Less Food Loss and Waste, Less Packaging Waste

RESEARCH REPORT

MARCH 2020

zeroWASTE
NATIONAL ZERO WASTE COUNCIL
An Initiative of Metro Vancouver

The National Zero Waste Council, an initiative of Metro Vancouver, is a leadership initiative bringing together governments, businesses and non-government organizations to advance waste prevention in Canada

ACKNOWLEDGEMENTS

This report has been completed by Value Chain Management International. The authors are Martin Gooch PhD, Delia Bucknell, Dan LaPlain, Peter Whitehead PhD, Nicole Marenick

This research project has been led by the National Zero Waste Council in collaboration with RECYC-QUÉBEC, Éco Entreprises Québec, and the PAC Packaging Consortium. The project responds to priority actions identified in the Council's national *A Food Loss and Waste Strategy for Canada*. The Council would like to thank the following for their generous financial support of the project:

Executive Summary

The food loss and waste (FLW) that occurs throughout the value chain, with its associated impact on economic, environmental, and social aspects, is at crisis levels. In Canada alone, each year, 11.2 million metric tonnes of avoidable FLW occurs. Much of this avoidable FLW is edible and could be redirected to support people in our communities who are food insecure. The total financial value of this potentially rescuable food is $49.46 billion. The carbon equivalent (CO_2E) and blue water footprints of this potentially rescuable food equates to 22.2 million tonnes and 1.4 billion tonnes, respectively.

Canada has committed to the United Nations Sustainable Development Goals (SDGs) and the Paris (climate) Agreement. As described in Section 2 of the report, by 2030, the Paris Agreement requires Canada to have reduced its total CO_2E emissions by 28 percent from its 2015 levels. The true extent of the changes required is emphasized by the SDG and Paris Agreement CO_2E emission goals only equating to 1) one-third of the CO_2E reductions required to keep temperatures under the threshold at which the world's ability to produce food would be severely harmed, and 2) one-fifth of the reduction in CO_2E emissions required to meet the commitment made by international businesses and NGOs in 2019 to prevent temperatures exceeding pre-industrial temperatures by more than 1.5°C.

The overall goal of this research was to identify how FLW and packaging waste, and their combined CO_2E emissions, could be reduced. The World Resources Institute (WRI), ReFED, the United Nations Environmental Program (UNEP), Organisation for Economic Co-operation and Development (OECD), and Waste and Resources Action Programme (WRAP) are amongst the globally respected organizations which state that packaging plays a crucial role in preventing the occurrence of FLW and minimizing its CO_2E emissions. Pollution caused by sub-optimized packaging materials and management systems has, however, become a sign of a linear economy typified by over-consumption, waste, and pollution. Creating a circular economy for food and packaging is essential to our planet's sustainability. It would lead to enormous reductions in CO_2E emissions, and represents a multi-billion dollar economic opportunity.

The research established an objective, defensible perspective on the relationship between preventing FLW occurring in 12 types of foods and beverages, and the utilization of different packaging solutions. Establishing an equilibrium between FLW and packaging includes offering customers the opportunity to purchase foods loose/bulk and reuse their own containers, where it will not result in unintended environmental or socio-economic consequences. Those foods most suited to selling loose or in bulk are drier, hardier, and more shelf stable than those less suited to selling loose or in bulk. Being drier, hardier, and more shelf stable reduces the potential for food-safety risks to arise, and losses to occur during handling or storage along the value chain and in the home.

Dried pasta is an example of a food suited to selling loose/bulk. That packaging accounts for 60 percent of dried pasta's total CO_2E footprint means that, if a reduction in FLW did occur from consumers purchasing according to their immediate requirements, this combined with an elimination of single use primary packaging would significantly reduce overall CO_2E emissions. If a small increase in FLW did occur due to being sold in bulk, the overall emissions could still be less than those associated with pre-packaged dried pasta. For most other foods studied, the reduction in CO_2E emissions achieved by not pre-packaging are insufficient to offset even a minor increase in FLW. In these situations, the primary focus should be on optimizing the design and utilization of packaging.

The research employed a combination of secondary and primary data analysis. Following an extensive literature review, primary data was provided by 220 stakeholders from the food, packaging, waste management and recycling industries, and representatives from all levels of government. Research findings guided the development of scenarios that explored trade-offs associated with various solutions for reducing FLW and packaging wastes.

Section 3 of the report discusses challenges associated with optimizing packaging to reduce FLW, the proven role that packaging plays in reducing FLW, and the circumstances in which this role is most evident. It also presents examples of where packaging has been optimized to measurably reduce FLW and overall CO_2E emissions. Section 4 summarizes materials commonly used to package foods and beverages, along with means to minimize their environmental footprint.

Section 5 describes the primary research process and its findings. Of the 220 responses, 200 were captured by an online survey, and 20 were confidential interviews with individuals from the aforementioned industries and stakeholder groups. The secondary and primary research guided the development of the 10 scenarios, forming Section 6 of the report. The scenarios showed that prevention of FLW has the largest impact on reducing the overall environmental footprint of the food system.

Reducing FLW by 50 percent, which is in line with Canada's SDG commitments, combined with the utilization of fully recycled packaging and the composting of all remaining FLW, lead to net CO_2E emissions being close to half of the baseline estimate — 10.45 $MtCO_2E$ versus 19.90 $MtCO_2E$, respectively. The other scenarios do not provide nearly the same scale of environmental benefits. The elimination of unnecessary and problematic packaging, the higher utilization of PCR content in the manufacture of packaging, and the recycling and composting of FLW and packaging further reduce total CO_2E emissions. Responsible behaviour by industry and consumers, combined with packaging innovation and optimization, not elimination, is therefore the key to minimizing total CO_2E emissions.

The report concludes (Section 7) with recommendations for establishing an equilibrium between FLW and packaging, and establishing a circular economy. There is presently a lack of incentives for the food industry to modify its marketing practices to proactively reduce FLW along the value chain, and motivate consumers to purchase and manage food and packaging in the home more responsibly. There is also a lack of incentives for companies to design products for recycling and composting, and challenges for municipalities that want to collect certain organic waste and packaging materials. The incentives required to optimize material recovery, recycling, and composting/AD systems are also lacking. Addressing this situation requires priority to be given to a mix of economic tools that stimulate new markets and engender behavioural changes required to drive systemic innovation along the entire packaging and food value chain.

The recommended interventions to drive systemic change are grouped into the five categories below. The stakeholders responsible for each recommendations' implementation and timelines are also presented.

1. FLW prevention — this includes optimizing the sale of loose/bulk vs. prepackaged
2. Address problematic and unnecessary packaging
3. Improve recycling infrastructure
4. Improve composting/AD infrastructure
5. Accelerate development of new packaging materials and solutions

Glossary of Terms

Bio-based plastics: packaging whose appearance is similar to petroleum based plastics. Manufactured from plant-based materials such as corn starch or sugar cane.

Biodegradable plastics: packaging that will be broken down by microbes over time.

Compostable packaging: packaging that breaks down within a reasonable timeframe (e.g. 8 weeks), does not leave behind toxic residues, and the resulting materials can be safely incorporated into soil.

Down-cycling: packaging that is recycled, though into a product with a lower value than its original form (e.g. garden furniture manufactured from recycled food packaging).

Fibre packaging: manufactured from wood or other plant-based material. Includes paper and cardboard.

High-density polyethylene (HDPE): A versatile, light weight and strong plastic manufactured from the monomer ethylene.

Laminates: packaging that contains multiple layers of material. Mono-laminates are manufactured from a single form of polymer (e.g. polypropylene). Multi-laminates are manufactured from different polymers, each layered on top of each other. Some laminates will be metalized, usually with aluminum.

Low-density polyethylene (LDPE): A light, soft, and flexible plastic manufactured from the monomer ethylene.

Modified atmosphere packaging (MAP): Products' shelf life is extended by the atmosphere within the package, being substituted with a different gas mix to that which exists in the surrounding environment. MAP mechanisms are typically characterized as passive, active, and smart.

Optimized packaging: packaging that is fit-for-purpose in all respects. It uses the optimum amount of packaging materials and incorporates the optimum mechanisms to protect, preserve, and promote the products contained within.

Paper/cardboard: packaging that is manufactured from fibre, usually wood. Paper and cardboard can be single or multi-layer. May be coated with materials such as resin, vinyl, or wax.

Polyethylene Terephthalate (PET): manufactured from ethylene glycol and terephthalic acid, it is a form of polyester. Clear, lightweight, and strong, it is commonly used in the manufacturer of rigid packaging, such as drink bottles and clamshells.

Polylactic Acid (PLA): one of the most common bio-based plastics. Similar in appearance to PET.

Polystyrene (PS): manufactured from styrene. It is a rigid and brittle material that is produced in solid or expanded (foamed) form.

Polypropylene (PP): manufactured from the monomer propylene. A tough and durable plastic, whose characteristics can be modified during the manufacturing process.

Up-cycling: products that possess a higher quality or economic value than the original materials from which they were manufactured.

Table of Contents

List of Tables

List of Figures

1.0 INTRODUCTION

The food loss and waste (FLW) that occurs throughout the value chain, with its associated impact from economic, environmental, and social perspectives, is at crisis levels. If the global food industry's current level of inefficiency continues on its present trajectory, by 2030, FLW is predicted to reach 2.1 billion tonnes worldwide. By 2050, the greenhouse gas emissions associated with FLW will equate to 6.2 gigatons. This is equivalent to the GHG emissions of Brazil — the world's sixth largest emitter of GHG. In Canada alone, 11.2 million metric tonnes of avoidable FLW occurs each year. Much of this FLW is edible food and could be redirected to support people in our communities who are food insecure. The total financial value of this potentially rescuable food is $49.46 billion. The carbon dioxide equivalent (CO_2E) and blue water footprints of this potentially rescuable food equates to 22.2 million tonnes and 1.4 billion tonnes, respectively.[1]

Canada has committed to the United Nations Sustainable Development Goals (SDGs) and the Paris (climate) Agreement. The SDGs include halving per capita consumer and retail FLW, and reducing FLW along the value chain, by 2030.[2] The Paris Agreement requires Canada to reduce its total CO_2E emissions by 28 percent from 2015 levels of 722 megatonnes, by 2030.[3] The prevention of FLW (not its management through redirecting to animal feed, composting, or transforming FLW into bio-energy through, for example, anaerobic digestion) is the only way of creating a sustainable future for food and the planet. Addressing linear take-make-waste approaches that lead to the production and disposal of excess food cannot be achieved without significant changes occurring along the domestic and international value chains with which the Canadian food industry is intimately connected.

The World Resources Institute (WRI), ReFED, the United Nations Environmental Program (UNEP), and Waste and Resources Action Programme (WRAP) are among the globally respected organizations which state that packaging plays a crucial role in today's global food industry by preventing the occurrence of FLW. Packaging has been identified as enabling efficient and effective transportation, extending shelf life, reducing energy requirements, improving food safety, preventing cross-contamination, enabling traceability, providing convenient food preparation/cooking/serving solutions, and providing a platform for communicating with consumers. It is also an important marketing tool. However, packaging, and in particular, overuse of single use plastic with limited recycling potential, has also become one of the world's greatest pollution problems. Pollution caused by certain types of packaging materials and ineffective management systems has become a sign of a linear economy typified by overconsumption, waste, and pollution. Establishing an equilibrium between FLW and packaging usage, by identifying where the two considerations intersect, and how to make the best choice possible around whether and how to best package food, is therefore imperative to our planet's sustainability.

The term "optimized packaging" is used to describe packaging that is fit-for-purpose. It uses the optimum amount of packaging materials to do the job required (protect, preserve, and promote). Sub-optimized packaging is packaging that does not use the optimum amount of packaging to do the job required. For example, under packaging can lead to costly damages that incur loss of both the package and the product, whereas over packaging uses excess materials, adds costs, and incurs a larger environmental footprint.[4]

1.1. Purpose and Objectives

Multiple organizations and researchers[a] state that critical to enhancing the global food industry's efficiency is improving the design and utilization of packaging. This will lead to simultaneous reductions in FLW and packaging waste. Achieving this requires the two issues of FLW and packaging to be tackled concurrently, from a systems (whole of life cycle) perspective. The circular economy concept reflects systems thinking, meaning that the individual parts that together comprise a system are viewed then managed holistically in order to ensure the system's long-term sustainability from maintaining the highest and best use of resources.

The purpose of the research is to establish an objective, defensible understanding of the relationship between FLW and packaging, with recommendations on how to apply these understandings to the prevention of FLW in 12 food types[b] and different packaging solutions. Establishing an equilibrium between FLW and packaging includes offering customers the opportunity to purchase foods loose/bulk and reuse their own containers, where it will not result in unintended environmental or socio-economic consequences.

A combination of secondary data analysis and literature review guided the development of defensible scenarios that explored economic and environmental related trade-offs associated with FLW and packaging waste that can be achieved from 1) having improved packaging design and utilization; 2) having increased the recycling, reuse, or composting of packaging materials; and/or 3) having redesigned supply chain business models. The scenarios used primary data gathered from stakeholders in the food, packaging, waste management and recycling industries, and representatives from all levels of government to explore the comparative environmental impacts of current, less effective, and optimized packaging solutions for reducing FLW and packaging wastes.

---

a Examples include: Ellen MacArthur Foundation, World Wildlife Fund, World Resources Institute, ReFED, United Nations Environmental Program, WRAP, Institute of Packaging Technology and Food Engineering (ITEGA), National Zero Waste Council, Provision Coalition, Second Harvest, Value Chain Management International, United States Environmental Protection Agency, Department of the Environment and Rural Affairs, Institute of Food Technologists, Institute of Grocery Distribution, and The Food Institute.
b Apples, berries, leafy greens, granulated sugar, dried pasta, sliced bread, frozen shrimp, fresh chicken, beef burgers (frozen), liquid milk, yogurt, fresh fish fillets.

The research was conducted in five phases:

1. Literature review, secondary data analysis, and exploratory consultations
2. Primary data gathering through a national online survey and interviews
3. Data analysis and extrapolation
4. Scenario design and conclusions
5. Reporting

Throughout the project, the research team consulted with a project advisory team comprising individuals from the National Zero Waste Council (NZWC), RECYC-QUÉBEC, Éco Entreprises Québec (EEQ), and The Packaging Consortium (PAC).

The report commences by reviewing intersections between FLW and packaging. The review summarizes 1) the role that packaging is known to play in mitigating or preventing FLW; 2) packaging innovations designed to reduce both FLW and packaging waste; and 3) efforts targeted at reducing FLW and packaging waste, by having optimized packaging's design, utilization, and the establishment of the systems and infrastructure required to create a circular economy. Literature pertaining to offering customers the option of purchasing foods or beverages in bulk and the potential impact of such on FLW was sought. So too was literature pertaining to social considerations, such as trends in consumer perceptions and behaviours towards packaging, and the drivers of these trends. How industry and governments are responding to those trends was also reviewed.

The review is followed by an analysis of primary data captured through two avenues. The first was an online survey completed by representatives from the food industry, packaging industry, government, NGOs, and researchers. The second avenue was a series of confidential interviews conducted with stakeholders representing the same sectors. Results produced by the literature review and primary research guided the development of 10 scenarios that use carbon equivalent (CO_2E) emissions as a measure to assess the comparative impacts of various approaches to reduce FLW and packaging. The scenarios act as range finders that industry, government, NGOs, etc., can use to guide commercial, policy, and regulatory considerations. They also act as a guide for future research. The report ends by presenting conclusions that emanate from the research and recommended actions. The actions include interventions that are required to reduce FLW and packaging waste more effectively than presently occurs, which would result in significant reductions in their overall carbon emissions.

1.2. Research Limitations

The research described in this report was rigorous and included 220 respondents from across the polymer, packaging, food, recycling and composting industries, as well as representatives from government, NGOs, and research institutes. The study utilized 12 foods that together encompass the six categories of foods and beverages established to conduct whole of chain FLW analysis,[5] along with different supply mechanisms (e.g. fresh vs. frozen) and packaging materials, to produce indicative findings that could be extrapolated across the wider food industry.

The methodology employed by the researchers was designed to enable statistical analysis of the primary data captured through the online surveys and stakeholder interviews. The methodology did not allow the primary data's margin of error and confidence intervals to be established in relation to the wider population. This study was not a scientific study of packaging materials or life cycle analysis.

Finally, the study's focus is not on the handling of loose/bulk foods and beverages. The focus is also not on determining whether to promote the sale of loose/bulk foods and beverages for ethical reasons. The metric used to assess the comparative benefits of whether to pre-package foods and beverages or sell them loose/in-bulk is carbon (CO_2E) emissions.

2.0 TRANSITIONING TO A CIRCULAR ECONOMY

What is a circular economy for food and other resource? Why is establishing a circular economy for food and packaging critical to ensuring a sustainable food industry?

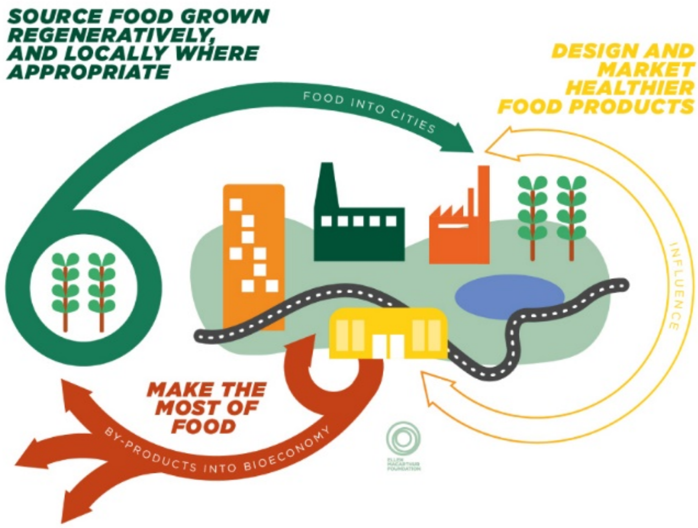
For a long time, our economy has been "linear." In a linear (make, use, dispose) economy, a product is produced with raw materials, then the product is used and, lastly, it is thrown away.[6] As presented graphically in the comparative diagrams produced by Institut EDDEC, in collaboration with RECYC-QUÉBEC,[7] (Appendix A), a circular economy is an alternative to a linear economy.

