of (plastic) packaging they buy and the need to recycle.

Changing consumption patterns affect the format of meat packaging, with examples including households becoming smaller, home deliveries increasing (especially since the pandemic), and the number of meals prepared outside of the home increasing – whether eaten out or ordered in.

At first it may seem surprising that sustainability is not top of consumers’ minds as a purchasing driver for meat itself (MLA 2020). However, effective packaging formats extend shelf life and reduce food waste, and less packaging is a benefit to consumers, especially those who do not have access to recycling facilities and to processors looking to reduce cost. Packaging also plays a key role in carrying information on origin, feed, and welfare. When environmental claims are clear and help consumers understand what they need to do, for example recycling labels, consumers have a better perception of a brand (ACOR 2020). Due to growing consumer interest and awareness of product sustainability, the MLA sees opportunities for Australian meat to differentiate itself (MLA 2020).

4.2.4 Retailers and Brands

Australian retailers, brand owners and the government are also influenced by non-governmental organisations and are in turn driving change. For red meat packaging, the industry at a minimum must meet APCO’s 2025 targets as well as retailers’ demands. What follows is a top line view of some Australian and global retailer packaging commitments. Most retailers are making their commitments to sustainability clear on their websites, and while the level of detail and progress reporting varies, packaging of own brands is an area that stands out. 2025 is a common deadline for products to achieve recyclability, reusability, or composability, although the emphasis differs between retailers.

4.2.5 Australia

Aldi, a founder member of the ANZPAC Plastics Pact, has nine plastics and packaging commitments within its 25by25 pledge. The retailer aims to reduce plastic packaging across own brand products by 25% by 2025 and will reduce or replace black plastic packaging such as those used in meat trays. Exclusive brands will be 100% recyclable, reusable or compostable by the end of 2025. Backing paper will be certified or 70% recycled. Aldi wants to stimulate an Australian circular economy by achieving on average of 30% recycled materials in its plastic packaging by end of 2025. 65% of the ALDI range now carries the AR (ALDI n.d.).

Cole's Under the Together to Zero pillar aims to make all its own brand packaging recyclable, reusable or compostable by 2025. The retailer is committed to a circular economy, supporting and creating end-markets to use recovered materials (including REDcycle soft plastic collected in stores), creating an end-market for recycled materials by using recycled content in packaging, labelling own brand packaging with ARL and driving the delivery of the 2025 National Packaging Targets (Coles n.d.).

Woolworths has committed to making all its own brand packaging reusable, recyclable or compostable by 2023 and is a leader in this respect. Specifically on beef, the retailer has removed 11.8 tonnes of plastic across seven popular cuts (Woolworths, n.d.). A trial that encourages customers to bring their own containers for deli, meat and seafood counters was recently launched (7 news, 2021).

4.2.6 USA and Canada

Walmart has a recycling playbook to guide suppliers. Under the category of advanced measures, the retailer requests that suppliers invest and engage in the development of recycling, reuse, take-back, or composting solutions – specifying heat in the bag, some advanced barriers, meat film and soaker pads, customer demand and life cycle considerations (Walmart 2021).

Loblaws has committed to making all plastic packaging reusable or recyclable by 2025, is collaborating with packaging suppliers, and is investing in more than \$1 million to support Canadian microplastic research, innovation, and community clean ups (Loblaw n.d.).

4.2.7 Europe, Nordics, UK

Albert Heijn targets a 25% reduction in packaging weight in 2025 compared to 2017, and 100% recyclable own brand packaging by 2025, aiming to make 25% of plastic packaging from recycled material and for single use plastics 35%. The Dutch supermarket is a signatory of the Ellen McArthur Foundation global commitment packaging report (Albert Heijn 2021).

Axfood place emphasis on developing climate-smart packaging for their own-brand products, designing them to avoid food waste and to be easily recyclable and cost effective. The Swedish retailer is working to reduce the use of plastics and prioritises renewable and recyclable material without hazardous chemical compounds. Axfood is driving awareness of hazardous chemicals in packaging within society and the industry and is working on eliminating SIN-listed compounds, for example Bisphenol-A, by 2022. They target a reduction of total use of plastics by 25% by 2025 and by 2030 own brand products will be made of renewable or recycled material. By 2022, packaging for own brand products will be recyclable (Axfood 2021).

Carrefour aims for 100% reusable, recyclable, or compostable packaging by 2025 and the retailer is a supporter of France's Plastic Pact. Carrefour in Spain rewards customers with bonus points for recycling properly with the ReciclaYa app. Customers have information on how to sort and recycle products by scanning their purchase receipts (Carrefour 2020).

Lidl UK's plastic strategy, Circular Motion, has a target of 2025 for all own label and branded packaging to be recyclable, reusable, or renewable. The retailer lists preferred / acceptable / to be avoided packaging materials and UK packaging suppliers are expected to be BRC certified. Bioplastic, biodegradable, or compostable plastics are not encouraged due to concerns about end-of-life and additional land use resource pressures. Their expectations extend to their branded suppliers. A founding member of the UK Plastics Pact, the retailer is part of the Schwarz Group who has joined the Ellen McArthur Foundation's New Plastics Economy. They have reduced their footprint by 18.5% compared to 2017 and are on track to achieve 20% by 2022. 2,000 tonnes of problem plastics have been removed including black plastics, PVC, and EPS (Lidl n.d.).

Marks and Spencer have committed to net zero by 2040. By 2026, they aim to increase the recycled content in plastic to 50% and reduce overall packaging tonnage by 25%. The retailer has a take back scheme for hard to recycle plastic packaging and will roll it out to all stores by March 2022. "Fill Your Own" launched in 2019 and is in 13 stores. The UK retailer has signed up to the UK Plastics Pact and the retailer On Pack Recycling Label Scheme. The packaging target is 100% recyclable plastic packaging in the UK by 2022 and 100% of plastic packaging will be recycled, reused, or composted by 2025 (Marks and Spencer, n.d.).

Morrisons has invested in a soft plastics recycling facility which will down-cycle plastic food packaging collected from Morrisons distribution centres into material that can be used in non-food applications for example, store fixtures (Hegarty 2021). A member of the UK Plastics Pact, the retailer has committed to recycling and reusing the equivalent amount of plastic it puts on the market. Morrisons led the movement in 2018 to let customers bring their own containers for counter service products including meat (Morrisons 2018).

Sainsbury is committed to reducing plastic packaging by 50% by 2025 (Sainsbury's n.d.) and the retailer claims a 70% reduction in packaging for steak which appears to be achieved by using a cardboard backing board and skin packaging.

Tesco was one of the first global retailers to commit to net zero emissions by 2035. Their 4R plastic strategy (remove, reduce, reuse, and recycle) was launched to suppliers in 2019 to address specifically the impact of plastics. In 2018 the retailer published its preferred materials list to support the removal of difficult to recycle materials including black plastic from own brand packaging. Soft plastic recycling points are being rolled out to all stores in the UK (Tesco n.d.). Since 2020, Tesco has used the LOOP scheme for reusable packaging including its own brands (Tesco n.d.).

Waitrose, the UK retailer, has issued the challenge to ban non-recyclable plastic from all branded and own brand packaging by 2021 (Waitrose n.d.).

4.2.8 South Africa

Woolworths has committed to zero packaging waste to landfill and aims to make all packaging reusable or recyclable by 2022. The retailer has embedded a systematic approach to packaging and waste with a strategy that aims to design for a circular economy, minimise the need to non-renewable resources, and encourage recycling (Woolworths Holdings n.d.)

4.2.9 UN Conference of the Parties (COP)

The UN COP climate conference brings together all countries once a year to agree to climate protection measures to keep global average temperatures no more than 1.5°C above pre-industrial times. While not legally binding, COP26 set the global climate change agenda for the next ten years. However, current pledges, if met, will only limit global warming to 2.4°C and countries will meet at COP27 to pledge further cuts of carbon dioxide (BBC 2021). While several national governments are criticised for lacking bold action, several retailers have announced net zero pledges which include their Scope 3 emissions in their supply chains (Race to Zero 2021). Supply chain emissions contribute up to 90% of total food retailer and brand emissions and their commitments will undoubtedly impact on food and packaging. Suppliers can expect to be asked for detailed product information which will include packaging specifications and most likely its carbon footprint. The expectation will be that suppliers cut their own emissions which includes reduction of packaging and changing packaging materials.