The circular economy aims to keep products and materials circulating at the highest utility and value. Waste prevention is prioritized above reuse and recycling. This leads to resources being kept in use for as long as possible, with systems put in place to extract the maximum value from them while in use, then recover and regenerate products and materials at the end of each service life.[8] As the National Zero Waste Council's *Food Loss and Waste Strategy for Canada* states,[9] "Applying appropriate packaging where needed to reduce spoilage, exploring new packaging materials that support a circular economy, and re-sizing packaged food portions are all important."

2.1. Resource Utilization

The Ellen MacArthur Foundation[10] describes a circular economy as based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. While there is no widely agreed view of what a circular economy would look like in food, the principles that underpin a circular food system are no different to those used to characterize a circular economy more generally. Shown below in Figure 2-1 is the food circular economy graphic contained in the Cities and Circular Economy for Food report launched at the World Economic Forum in Davos in January 2019.[11]

Figure 2-1: Ambitions Exhibited in the Creation of a Circular Economy for Food

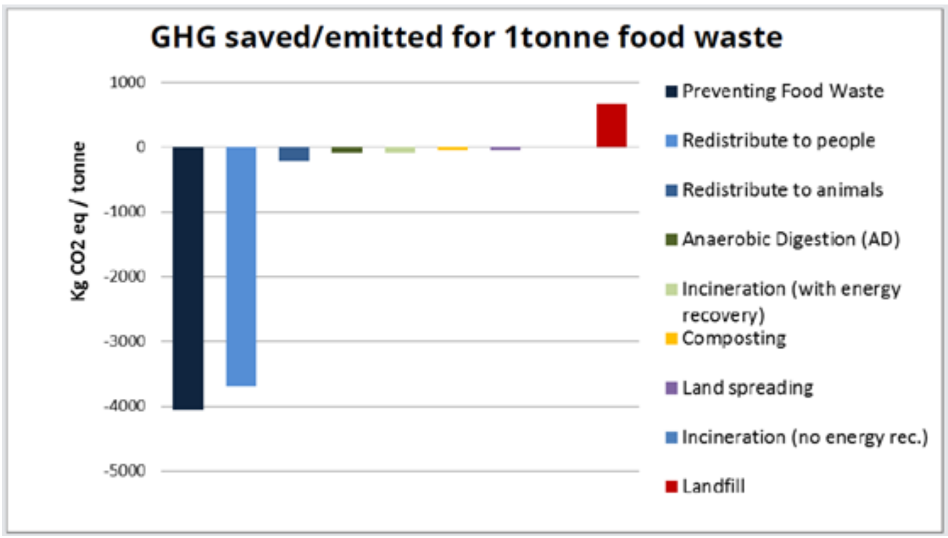


Source: Ellen MacArthur Foundation (2019)

Guelph is one of the cities participating in the *Cities and Circular Economy for Food* pilots that are being extended to over 20 major cities across the world. Along with the County of Waterloo, efforts that will be undertaken to create a circular food economy include "transitioning to renewable and reusable resources, redesigning waste and pollution out of the system, preserving and extending what is already made; and redefining growth with a focus on society-wide benefits that build economic, natural and social capital."[12] On the broader scale, a circular economy for food will focus foremost on preventing the occurrence of FLW wherever possible. This includes the recovery and distribution of excess edible food to charities. Resources bound up in whatever FLW cannot be prevented will be recovered through reuse (e.g. transforming into vitamin supplements), repurposing (e.g. directing to animal feed), and valorization (e.g. composting or anaerobic digestion to produce biofuel).

WRAP[13] showed why, from an environmental perspective, preventing FLW is key. Shown below in Figure 2-2 are the average carbon equivalent (CO^2E) footprints for one tonne of food waste prevention and redistribution compared to options for managing food waste, if it occurs. Analysis completed by ReFED illustrated the extent to which greenhouse gas emissions and broader environmental externalities (incl. those associated with the unnecessary use of water and fertilizer) can be reduced by preventing FLW.[14]

Figure 2-2: GHG Saved/Emitted for One Tonne of Food Waste



Source: WRAP 2015c

As can be seen, with each tonne of food waste that is prevented from occurring, the amount of CO_2E entering the environment is reduced by four tonnes. Due to transportation, handling, etc., a little less CO_2E is saved when food is redistributed. Regardless of how FLW is managed, it constitutes close to four tonnes of unnecessary CO_2E entering the environment. The CO_2E emissions reduced through redistribution to animals, anaerobic digestion, incineration, and composting are minimal. Landfill adds an additional ~500 kg (totaling ~4.5 tonnes) of CO_2E that enters the environment for each tonne of food wasted. HRI and household FLW cannot be redirected to animal feed due to contamination and food safety related risks.

The CO_2E footprint of packaging manufactured from virgin materials equates to less than 10 percent of the CO_2E footprint of the food contained within.[15] That the CO_2E footprint of packaging can be reduced by 90 percent when manufactured from recycled materials[16] emphasizes the need to consider symbiotic relationships that exist between food and packaging decisions in establishing a circular economy.[17]

2.2. Sustainable Development Goals (SDGs)

Taking action related to the circular economy contributes directly and indirectly to achieving 49 of the 169 targets set out in the Sustainable Development Goals (SDGs) established by the United Nations.[18] Canada has committed to achieving these SDGs targets, which formed the basis of the 2018 Paris (climate) Agreement, and amounts to reducing CO_2E emissions by 28 percent from 2015 levels of 722 megatonnes, by 2030.[19] Examples of how transitioning to a circular economy for food and packaging can aid Canada achieve specific SDG commitments (in particular, SDG #12, which pertains to achieving responsible production and consumption by fostering the innovation capacity required to promote and enable the adoption of design-led approaches to production and end-of-life use for foods and packaging) include:

- SDG 12.3 (halve per capita consumer and retail FLW, and reduce FLW along the value chain);
- SDG 12.4 (environmentally sound management of chemicals and all wastes through their lifecycle);
- SDG 12.5 (reduce waste generation through prevention, reduction, recycling, and reuse); and
- SDG 12.6 (encourage companies to adopt sustainable practices in their operations and reporting).

While the wording of the SDGs does not specifically relate to packaging, establishing a circular economy by optimizing packaging's design, utilization, and post-life management to reduce FLW and packaging waste aligns most closely with the four SDGs listed above. With only 8.6 percent of extracted resources being circled back into the economy,[20] achieving or even striving for SDG 12 will require an overhaul of our linear, take-make-waste patterns of production and consumption in favour of a circular system.[21]

The extent of changes required is emphasized by the SDG and Paris Agreement CO_2E emission goals equating to just one-third of the CO_2E reductions required to keep temperatures under the threshold at which the world's ability to produce food would be severely harmed.[22] Stabilizing climate change under this threshold—2°C above pre-industrial temperatures—requires an annual rate of CO_2E reduction that is six times that achieved over the last decade, and for that trend to be sustained until 2050.[23] A five times greater reduction in CO_2E emissions than contained in the Paris Agreement is required to meet the commitment made by international businesses and NGOs in 2019 to prevent temperatures exceeding pre-industrial temperatures by more than 1.5°C.[24]

To feed a population of over nine billion, the agri-food industry faces a 70 to 100 percent increase in demand for food by 2050. Unless the industry is able to decouple food supply and economic growth from CO_2E emissions in unprecedented ways, the agri-food industry's ability to sustainably supply food at even current levels of production is questionable.[25] So too are the societal benefits associated with the robust economies that result from sustainable food systems that meet consumers' health and nutritional needs.

Establishment of a circular economy is the only means by which Canada can meet its CO_2E commitments. This would lead to considerably less food and packaging resources being required to satisfy downstream requirements than is currently the case. This can be achieved by at least reducing, and where possible, completely avoiding waste occurring throughout food and packaging value chains. Managing current levels of waste more responsibly is not the solution.[26]

Transitioning to a circular business model for food and packaging starts with the recognition of the lost market value, then deliberately designing systems to create different valuation models for packaging and the material from which it is manufactured. Creating a restorative or regenerative system in which all products are designed and marketed with reuse and recycling in mind requires changes to occur at every phase of the food and packaging life cycle. This will require businesses to innovate in ways that are “purposeful, focused, and agile enough to adapt to multiple evolving demands.”[27]

3.0 FOOD LOSS AND WASTE PREVENTION

For reasons described in the previous section, it is imperative to reduce FLW through prevention. Studies[28] show that packaging can reduce FLW by 30+ percent compared to non-packaged or less effectively packaged foods. The following section describes the vital role that packaging plays in preventing FLW throughout the value chain. Those foods and beverages where packaging can enable the greatest reductions in FLW, and where opportunities exist to reduce or eliminate packaging without it leading to increased FLW, are also described.

Globally respected organizations, including The World Resources Institute (WRI), ReFED, the United Nations Environmental Program (UNEP) Organization for Economic Co-operation and Development (OECD), and Waste and Resources Action Programme (WRAP), have stated that packaging plays a vital role in preventing the occurrence of FLW.

While any form and amount of packaging is not by itself a panacea for reducing FLW,[29] the widespread removal of packaging would lead to an exponential increase in food waste, and consequently CO_2E emissions, along with other environmental externalities.[30] Reasons why less effort has been placed in reducing packaging waste than FLW are said to include that packaging has a lower environmental footprint than food.[31]

Multiple researchers[32] have stated that packaging plays a critical role in reducing FLW. This role extends along the entire chain, from primary production through to the home. Packaging is grouped into three types, with the specific role of each for reducing FLW differing according to its use in the value chain and food type:

1. Primary or sales packaging: what shoppers take home;
2. Secondary packaging: boxes, trays, and cartons, often seen on retail shelves; and
3. Tertiary packaging: large containers, pallets, and wrap that allow products to be transported.

Of the three types of packaging, the research paid greatest attention to primary packaging. Reasons for this include that it typically constitutes the largest array in packaging materials (incl. plastic: petroleum and bio-based; paper/cardboard; metal: tin, steel aluminium; and glass). As well, primary packaging typically has the greatest impact on FLW occurring along the value chain and in the home.[33] This does not underplay the role of tertiary and secondary packaging in minimizing FLW. Tertiary packaging materials include wood (pallets), flexible wrap (plastic), containers (cardboard), and returnable plastic containers (plastic). The most common form of secondary packaging is cartons and trays (cardboard).

This section on preventing FLW by optimizing the design and utilization of packaging begins by briefly summarizing key factors that the literature review identified as affecting the establishment of a sustainable circular economy for food and packaging. They include business decisions and the drivers of, sale of loose/bulk foods and beverages, and consumers' acceptance of this option versus continuing to purchase pre-packaged foods. The optimization of packaging to reduce FLW rests on these factors being acknowledged during the design and implementation of FLW and packaging waste reduction initiatives.

3.1. Barriers and Enablers to Change

3.1.1. Food / Beverage Industry

Retailers (and foodservice operators) have an important, often underutilized, role to play in driving reductions in packaging and food waste along the entire value chain. As shown by initiatives introduced by Walmart, Tesco, and Kroger, amongst others, the upstream and downstream influence possessed by retailers enables them to motivate and encourage consumer acceptance of FLW solutions, including merchandising and packaging innovations, in ways that other stakeholders cannot.[34]

The food industry can, however, be resistant to playing a leading role in driving reductions in FLW and driving packaging innovation. This includes optimizing pack size to suit consumer needs, and designing packaging for reuse, recycling, or composting.[35] The former is particularly important given the direct link that exists between pack size and household FLW.[36] Despite the fact that companies such as Unilever have committed to extensively changing packaging arrangements and utilizing high levels of recycled content in their packaging, while simultaneously retaining a commitment to reduce FLW, in markets such as the UK, less innovation has occurred in branded products versus private label.[37] That said, there is a broad level of support from across the food industry to the UK Plastics Pact, which commits businesses to reduce plastics pollution.[38]

Reasons cited for industry's reluctance to change include consumer behaviour and investor pressure, leading businesses to focus on maximizing sales volume and market share by minimizing per unit production costs and price.[39] The drive to maximize sales in a stagnant economy leads to vendors and retailers basing packaging design decisions (including materials used in their manufacture and pack size) on marketing considerations and visual appeal ahead of environmental considerations.[40] Incentive systems lead individuals to purposely not seek to assist the business for whom they work to reduce FLW along the value chain and in the home, nor to optimize their date coding practices.[41] Such practices reflect the market failures that occur when food and packaging material prices do not reflect the true cost of production, which includes externalities such as environmental costs.[42]

3.1.2. Compostable and Biodegradable Packaging

Misused terms that lead to sub-optimized packaging design and utilization include biodegradable, compostable, and bio-based plastic[c].[43] The terms biodegradable and bio-based typically refer to materials that naturally breakdown by themselves, while the term compostable is typically used to describe materials that require specific conditions to breakdown. The term bio-based plastic is the term given to plastic-like materials manufactured from renewable biomass.[44]

While all three types of materials appear beneficial to the environment, leading to businesses and consumers choosing them ahead of alternative materials, the environmental footprint and ecological impact of packaging that is marketed using these terms can be greater than alternative materials.[45] This is particularly true when compared to those materials that form part of a coordinated food and packaging value chain.[46]

That a product is termed bio-based plastic and biodegradable also does not denote that it is actually compostable or will degrade without releasing toxins or micro-plastics.[47] Oxo-degradable plastics are not desirable, because they break down into micro-plastics that pollute the environment. Biodegradable and bio-based plastics also negatively impact the economic viability of established post-consumer recycling systems.[48] While some bio-based plastics can be recycled, this process requires specialized infrastructure.

Due to the resources required to produce biodegradable, compostable and bio-based plastic packaging, they may only produce a net environmental emission benefit when they reduce FLW more than current solutions.[49] That such materials can cause consumers to be "less careful with their discards"[50] means that incorrectly promoting packaging materials on their environmental credibility, and not having the systems required to responsibly manage the entire packaging materials' life cycle, can actually hamper, not assist, the establishment of circular food and packaging economies.[51]

---

c While commonly referred to as bioplastic, bio-based plastics and bioplastics are not necessarily the same.

3.1.3. Consumer Attitudes and Behaviour

Consumers play a critical role in establishing a circular economy. Multiple research has identified that it is not packaging per se that is the key challenge to combat FLW and packaging waste by establishing a circular economy. The bigger challenge, according to many, is consumer attitude and behaviour.[52] Consumer behaviour is critical to maximizing packaging products' shelf life in the home.[53] Consumer behaviour is also the cornerstone of effective packaging recycling programs, such as that which have existed in Sweden for decades.[54]

Seventy-five percent of respondents who participated in a 2019 study in Quebec stated that they are taking action to reduce FLW.[55] In a 2019 national study of 1,500 Canadians, 76 percent of respondents said that they wanted to see a reduction in the volume of food packaged in plastic; though not if it impacted the availability of certain products, increased the price of food, or led to increased FLW.[56]

An Australian study identified that consumers are less motivated to proactively reduce packaging waste than FLW.[57] In the UK, four in ten consumers are not prepared to pay more for an item with better environmental and social credentials.[58] Despite 60 percent of consumers claiming that they would prefer products with less or no packaging, 38 percent suggested they would not tolerate a shorter shelf life due to more sustainable packaging. As well, consumers are reluctant to change purchasing behaviour, even when the increase in cost associated with adopting more environmentally conscious behaviour is negligent to non-existent.[59] Engendering consumer attitudes and behaviour are therefore critical to achieving an equilibrium between FLW and packaging, simultaneously minimizing their combined environmental footprint.[60]

How food is marketed also impacts the occurrence of FLW.[61] Bulk packages and creating the illusion of abundance by stocking shelves high encourages shoppers to buy beyond their needs.[62] When foods are on sale or heavily promoted, consumers buy on impulse — then discard the surplus. This is particularly the case with those consumers who Audet & Brisebois[63] term "improvisors" (*improvisateurs*). This type of consumer responds to promotions and best before dates ahead of objective reasoning, and are unlikely to acknowledge the economic or environmental implications of their actions.

3.1.4. Consumer Awareness

Lack Lack of consumer awareness regarding the role of packaging in reducing FLW creates a barrier to packaging playing a more impactful role in measurably reducing FLW.[64] In a UK report, 25 percent of people ranked plastic as the worst material for sustainability, rising to 37 percent for single use plastics. This suggests that for many consumers, the negative connotations of plastic packaging outweigh the positives.[65]

Consumers discard food that is near or past its best-before date, despite product dating practices having no correlation to food safety. Food that has reached or exceeded its best before date can often still be safely eaten.[66] That food and beverage manufacturers are not required to ensure that the date codes they apply to products match the shelf life provided by packaging exacerbates the creation of avoidable FLW.[67]

That consumers often discard food and packaging without considering the economic or environmental implications[68] led to a UK initiative that connects communicating product dating to the potential for selling products in bulk. Both approaches are important for reducing avoidable food waste in the home. Dating information enables consumers to make more informed decisions on when to eat versus discard. The option to purchase loose enables consumers to buy only what they need. The initiative also encompasses a process for retailers and their vendors to examine means to improve packaging where the sale of loose items is not a viable option. Titled "Label better, less waste: Fresh, uncut fruit and vegetable guidance," and produced by WRAP, FSA, & DEFRA,[69] development of the guidance was steered by supermarket visits, the examination of 2,000 foods most frequently wasted in the household, and retailers piloting the sale of loose fruits and vegetables.

In Canada, an increasing array of packaging materials, combined with a lack of objective information and current curbside collection practices differing between municipalities, leads to avoidable packaging waste due to consumers being confused about how to correctly recycle.[70] These consumer related issues are exacerbated by a lack of investment in the development of standardized policies or practices surrounding consumer messaging and best practices for managing specific foods and packaging in the home.[71]

3.2. How Packaging Reduces FLW

A detailed analysis of the specific role that each type of packaging plays for minimizing the negative economic and environmental impacts of both FLW and packaging waste is beyond the scope of this review. Therefore, examples are used to illustrate the economic and environmental outcomes that can be achieved by designing packaging from a whole of chain (lifecycle) perspective.