Many are disappointed in the lack of COP26 ambition (The Diplomat 2021) and young people especially are disillusioned (BBC 2021). In the absence of strong institutional leadership, people look to their own actions to make change and one of the perceived easiest ways is through individual consumption. This will manifest in consumer choices such as choosing sustainably produced and packaged products (Fig 2 and Fig 3).

4.3 The role of packaging in the red meat value chain

To identify a way forward for sustainable meat packaging, it is important to understand the intrinsic role of packaging in the current retail/foodservice model.

4.3.1 Drivers for current packaging design

Packaging must meet certain requirements which are determined by who interact with it and the required function. Along the value chain from industry through to consumers, packaging has different functions whether a single material, or a packaged product.

For example, industry is concerned with how well the packaging handles inline, retailers are interested in how the packaging displays on shelf, and consumers are interested in how long they can store the product and if the packaging is easily recyclable.

As packaging ends its life, it must be recyclable and ideally be transformed into useful material for new packaging, therefore closing the loop.

Every value chain actor makes decisions based on function and sustainability when choosing packaging. The economic cost is an additional key factor, and we note that carbon pricing may add another tool to decision making. Forward thinking companies are using this measure in their internal calculations (ref Unilever).

4.3.2 Definitions of functional, sustainable packaging

Two definitions of sustainable packaging are relevant for meat, and we used these to support our evaluation of the surveyed packaging and packaging solutions:

The primary function of packaging is to contain and protect products from the point of manufacture, through the supply chain to the retail store or end user, to attract people to buy a product to achieve more sales, and to provide product information. 'Sustainable packaging' is packaging that

performs this primary function but also has a lower environmental impact compared to existing or conventional packaging. Sometimes achieving the lowest possible environmental impact can be challenging, particularly when balancing various environmental criteria with other functional and commercial considerations. (APCO 2020)

- Meets all existing technical requirements of meat packaging to ensure protection, traceability, health and safety/ hygiene requirements and expectations
- Minimises the use of materials
- Meets consumer expectations in terms of appearance and function (including ease of use)
- Is cost competitive with existing packaging (across the supply chain)
- Is made from materials that can demonstrate low impact
- Is technically recyclable by existing waste re-processors (which may include composters)
- Is practically recyclable through existing kerbside collections across a large proportion (for example 80%) of local government areas
- Provides information for users on recycling/waste management
- Is made from materials that have a value in secondary markets
- Reduces impacts across the packaging supply chain. (MLA 2016)

The functional and sustainability needs will differ in priority between meat types, and who is handling the packaging. A balance must be struck across the needs during packaging design.

Addressing functionality requirements can have a positive impact on sustainability, for example, new peelable packs are more easily handled by consumers and the reduction in amount of material allows more units to be stacked per shelf space which reduces time for staff to load and saves energy costs in cooling. Vacuum skin packaging (VSP), which reduces the amount of plastic and increases shelf life, gives consumers a positive perception because the meat looks appealing, the product is protected, the amount of packaging material is minimal (and therefore less for the consumer to dispose of, and the cost is attractive (Langley et al. and Fight Food Waste CRC 2020).

In the UK a significant amount of beef is wasted, with approximately 35% wasted due to cooks preparing or serving too much at home and 23% is because it is not used in time. Good packaging design, for example, tear off packs, would support better portioning, increase shelf life and reduce the amount of food waste (WRAP 2021). Co-op reduced the instore waste of steaks by 8% by extending shelf life with skin packs and vacuum packaging (WRAP 2020).

4.3.3 Functions of sustainable meat packaging

Physical protection

Packaging protects products. In red meat, primary packaging keeps physical contaminants away from directly contacting the product and resists punctures and tears. Internally, this may be caused by boned product rupturing the film. Externally, it is protection from outside forces such as mishandling.

Retain and / or enhance quality

Packaging ensures enhanced consumer appeal. Pack size, design and proportion all play a role. Print quality and the quality of the information can impact the consumers decision to purchase. In plastic films, the gloss and clarity of the material can play an important part in the overall consumer appeal. In red meat packaging, the use of vacuum or modified atmosphere can visually affect the

appearance of the meat. This can be both redness or bloom caused by high oxygen and visual changes that occur in meat during the ageing process that is enabled by a long shelf life in a low oxygen environment.

Carry information

Packaging can inform and educate consumers through its listing of information such as steps on how to recycle, as well as use by dates and cooking instructions. Providing the producers story, a QR/2D barcode, or a website link, are all increasingly essential ways to promote a product's value, as well as facilitating traceability should there be an incident (Inside FMCG 2021). The National Traceability Accord recently announced that it would encourage a co-ordinate and harmonised approach toward sustainable end-to-end supply chain traceability and trade modernisation (GS1 2021).

Facilitate ease of use

Packaging should provide a positive consumer experience from purchase to disposal. The pack must provide clear information about the product plus information for correct use and recycling or disposal of the packaging. Features such as a tab to facilitate easy opening of a tray are viewed positively. Easy peel or easy tear mechanisms are increasingly expected. The ability to conveniently separate pack components for recycling is a key sustainability attribute of the overall pack.

Preservation

Crucially in meat, packaging ensures the product achieves a given shelf life, keeping it free from spoilage and retaining safety. Current technology used for preserving fresh meat requires different types of packaging to offer different shelf lives.

4.3.4 How packaging can contribute to achieving sustainable meat

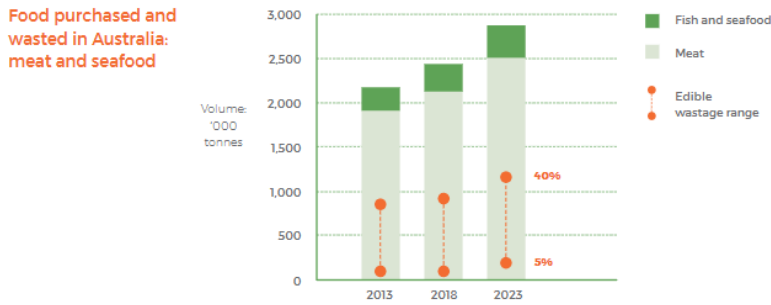
Food waste is responsible for approximately 3% of Australia's annual greenhouse gas emissions (DAWE n.d). 34% of all food waste in Australia is consumer food waste and 92% of this waste goes to landfill (Langley et al. and Fight Food Waste CRC 2020). When food is in landfill, it releases methane, a potent greenhouse gas. In addition, resources such as water and labour used to bring the meat to market, have been wasted (MLA 2020).

Household red meat waste is a waste "warmspot" the climate impact is outsized, generating carbon dioxide equivalents (CO₂-e) released during red meat production. (FIAL 2021).

The amount of waste is predicted to increase in Australia in a range of 5-40%, along with increased meat consumption. The role of packaging in reducing food waste must be better understood by consumers and this presents an opportunity for the meat industry to communicate and engage with them. Consumers would appreciate well designed packaging that helps reduce food waste and is recyclable (Langley et al. and Fight Food Waste CRC 2020).

Commented [MF1]: @Sarah Blanchard 4.3.4 do these et al references beed the date ? @Mark Field yes, well spotted!

Figure 4: Food purchased and wasted in Australia (Langley et al. and Fight Food Waste CRC, 2020)



(Data adapted from Euromonitor (2019, 2018a, 2018b); Reutter et al 2017)
 Note: values are presented in Table 8 of the Appendix (p 37)

Meat, with its high sales volume, percentage of waste, and contribution to greenhouse gas emissions across its lifetime, is a prime area for focussing good packaging design. The total carbon footprint of red meat is significantly higher than the packaging that contains it (Ritchie 2020). Therefore, a balance between reducing plastic and not increasing food waste must be struck.

Responsible consumption of sustainable meat is key to limiting meat's impact on the environment and is one of the routes to achieve UN SDG 12. Packaging can help reach this goal with a design that limits food waste, makes recycling easy and carries information to help consumers choose the more sustainable meat product based on, for example, carbon footprint and animal welfare.

4.4 Trends in packaging formats

4.4.1 Australia

The research identified different types of packaging, with plastic dominating in the Australian fresh meat market. We found that there has not been a step-change in the type of packaging used in red meat – much is as presented by the MLA in 2016 (MLA 2016). What has changed is:

- **Type of plastic material** - for example, the use of recycled and renewable material such as Coles' rPET trays with starch barriers. The barrier is removed during washing in the recycling process and the tray can be recycled. (Creagh 2018)
- **Design of plastic trays** - for example, Coles' PP tray design that does not need a soaker pad because it captures moisture in the base of the tray. As a result, Coles removed 31 million soaker pads from meat trays in 2020 that would otherwise have gone to landfill. Currently 750,000,000 soiled pads from fresh meat in Australia and New Zealand are sent to landfill every year (Wheeler 2019).
- **Introduction of fibre-based trays and backing boards** - for example, Woolworth's own brand premium beef ranges. The introduction is estimated to use 75% less packaging than previous formats, eliminating 114 tonnes of plastic each year. The tray and film must be separated to be recycled – trays to curb side, and film and tray lining to REDcycle bins in Woolworth's stores (Woolworths Group 2020).

- **Fewer EPS trays and PVC overwrap** – used mainly in counter butcheries, EPS is being banned in Australia from 2022. The main retailers are ahead in this aspect now. Polyolefin-based (fossil fuel) overwrap and PET, Polypropylene (PP) or fibre-based trays are used instead.
- **Reusable containers** – Woolworths is trialling bring your own containers for its deli, meat and seafood counters (Sinclair 2021).

4.4.2 Global





Retailers overseas are acting in a similar way to Australian counterparts, although recycling schemes are at different stages of development. Increasingly, reusable and returnable containers are being (re)introduced in Europe, for example deposit scheme for glass containers in Intermarche in France (LCI 2021) and bring-your-own containers at Morrisons in the UK (Morrisons 2018).

4.5 Plastic’s functionality is integral to meat distribution and sales

4.5.1 Plastic’s role in meat packaging

To understand why plastic continues to be used for meat, it is important to reemphasise its unique properties in preserving red meat and hence its contribution in reducing food waste. There are four main plastic packaging formats, fulfilling different functions to achieve shelf life and quality:

Table 6: Plastic packaging formats

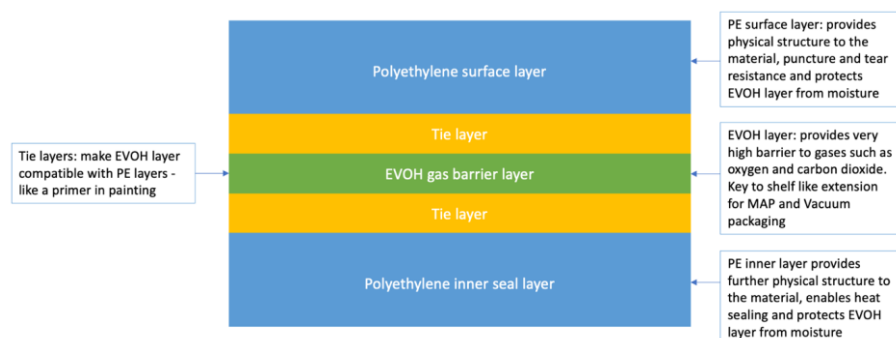
			
<p>All pictures MLA 2016</p>			
<p>Modified Atmosphere Packaging (MAP) with a barrier film for high or low oxygen environment</p>	<p>Vacuum Packaging (VP) with a barrier film</p>	<p>Vacuum Skin Packaging (VSP) with a barrier film</p>	<p>Tray and overwrap with no barrier film</p>

MAP and VP require packaging materials whose structure provide a high gas barrier and prevent gas molecules rapidly moving through the film. This is typically achieved by adding a layer(s) of material to the structure that impart the gas barrier, for example, Ethylene Vinyl Alcohol (EVOH), a common barrier material. EVOH has a gas barrier several thousand times more effective than Polyethylene, a common flexible packaging material. A film with or without a layer of EVOH looks identical but the impact on the shelf life of red meat is significant – a few days versus six or more weeks of shelf life. Fig 5 shows a typical plastic layering with barrier.

Common gas barrier materials used in meat packaging are:

- High barrier - PVDC, EVOH, PLANTIC™
- Medium barrier - PET – Polyester, Nylon – Polyamide

Figure 5: Typical (coextruded) plastic multilayer plastic structure



The performance of these materials and films is crucial for the industry, such as being able to seal perfectly and not puncture. However, they can impede recycling and some materials are being phased out, like PVC by 2025. PVDC will be allowed in amounts up to 10% in REDcycling flexible plastics schemes, but its ongoing use is under review with CEFLEX.

High barrier plastic packaging is essential to preserve fresh red meat. During its shelf life, meat degrades due to oxidation of fats and microbial activity which are brought on by exposure to oxygen and temperature increase. Gases such as oxygen and carbon dioxide move through a sealed plastic pack and the dramatic difference in this rate between plastics is generally not well appreciated.

4.5.2 Alternative materials to single use polyolefin-based (fossil fuel) plastic

As plastic packaging plays a key role in meat retail and wholesale, alternatives sourced from non-virgin fossil fuels are needed as well as a reduction in the amount of plastic. Packaging alternatives which reduce or remove plastic are available, although for some, their preservation function is limited. Table 7 discusses the alternative materials with examples.

Table 7: Alternative materials to single use polyolefin-based (fossil fuel) plastic

	<p>Recyclable or REDcycle - options are available for red meat packaging. Trays manufactured from both PP and PET are recyclable provided they are cleaned by the consumer and placed in the recycling bin for curbside collection. Barrier films for both lidding and vacuum applications are available from leading packaging suppliers that are designed to be recycled under the REDcycle scheme. The materials must be</p>
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Woolworths' fibre board tray backing with disposal labelling for the film

cleaned by the consumer and returned to collection bins at the store of purchase.



This packaging is recyclable in Australia through the REDcycle Program. To find your nearest drop off location, visit www.redcycle.net.au.

REDcycle drop off logo



Coles instore recycle bin

Pictures: top to bottom, left to right: Recycling Near You n.d., Woolworths n.d., Coles n.d.



Woolworths n.d.

Fibre board – the board provides structure and requires a plastic barrier film to prevent moisture soaking the board and to preserve the meat.

An example is: Woolworth's grass-fed beef rump medallion. The fibre tray is lined with high barrier plastic lining and sealed with a matched high barrier vacuum film to provide the necessary shelf-life. The board can be recycled curb side and the film REDcycled in store. The tray uses 75% less plastic than the previous format, taking out 114 tonnes of plastic every year across seven beef cuts (Woolworths Group 2020).

The environmental footprint of a wood fibre format versus a recyclable plastic tray is not necessarily better under the current linear to recycling system (Cleanaway 2018). However, a Life Cycle Assessment of the two options is the objective way to measure the impact.

While non-subjective LCAs are not commonly carried out yet in food packaging, an LCA in 2020 of paper and plastic bags in New Zealand found that the locally made courier bag containing 80% recycled plastic had a smaller carbon footprint than that of a paper courier bag (NZ Post 2021).



MLA 2020

Compostable and biodegradable plastic – this plastic is made from plant-based materials although packaging recovery and recycling systems are not yet established to manage these materials.

The innovative Corumat tray is an example where a fully circular system would benefit the development of such products and where technologies such as digital watermarking would help to ensure the packaging waste stream is handled correctly.

The Corumat tray is made from food waste, is compostable and is 20% cheaper than plastic meat trays (MLA 2020).

Design of these materials is challenging for the containment of wet products such as meat because presence of moisture is one of the triggers for degradation to commence. Until a circular infrastructure is established, compostable and biodegradable products are not preferred options because plastics designed to compost or biodegrade are easily confused with regular plastics and disrupt plastics recycling systems.

On the hierarchy of preferred options for packaging, compostable materials are a last resort if options of designing to eliminate, reuse and recycle are not possible (APCO 2020).



Smooth wall aluminium trays for example: Waitrose beef grill steaks (Waitrose 2021).

Aluminium is an exceptional barrier but still requires plastic lidding to create a hermetic seal. Lidding films can be returned to store and REDcycled to a downcycled function.