PAC, IGD, ReFED, WRAP, AFPA, and Denkstatt[72] are amongst those who have published best practice examples of how FLW can be reduced through improved packaging. Gooch et al[73] categorized the mechanics that lead to packaging playing an important role in reducing FLW as:

1. **PROTECT PRODUCT:** Food handling and safety, damage protection, product monitoring, tamper-proofing, cold chain management
2. **EXTEND SHELF LIFE:** Barrier technology, spoilage and contamination prevention
3. **PROMOTE BEHAVIOUR CHANGE:** Dosage and portion control, resealable features, freshness indicators, consumer messaging, dating

That the mechanics associated with individual packaging cross all three categories indicates the compounding effect that multiple attributes have on packaging's role in reducing food waste. For example, passive modified atmosphere (MA) technologies, resealability, portion sizing, and more can be designed into one package. Stronger tertiary and secondary packaging leads to less food being disposed of due to damage, leakage, or spillage.[74] Freshness and standardized labeling/dating policies reduce the occurrence of avoidable waste.[75] Effective date labelling policies include limiting their use to only those products and circumstances in which they are required for food safety purposes.[76]

3.3. Effectiveness, Functionality, and Innovation

Factors driving the need for more effective and functional packaging include "a decrease in household size, more people buying smaller portions of food, higher living standards leading to the purchase of more consumer goods, transport over long distances, and higher demands for convenience and processed food."[77] Combined with consumer advice, including the design and communication of date labeling, increased functionality plays a significant role in reducing FLW—particularly at the household level—by leading to more purposeful and informed consumer behaviour.[78]

A 2015 survey[79] identified the most popular changes in packaging desired by US consumers. Respondents said they would like to see more resealable packages (57%) and more variety in product sizes (50%). Top ranking responses for where changes should occur included baked goods, bagged salad, bread, and meat (43%, 41%, 39%, and 29%, respectively). Fresh produce in general was mentioned by respondents as an area in which they would like to see more changes in packaging size and design.

Hanson and Mitchell, PAC, WRAP, Koelsch Sand, and Dennis[80] are amongst those who have shown that the most effective packaging optimization occurs when retail and foodservice customers collaborate with their suppliers. Some examples of economic and environmental benefits achieved by redesigned packaging and supply chain processes implemented through value chain collaboration include the following:[81]

1. Changing from modified atmosphere packaging (MAP) to active technology packaging more than doubled the shelf life of fresh pasta. The financial benefits produced by a reduction in retail shrink more than offset any increase in packaging costs. MAP packaging is generally categorized as active or passive. Both forms extend products' shelf life by creating an internal atmosphere, often by modifying the gaseous oxygen and CO2E mix to a ratio that helps extend products' longevity.
2. More robust primary packaging produced a 75 percent reduction in the number of frozen pizzas damaged before reaching consumers. While the change increased primary packaging by 4 percent, it allowed a 4,000 tonne annual reduction in the outer (secondary and tertiary) packaging needed to transport frozen pizzas to retailers. As new packaging allows more efficient stacking on each pallet, a 1.6 million kilometre annual reduction in transportation was also achieved.
3. The percentage of 8-pound processed hams going to waste was reduced from 7.13 to 1.25 percent by adding an additional layer of protection around the shank bone only. This equated to an 82 percent improvement in performance. Although this additional protection increased the packaging weight by 25 percent, it resulted in a significant reduction in total CO_2E emissions and markedly reduced overall operating costs, whilst simultaneously increasing revenues.
4. The foodservice industry has embraced flexible packaging for a range of items, such as fresh pack tomatoes. The move eliminated a workplace health and safety issue (no sharp edges) and reduced the amount of packaging waste (volume and weight). The resulting financial benefits included a reduction in food waste, reduced packaging waste, reduced employee absenteeism, and reduced compensation payments.
5. Light blocking bags extend fresh potatoes shelf life by over 20 percent. The packaging prevents exposure to light, which leads potatoes to turn green and also develop a bitter taste, due to a chemical called solanine (which can be harmful to health).

6. A 12kg banana carton was specifically designed to match supply with demand in convenience stores. Smaller than the traditional 18kg banana box, the box reduces store waste by 90 percent. This also leads to consumers purchasing more consistent quality bananas, resulting in an expected reduction of waste in the home.
7. Moving from a standard tray and film pack to a shrinkable bag for fresh chicken produced a 68 percent reduction in packaging weight, while simultaneously increasing shelf life by two days. Supply chain efficiencies were measurably improved through increasing the number of birds contained in each crate shipped to distribution centres and onto stores.
8. TerraCycle® has set up closed loop systems focused on "developing recycling solutions for difficult-to-recycle packaging and products." A partnership with UPS allows consumers to send waste to TerraCycle® for recycling, thereby eliminating two common barriers: local access and the logistics of collection".[82] Multinational corporations currently piloting the system include Nestlé, Procter & Gamble, PepsiCo, and Mars. Online shoppers will have approximately 300 zero-waste products to choose from—such as Haagen-Dazs Ice Cream, packed in a double-walled, stainless-steel tub, designed to keep ice cream cold longer.
9. Technologies such as Apeel[83] are natural compounds that form a layer of protection on fruits and vegetables, and form an edible peel that could replace some primary plastic packaging. They reduce water loss and oxidization, or interfere with natural ripening processes, resulting in extended shelf life and quality.

3.4. Food Types Where Greatest Opportunities Lie

WRAP (2015a) estimated that one additional day's shelf life could reduce avoidable food waste in UK households by 200,000 tonnes, annually.[84] This equated to approximately five percent of overall UK food waste. The greatest gains could be achieved in perishable foods, those with a shelf life of 30 days or less. Extended shelf life would benefit businesses by it resulting in increased sales and reduced costs.[85]

A valuable resource for industry and researchers is the online interactive Waste Reduction Model (WARM). Produced by the Environmental Protection Agency,[86] WARM provides data on the comparative carbon footprints of multiple foods and packaging types, along with how different management methods (incl. recycling, compost, landfill) affect the total volume of CO_2E for FLW versus packaging type (e.g. paper, specific plastics, glass, and metal).

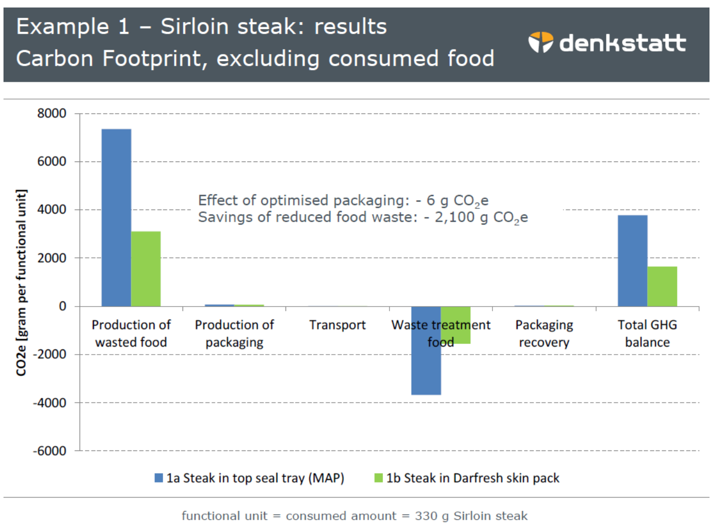
Research completed for the American Institute for Packaging and the Environment (AMERIPEN) by Gooch et al[87] estimated that optimized packaging could produce a 20 percent reduction in FLW in fruits, vegetables, and meats. They estimated that, conservatively, the potential reduction in US food waste from having utilized more effective packaging totalled 7.68 million tons, worth a total of $30.58 billion dollars. Reducing FLW by 7.68 million tons equated to a $1.98 billion reduction in the value of CO_2E emissions, and a water footprint saving that equated to just under 358,000 Olympic size swimming pools. A Canadian Produce Marketing Association study estimated that the premature elimination of current plastic packaging could increase FLW in fresh produce by approximately 500,000 tonnes per year. This would result in unintended environmental, economic, and social consequences.[88]

The extent of environmental benefits achievable by either packaging currently unpackaged products or improving the design of current packaging is illustrated by:

1. The comparative carbon footprints of packaging versus food; and
2. The extent to which packaging can extend the shelf life of perishable foods, in particular.

Packaging can extend the shelf life of fresh foods by a factor of two to ten times compared to non-packaged foods.[89] This is amongst the factors that have enabled retailers alone to reduce FLW in perishable items, such as grapes, by 20 percent.[90] The impact of optimized packaging on reducing the environmental impact of FLW, calculated as CO_2 equivalent (CO_2E), is illustrated below in Figure 3-1. As also shown below, the optimized packaging was skin-pack. The combined effect of having packaged a 330 gram sirloin steak in optimized packaging is a 2,106 grams reduction in CO_2E. Preventing the beef from going to waste equates to a reduction of 2,100 grams in CO_2E emissions. Having improved packaging design equated to a reduction of 6 grams in CO_2E emissions.

Figure 3-1: Reduction in Carbon Footprint of Sirloin Beef from Optimized (Skin Pack) Packaging



Sirloin steak (330gm) in skin pack

Source: Denkstatt, 2015

The above conclusions reflect Sealed Air's analysis, which found that the typical carbon footprint of beef is 370 times that of the packaging in which it is contained, while the carbon footprint of cheese can be 52 times that of its packaging.[91] The comparative CO_2E footprint of fruits and vegetables can be 150+ times that of the materials in which they are packaged.[92] Even though packaging counts for a fraction of the global environmental impact of food, it plays a crucial role in preventing FLW. This means that it prevents the majority of the environmental impacts associated with FLW from occurring.

4.0 FOOD AND BEVERAGE PACKAGING MATERIALS

A scientific comparison of material used for packaging to reduce FLW, along with examples of their comparative benefits and weaknesses, is beyond the scope of this report. The following section describes materials commonly used to package food, and how they can be managed responsibly to minimize total CO_2E emissions by having created a circular economy for food and packaging. It also summarizes why policies, legislation, and regulations must be designed and implemented from a systems perspective.

4.1. Packaging Materials

Traditional materials used for the transportation and storage of food include glass, metals (such as aluminum and steel), paper, cardboard, plastics, and laminates. To provide practical functionality, support the marketing of foods or beverages, and aid consumer communication, packaging manufacturers typically combine several materials into one solution. However, this combining of materials often represents a barrier to establishing a circular economy for packaging.[93] That packaging material choices also impact the management options available for diverting FLW away from landfill (e.g. to composting) also affects the creation of a circular economy for food.[94] For example, plastic product identification stickers applied to fresh produce are viewed by composting facilities as a contaminant. This results in peelings/skins discarded by households and spoiled produce discarded by distributors or retailers being unacceptable for composting.[95]

Plastics have become the most commonly used material for food packaging—particularly for highly perishable foods.[96] Reasons for this include that plastic packaging is inexpensive, lightweight, effective, and can be moulded to almost any shape and size. Plastics are also the most effective in terms of enabling users to modify its mechanics to suit specific products, markets, and customers. Plastic packaging is also easy to print, and easily integrated into production processes where the package is formed, filled, and sealed on one production line. Depending on the polymer from which it is manufactured and how polymers are recycled, plastic packaging can be reused countless times.[97]

The downside of plastic packaging is that the over 30 types of plastics that exist[98] vary greatly in their recyclability. Combining multiple plastics (incl. polymers, black/coloured plastics, metallic inks, and certain adhesives) into one packaging solution also impacts the cost and effectiveness of recyclability efforts.[99] This means that circular economic considerations cannot be applied equally to all packaging solutions.[100] An example of this is using nanomaterials to reduce FLW by simultaneously improving food safety, extending freshness and nutritional content, and enhancing the functionality of packaging.[101] While nanomaterial packaging can appeal to consumers to the point that they express a willingness to pay higher prices for foods such as chicken,[102] the economic recycling of multi-layer and active packaging is a challenging endeavour at best.[103]

4.2. Optimizing Packaging Materials Design and Use

Extensive international research[104] has examined packaging technologies that could assist in reducing FLW. Optimizing packaging to reduce its own environmental footprint, while simultaneously reducing FLW in ways such as those presented in Section 3.2, rests on improvements in packaging's design, distribution, and consumption from a whole of chain perspective.[105] It also rests on addressing the current ambiguity and misrepresentation of terms used to describe packaging, which stems from a lack of legally enforceable standards and protocols.[106] Examples include biodegradable, bio-based plastic, and compostable.

4.2.1. Life Cycle Assessment

Increased consumer and governmental awareness is driving a need to rethink how FLW and packaging are managed to reduce their overall environmental impact. Life cycle assessment (LCA) is considered to be a useful method for performing a complete analysis of the environmental impact of food packaging systems. Historically, LCA would focus on the packaging and would assess varying packaging material formats and configurations. Recent research has acknowledged that encompassing the packaging's impact on the content (i.e., the food or beverage) when conducting LCAs is of even greater overall importance.[107] Molina-Besch et al's 2019 study concluded that current research is insufficient to fully understand the influence of certain packaging characteristics (e.g. shape, weight, and type of material) on consumer behaviour, and the indirect environmental impact of packaging choices.

Food packaging LCAs should therefore include the direct environmental impact with regard to packaging material production and end-of-life management, plus its indirect environmental impact on "the food product's life cycle, e.g. by its influence on food waste and on logistical efficiency."[108] Important considerations therefore include packaging materials (plastic, cardboard, paper, glass, and metal); logistics (transport and storage); impact on food waste through the chain — including food safety and cooking preparation (mechanics); as well as end-of-life management of the packaging and for the food contained in it.[109]

Given the extent to which prices influence consumers' food purchasing behaviour,[110] economic considerations should also be factored into LCAs. Examples of why include that light-weighting reduces both packaging waste and FLW by reducing the volume of packaging while maintaining (potentially improving) functionality. The costs associated with modifying equipment to accommodate light-weighing are offset by the savings achieved from using less plastic. This allows businesses to recoup the capital investment without increasing prices paid by consumers.[111] The light-weighted packaging could be manufactured from 100 percent recycled materials.[112]

Holistic LCAs would enable commercial and consumer-centric considerations to be contrasted and extrapolated against environmental and economic considerations. This would include how products retailed to consumers loose or in bulk could be flowed along the value chain without increasing FLW and overall CO_2E footprints. These considerations are critical, given that a study by Gooch et al[113] identified that a forced broad-stroke switch to alternative packaging, such as compostable PLAs, or no packaging at all in the Canadian fresh produce industry could have greater impact on the environment and on industry and consumers. FLW could increase by almost half a million tonnes.

Logistical inefficiencies resulting from less effective packaging would impact transportation, leading to higher energy usage and emissions and many fruits/berries becoming seasonal only. Systems and processes required to recycle relatively new and innovative packaging materials may not exist or be economically viable. The combined effects of less choice, higher prices, and limited availability could negatively impact consumer health and well-being.

4.3. Responsible Material Management

Increased public sentiment towards environmental concerns is driving companies and wider industry stakeholders to rethink food packaging and FLW reduction strategies.[114] While environmentally sustainable packaging has been a driver of innovation for some time amongst packaging manufacturers and food producers/marketers,[115] consumers' demand for environmentally sensitive packaging solutions is increasing the pace of change.[116]

The volume of packaging per unit of food or beverage sold has been measurably reduced through material and packaging redesigns.[117] In addition to reducing the volume of packaging, food companies, including Anheuser Busch, Coca-Cola, Danone, Kellogg, McCormick, McDonald's, Nestlé, Starbucks, PepsiCo and Unilever,[118] are among the food companies that have committed to utilizing significant levels of recycled materials in their packaging. Packaging manufacturers, including Cascade, Sealed Air, Orora Fresh, Dupont, and BASF, have committed to producing packaging that contains up to 100 percent recycled material, and packaging that can be recycled or composted without releasing harmful toxins.[119]

Three retail driven initiatives (Tesco, Walmart, Kroger) are examples of the extent to which industry is driving broad changes in packaging and process innovation that extend beyond food and along the entire product and packaging value chain. Together, with the examples contained in Section 3.1 and the following section, they reflect the hierarchical approaches of reduce, reuse, or recycle packaging being employed by industry to create a circular economy.

Tesco, an international retailer headquartered in the UK, has categorized packaging materials into "Red, Amber, and Green." Vendors can no longer package goods in materials listed in the red category, e.g. PVC and industrial compostable, as these were not acceptable after December 31, 2019. Materials categorized as amber are only allowable while companies transition to preferred (green) materials.

Walmart's "Recycling Playbook: Optimize, Change, Advance" playbook[120] ensures its vendors optimize their packaging material choices. The decision tree contained in Walmart's "Sustainability Priorities" playbook[121] guides vendors through the process of choosing packaging materials based on their recyclability. The Kroger[122] initiative includes removing primary, secondary and tertiary packaging along the value chain by making greater use of returnable plastic containers (RPCs), and establishing collection points for multiple plastics in stores and throughout their distribution system.

4.3.1. Reduce

Means to reduce the volume of packaging used include light-weighting and the sale of loose versus prepackaged foods and beverages. Light-weighting includes eliminating unnecessary materials, those for example that are used for marketing purposes only and hinder packaging from being reused, recycled, or composted.[123]

While zero waste stores represent a microcosm of the overall retail landscape, they are capturing consumer and industry attention.[124] Examples of independent retailers that are focused on reducing packaging by selling items loose include Market Smor[125] in Cobourg and Épiceries Loco in Montreal.[126] Mainstream Canadian retailers, including Metro, Sobeys, and Loblaw, are piloting the sale of bulk/loose foods.[127] Carrefour, an international retailer, has announced that it will remove single use plastic (SUP) packaging and non-recyclable plastic wrapping from own-label fresh produce.[128]

In the UK, where the percentage of foods sold prepacked is measurably higher than in North America (61 versus 46 percent, respectively[129]), materials have been developed to guide retailers and their suppliers through the process of determining where the merchandising of loose uncut fresh produce is a viable option versus prepackaged. “While the (UK) pilots’ impact on waste is unclear, when offered loose produce, customers often shop more often and for smaller quantities. In certain circumstances, this could be particularly beneficial for items found to have high wastage in UK homes, such as potatoes.”[130] As a comparative benchmark, in Germany, 74 percent of food is sold prepacked.[131]

That the UK guidance applies to a limited range of uncut fresh produce reflects some of the food safety and quality related challenges associated with selling foods loose or in bulk versus prepackaged. This fact, and that consumers’ purchase decisions often do not match their voiced intents, reflects why some of the retailers who have experimented with selling unpacked products are revising their programs due to reduced sales and/or increased waste.[132] To lessen the likelihood that selling only loose/bulk items will deter consumers from frequenting their stores, many retailers are offering consumers the option of buying a select number of items loose/bulk or prepacked.