As a recycled source material, trays can be recycled via domestic collection schemes. Aluminium is endlessly recyclable and therefore fully circular. The cost is a barrier which means the material is more suited to added value products. Widespread adoption of Aluminium trays is impacted by tray performance, life limitations and availability compared to more widely used materials

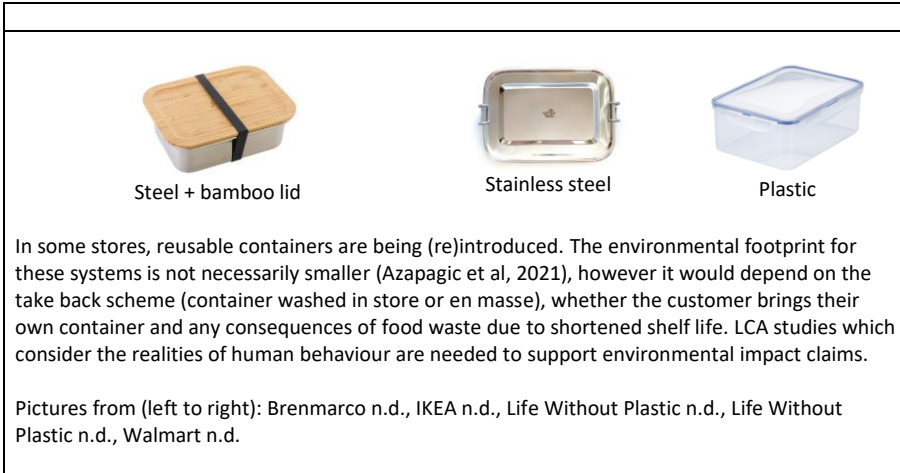


Butcher's paper



Glass + plastic lid

Butchers' paper or reusable packaging such as metal, glass, or rigid plastic offer physical protection but no shelf-life advantage.



Given the need to achieve shelf life, and the handling required in the current retail self-service model and long shelf-life foodservice model, there is no practical alternative to plastic for fresh meat yet. There are, however, alternative plastic materials using recycled content, reduced quantities of plastic and improving recycling technologies. These are discussed in Section 4.6.

4.5.3 New or novel plastic packaging formats for red meat

Five formats stand out which perform different functions for different cuts, that are in line with a circular model and that are commercially available now. Note that the full circularity is reliant on there being adequate consumer information, recovery, and recycling systems in place.



Corrugated tray for example from GEA (GEA n.d.)
Combines a corrugated paperboard and plastic film which can be easily separated. ‘Up to 80% reduction in use of plastic compared to a traditional tray solution’.



Flow-wrap mince format for example used at Albert Heijn (Albert Heijn 2021). Suitable for MAP, recyclable, tear open. Typically, this kind of packaging saves up to 70% plastic.



Multipacks for steaks and other cuts for example as used at Woolworths SA (Woolworths 2021). The individual vacuum skin packed steaks are bundled in a sealed clear outer bag.



Returnable or reusable containers as introduced in Woolworths, Australia (7 news 2021). Customers can bring their own clean containers to use for counter service.



Returnable containers with deposit scheme for example as used by Intermarché in France (LCI 2021) Customers pay a deposit for the glass container with plastic lid. Empty containers are returned to the store, and they are cleaned on site. The customer gets their money back when they scan the empty container. The scheme is run in partnership with Noww (Noww n.d.).

Under the dominant meat and foodservice retail model plastic packaging continues to play a major role due to its convenience and shelf-life properties. However, consumers are beginning to look at alternative ways to buy meat, therefore the bring your own and deposit scheme containers are notable in this respect. We expect that plastic will remain a key part in packaging whole cuts and part primals for delivery into counter service and foodservice models. We discuss the sustainability limitations in Table 13, Appendix 8.1.2

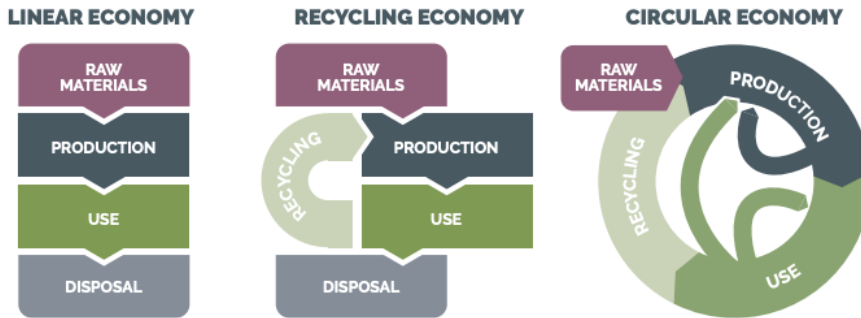
4.6 Improving plastic packaging towards a circular economy

Sustainability drivers, namely carbon footprint and plastic waste pollution, mean that plastic's use is continuously questioned. However, if the essential role of plastic in preserving fresh meat under the current dominant meat consumption model is acknowledged, we find several options for improvement. Packaging must be seen as part of a system, with an entire infrastructure to support its sustainable use. Instructions for packaging disposal, collection, sorting, and recycling systems are all part of the considerations. The options for improvement are many when taking a systematic approach.

4.6.1 Phases of improvement

The goal for packaging manufacturers and meat processors should be to operate according to circular economy principles where waste is treated as a resource. Using APCO's characterisation (APCO 2020), we grouped the survey packaging improvements into linear, recycling and circular economy models as illustrated in Fig. 6.

Figure 6: The transition to a circular economy: Our Packaging Future, APCO (2020)





4.6.2 Sustainability assessment of packaging formats

To arrive at the linear / recycling / circular grouping, a high-level analysis of the different formats was carried out using publicly available information, PREP tool and our own assumptions to calculate a score. The analyses are shown in Table 13 (Possibilities and limitations of different packaging formats) and in Table 14 (Sustainability of different packaging formats), Appendix 8.1.2.

4.6.3 Packaging mapped to linear, recycling, and circular economy models

Actors are at different phases in their sustainable packaging development, with some at model 1 (linear) and others established in model 2 (recycling). Table 8 outlines the 3 models as relevant to meat packaging.






Table 8: Summary of 3 economy models relevant to meat packaging

↓		
Model 1: Linear Economy: remove, reduce, renew	Model 2: Recycling Economy: recycle, reuse, renew	Model 3: Circular Economy
Ongoing improvements are being made to reduce the amount of plastic used, the removal of chemicals considered harmful to the environment and the introduction of fibre-based material.	Materials are being designed with Model 1 + recyclability and reusability embedded. However, the current mechanical recycling technology remains limited for producing food contact material due to the inability to separate mixed plastic streams and multilayer structures.	Model 1 + Model 2 + advanced recycling technologies (see Fig 8 Appendix 8.1.1), biopolymers and effective labelling-collection-sorting.
MAP moving to VSP and VT.	Plastic designed to be recycled.	Chemical recycling of Polyolefins.

Exports moving from whole carcass to retail-ready packaging formats.	Recyclable plastic trays containing mono PET, PET PLANTIC™, PP.	Hydro-thermal liquefaction.
PVC and PVDC plastics phasing out.	Recyclable plastic trays containing recycled plastic	Depolymerisation of Polyesters (PET)
EPS trays phasing out	Fibre based packaging.	Biopolymers
		Label information gives consumer advice on disposal streams.
		Kerb-side collection of flexible packaging.
		Advanced plastics sorting at Material Recovery Facilities (MRFs).

We have mapped the examples of packaging according to their fit with the model in Table 8 with a brief discussion. The technologies must be reviewed alongside the opportunities and limitations offered by each packaging material and its contribution to a circular economy which are outlined in Appendix Section 8.1.2, Tables 12 and 13.