Light-weighting reduces both packaging waste and FLW, by reducing the volume of packaging while maintaining (potentially improving) functionality during the distribution and sale of food. Examples of the light-weighting of primary (consumer) packaging that has occurred in Canada include the use of thinner plastic wrap on English cucumbers and the introduction of top-seal packaging. Greenhouse growers have taken the lead in North America, with studies reporting that it has reduced the volume of Canadian packaging materials by over 4,500 tonnes, and enabled labour to be reduced by as much as 50 percent.[133]

4.3.2. Reuse

Reusing packaging multiple times supports an overall reduction of materials. In Quebec, Sobeys/IGA and Metro allow consumers to reuse their own containers when purchasing deli, meat, fish, seafood, pastry, and ready-to-eat meals.[134] Due to the fragility of glass, along with food safety and cleanliness concerns, more training has been introduced for store staff, who must follow risk mitigation processes and protocols when handling containers brought into stores by customers.

In addition to offering customers the option of reusing their own containers, Bulk Barn (Canada's largest bulk chain of 275+ stores, with each store stocking a range of over 4,000 dried pantry items) have introduced Abeego.[135] This is a natural food wrap made from cloth and beeswax, which customers can use instead of plastic wrap.[136]

Reusable packaging extends to what is typically considered SUP produce bags and shopping bags.[137] A number of retailers have found that, regardless of whether they increase the range of loose/bulk options on sale and price loose/bulk items lower than pre-packaged, most consumers continue to purchase pre-packaged foods. This is regardless of retailers such as Sainsbury's withdrawing lightweight produce bags from their stores, actively promoting reusable bags for use when purchasing produce/etc., and pricing loose fruits and vegetables up to 25 percent less than their pre-packaged equivalent.[138]

Shopping bags provide an example of why legislation aimed at forcibly introducing reuse practices must not be considered in isolation or in preference to awareness-raising campaigns. As the availability of lightweight shopping bags has diminished, due to legislation, the sale of bin liners and use of other plastic bags (e.g. instore produce bags) has increased.[139] Many consumers have not changed their behaviour; with no shopping bags to reuse, they instead purchase and use bin liners.[140] Whether bin liners are manufactured from recycled materials differs by brand.[141] The widespread utilization of reusable shopping bags, which each contain a higher volume of plastic than traditional shopping bags, is a key reason behind why plastic usage in UK retailing has increased, not decreased, in recent years.[142] Unless a reusable package is designed for recycling, its environmental footprint can be higher than options designed for single use and fit within a circular economy.[143]

4.3.3. Recycle

All products have a finite lifespan. “Brands, recyclers, the packaging industry, and consumer education are fueling the circular economy to enable more recycling.”[144] In a 2018 survey of Canadians, almost 80 percent of 1,500 surveyed said the best way to reduce plastic waste was to improve recyclability and recoverability of plastics.[145] ECCC[146] estimated that the economic opportunities offered by preventing Canadian plastics alone being lost to landfill or released into the environment is $7.8 billion.

Recycling packaging materials can greatly reduce their environmental footprint. This is particularly the case for materials that lend themselves to recycling.[147] An extensive study conducted in Denmark, Norway, and Sweden to ascertain the environmental benefits resulting from the recycling of common materials showed that, on average, all materials associated with the packaging of food have lower GHG emissions when manufactured from recycled *(secondary production)* versus virgin *(primary production)* material. The study’s results form Table 4-1. “The unit used is kg CO_2-equivalent (CO_2E)/kg material, and the material output is assumed equal to the amount of treated waste (after losses), except for organic waste.”[148]

Table 4-1: Comparative Differences in Secondary (Recycled) and Primary (Virgin) CO2E Emissions

Material	Primary production (kg CO_2E/kg)	Secondary production (kg CO_2E/kg)	Difference: secondary – primary (kg CO_2E/kg)	Percent variance: secondary vs. primary
Glass	0.9	0.5	-0.4	-41%
Aluminium	11.0	0.4	-10.6	-96%
Steel	2.4	0.3	-2.1	-87%
Plastics	2.1	1.3	-0.8	-37%
Paper and cardboard	1.1	0.7	-0.4	-37%

As can be seen, the greatest reduction in GHG emission is for aluminium (-96%), followed by steel (-87%). This is followed by glass (-41%), then plastics and paper and cardboard (both -37%). While no statistical difference exists between the average benefits produced by using recycled glass, paper/cardboard, or cardboard versus virgin, recycling measurably reduces the GHG footprint of all materials.

4.3.4. Recycling Plastic Packaging

Due to its ability to be modified to suit specific conditions and purposes, plastic is the most commonly used material to package food.[149] Perugini et al[150] identified that of the different forms of management practices for post-consumer plastic packaging (landfill, combustion, and recycling), recycling was significantly more environmentally friendly than other options. The reduction in carbon (CO_2E) possible from recycled plastic versus virgin ranges from 30 to 90+ percent,[151] meaning plastics differ markedly in the extent to which CO_2E emissions can be reduced by recycling. Room exists to further improve recycling efficiencies by utilizing different recycling technologies and more effectively managing plastic packaging systems and processes from resin/polymer production through to post-consumer handling.[152]

Analysis conducted by researchers and industry organizations[153] identified that the plastics commonly used in the packaging of food and beverages, such as HDPE, LDPE, PET and PP, are highly recyclable. Their CO_2E emissions when recycled is also less than other plastics.[154] As can be seen below in Table 4-2, the CO_2E footprint of HDPE, LDPE, PET and PP polymers are approximately 90 percent less if sourced from post-consumer recycled (PCR) materials versus virgin.

Table 4-2: Metric Tonnes of CO2E per Metric Tonne of Material

Plastic Type	Emissions from Virgin Plastic Inputs	Emissions from Recycled Plastic Inputs	Reduction from Using PCR (Tonnage / Percentage)	
HDPE	0.49	0.05	-0.44	-91%
LDPE	0.58	0.05	-0.54	-92%
PET	0.54	0.05	-0.49	-92%
PP	0.54	0.05	-0.49	-92%

Sources: Resource Polymers (2011); EPA (2006)

Because an item such as PET is recyclable does not, however, mean it is recycled. In Canada, just nine percent of plastic waste is recycled,[155] four percent is incinerated with energy recovery, and 86 percent is landfilled.[156] This is typically due to inadequate sorting and lack of viable end markets. However, it is also due to lack of infrastructure to collect and process items in order to be recycled and recovered in an economically feasible manner.[157] For the recycling of packaging to be economically viable without government regulation, subsidy, or other form of market intervention, the value of the post-consumer resource must cover the collection, sorting, processing, and residue disposal costs.

While “down-cycling” is not the preferred focus of recycling initiatives, because it does not optimize materials’ value and utility, it can aid the creation of economically viable recycling systems through the establishing of new markets. Keeping in mind that not all packaging can be recycled into food grade packaging, Sobeys[158] and Ice River Springs[159] are among the businesses that are manufacturing outdoor furniture from post-consumer plastic packaging. Recycled plastic and glass packaging is also being incorporated into asphalt.[160]

4.4. Recycling Economics

An almost limitless number of ink, adhesive, and material combinations has resulted in no two food and beverage packaging solutions being identical in their cost effectiveness and ease of recyclability.[161] This has impacted the economics of recycling, and led to calls for the range of packaging materials to be streamlined.[162]

Materials with the most value when recycled are steel and aluminum, used for canned food. PET is an example of a plastic that has a high residual value and can be cost-effectively recycled an infinite number of times. Food packaging can be entirely (100%) manufactured from recycled PET.[163] The economic viability of paper and cardboard recycling differs markedly by source. For example, mixed paper versus office paper, and corrugated cardboard versus flat cardboard. Whether paper and cardboard is contaminated by grease or other substance also markedly affects its recyclability.[164]

While the above factors have led to the cost of and challenges associated with recycling packaging increasing exponentially,[165] a lack of demand for PCR materials[166] has led to commodity prices paid for recycled paper, plastics, glass, and aluminum falling. At times, recycling companies have to pay to get rid of materials for which there is no demand, or had contaminated their supply chain and cannot be recycled. These are among the reasons why recycling programs have been cancelled[167] in some US cities, and a lack of investment in recycling infrastructure and technologies has occurred in Canada.[168]

The above factors speak to the importance of ensuring industry (through appropriate pricing of materials and consumer products) invests in schemes that ensure the responsible post-consumer management of materials and sustainable circular economies for packaging. Appendix A discusses how these considerations factor into the evolving design of extended producer responsibility programs.

4.5. Composting

Most compostable packaging currently goes to landfill, where it does not degrade. For reasons described below, the use and management of compostable packaging is a complex issue that numerous stakeholders are working to address.

At the present time, successful composting systems for food and packaging are typically closed systems in venues such as amusement parks, stadiums, and schools, where compostable and organic waste is carefully monitored and controlled to ensure proper disposal.[169] While there has been considerable investment in the design and production of compostable packaging, less investment has occurred in ensuring their responsible post-life management.[170] Compostable packaging and bio-based plastics may not be as effective at preventing FLW compared to plastic packaging, such as PET, HDPE, LDPE and PP.[171]

In North America, only a few jurisdictions possess the infrastructure and systems required to sort and manage the processes required to compost packaging.[172] A large number of Canadian municipalities do not have access to composting facilities and/or do not operate organic programs. Of the Canadian composting facilities that do exist, few provide the conditions (heat, cycle time, etc.) required to fully compost compostable packaging. Therefore, even certified compostable packaging is separated from organics part-way through the composting process and disposed of with other contaminates.[173] Due to reasons that include its inability to fully breakdown within a set timeframe and contaminants (including inks, adhesives, etc.), cardboard that reaches composting facilities is also often separated out.[174] The usual destination for contaminates disposed of by composting facilities is landfill.[175]

As discussed in Section 3.1, a lack of clearly defined standards and specifications impacts the effectiveness of composting packaging initiatives, the willingness of stakeholders to strategically invest in their development, and consumers' knowledge of what packaging is actually compostable in their local municipality—and how to dispose of that packaging appropriately. Additional challenges pertaining to compostable packaging include that materials manufactured from starch or other biomaterials, such as PLAs, are difficult for most material recovery facilities (MRFs) to differentiate from PET. This leads to it contaminating recycling systems, negatively impacting the economic viability of recycling practices.[176] When removed from recycling streams, along with other contaminates, packaging that is compostable goes to landfill, where the majority of it will not decompose.

The environmental footprint of compostable packaging can also be higher than current packaging materials.[177] Reasons for this include that more resources can be required to manufacturer compostable packaging than those used to manufacture commonly used materials, such as PET and HDPE. As well, compared to certain plastics, paper, and glass, compostable packaging materials are typically less cost-effective to recyclable.[178]

The degree to which plastic produce stickers create avoidable FLW and packaging waste by interfering with the composting of FLW[179] has led a number of major UK retailers to recently state that they will only accept fresh produce carrying compostable stickers.[180] The New Zealand government is reviewing options that include a national ban on non-compostable produce labels.[181] Because it does not breakdown within the required timeframes and is often coated (e.g. with vinyl or wax), composting facilities are also reluctant to accept paper and cardboard packaging. This means that cardboard and paper that is contaminated with grease, organic matter, coatings, etc., is often landfilled.[182]

4.5.1. Anaerobic Digestion

Anaerobic digestion (AD) is an alternative management system for organic waste and compostable packaging. As described in Section 2.1, AD reduces FLW CO_2E emissions a little more than composting. AD is a natural process, where bacteria breaks down organic materials and produces biogas, which is captured as an energy source. While there is insufficient data to assume that AD is commonly used in North America to recover energy from FLW and packaging waste,[183] in the UK, large quantities of FLW are sent to AD. Such arrangements are often organized directly by grocery store chains.[184] Rather than invest strategically in AD, most Canadian municipalities' organic programs continue to rely on composting.

An exception is the City of Surrey in BC, which opened the first fully integrated closed-loop organic waste management system in North America in March 2018—to convert curbside organic waste into renewable biofuel to fuel the City's fleet of natural gas powered waste collection and service vehicles. Excess fuel will go to the new district energy system that heats and cools Surrey's City Centre. The project set-up cost \$68 million.[185]

5.0 PRIMARY RESEARCH

To enable insights produced by the literature review to be tested and expanded upon in the context of the Canadian food and beverage industry, findings summarized in the preceding sections guided the design of primary research. The goal was to test the accuracy of findings resulting from the review, and identify opportunities to improve the equilibrium between FLW and packaging waste, and their combined emissions, by employing a scenario analysis methodology. The subsequent analysis and extrapolation of data guided the development of recommendations for establishing a circular economy for food and packaging.

Together with an online survey and interviewing experts from the packaging and food value chain, the primary research was aimed at helping to quantify in which situations an increase in the sale of loose/ bulk foods could occur without it creating unintended economic and/or environmental consequences. It also sought to identify opportunities to simultaneously reduce the environmental footprints of FLW and packaging. The online survey attracted 200 responses. Twenty food and packaging industries stakeholders were subsequently interviewed.

The online survey utilized a combination of Likert scale[d] and open questions to test the strength of opportunities and respondents' attitudes toward various factors associated with packaging utilization, including consumer messaging, to reduce avoidable FLW. In addition to the survey, qualitative and quantitative data were gathered from consultations conducted with packaging manufacturers and researchers, food and beverage manufacturers, retail and foodservice operators, municipalities' solid waste programs, material recyclers, and sustainability experts. Together with the survey, these confidential interviews assisted in identifying innovations designed to reduce FLW and packaging waste, and optimizing packaging to reduce FLW. The surveys and interviews were bilingual.

---

d Likert scaled questions use a numerical rating system to quantitatively assess an individual's strength of opinion towards a specific factor. Their value also comes from producing measurements that can be analyzed to identify commonalities or differences across respondents.

5.1. Industry Consultation

5.1.1. Respondents

A total of 200 individuals (English language = 150, French language = 50) responded to the online survey. Six respondents identified themselves as having operations outside of Canada; four respondents identified themselves as being from the US; and two simply responded that they were from “other” jurisdictions. Responses were received from across the food/packaging value chain and from policy focused organizations, such as governments and NGOs. Not all respondents completed every question. Reasons for this included that some questions pertained to technical considerations regarding the manufacture and recycling of plastic packaging.

Shown below in Table 5-1 is the industry or sector with which respondents self-identified themselves.

Table 5-1: Respondent Categorization (Online Survey)

Industry Classification	Responses
Packaging Industry	17
Food Industry	46
Retail/Consumer	31
Foodservice (HRI)	7
Waste Management/Recycler	22
Government	45
NGO/Non-Profit	10
Other	22
Total	**200**

From the packaging industry, 3 respondents were resin/polymer suppliers and 8 were in manufactured packaging. From the food industry, 27 respondents were primary (incl. fresh produce packers) and secondary processors, 6 were distributors, 23 were retailers,[e] and 5 were from foodservice. Ten respondents were involved in food rescue and redistribution. Six respondents were material recovery facilities (MRFs), while 7 were packaging recyclers. Of the government respondents, 29 were municipal, 11 were provincial or territorial, and 3 were federal. The 22 respondents who categorized themselves as "other" came from industry associations, academia, research, consultancy, and advocacy (e.g. environmental) groups.

Grouped into the same categories as above, the 20 individuals who participated in confidential interviews are listed below in Table 5-2. Eleven of the respondents are based in Quebec or have operations in Quebec. Two respondents are located in the US and employed by organizations that have significant operations in Canada. One of the respondents is based in the US and works with international business, including a number that operate in Canada. Together, the interviewees included food/beverage processors, retailers, packaging manufacturers, packaging researchers, government and NGOs.

---

[e] While the survey was distributed to industry stakeholders only, eight respondents indicated they were responding as a consumer. As retail stores are the primary interface between industry and consumers, these responses were therefore grouped with retailers.

Table 5-2: Respondent Categorization (Interviews)

Industry Classification	Responses
Packaging Industry	4
Food Industry	4
Retail/Consumer	2
Foodservice (HRI)	0
Waste Management/Recycler	2
Government	4
NGO/Non-Profit	2
Other	2
Total	**20**

From the packaging industry, all 4 respondents were from packaging manufacturers, though 2 of these companies were vertically integrated—meaning that they owned recycling subsidiaries from where they sourced materials. From the food industry, the 4 respondents were primary (incl. fresh produce packers) and secondary processors, of which 2 also distributed their own products. Two respondents were retailers. No respondents from foodservice were interviewed. Two respondents were packaging recyclers. Three of the government respondents were municipal, one was provincial. Their individual roles include the operation of material recovery and sustainability portfolios. The respondents categorized as “other” were both scientific packaging researchers.

5.1.2. Percentage of Each Food Sold to Consumers Pre-Packaged

To enable the research to produce outcomes that could be extrapolated across the wider food/beverage industry and differing packaging materials/formats, a range of 12 products were chosen in consultation with the project advisory group, which comprised individuals from NZWC, RECYC-QUÉBEC, ÉEQ, and PAC. Factors determining the list of products considered included the ability to establish an empirical connection to the six categories of foods and beverages developed during "The Avoidable Crisis of Food Waste" analysis,[186] and a CO_2E calculator developed for Second Harvest.[187] This ensured that statistically robust data on FLW and environmental footprints were included in the decision process. The 11 foods and 1 beverage chosen for the analysis are listed below in Table 5-3. For consistency, all 12 are subsequently referred to as "food."

Table 5-3 also shows the median of 188 responses received to the survey question, "What proportion of each type of food/beverage do you estimate is sold to consumer prepackaged?" The median shows that 50 percent of responses are below the level indicated, while 50 percent are above. As identified, for 10 of the 12 foods, there is consensus from respondents that 81 to 90 percent of the products are sold to customers pre-packaged. The product that respondents from the food industry and wider stakeholders believe likely not to be purchased by consumers prepackaged is apples.