Table 9: Linear economy model

		<p>Model 1: Linear economy: remove, reduce, renew</p> <p>Ongoing improvements are being made to reduce the amount of plastic used, the removal of chemicals considered harmful to the environment and the introduction of fibre-based material.</p>
 <p>MLA 2016</p>	 <p>MLA 2016</p>	<p>MAP is moving to Vacuum Skin Pack (VSP) and Vacuum Thermoform (VT) due to space efficiency and quality drivers. VSP and VT use less plastic and enable more products to be transported per given space (secondary packaging, pallet, container), take up less shelf space and use less energy to keep chilled in transport / storage / shelf display. MAP has a negative effect on beef and lamb tenderness (Condon 2016).</p>
 <p>Tyson n.d.</p>		<p>Exports are moving from whole carcass to retail-ready packaging formats (Condon 2019). This enables for example, a reduction in meat wasted, decrease in labour costs, improved stock management and increased sales.</p>
		<p>PVC and PVDC plastics are being phased out due to environmental and perceived environmental concerns (DAWE 2021).</p>




 <p>MLA 2016</p>	<p>EPS trays are being phased out to meet regulation in 2022 (DAWE 2021).</p>
<p>NOTE: Rapid progress is being made on the Australian market by the large retailers in line with government packaging targets for 2025. All materials that are required to achieve the 2025 packaging targets are available for example rPET and recyclable PET trays, and films for vacuum-shrunked and lidding films that are REDcycle compatible.</p> <p>However, its likely that not all meat processors’ packaging machines can run the materials and to make a rapid change has a cost implication. Films compatible with the REDcycle program would be available at the scale required at a reasonably short ramp up time. A move of current trays to recycled PET may put a strain on rPET supplies. The rPET trays are at a premium and REDcycle compatible films are assumed a premium.</p>	

Table 10: Recycling economy models

 <p>Model 2: Recycling Economy: recycle, reuse, renew</p> <p>Materials are being designed with Phase 1 + recyclability and reusability embedded. However, the current mechanical recycling technology remains limited for producing food contact material due to the inability to separate mixed plastic streams and multilayer structures.</p>	
 <p>Planet Ark n.d.</p>	<p>Plastic designed to be recycled. The REDcycle system takes mono plastics which meet the criteria of the ARL PREP tool.</p> <p>The scheme does require consumers to take plastic to store deposit bins.</p>
<p>NOTE: Foodservice (whole or part carcass) packaging is not included in the REDcycle scheme which limits the ability for operators as well as meat processors and packaging suppliers to achieve the 2025 targets. While packaging suppliers are working with the foodservice industry, there currently is no B2B collection and recycling solution as there is in retail with the RED group. Recycling company Replas currently recycle retail mixed soft plastics however a cleaning and collection scheme is yet to be established. The landscape is rapidly changing, however. REDcycle announced a partnership with iQRenew to be the primary supplier to the plant, which opens the opportunity to include recovery of material from other sectors, potentially foodservice (Bate 2021).</p>	
<p>Recyclable plastic trays containing mono PET, PET, PLANTIC™ (PLANTICT n.d.), PP. PLANTIC™ is used as a barrier and is suitable for a circular economy</p>	








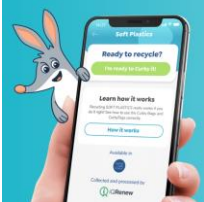


 <p>PLANTIC™ n.d.</p>	<p>system. However, in a chemical recycling system (see model 3), it is not as necessary. If more shelf life is needed than can be offered by mono rPET trays, PLANTIC™ is a sustainable way to increase this. The barrier is produced from renewable industrial crops including corn and tapioca. The material is said to use 50% less energy to produce and creates 70% less greenhouse gases (FIAL 2021).</p>
 <p>Martogg n.d.</p>	<p>Recyclable plastic trays containing recycled plastic. In Australia there is a local supply of rPET for example: Martogg’s “MarPET” (Martogg n.d).</p>
<p>NOTE: Recycled material can only come from clear PET that has been used for food contact for example PET bottles to prevent contamination from non-food contact chemicals. There is the possibility to use more recycled material however the plastic’s appearance is cloudy and may impact consumer perception. Chemical recycling (discussed in phase 3) would remove the issue.</p>	
 <p>Woolworths n.d.</p>	<p>Fibre based packaging is being used where possible.</p> <p>For example, Woolworth’s fibre backing and skin pack steaks. Note that although fibre is renewable the water footprint is generally larger than the plastic equivalent. It is however light weight, uses less plastic and optimises space on shelf and transport. Shelf life is longer than MAP equivalent. The board is recyclable when separated. The film is not recyclable into food contact but is downcycled.</p>

Table 11: Circular economy model

	<p>Phase 3: Circular Economy</p> <p>Phase 1 + Phase 2 + advanced recycling technologies (see Fig 8, Appendix 8.1.1), biopolymers and effective labelling-collection-sorting.</p>
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 <p>Packaging Europe 2021</p>  <p>Packaging Europe 2021</p>	<p>Chemical recycling of Polyolefins (Polyethylene, Polypropylene) breaks down polymers into monomers which are transformed into new plastic suitable for food contact. The process emits approximately 1.5 tonnes of CO₂ per tonne less per plastic recycled than the equivalent incinerated (Dow 2021). For example, Dow and Bolloré’s pilot which creates recyclable food contact film from recycled plastic retrieved from mixed plastic waste (Skoda 2021). Sealed Air’s food contact film which uses recycled soft plastic from instore deposit (Packaging Europe 2020).</p>
 <p>Licella n.d.</p>	<p>Hydro-thermal liquefaction transforms plastic into oil using water at high temperatures. For example, Cat-HTR™ (Licella n.d.) uses water at near or supercritical temperatures to transform plastic at a chemical level back to the oil from which it originally came. This recycled oil is a direct substitute for fossil oil, reducing the demand for natural resources and transforming waste plastic into a truly circular resource.</p>
 <p>Samsara n.d.</p>	<p>Depolymerisation of Polyesters (PET) breaks down long chain polymers into component monomers. The process allows the monomers to be reclaimed to make new polymers that have properties which match the original material. For example, Woolworths’ and Samsara’s project which uses the start-up’s enzyme technology to break down plastic into its monomers so that it can be continuously recycled. The goal is to create an infinite loop to replace the need for new plastic. The process can break down coloured plastic into clear plastic which would be applicable to premade and thermoformed plastic trays. The technology is being trialled on Own Brand packaging and will use the first 5,000 tonnes of Samsara plastic. First products are expected by end 2023 (Woolworths Group 2021).</p>

 <p>The Coca Cola Company 2021</p>	<p>Biopolymers – plant based PET is available as announced by Coke who has developed a limited run prototype using sugar from a corn feedstock (Oakley-Newell, 2021). Polyethylene and polypropylene manufactured from renewable sources is commercially available but command a price premium.</p>
<p>NOTE: Biodegradable biopolymers are either protein (for example, bovine gelatine, catfish skin, soy protein) or starch based (for example from corn). Protein based polymers are not as effective as PO based film for meat. Starch based polymers allow oxygen transfer so are also not suitable for meat. However, PLANTIC™’s new technology provides low oxygen transmission and is a suitable replacement for EVOH (as discussed in model 2). Note that sustainable sourcing of biopolymers and ensuring they are recycled will be critical to ensure circularity and avoid unintended consequences for example, environmental damage from pesticides used in growing the plants or removing a potential food or feed source.</p>	
 <p>Planet Ark n.d.</p>  <p>Planet ark n.d.</p>	<p>Label information to support consumer advice on collection, sorting and recycling. APCO and Planet Ark promote the use of ARL on packaging so that consumers know how to dispose of it correctly (RecyclingNearYou n.d.).</p>
 <p>Curby n.d.</p>  <p>iQRenew 2021</p>	<p>Kerbside collection of flexible packaging.</p> <p>For example, a supply chain collection and recycling collaboration with different actors who represent the process – Curbcycle (soft plastic collection), iQ Renew (MRF operator), Licella (feedstock recycler who uses Cat-HTR technology), Nestlé, material, and packaging manufacturers. The trial is a feasibility test to assess collecting and recycling of household soft plastics at scale. The collaborative partnership project is running a kerbside collection trial on the NSW Central Coast of soft plastics from 2,000 homes. Bags are manually separated from mixed recyclable plastics at iQRenew. Soft plastics from the trial were reprocessed into PP to make a prototype for a KitKat chocolate bar with 30% recycled content (iQRenew 2021).</p>
	<p>Advanced plastics sorting at Material Recovery Facilities (MRFs), for example:</p> <p>The Holy Grail 2.0 program is developing digital watermarks that can be printed on packaging which is easily seen and sorted in MRFs. The watermark carries information on the plastic type and food contact status.</p>

	<p>The first prototype sorting detection unit has been validated in Denmark and digitally watermarked products could be introduced to stores in Denmark, France and Germany by June 2022 for demonstrations and industrial-scale trials. The European Commission is likely to introduce legislation for mandatory use of digital watermarking by 2030 (Holy Grail n.d.).</p>
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Digital Watermarks n.d.

The development phases show how red meat packaging can (and is already moving, in some instances) towards a circular system and therefore achieve packaging and food waste sustainability goals.

4.7 Complementary technologies that interact with packaging

In addition to the packaging itself, there are technologies which can enhance packaging's function in preservation, traceability, and communication. It is necessary to highlight these technologies as they play a role in achieving wider sustainability goals of reducing food waste and providing transparency of, for example, origin. Certain technologies can also support consumer education.

Note that the terms active, intelligent, and smart are sometimes used interchangeably. We have classified them as follows:

- Intelligent packaging** – gives information on the storage conditions of the food which might affect the food's quality or safety. Examples are temperature time indicators (TTI), and leak detectors. The technologies have existed for many years and while showing some success in other categories, for example Mimica used in dairy (Mimica n.d.), there are various reasons why these are not yet widely used in meat namely, the metal chips make packaging difficult to recycle, the cost is considered a barrier and intense collaboration throughout supply chains are needed for these to be effective.
- Smart packaging** – in this category, QR codes or digitally printed unique codes allow tracking of individual packs through the supply chain. When linked to supply chain data such as temperature and time, these technologies allow a real time view of a product's performance and can enable efficient quality control procedures and targeted product withdrawals and recalls. In addition, modelling microbial activity and linking this with time and temperature throughout the supply chain can give a dynamic evaluation of shelf life for example, FreshIndex (FreshIndex n.d.). When this is further linked to pricing systems, the cost to consumers can be optimised dependent on shelf life for example, Wasteless (Wasteless n.d.). The codes also give consumers additional information when they scan them for example detailed environmental impact, producer stories and recipe suggestions. For end of life, the Holy Grail 2.0 program is developing digital watermarks that can be printed on packaging which is easily seen and sorted in MRFs. The watermark carries information on the plastic type and food contact status. The European Commission is likely to introduce legislation for mandatory use of digital watermarking by 2030 (Holy Grail 2.0). This technology looks to be the most promising for meat packaging.
- Active Packaging** - compounds such as antioxidants and anti-microbials in packaging materials absorb substances from the food or environment to release agents from the packaging into the environment or food. Active packaging has an active role in preserving

food by interacting with the product and environment to give a positive characteristic of the food namely improvements in shelf life. It is sometimes raised as an opportunity for red meat and while the technology merits highlighting, it is not appropriate for meat as it impacts negatively on recycling (McMillan 2017).

4.8 Instruments to support sustainable packaging development

Regulation (current and proposed), targets, guidelines, and tools relevant to meat packaging are in place in Australia. There are in addition, regulations that are imposed by importing countries. A summary with links to the relevant guidance are in Table 12.

Table 12: Instruments to support sustainable packaging development – legislation, roadmap, tools, schemes, pledges

Instrument	Name	Good to know
Legislation and legally binding targets	National Waste Policy + Action Plan (DAWE 2018)	Strategy 10 covers Plastics and Packaging.
	National Plastics Plan (DAWE 2021)	A government plan designed to address issues associated with plastics use and disposal.
Roadmap	Our Packaging Future – Australia’s Roadmap to 2025 (APCO 2020)	Defines a framework for the achievement of the 2025 National Packaging Targets.
Tools	Sustainable Packaging Guidelines, APCO (AUS) (APCO 2020)	Guidance in the form of a 10-step process leading to sustainable packaging design outcomes.
	Design Smart Material Guide, APCO (AUS) (APCO n.d.)	Offers guidance to enable the design of more sustainable flexible packaging.
	The Packaging Recyclability Evaluation Portal (PREP), APCO (AUS) (PREP n.d.)	Verify if packaging is or isn’t recyclable in Australian and New Zealand kerbside collections. Use when changing tray design.
	ANZPAC Specifications (AUS, NZ) (ANZPAC n.d.)	Packaging suppliers can be asked to work with these templates developed specifically for food.
	CEFLEX Project Barrier guidelines (EU) (CEFLEX 2020)	Use to check recyclability of plastic-based flexible barrier packaging.
	REDcycle / SPRS Recyclability Guidelines (AUS) (REDcycle n.d.)	This site provides a good reference for the types of soft plastic that will and won’t be accepted by the REDcycle program.
	CEFLEX Guidelines (EU) (CEFLEX n.d.)	Use to design flexible packaging.
	Ellen McArthur Guidelines (Global) (Ellen McArthur Foundation 2021)	APCO guidelines take these into account although the limits for recycled material are slightly higher than REDcycle and SPRS. May be relevant for exports.

	Consumer Goods Forum Golden Design Rules (Global) (CGF n.d.)	Another useful guide to the design of sustainable packaging.
Scheme	Australasian Recycling Label (RecyclingNearYou and Planet Ark) (APCO n.d.)	On-pack labelling to help consumers recycle correctly. Supports brand owners to design packaging that is recyclable at its end of life. Producers exporting meat should consult relevant label schemes for importing countries.
Pledges	ANZPAC Plastics Pact Targets (AUS, NZ) (ANZPAC n.d.)	Eliminate unnecessary and problematic plastic packaging through redesign, innovation and alternative (reuse) delivery models.
	National Compostable Packaging Strategy, APCO (AUS) (APCO 2021)	A national strategy for the appropriate use of compostable packaging
	Considerations for Compostable Plastic Packaging, APCO (AUS) (APCO n.d.)	Note that composting should be last on the waste hierarchy – see decision making guide p14

5.0 Conclusion

5.1 Key findings

Sustainable packaging presents an opportunity to enhance Australian red meat's reputation and secure its clean, green, and safe image. Consumers are looking for ways to reduce their impact on the environment and recycling is a key way they want to do this. The carbon footprint of red meat waste is significant and sustainable packaging design which considers shelf life and portioning is a way to prevent this waste.

Packaging with reduced and / or non-petrochemical based plastic alternatives are available on shelf, however complete elimination of plastic is not feasible under the current consumption model which requires a robust shelf-life performance. Certain retailers have introduced bring-your-own or deposit scheme containers for meat counter services.

Rapid progress is being made on the Australian market by the large retailers in line with government packaging targets for 2025. The amount of plastic used is being reduced, chemicals considered harmful to the environment are being removed, and some fibre-based material is being introduced.

Some notable formats are a corrugated paperboard and plastic film which delivers up to 80% reduction in plastic, a flow-wrap format for mince which typically saves up to 70% plastic, multipacks for steaks and other cuts.

Packaging should not burden consumers therefore it must be designed to be recycled and be labelled accordingly. Systems to deposit or collect used packaging together with sorting and reprocessing into packaging materials are essential to achieve a circular plastic economy. Technologies are developing rapidly, and retailers are partnering with innovative materials suppliers and actors in the recycling ecosystem to collect and reprocess plastic waste. This is still limited.

Materials are being designed with recyclability and reusability embedded for example, recyclable plastic trays containing mono materials and recyclable plastic trays containing recycled plastic are available.

Advanced recycling technologies are piloting, biopolymers are being tested and effective labelling-collection-sorting schemes are having some effect.

Circular plastic economy - sustainable packaging is more than the type of material or the amount of material used - it is the entire system that surrounds it. From its conception, sustainable packaging designs out waste and ensures that packaging can be easily disposed of, collected, sorted, and reprocessed into material that can re-enter the food chain. Pilots are underway to test these systems for example, soft plastics deposit and recycling, but are limited.

Attention to choosing the right material for the product and consumer need is crucial together with sustainability considerations. There are several tools and collaboration networks that are available can support red meat companies to develop their packaging and ensure that changes are truly sustainable and credible.

5.2 Benefits to industry

Designing for a circular plastic economy is an opportunity. Sustainable packaging reduces the amount of material used, saves costs, and improves handling in transportation and instore. When it is recyclable and the labelling clearly indicates this, it has a greater chance to be reprocessed into materials for reuse (ideally food packaging) and retains a value. In addition, the packaging stays out of landfill or does not leak into the natural environment.