Table 5-3: Proportion of Foods/Beverages Sold to Consumers Prepackaged (n=188)

Product	Median Response
Leafy greens	51-60%
Berries	81-90%
Apples	31-40%
Fresh chicken	81-90%
Beef burgers (frozen)	81-90%
Liquid milk	81-90%
Yogurt	81-90%
Granulated sugar	81-90%
Fresh fish fillets	71-80%
Shrimp-frozen	81-90%
Sliced bread	81-90%
Dried pasta	81-90%

**Options provided in survey: less than 10%, 11-20%, 21-30%, 31-40%, 41-50%, 51-60%, 61-70%, 71-80%, 81-90%, Don't Know*

A divergence of responses was received for three products: apples, leafy greens, and fresh fish fillets. This may reflect the retail store(s) where individuals' purchase their foods. Depending on the specific product, leafy greens and apples are often sold pre-packaged and loose/bulk in retail. Therefore the range in the percentage of items expected to be sold loose versus prepackaged is not unexpected. The majority of respondents indicated that close to 30 percent of fresh fish fillets are not sold prepackaged.

Compared to overall responses, respondents from the foodservice HRI (hotel, restaurant, institution) sector typically responded that the percentage of these three products sold pre-packaged is lower. Presumably this is because HRI is more likely to receive these items in bulk with minimal packaging, and prepare them ahead of sale to consumers as part of a prepared meal that is consumed in-house or as a takeout.

5.1.3. Effectiveness of Packaging Type for Preventing FLW

To evaluate viable product/packaging combinations, for each of the 12 foods, respondents were asked to rate on a score of 1 to 5[f] the effectiveness of four materials in which various types of foods are commonly packaged. The term "tin" was used, as it is the term commonly used to describe metal packaging. In reality, steel and aluminum are the most common materials used in metal food packaging. Tin is a small component of steel cans, which are usually coated with plastic on the inside to prevent direct contact with food.

The median responses for each product and packaging combination was calculated and are presented below in Table 5-4. Options showing a median of one are irrelevant product-package combinations. The cells highlighted in green are what the analysis identified as the most effective packaging formats for reducing FLW in that food item. These are the options used in the subsequent analysis. Highlighted in red are the options that were removed from the subsequent analysis.

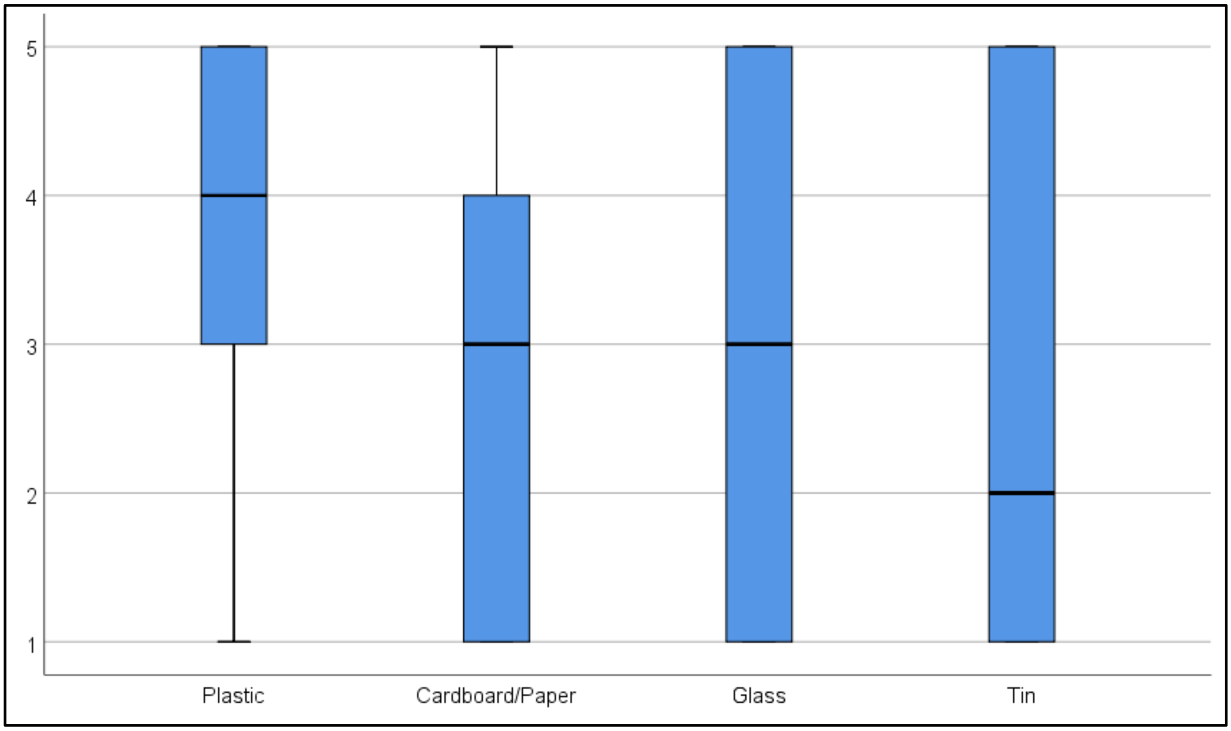
Table 5-4: Effectiveness of Packaging to Prevent FLW (n=76)

Product	Cardboard/ Paper	Plastic	Glass	Tin
Leafy greens	2.00	3.00	1.00	2.00
Berries	3.00	3.50	2.50	2.00
Apples	3.00	3.00	1.00	1.00
Fresh chicken	1.00	4.00	1.00	2.00
Beef burgers (frozen)	1.00	5.00	1.00	1.00
Liquid milk	4.00	5.00	5.00	2.00
Yogurt	1.00	4.00	5.00	1.00
Granulated sugar	4.00	3.00	4.00	4.00
Fresh fish fillets	1.00	4.00	1.00	1.00
Shrimp-frozen	1.00	5.00	2.00	2.00
Sliced bread	3.00	4.00	1.00	1.00
Dried pasta	5.00	5.00	4.00	2.50

[f] The online survey's Likert scale questions used a scale of 1 to 5 (1 = not effective at all; 3 = moderately effective; 5 = very effective)

The above table and subsequent analysis (presented below in Figure 5-1) illustrates that respondents view plastic as the most viable material for preventing FLW across all 12 of the food types.

Figure 5-1: Effectiveness of Packaging Type for Preventing



The above figure and subsequent box plots show the distribution of responses received. The thick black line gives the median response — 50 percent of responses were above this point and 50 percent were below this point. The box gives the quartiles above and below the median (a quartile is 25% of the responses). The box is therefore the middle 50 percent of responses. The bars that extend outside of the box give the first and fourth quartile. Any dots indicate outliers in the data.

As shown by the thick horizontal line across each of the four bars in Figure 5-1, the median response for plastic was 4. The median response for tin was 2. The median response for cardboard/paper and glass was 3. Except in a small number of cases, the lowest response for plastic across any of the foods was 3.

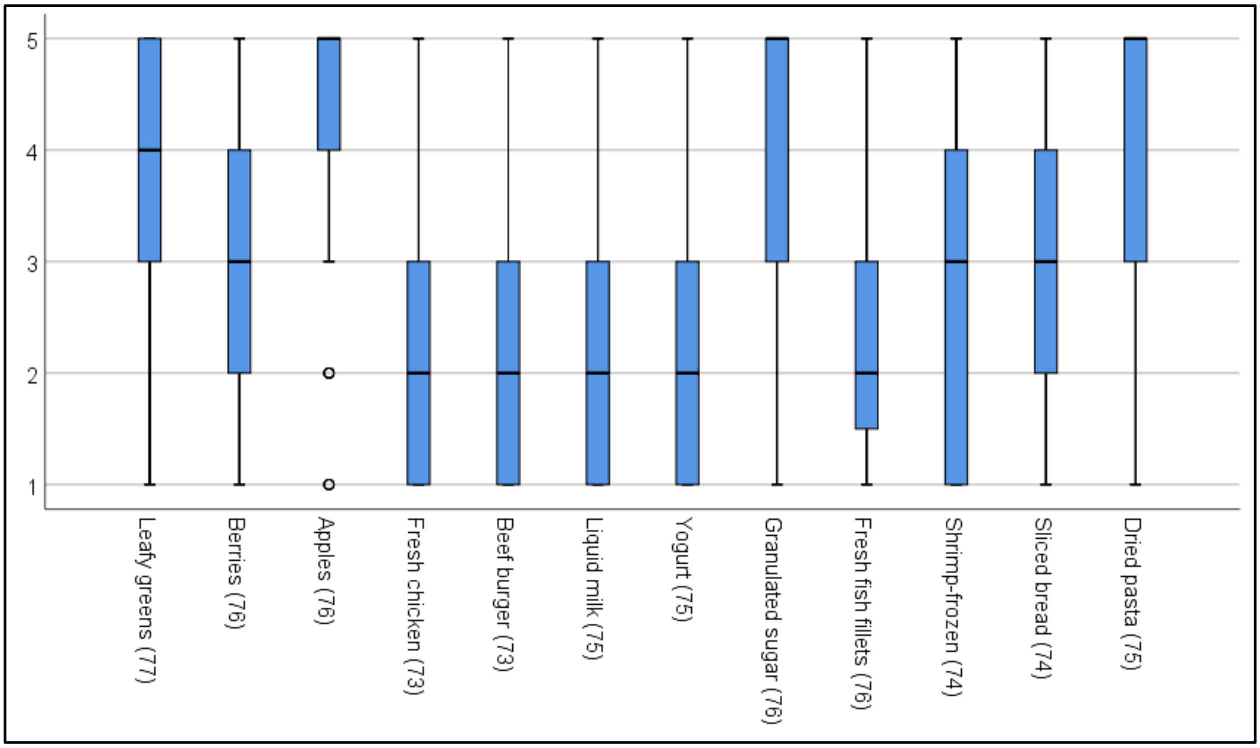
While glass, tin, and cardboard/paper are effective in specific situations, respondents do not consider them a viable primary packaging option for preventing FLW in many foods. As identified in the literature review, cardboard's primary role is secondary packaging, such as cartons. This is external packaging in which the food items purchased by consumers are transported to the point of sale. Cartons often feature in retail displays. Glass has a role in specific foods, as once opened it can be closed again. This is unlike tin, which is closely associated with further processed foods that are often opened and used immediately.
For a number of reasons, further processed foods were not included in the analysis. These reasons include the complexity of adequately estimating a representative carbon equivalent (CO_2E) footprint.

5.1.4. Potential to Increase Sales of Loose/Bulk and Any Associated Increase in FLW

Respondents were asked for their opinion on each of the 12 foods' potential to be sold loose (bulk) versus prepackaged. Respondents were then asked to estimate the degree to which increasing the percentage of each food that was sold loose would impact the level of FLW experienced with that same item. For any of the 12 foods, a maximum of six percent of respondents believe selling it loose would lead to reduced FLW. Typically, just two or three percent believe that reducing the percentage of any specific food sold prepackaged would lead to a reduction in FLW. The research results are presented below in Figures 5-2 and 5-3.

Respondents indicated that, where conditions allow, four items lend themselves to being sold loose (not prepackaged). These are leafy greens, apples, granulated sugar, and dried pasta. Berries and sliced bread, say respondents, have moderate potential for increased sale as loose versus prepacked. Interviewees commented, however, that the ease with which berries can be damaged and their general perishability should not be underestimated as a barrier to their viability for selling loose. Not suited to increased sale as loose, say the majority of respondents, are fresh chicken, beef burgers, milk, yogurt, and fresh fish fillets (all have a median 2). The number of responses received for each of the 12 foods is listed along the bottom axis in brackets.

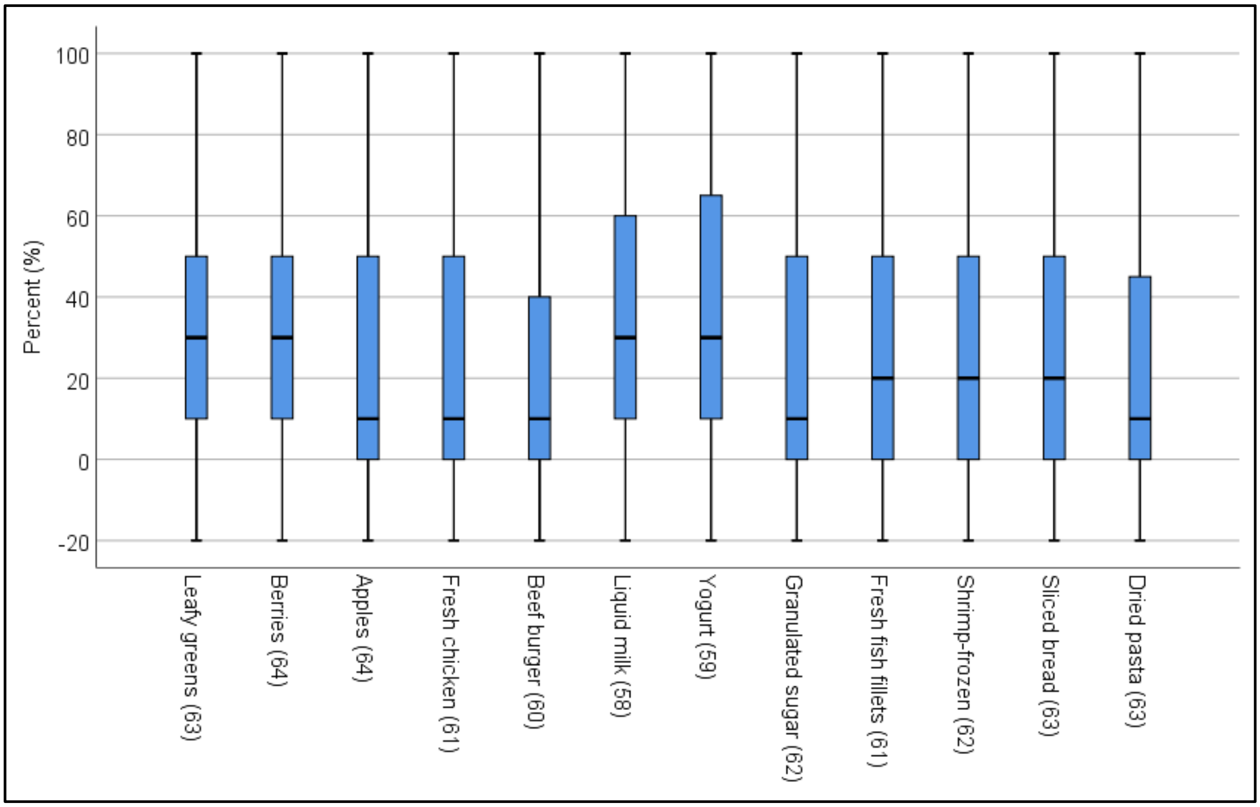
Figure 5-2: Potential to Increase Bulk/Not Packaged Sales? (1 = None, 3 = Moderate, 5 = Significant)



Responses to frozen shrimp was bimodal (1 & 3) with a median of three; therefore, responses tended toward the unlikely. With the exception of apples, there was no statistically significant difference amongst respondents from various sectors of the value chain regarding the potential to increase the percentage of items sold loose. For apples, the food industry and retailers/consumers see an opportunity to increase bulk sales of apples, while the fresh produce packing industry indicated less potential to increase sales of loose apples.

Why many foods and beverages are unsuited to selling loose or in bulk is shown below in Figure 5-3. The majority of respondents to the online survey expect a measurable increase in FLW above current levels to occur when food and beverages are sold loose versus prepacked. Respondents therefore see a correlation between FLW and the sale of loose versus prepacked foods/beverages. The number of responses received for each item is listed in brackets.

Figure 5-3: Expected Increase in FLW If Not Packaged



Of the 12 individual foods, the median increase in FLW that are expected to occur from selling loose versus prepackaged is 30 percent in berries, leafy greens, milk, and yogurt; 20 percent in sliced bread, fresh fish fillets, and frozen shrimp; and ~10 percent in apples, fresh chicken, beef burgers, granulated sugar and dried pasta. The median is the midpoint in responses. As can be seen in the above chart, a considerable number of respondents believe that the FLW that would occur from selling loose/bulk food has the potential to be considerably higher. For example, while the median for yogurt is 30 percent above current levels, a quarter of respondents see the potential for losses to exceed 65 percent above that which currently occurs. Those items where 50 percent of respondents see the comparatively lowest increase in FLW to occur due to selling them loose/bulk versus pre-packaged are apples, fresh chicken, beef burgers, granulated sugar, and dried pasta.

As reported in the literature summarized in Section 3, the viability of selling loose versus prepacked foods is contingent upon a retail store or foodservice operations' location and format. In turn, these are dependent on the purchasing preferences of consumers frequenting that store or HRI. Interview respondents stated that, while more foods such as chicken and beef can potentially be sold not prepackaged, mitigating the food safety risks associated with the selling of loose/bulk items such as chicken and beef burgers will increase operators' operating costs due to added labour, more sanitization practices, etc.

Food safety considerations apply to other foods too. For example, as illustrated by the UK initiative "Label better, less waste: Fresh, uncut fruit and vegetable guidance,"[188] the potential for selling fresh produce (leafy greens, berries and apples) is heavily dependent on whether it has been processed in any way. A number of the interviewees stated that, while whole heads of lettuce for example can be sold loose, it is different with precut salad mixes. This is again is due to food safety, and oxidation affecting foods' quality/appearance/shelf life/taste.