When equipped with knowledge about circular economy packaging developments, the industry can prepare itself for change in advance. Innovative companies will take this as an opportunity to lead in product development and answer the needs of consumers and retailers who are demanding change.

Alternative packaging formats and materials enables processors to reduce their plastic packaging, save costs and enhance the reputation of red meat brands.

A guide to choosing sustainable packaging can be adopted by the industry to make better decisions with a sustainability lens.

A path forward is proposed that shows how the industry can move to a fully circular economy which is a desired destination for food and packaging, reducing greenhouse gas emissions and food waste.

6.0 Future research and recommendations

Recommendations are grouped according to communication, collaboration, product development, implementation, and monitoring.

New product development

- **Ingrain circular economy thinking when developing new packaging.**

A closed loop approach which fulfills circular economy principles is advisable, especially on a local level. For example, recycling plastic waste locally, not exporting it. Accounting for the full product life cycle in any development is key to avoid unintended consequences. Support MLA members with awareness and training.

- **Carry out Life Cycle Analysis for all packaging options.**

Existing and new packaging formats must be assessed for their environmental impact using LCA with recognised methodology. The reason to perform LCAs are:

- To support the right decision making in choosing a packaging type
- It is highly likely that environmental impact scoring will arrive in Australia and packaging's contribution can be assessed based on realistic data.
- LCAs allow the carbon footprint to be communicated credibly to consumers and avoid greenwashing.
- To avoid unintended consequences when shifting from one solution to another, which may not necessarily be better for the environment.

- **Use consumer insights research to develop sustainable packaging designs.**
- **Review the current meat sales model**

Following ongoing moves in Europe, the UK and recently Australia (Woolworths) to revive instore butcheries in supermarkets and to allow consumers to bring returnable and reusable packaging to the counter, we recommend a further feasibility study of this model and what it would mean for plastic use. If retailers introduce instore butcheries and encourage shoppers to bring reusable packaging the recyclability of plastic for these larger formats will be crucial.

Implementation and monitoring

- **Update and implement existing guidelines**

There are numerous resources available for meat processors to use and improve their packaging (Section 4.8, Table 12) in line with upcoming regulations, customer, and consumer expectations. Adapting these guidelines to meat may be a useful additional support. For example, APCO has developed guidance with the Australian Dairy Industry and something similar could be designed for meat. ANZPAC specifications are available for packaging suppliers. Packaging suppliers should be tasked with achieving recognised quality certification for example, BRC and sustainability certification for example, FSSC.

A roadmap for the meat sector is advisable. An example is The Australian Dairy Sustainable Packaging Roadmap (APCO 2021) which aligns its roadmap to the National Packaging Targets.

- **Monitor and track packaging use**

Understanding progress over time is crucial to achieve packaging sustainability. Meat processors are recommended to track, monitor, and communicate quantities of materials improved. This will enable them to credibly communicate their packaging's environmental impact as part of their overall environmental footprint.

Collaboration

- **Join partnerships to collaborate for circularity**

Sharing knowledge and collaborating for better design, recycled packaging availability, collection and sorting schemes, end market development and consumer education would support MLA's sustainability goals and raise the industry's credibility. Collaborations could be with for example, ANZAC Plastics Pact, APCO, Australian Recycling Label REDcycle, Licella.

Achieving sustainable packaging solutions requires collaboration with multi-stakeholders. We have adapted The Australian Dairy Council and APCO's (APCO 2021) guidance which outlines the different actors and their roles in meat packaging:

- Packaging manufacturers and researchers – to innovate and increase recyclability. To keep abreast of new issues arising and assess their relevance to meat, for example PFAS.
- Recyclers – to meet demand for food-grade recycled materials, to allow manufacturers to meet recycled content targets while securing product quality and safety.
- National, state, territory, and local governments – to provide fit-for-purpose regulatory frameworks, to ensure safety standards and verification of end-to-end resource recovery and recycling systems.

- Industry-based regulators - to support achievement of the National Packaging Targets for 2025 and ensure appropriate safety standards are in place.
- Consumers – to make sustainable packaging choices and correctly dispose of dairy packaging at end-of-life.
- Packaging and Circular economy NGOs – to keep abreast of developments in circular economy and innovations that may be applicable cross sector and industry.

Communication

- **Drive positive perception of plastic's role in meat consumption and the need for responsible disposal.**

Retailers, manufacturers, exporters, foodservice suppliers, and consumers all need the shelf-life extension enabled by high barrier plastic. If the current model of meat production and sale is to continue, consumers must be engaged to help them understand the crucial role of plastic and how to dispose of it. Helping consumers understand their role in disposing of plastic responsibly is recommended. The National Consumer Education Campaign which runs until 2022 is an example (APCO n.d.).

An independent study of consumer behaviour by the Australian Council of Recycling (ACOR) found that recycling information on consumer products and packaging is confusing for consumers and does not support better recycling. Therefore to help consumers make the right choices, there needs to be a clear, concise and evidenced based label on all products and packaging types (ACOR 2020). Meanwhile, 76% of respondents agreed that the ARL is easy to understand and would make them more likely to recycle and 39% said that the ARL would influence their decision to buy a product (ARL and APCO 2021).

- **Link packaging and food waste**

Most consumers think that packaging is a greater climate change issue than food waste (Langley S et al. and Fight Food Waste CRC 2020), therefore partnering with food waste educators to communicate about the role of packaging in limiting food waste is recommended.

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8.0 Appendix

8.1. Data used to support sustainability assessment of packaging

8.1. Recyclability guidelines and advanced recycling technologies

Figure 7: Recyclability summary ANZ vs Global Direction (Except USA). Reproduced with permission.

	REDcycle/SPRS Guidelines	Ellen MacArthur Guidelines (Min Criteria – Polyolefins Stream)
Minimum PP/PE	70%	80%
PET	30%	0%
Paper	30%	0%
Al	30%	0%
EVOH	30%	10%
Nylon	30%	10%
PVdC	10%#	0%
PVC	0%	0%
PS	0%	Not defined
Degradables*	0%	Not defined

- All figures are maximum limits apart from PP/PE which is a minimum requirement
- Calculation is based on percent by weight in the overall structure
- The Amcor pledge for 2025 aligns with CEFLEX guidelines
- *Consists of biodegradable, compostable, oxo-degradable materials
- #SPRS allowance for PVdC is 0%



Figure 8: Advanced recycling technologies. Reproduced with permission.

Waste %	INPUT (WASTE STREAM)	ADVANCED RECYCLING TECHNOLOGY	OUTPUT COMMODITIES
70%	Polyethylene & Polypropylene 	Thermal Cracking 	Solvent Naphtha Oil Wax
15%	PET – Polyethylene Terephthalate 	Depolymerization 	Monomers Polymers (PET, PBT)
10%	Polystyrene 	Solvolyis 	Styrene Polymers (EPS, PS)
5%	Others 	Thermal Cracking Solvolyis 	Syngas Monomers Naphtha Diesel