5.2. Packaging Design and Materials

5.2.1. Importance of Packaging Related Factors for Reducing FLW

Respondents were asked to rank, on a scale of 1 to 5, the impact that various packaging design factors and their utilization have on reducing FLW for each of the 12 products investigated. Figures 5-4 and 5-5 show the median responses for each of the options presented. Reflecting insights produced by the literature review, the factors investigated were:

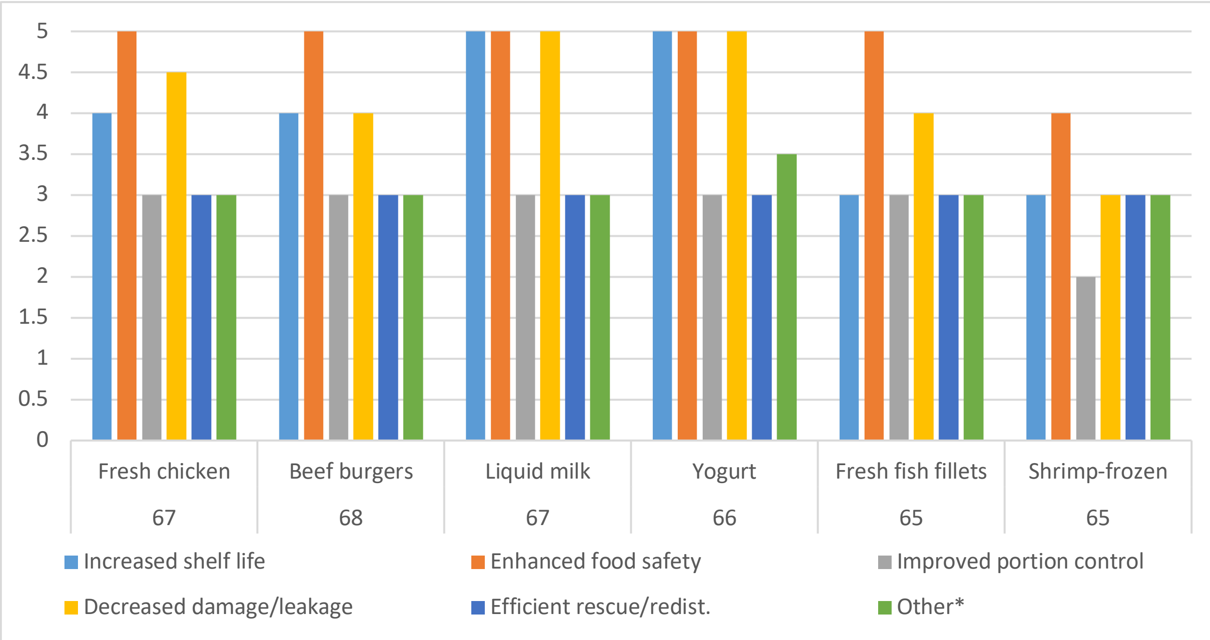
1. increased shelf life,
2. enhanced food safety,
3. improved portion control,
4. decreased damage/leakage,
5. efficient rescue/redistribution,[g] and
6. other.[h]

---

[g] Packaging that is designed to allow for food to be rescued/redistributed more effectively and efficiently.
[h] Other includes: prevent contamination, prevent adulteration, support consumer messaging, assist in traceability.

The number of responses received for each of the 12 foods is listed along the bottom axis.

Figure 5-4: Impact of Design/Role of Packaging on Reduced FLW in Protein, Dairy & Marine

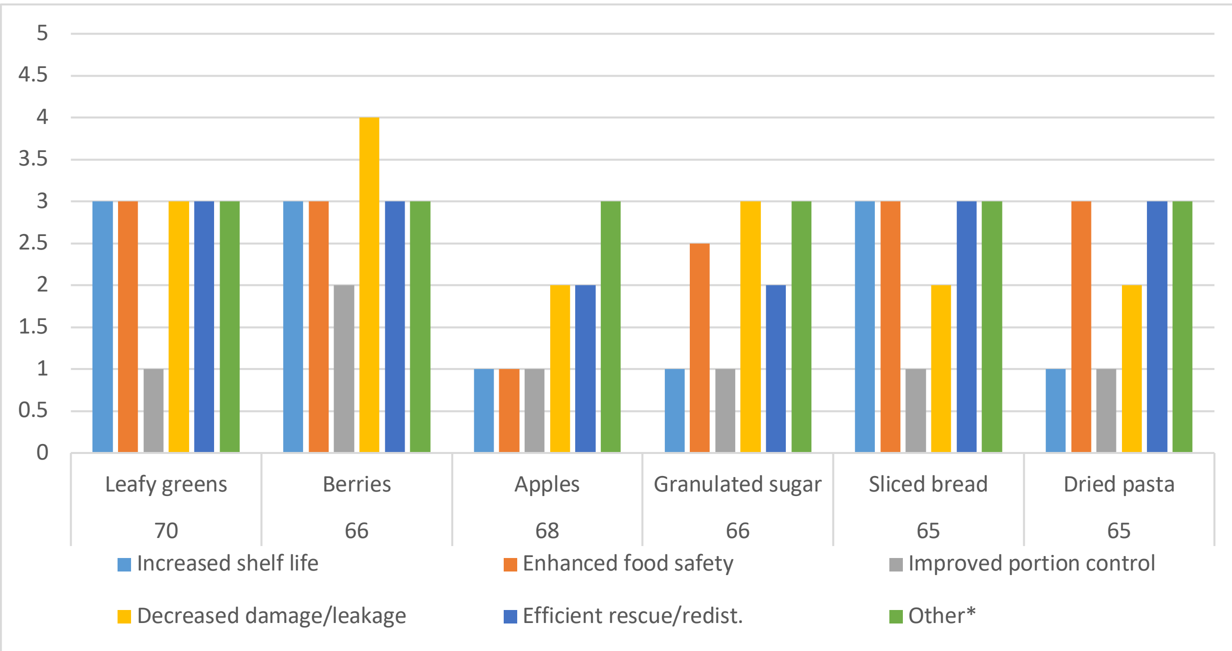


** Other includes: prevent contamination, prevent adulteration, support consumer messaging, assist in traceability*

All sectors of the food industry responded similarly in terms of packaging designs and roles that had greatest impact on FLW in each of the 12 foods. Respondents identified that the highest impact of packaging for reducing FLW in protein items (e.g. meat, dairy and seafood) was increased shelf life, enhanced food safety, and decreased damage or leakage. These factors are viewed as having comparatively less impact in the case of produce, bread, and shelf-stable items. The exception is berries, where the prevention of damage or leakage is deemed as most important.

With the exception of frozen shrimp, there was no statistically significant difference in the median responses received from respondents operating at different points along the value chain. HRI respondents believe that packaging for efficient rescue and redistribution could be highly significant for frozen shrimp, while the packaging industry were more likely to indicate that this was of minimal significance.

Figure 5-5: Impact of Design/Role of Packaging on Reduced FLW in Fresh Produce, Sugar, Bread & Pasta



** Other includes: prevent contamination, prevent adulteration, support consumer messaging, assist in traceability.*

Not surprisingly, the overall impact and importance of specific packaging mechanics on reducing FLW in individual foods tend to reflect those foods previously identified as lending themselves to selling (in certain circumstances) loose/bulk versus prepackaged. For example, in apples, sugar, and pasta, the importance of packaging to increase shelf life and improve portion control is considerably less than virtually all other foods. The role of packaging to protect against contamination and improve traceability is viewed as equally important across all foods.

Respondents view packaging as an important contributor to the efficient and effective rescue/recovery and redistribution of excess edible food. As shown by the WRAP[189] CO_2E analysis, next to prevention, recovery and redistribution of excess foods to charities is the most important means to reduce CO_2E emissions created by FLW. The efficient and effective recovery and redistribution of food is therefore an important social good that is aided by packaging.

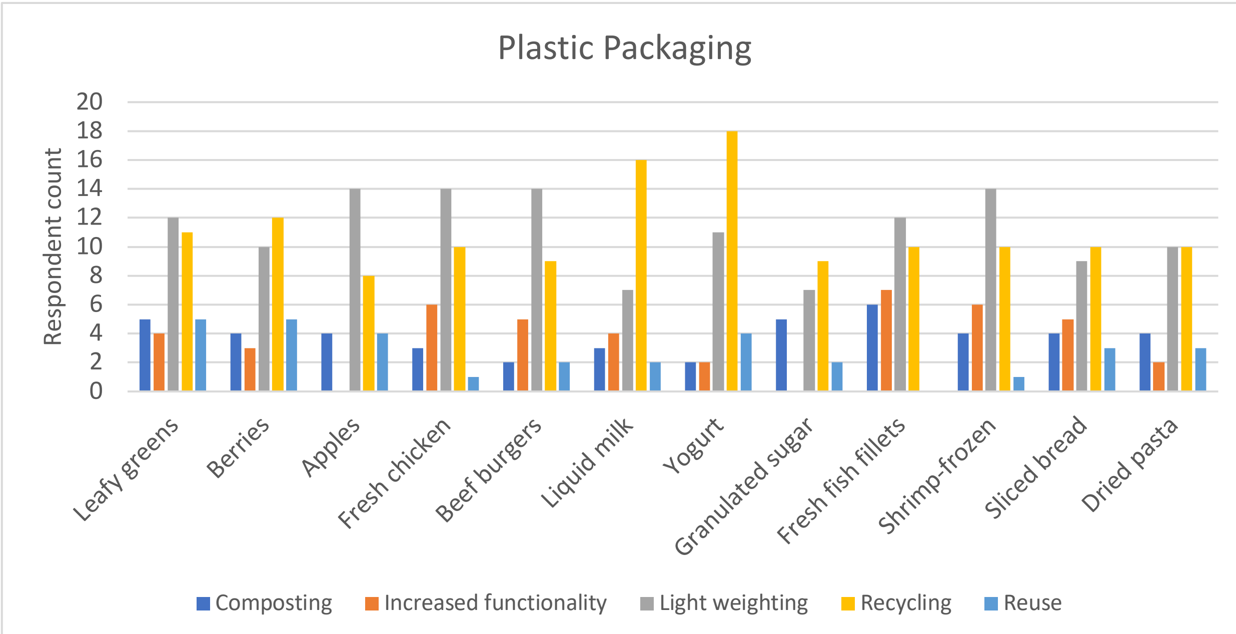
5.2.2. Packaging Design to Reduce Environmental Footprint

Respondents were asked to identify what they viewed as the most effective and practical way to reduce the environmental footprint of packaging for each of the 12 food types researched. The responses presented below are for plastic (Figure 5-6), cardboard/paper (Figure 5-7), and glass (Figure 5-8). These are the packaging materials that respondents identified as most suited and effective for reducing FLW. As "tin" was identified by respondents as having limited use across the 12 foods, it is not included in the following section.

Shown below in Figure 5-6 is the number of respondents that identified either composting, increased functionality (e.g. resealable), light-weighting, recycling, or reuse as the most preferred option for reducing the environmental impact of packaging in each of the foods. As can be seen, the most commonly preferred means to reduce the environmental footprint of plastic packaging is to increase recyclability, followed by light-weighting. The vertical axis identifies the number of respondents that identified each option as the preferred means to reduce the environmental footprint of packaging for each of the relevant foods.

Many respondents would also like to see the increased use of compostable of plastics. However, as identified in the literature review and confirmed by multiple interviewees, this is a problematic option on a number of levels.

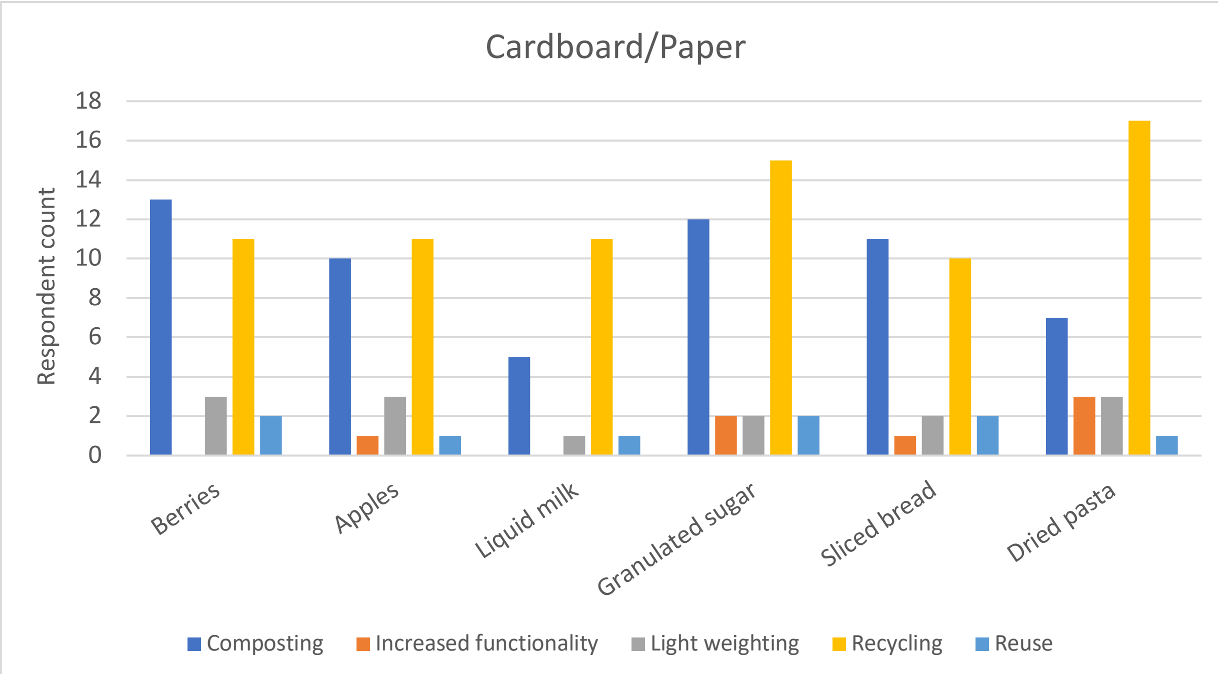
Figure 5-6: Reducing Environmental Footprint of Plastic Packaging (n=46)



A number of interviewees performing recycling and sustainability roles, for commercial businesses and municipalities alike, unequivocally stated how compostable packaging (often referred to as bio-based plastics and PLAs) was detrimental to the recycling of other materials—particularly plastics—as it contaminates solid waste streams. Interviewees from the composting sector said that this problem will not go away unless businesses stop using compostable packaging, or public and private stakeholders get serious about establishing and investing in the creation of effective composting collection systems and infrastructure. This will require mandatory standards, specifications, and certifications that are directly aligned with the actual composting practices and systems. Fewer respondents identified increasing functionality or reuse as preferred means to reduce the environmental footprint of plastic packaging.

As shown below in Figure 5-7, for those six foods where cardboard/paper packaging is seen as an effective option for reducing FLW, the preferred means to decrease its environmental footprint is recycling, followed by composting. Light-weighting, increased functionality, and reuse were viewed by comparatively few respondents as the preferred means to the environmental footprint of cardboard/ paper packaging.

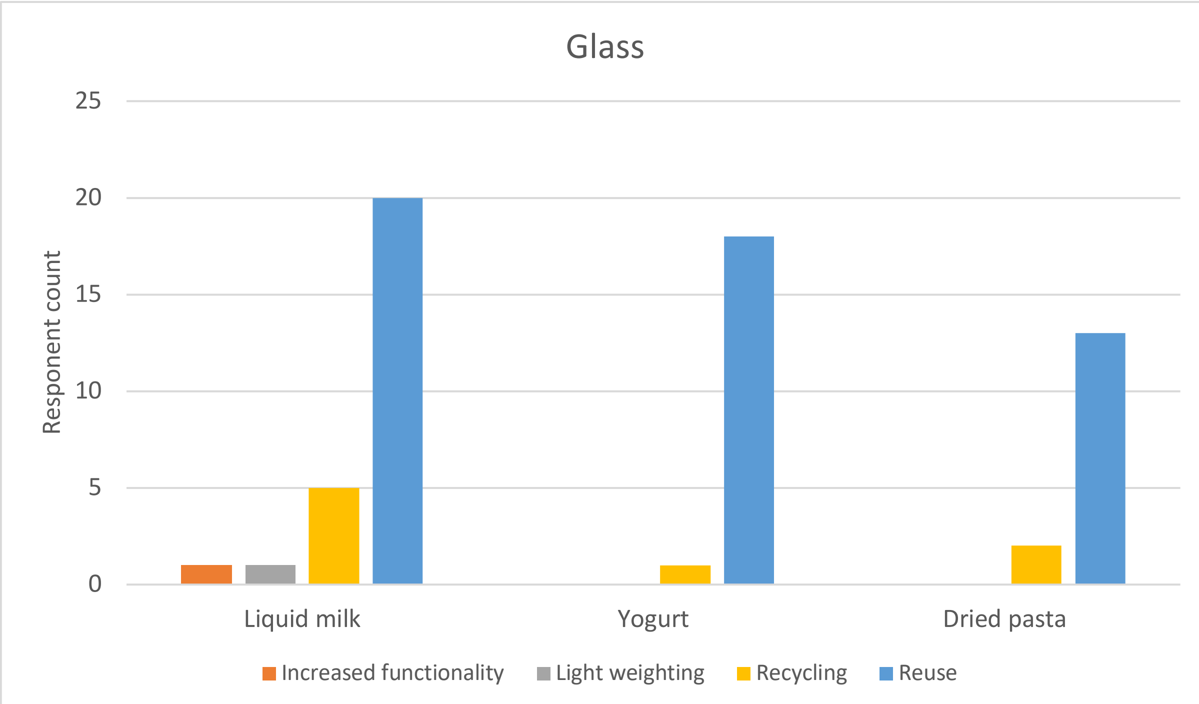
Figure 5-7: Reducing Environmental Footprint of Cardboard/Paper Packaging



As identified in the literature review, the composting of paper and cardboard packaging is a challenging endeavour. Different forms of paper/cardboard break down at different rates (e.g. office paper versus corrugated) and the paper/cardboard typically used for food packaging is coated with vinyl, wax, etc., or contains additives. As well, most composting facilities are not designed to handle paper/cardboard of any type. That individual composting facilities base their procurement decision on the standards and protocols required to meet customer requirements also limits the acceptability of paper/cardboard for composting.

Glass was identified as an effective packaging material for reducing the occurrence of FLW in three foods: liquid milk, yogurt, and dried pasta. As can be seen, the majority of respondents view reuse as the preferred option to reduce the environmental footprint of glass. As identified in the literature, however, some retailers do not allow consumers to bring glass containers into their stores, due to fragility and food safety concerns.

Figure 5-8: Reducing Environmental Footprint of Glass Packaging



Considerably fewer respondents identified recycling, followed by light-weighting and increased functionality, as the preferred means to reduce the environmental footprint of glass. As identified in the literature review, this sentiment also reflects the limitations and weaknesses of glass as a packaging option for many foods and beverages.

That certain types of packaging (predominately plastic, as expressed by respondents) lend themselves particularly well to reuse purposes supports the need for consumer marketing and communication efforts on how to safely use reusable packaging when purchasing loose/bulk food and beverages.