8.1.2 Packaging sustainability assessment

Table 13: Possibilities and limitations of different packaging formats

Format	Model			Downcycled options
	↓ Model 1: Linear	♻️ Model 2: Recycling	♻️ Model 3: Circular	
Films with barrier - retail	Fossil fuel sourced. Not renewable. Films cannot be recycled or REDcycled because they have levels of barrier materials that exceed the PREP tool limits.	Fossil fuel sourced. Not renewable. Films can be returned to store and REDcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	Sourcing a mix of chemically recycled and bio based. Films can be fully recycled and returned to original food contact status and purpose. Process is chemical recycling. Required compatible polymers. No PET, No PVDC.	Films Mixed flexible plastics are melted down and used in the manufacture of plastic wood. This is currently used in decking boards and on playground equipment.
PET tray	Fossil fuel sourced. Not renewable. Cannot be recycled if contaminated or if it is a multilayer material.	Recycled source. Trays can be recycled via domestic collection schemes and sorted for use as a downcycled option.	Sourcing a mix of depolymerisation recycled and bio-based. PET trays can be fully recycled and returned to their original food contact status and purpose. The process is depolymerisation where chemical or enzymic processes are used to break the polymer down to monomers.	PET Trays PET can be recycled into non food contact PET containers, carpet, clothing, protective packaging, industrial strapping, automotive parts, construction materials.
PP tray	Fossil fuel sourced. Not renewable. Cannot be recycled if contaminated. Recycling will tolerate a barrier layer if EVOH.	Fossil fuel sourced. Not renewable. Trays can be recycled via domestic collection schemes and sorted for use as a downcycled option.	Sourcing a mix of chemically recycled and bio based. PP Trays can be fully recycled and returned to original food contact status and purpose. Process is chemical recycling. Required compatible polymers. No PET, No PVDC.	Films PET can be recycled into non food contact PP containers, carpet, clothing, protective packaging, industrial strapping, automotive parts, construction materials.
Fibre based trays and backing boards	Contaminated fibre packaging should not be recycled.	Renewably sourced. Fibre is considered circular with some degradation due to shortening of fibre length and contamination. May not be suitable for direct food contact and may require a plastic film or coating for direct food contact.	Renewably sourced. Fibre is considered circular with some degradation due to shortening of fibre length and contamination. May not be suitable for direct food contact and may require a plastic film or coating for direct food contact.	

Table 14: Sustainability of different packaging formats

Packaging type	Model	Tray / Backing	Tray / Backing Status	Film	Film Status	Total score	Score - fitness for purpose	Score - sustainability	Cost	Function	Commercially available
PET tray and lid for MAP	Linear - Typical configuration 2021.	PET	Fossil fuel sourced, not renewable. Can not be recycled if contaminated or if it is a multilayer material.	PVDC Primary Barrier	Fossil fuel based. Not Renewable. Film contains levels of barrier materials that exceed the PREP tool limits. Can not be returned to store for recycling	36,0	23,0	13,0	2,0	High gas barrier MAP	Yes
	Recycling - Best practice and compliant configuration for 2025	rPET	Recycled source material. Trays can be recycled via domestic collection schemes and sorted for use as a downcycled option.	EVOH Primary Barrier	Fossil Fuel based. Films can be returned to store and REcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	41,5	23,0	18,5	1,5	High gas barrier MAP	Yes
	Circular Packaging fully Sustainable	rPET	PET Trays can be fully recycled and returned to their original food contact status and purpose. The process is depolymerisation where chemical or enzymic processes are used to break the polymer down to monomers.	EVOH Primary Barrier	Sourcing a mix of chemically recycled and bio based. Films can be fully recycled and returned to original food contact status and purpose. Process is chemical recycling. Required compatible polymers. No PET, No PVDC	48,0	23,0	25,0	1,0	High gas barrier MAP	No
PP tray and lid for MAP	Linear - Typical configuration 2021.	PP Various Primary Barrier	Fossil fuel sourced. Not renewable. Can not be recycled if contaminated. Recycling will tolerate a barrier layer if EVOH.	EVOH Primary Barrier	Fossil fuel sourced. Not renewable. Films cannot be recycled or REcycled because they have levels of barrier materials that exceed the PREP tool limits	35,5	21,0	14,5	2,0	MAP	Yes
	Recycling - Best practice and compliant configuration for 2025	PP - EVOH Primary Barrier	Fossil fuel sourced. Not renewable. Trays can be recycled via domestic collection schemes and sorted for use as a downcycled option.	EVOH Primary Barrier	Fossil fuel sourced. Not renewable. Films can be returned to store and REcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	39,0	21,5	17,5	1,5	MAP	Yes
	Circular Packaging fully Sustainable	rPP-EVOH Primary Barrier	Sourcing a mix of chemically recycled and bio based. PP Trays can be fully recycled and returned to original food contact status and purpose. Process is chemical recycling. Required compatible polymers. No PET, No PVDC.	EVOH Primary Barrier	Sourcing a mix of chemically recycled and bio based. Films can be fully recycled and returned to original food contact status and purpose. Process is chemical recycling. Required compatible polymers. No PET, No PVDC	46,5	21,5	25,0	1,0	MAP	No

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Packaging type	Model	Tray / Backing	Tray / Backing Status	Film	Film Status	Total score	Score - fitness for purpose	Score - sustainability	Cost	Function	Commercially available
Vacuum shrink & thermoform packaging (VP)	Linear - Typical configuration 2021.	NA	NA	PVDC Primary Barrier	Fossil fuel based. Not Renewable. Film contains levels of barrier materials that exceed the PREP tool limits. Can not be returned to store for recycling	34,0	16,5	17,5	3,0	VP	Yes
	Recycling - Best practice and compliant configuration for 2025	NA	NA	EVOH Primary Barrier	Fossil Fuel based. Films can be returned to store and REDcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	36,0	16,5	19,5	2,5	VP	Yes
	Circular Packaging fully Sustainable	NA	NA	EVOH Primary Barrier	Sourcing a mix of chemically recycled and bio based. Films can be fully recycled and returned to original food contact status and purpose. Process is chemical recycling. Required compatible polymers. No PET, No PVDC	43,0	16,5	26,5	1,5	VP	No

Vacuum skin packaging (VSP)	Linear - Typical configuration 2021.	PET	Fossil fuel sourced, not renewable. Can not be recycled if contaminated or if it is a multilayer material.	PVDC Primary Barrier	Fossil fuel based. Not Renewable. Film contains levels of barrier materials that exceed the PREP tool limits. Can not be returned to store for recycling	40,0	22,0	18,0	2,0	VSP	Yes
	Recycling - Best practice and compliant configuration for 2025	rPET	Recycled source material, Trays can be recycled via domestic collection schemes and sorted for use as a downcycled option.	EVOH Primary Barrier	Fossil Fuel based. Films can be returned to store and REDcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	44,5	22,0	22,5	2,0	VSP	Yes
	Circular Packaging fully Sustainable	rPET	PET Trays can be fully recycled and returned to their original food contact status and purpose. The process is depolymerisation where chemical or enzymic processes are used to break the polymer down to monomers.	EVOH Primary Barrier	Sourcing a mix of chemically recycled and bio based. Films can be fully recycled and returned to original food contact status and purpose. Process is chemical recycling. Required compatible polymers. No PET, No PVDC	49,0	22,0	27,0	1,5	VSP	No
	Current Fibre Based Woolworths Tray	Board	Renewably sourced. Fibre is considered Circular with some degradation due to shortening of fibre length and contamination. May not be suitable for direct food contact and may require a plastic film or coating for direct food contact.	EVOH Primary Barrier	Fossil Fuel based. Films can be returned to store and REDcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	45,5	21,0	24,5	1,5	VSP	Yes

Packaging type	Model	Tray / Backing	Tray / Backing Status	Film	Film Status	Total score	Score - fitness for purpose	Score - sustainability	Cost	Function	Commercially available
MAP flow wrap	Recycling - Best practice and compliant configuration for 2025	NA	NA	EVOH Primary Barrier	Fossil Fuel based. Films can be returned to store and REDcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	38,5	19,5	19,0	2,0	Flowwrap MAP	Yes
Smooth wall aluminium tray and lid	Recycling - Best practice and compliant configuration for 2025	Aluminium	Recycled source material, Trays can be recycled via domestic collection schemes. Aluminium is endlessly recyclable and therefore fully circular.	EVOH Primary Barrier	Fossil Fuel based. Films can be returned to store and REDcycled to a downcycled function. Films must not exceed prescribed limits on secondary barrier materials.	46,5	23,5	23,0	1,0	High gas barrier MAP	Yes

Acronyms and Glossary

ARL	Australian Recycling Label
APCO	Australian Packaging Covenant Organisation
CEFLEX	The Circular Economy for Flexible Packaging
MAP	Modified Atmosphere Packaging
Mono	Mono material
MRF	Material Recycling Facilities
PE	Polyethylene polymer
PP	Polypropylene polymer
PET	Polyethylene terephthalate
rPET	Recycled Polyethylene terephthalate
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)
PVC	Polyvinyl chloride polymer
PVDC	Polyvinylidene chloride polymer
SDG	Sustainable Development Goal
VP	Vacuum Packaging
VSP	Vacuum Skin Packaging
VT	Vacuum Thermoform

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