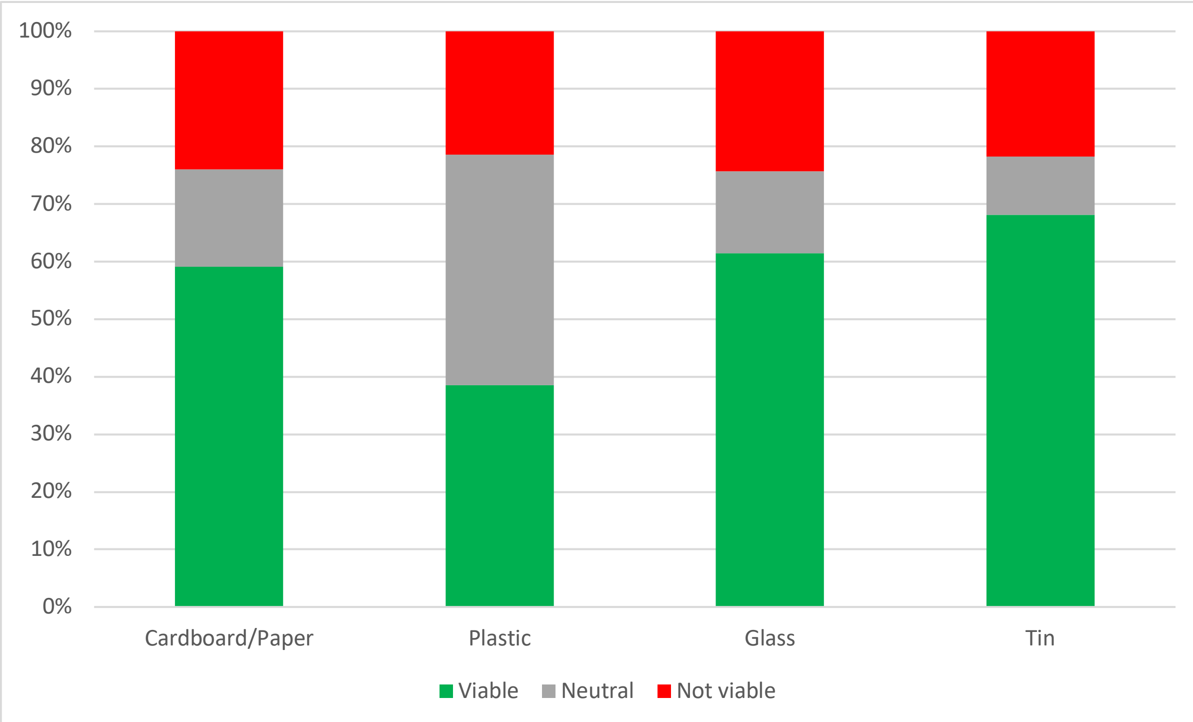
5.3. Recycling Options and Viability

To include post-consumer recycled (PCR) materials in the manufacture of food packaging, recyclers and packaging manufacturers must obtain a “Letter of No Objection” from Health Canada. It is verification of sourcing and industrial manufacturing processes used to produce and utilize PCR materials that are evaluated by Health Canada, not the materials themselves.[190] While Health Canada can make a determination of which recycled packaging material and in which circumstances they are appropriate for packaging specific foods, this typically only occurs if requested by industry or if a potential health concern has been.

5.3.1. Economic Viability

All respondents were asked, on a scale of 1 to 5, “How economically viable is it to recycle this material for use in the manufacture of food grade packaging?” As seen in Figure 5-9, the majority of respondents indicated that cardboard, glass, and tin are economically viable to recycle into food grade packaging. Responses for plastic was more nuanced, with 40 percent of responses being neutral and 38 percent of respondents suggesting it is economically viable. As identified in the literature, this is likely because individual plastics vary greatly in how economically viable it is for recycling and reuse in the manufacture of food grade packaging.

Figure 5-9: Economic Viability of Recycling Material Types into Food Grade Packaging

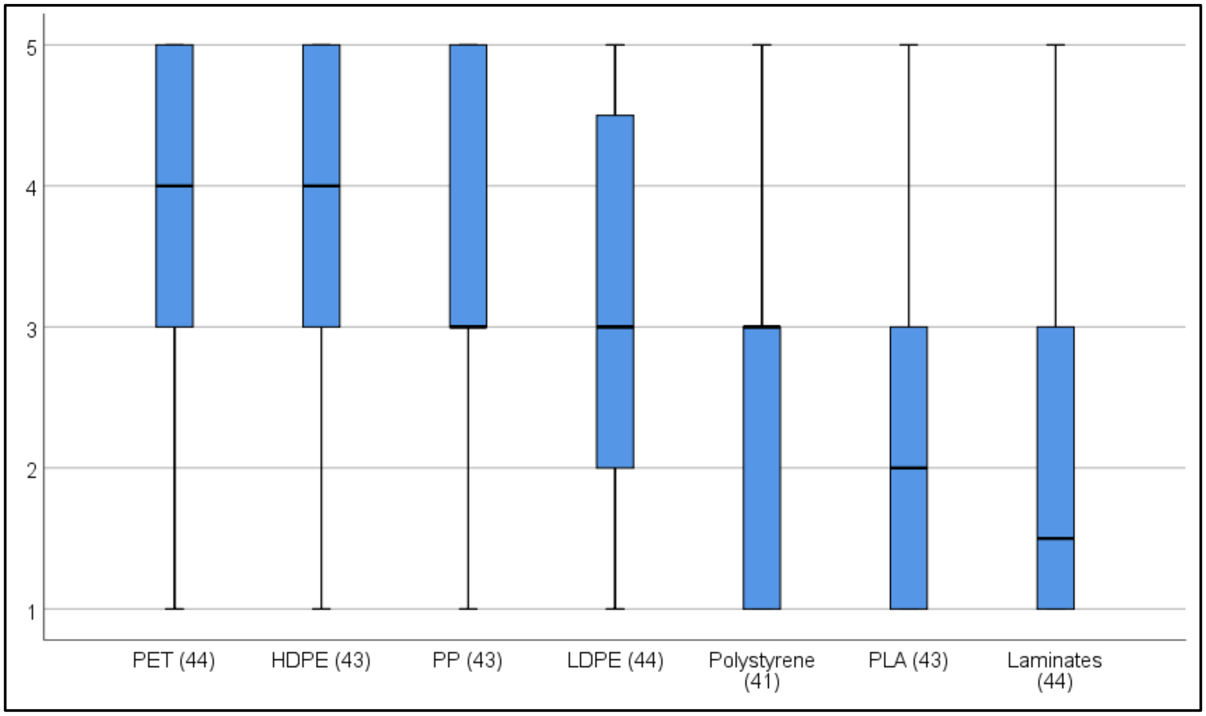


Interestingly, a similar percentage (21 to 23%) of respondents did not view any of the four materials as economically viable candidates for recycling. No individual stakeholder group accounted for a greater proportion of these negative responses than another.

Those respondents who self-identified themselves as possessing technical knowledge pertaining to the recycling and/or manufacture of plastic food grade packaging were asked to rate the economic viability of recycling specific types of plastic, on a scale of 1 to 5.

As shown below in Figure 5-10, respondents believe that the economic viability of recycling various plastics differs considerably. There is consensus among respondents that the economic viability of recycling PET and HDPE is reasonably high, while economic viability of recycling PLA and laminates is low. The dark lines indicate the median where 50 percent of responses were above and below this point. The blue boxes illustrate where the range within which the middle 50 percent of responses lie. These are the second and third quartiles.

Figure 5-10: Economic Viability of Recycling Plastic Types into Food Grade Packaging



Seventy-five percent of respondents stated that PET and HDPE are somewhat to very economically viable (3-5) to recycle. The frequency tables contained in Appendix C show that over 60 percent of responses were 4 or 5. Considered comparatively less viable are Polypropylene (PP) followed by LDPE. The frequency table for PP shows that responses are bi-modal: 30% of respondents said PP is somewhat economically viable (3), and 30 percent said that it is very viable (5). The responses for LDPE saw more variability, with 36.4 percent of responses tending toward the not economically viable end of the scale (1 or 2) and 47.7 percent tending toward the viable end of the scale with a response of 4 or 5, hence the larger range of the boxplot for LDPE.

Polystyrene, PLA, and complex or multi-layered laminates/films are not viewed by respondents as economically viable options for recycling into food grade packaging. A number of interviewees, however, provided evidence that this is changing. Examples given included Cascade,[i] which manufactures expanded polystyrene trays containing 50 percent PCR. Canadian chemical recycling innovators, such as Pyrowave,[j] Polystyvert,[k] and Loop Industries,[l] are developing technologies that increase the economically viability of plastics, such as polystyrene and polyester, that have traditionally been difficult to recycle.

A number of interviewees commented that, while chemical (versus mechanical) recycling conceptually offers opportunities that are not currently realizable in terms of the types of plastics that are economically viable to recycle, in their view, chemical recycling remains unproven on a commercial scale. Interviewees stated that establishing a minimum mandatory PCR content for all packaging would, by itself, drive significant innovation in packaging materials and the utilization of packaging. This they perceive would include expediting the commercialization of chemical recycling.

5.3.2. Maximum PCR Content

All respondents were asked "What is the maximum PCR content that can be included to manufacture food grade packaging?" The number (n=) of responses, along with the median response, are listed for each material. The median shows that 50 percent of responses are below the level indicated, while 50 percent are above. As illustrated in Table 5-5, glass and tin are regarded as being able to contain the highest post-consumer recycling content.

---

[i] https://food-packaging.cascades.com/en/evok/
[j] https://www.pyrowave.com/en/pyrowave-technology
[k] http://www.polystyvert.com/en/
[l] https://www.loopindustries.com/en/

Table 5-5: Maximum PCR Content, All Materials

	Cardboard/ Paper PCR	Plastic PCR	Glass PCR	Tin PCR
n=	44	44	43	38
Median*	3.0	3.0	5.0	5.0

** Responses Coded: 1 = 20% or below, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%*

As can be seen below in Figures 5-11 and 5-12, the responses received regarding the maximum PCR content that can be included in paper and plastic food grade packaging were more diverse, with responses for paper leaning toward the higher levels of PCR content, and plastic in general towards the lower end. The responses for plastic again reflects, as described in the literature, the extent to which individual plastics vary in their viability for recycling into food grade packaging. The vertical axis identifies the number of responses received for each of the maximum PCR content percentages.

Figure 5-11: Maximum PCR Content, Plastic

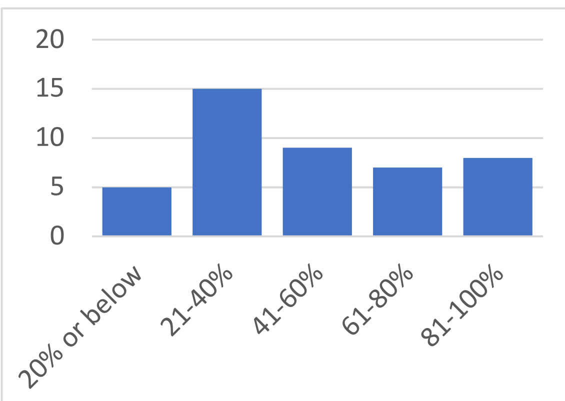
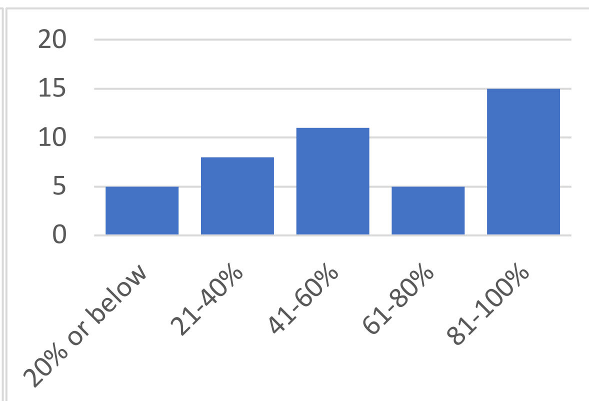


Figure 5-12: Maximum PCR Content, Paper



Of the 95 respondents who indicated that they are familiar with plastic food packaging, 37 answered the technical question regarding the maximum PCR that could be included in specific forms of food grade plastic packaging. That not all respondents answered the question for all types of plastic suggests that they limited their responses to those plastics with which they are familiar.

The statistical analysis of responses is shown below in Table 5-6. The number (n=) of responses, along with the median response are listed for each material. The median shows that 50 percent of responses are below the level indicated, while 50 percent are above. Further analysis of the data identified that, for food grade plastic packaging, the highest level of PCR content that can be included in its manufacture is PET, HDPE, and PP (81-100%). This is consistent with the literature.

Table 5-6: Statistical Analysis of Maximum PCR Responses for Plastic Packaging

	PET	HDPE	PP	LDPE	PS	PLA	Laminates	Other
n	37	36	34	35	33	34	36	15
Median	3.00	3.00	2.50	2.00	2.00	1.00	1.00	2.00

** Responses Coded: 1 = 20% or below, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%*

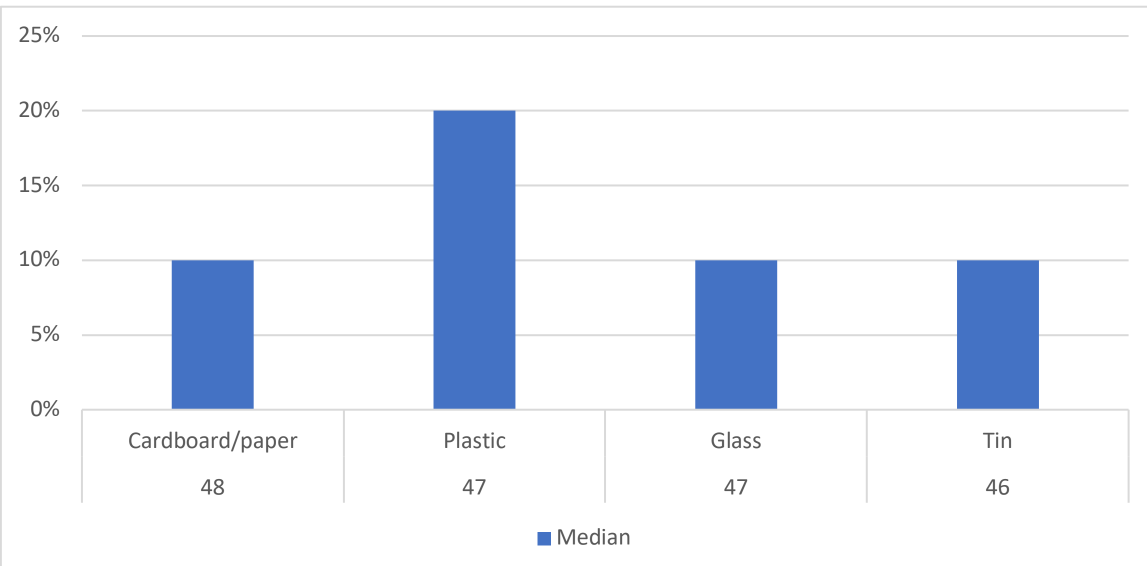
By comparison, the maximum PCR content that the majority of respondents believe can be included in all other plastics is relatively low. In PLA and complex laminates/films, 20 percent or lower PCR content was the most common response. The majority of respondents also believe that, while LDPE can contain a higher PCR content than polystyrene, PLA, laminates, and “other,” the PCR content is measurably less than that which can be utilized in the manufacture of PET, HDPE, and PP.

These results from the PCR content questioning are consistent with the literature and the stakeholder interviews, which emphasize the economic viability and environmental benefits that can be attained from the recycling of PET, HDPE, and PP in relation to other forms of plastic used to package food.

5.3.3. Increased Cost of Packaging Due to Utilizing PCR Content

All respondents were asked to estimate the degree to which the inclusion of the maximum possible PCR in the manufacture of food grade packaging would alter the cost (+/-) of packaging compared to the same packaging being manufactured from virgin material. As shown below in Figure 5-13, in general terms, respondents expect that the maximum inclusion of PCR would incur a greater cost difference for plastic packaging versus cardboard/paper, glass, and tin (20% vs. 10%, respectively). The number of responses received for each of the four materials is listed along the X (bottom) axis.

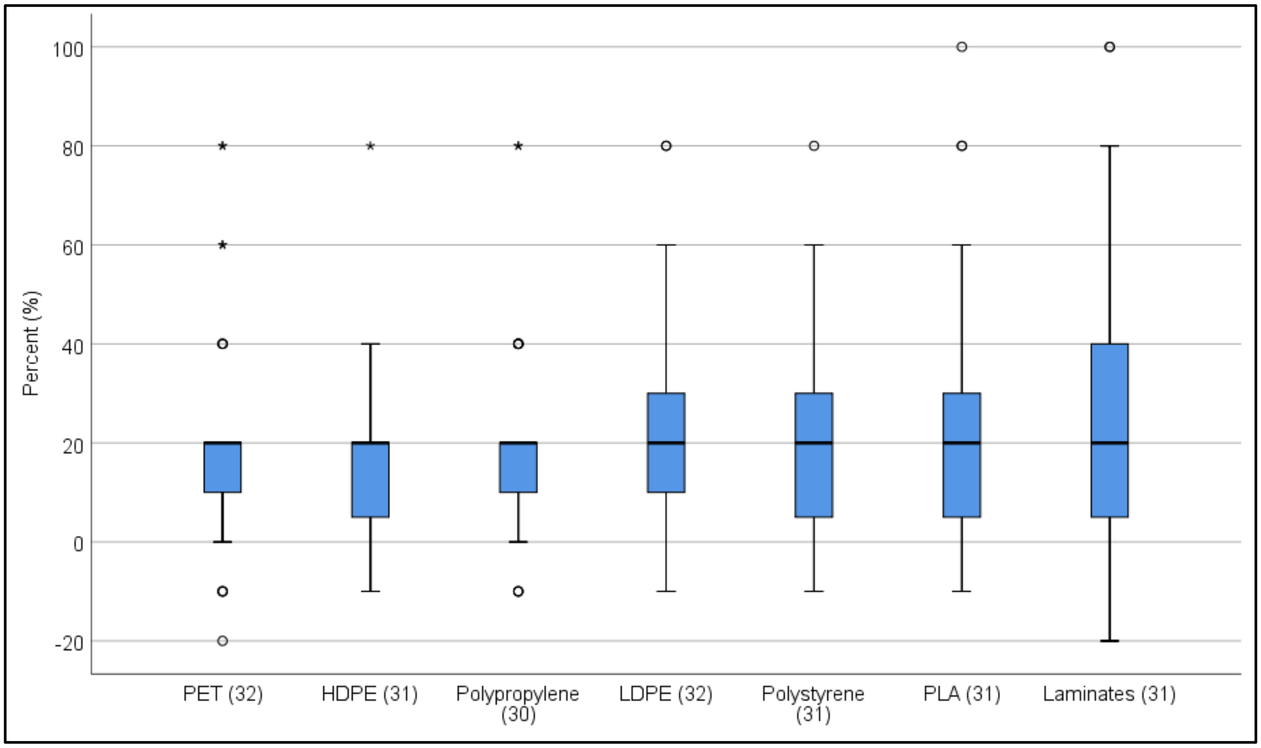
Figure 5-13: Cost Increase Due to Inclusion of Maximum PCR: All Materials



Including the maximum PCR content in paper/cardboard, glass, and tin is expected to increase the cost of packaging by 10 percent. Including the maximum PCR content in plastic generally is expected to increase the cost of packaging by 20 percent.

Thirty-two of the respondents who had previously self-identified themselves as technically familiar with plastic packaging answered the question regarding cost differentiations caused by the maximum inclusion of PCR materials in specific plastics. As shown in Figure 5-14, PET and PP had the lowest variability, with the majority of respondents expecting the cost to increase between 10 to 20 percent. HDPE also performs well, with many respondents expecting the cost increase to be less than that associated with PET and PP. For laminates, the majority of respondents believe that the cost could increase between 4 and 40 percent. The number of responses received for a specific plastic is listed along the bottom axis in brackets.

Figure 5-14: Cost Increase Due to Inclusion of Maximum PCR: Plastic Packaging



As can be seen in the above figure, a small number of respondents believe that including the maximum possible PCR content could lead to reductions in the cost of plastic packaging. The literature, along with insights produced from the interviews with packaging and recycling experts, suggest that this is unlikely.

What is borne out by the literature, overall responses to the survey, and the interviews with packaging and recycling experts, is the degree to which the recycling of packaging materials—most notably plastic packaging materials—significantly reduces their environmental impact.

A number of interviewees commented that an important factor impacting the demand for recycled versus virgin materials is that the cost of virgin plastic production does not include externality costs to society. This is because their comparative emissions are not factored into pricing. That results in market failure and an economically inefficient market. They and other interviewees said that effective means for addressing this situation, while simultaneously driving an increase in the volume of recycled packaging, included government establishing a minimum PCR content for all packaging, ideally in conjunction with extended producer responsibility (EPR) fees that reflected those same materials' ease of recyclability and their PCR content.

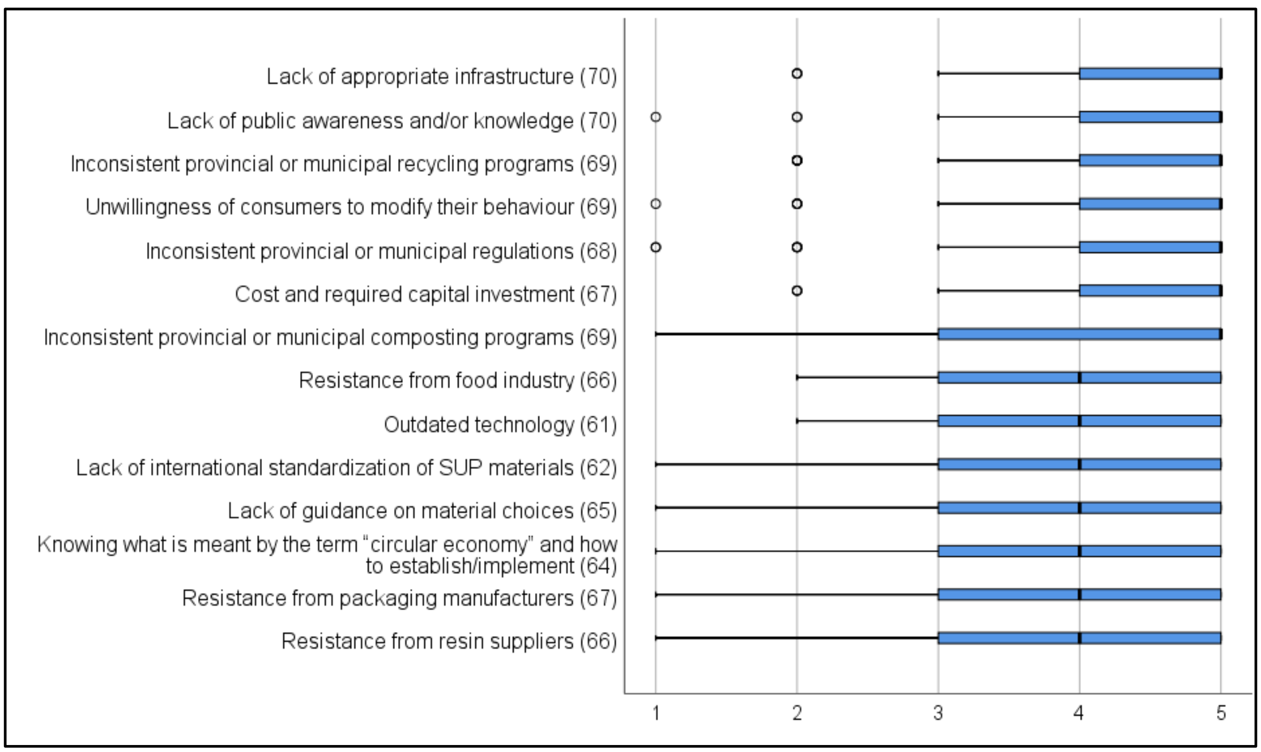
A food industry respondent based in Quebec described how EPR fees that encouraged use of materials which contained a high PCR content and were easily recyclable, combined with an innovative packaging supplier, were enabling him to make extensive changes to his packaging. He stated that almost all of the packaging he uses will soon be fully recyclable. Much of it will also be manufactured from 100 percent PCR. That the EPR levies for this type of packaging are significantly lower than if using less recyclable and non-PCR content packaging made a strong business case for this change. He also expected the move to enable market expansion in Canada and internationally.

5.4. Barriers to Minimizing FLW and the Impact of Packaging

Online survey respondents were presented with a list of 14 barriers to the establishment of an economically viable circular economy for food and packaging, and asked to rank the barriers' relative impact on a scale of 1-5 (1 = minimal impact, 3 = moderate and 5 = significant impact). All barriers listed in the survey were cited in the literature as representing potential hurdles to the establishment of an economically viable circular food and/or packaging economy.

While (as seen in Figure 5-15) for all the listed barriers the majority of responses were 3 or above, respondents identified six barriers as being particularly significant with over 75 percent of respondents rating these six barriers as 4 or 5. These are: 1) lack of appropriate infrastructure, 2) lack of public awareness and/or knowledge, 3) inconsistent provincial or municipal recycling programs, 4) unwillingness of consumers to modify their behaviour, 5) inconsistent provincial or municipal regulations, and 6) cost and required capital investment. The number of responses received for each barrier is shown in brackets.

Figure 5-15: Barriers to the Creation of an Economically Viable Circular Economy



While the other eight factors are still deemed to be moderate to significant impediments to change by the vast majority of respondents, interviewees confirmed that a number of the factors are viewed as outcomes resulting from the first six. For example, outdated technology has resulted from lack of investment and inconsistent regulations. A number of interviewees stated that incongruent municipal and provincial regulations have led to a lack of investment in areas such as food manufacturing and distribution technologies. Incongruent regulations have also led to less investment in the development of innovative packaging solutions. This situation partly stems from how inconsistent regulations and programs have negatively impacted industry and consumers' motivation to prevent FLW and its environmental impact by having purposely changed their behaviour.

The need to address this is supported by the literature and interviewees having cited the extent to which consumers' resistance to modifying their behaviour results in avoidable FLW and the sub-optimal utilization of reusable packaging. Consumer behaviour also contributes to the environmental and ecological impact of all packaging being unnecessarily high.

Additional reasons for why the present situation exists include that the innovation that has occurred has largely occurred in isolation. An example of this, that was cited in the literature and reiterated by interviewees, is that, while considerable investment has been made in the development of compostable packaging by individual businesses, little investment has been made to establish the standards, systems and processes required to optimize the management of compostable packaging post-consumer. Interview respondents also cited how factors that include inconsistent government regulations, lack of investment in infrastructure, lack of international PCR standards, and lack of unbiased guidance on material choices have negatively impacted the food industry's willingness to invest in long-term innovative solutions to address FLW and packaging waste.

5.4.1. Differences in Value Chain Stakeholders' Perceptions

An analysis was conducted to assess the degree to which individuals' perceptions regarding the potential impact of individual barriers to establishing a circular economy for food and packaging differ by the level of the value chain with which they identified themselves. This was achieved by comparing the median responses of respondent groups to the question, *"What are the key factors impacting the establishment of an economically viable circular economy? Please identify their impact on a scale of 1-5 where 1 = minimal impact, 3 = moderate impact, 5 = significant impact. Please ignore any options that you consider inappropriate."* The results form Figure 5-16 below.

The factors are listed in order of the degree to which online respondents view them as impediments to change, and the number of respondents who identified a particular response. The order is therefore based on weighted medians. The number of responses received for each barrier is shown in brackets.

Generally, everyone views lack of investment, lack of appropriate infrastructure, inconsistent recycling infrastructure and programs, and inconsistent regulations as significant barriers. Waste management and recyclers see all but outdated technology and inconsistent composting programs as significant barriers (5 out of 5). Government and NGOs point towards a resistance from industry as having a high impact on preventing the required changes to occur. Industry does not share this sentiment to the same degree. More impactful from industry's perspectives are inconsistent municipal recycling programs and a lack of infrastructure.

A number of interviewees commented that there is a finite degree to which industry will invest capital in the development of new technologies, infrastructure, materials, and programs/processes when the current regulatory environment is typified more by inconsistency than standardization. This can lead industry to focus on achieving the lowest common denominator, which negatively impacts the pace of innovation. It also leads industry to react to short-term challenges, and not proactively strategize and invest for the long term.

*Table 5-7: Median Responses to Individual Barriers by Stakeholder Group**

Industry Classification	Packa-ging Industry	Food Industry	Retail/ Consu-mer	HRI	Waste Mngt.	Govern-ment	NGO	Other	Overall Median
Lack of appropriate infrastructure (70)	5	5	5	5	5	4	5	5	5
Lack of public awareness and/or knowledge (70)	5	5	4.5	4.5	5	4	3.5	4	**5**
Inconsistent provincial or municipal recycling programs (68)	5	5	5	5	5	4	5	5	**5**
Unwillingness of consumers to modify their behaviour (69)	4.5	5	4	3	5	5	4	5	**5**
Inconsistent provincial or municipal regulations (68)	5	5	5	5	5	5	5	5	**5**
Cost and required capital investment (67)	5	5	3.5	4.5	5	4	4.5	4	**5**
Inconsistent provincial or municipal composting programs (69)	5	5	5	5	4	4	5	5	**5**
Resistance from food industry (66)	3	4	3	4	5	5	5	4	**4**
Outdated technology (61)	4	4	3.5	4	4	4	3	5	**4**
Lack of international standardization of SUP materials (62)	3	5	3	5	5	4.5	3	3	**4**
Lack of guidance on material choices (65)	3	4	4	4.5	5	5	4	4	**4**
Knowing what is meant by the term "circular economy" and how to establish/implement (64)	4	5	3	4.5	5	5	3	3	**4**
Resistance from packaging manufacturers (67)	3	4	3	3	5	4	5	4	**4**
Resistance from resin suppliers (66)	3.5	3	3	3	5	4	5	4	**4**

**For ease of reading, like values are coloured the same.*

While all respondents groups view “Inconsistent provincial or municipal regulations” as a significant barrier to change, the overall results suggest that industry and government representatives view the impact of individual barriers to change from different perspectives. There is a tendency among government to view the top six barriers to change as being less impactful than other respondents perceive them to be. As well, government respondents tend to view resistance from the food industry, knowing what is meant by the term “circular economy,” and lack of guidance on material choice as greater impediments than other respondent groups.

A number of interviewees suggested that government does not see the extent to which inconsistent government programs and regulations impact industry’s and consumers’ motivation to change. A number of online and interview respondents from the food industry stated how they are actively working with other food business and packaging suppliers to address FLW and packaging waste; however, the range in standards and requirements implemented by municipalities creates challenges and issues that complicate the process and lead to sub-optimized solutions. National standardized municipal recycling and composting programs, say interview respondents, would enable and motivate considerably more circular economy related innovation than presently occurs.

While the literature review, most of the online survey responses, and interviews show that consumer resistance to change is a key barrier to establishing a more circular economy, a number of interviewees stated that the crux of the issue is not that consumers are necessarily unwilling to change; the crux of the issue is that they are confused about what changes to make, and demoralized when they realize that their efforts may be in vain. This is particularly the case in terms of optimizing the utilization of packaging and ensuring its effective management through recycling and/or composting. This said, a number of stakeholders interviewed stated that this is also partly due to inconsistent municipal level and provincial programs.

Addressing the misalignments described above, which is required to engender sustainable collaborative partnerships between industry, government and NGOs, will require the application of systems thinking and approaches. Work completed by the Canadian Produce Marketing Association in 2019 is an example of where this is beginning to occur in Canada. The UK Plastics Pact (WRAP, 2019b/c) is an example of where the private and public collaboration required to achieve purposeful strategic change is at a more advanced stage than currently exists here. The need for a national approach, supported by common standards and specifications, was expressed by numerous online respondents and interviewees.

Interview respondents expect the retail sector, in particular, to proactively take a greater role in addressing the misalignments described above, by informing consumers about minimizing food waste in conjunction with optimizing their packaging choices. Retailers have the potential to drive changes across their supplier base by utilizing science-based standards and specifications developed by third-parties. The same potential exists amongst foodservice operators. These changes will be enabled by having implemented systemic approaches to evaluate then implement FLW and packaging decisions. The interviewees expect marketing that is designed to educate consumers and inform their purchasing decisions in relation to packaging options (e.g. no packaging, reusable program, recyclability, bio-based plastic) to become more prevalent. This will lead to the bringing of reusable containers into grocery stores becoming normalized amongst a larger population of consumers than is presently the case.

5.5. Foods' Suitability to Selling Loose/Bulk versus Prepacked

The following section evaluates which of the 12 foods examined lend themselves to being sold loose or in bulk versus prepacked, and why. Presented below in Table 5-7 are findings that resulted from the literature review, the analysis of primary data captured by the online survey, and stakeholder interviews. While, to varying degrees, the majority of survey respondents and interviewees expect the selling of loose/bulk (rather than pre-packaged) foods and beverages to lead to increased FLW across all items, where appropriate circumstances exist (which include consumers' willingness to buy loose/bulk rather than pre-packaged), certain foods lend themselves to being sold loose/bulk (versus pre-packaged) more than others. [191] Also listed is the optimum packaging material identified by the research.

The items on which the primary research focused have been categorized in terms of their suitability for selling loose or in bulk: high, moderate, and low. The categories are not definitive and should be used for guidance purposes only. Key factors impacting how the foods are categorized and identified during the research are summarized in the right-hand column. Those foods most suited to selling loose or in bulk are drier, hardier, and more shelf stable than those less suited to selling loose or in bulk. Being drier, hardier, and more shelf stable reduces the potential for food-safety risks to arise, and losses to occur during handling.

Table 5-8: Foods' Suitability to Sell Loose or In Bulk versus Pre-packaged

Product	Median expected increase in FLW if not pre-packaged	Potential to increase sales of loose/ bulk*	Most effective packaging type	Factors impacting their suitability for selling loose/bulk versus pre-packed
Apples	10%	High	Paper/ plastic*	Apples lend themselves to selling loose as a hardy produce item. Key reasons to package are to extend shelf-life/quality, damage prevention, and mitigate food safety risks.
Granulated Sugar	10%	High	Paper/ glass	Sugar lends itself to selling in bulk as it is easy-flowing and dry. Key reasons to package are to prevent loss/leakage, prevent cross-contamination, and mitigate food safety risks.
Dried Pasta	10%	High	Paper/ plastic*	Dried pasta lends itself to selling in bulk as easy to handle and dry. Key reasons to package are to prevent cross-contamination, prevent loss/leakage, and mitigate food safety risks.
Leafy Greens	30%	Moderate	Plastic*	Different leafy greens (e.g. whole heads versus pre-mixed salads) vary in their viability to sell loose/bulk. Key reasons to package are mitigating food safety risks, damage prevention, extending shelf-life/ quality, and product range.
Berries	30%	Moderate	Plastic*	Berries are highly perishable and easily damaged, particularly items such as raspberries. Key reasons to package are decreased damage, extending shelf-life/quality, and mitigating food safety risks.
Frozen Shrimp	20%	Moderate	Plastic*	Frozen shrimp are reasonably hardy, though the consequences of unintended thawing could be severe. Key reasons to package frozen shrimp are mitigating food safety risks, preventing cross-contamination, and extending shelf-life/quality.
Bread	20%	Moderate	Plastic*	Non-packaged bread must be sliced at time of purchase or in the home. Key reason to package is extending shelf-life/quality.
Fresh chicken	10%	Low	Plastic*	Due to pathogen related issues, fresh chicken constitutes handling, cool chain, and cross-contamination challenges. Key reasons to package fresh chicken are mitigating food safety risks, preventing loss/leakage, and extending shelf-life/quality.

Beef Burgers (frozen)	10%	Low	Plastic*	Due to pathogen related issues, beef burgers constitute greater handling and cross-contamination challenges than cuts of beef. Key reasons to package beef burgers are mitigating food safety risks, extending shelf-life/quality, and preventing loss/leakage.
Liquid Milk	30%	Low	Plastic*/ glass	Like chicken and beef, milk can quickly spoil if not kept at a low temperature and in sterile conditions. Key reasons to package liquid milk are extending shelf-life/quality, mitigating food safety risks, and preventing loss/leakage.
Yogurt	30%	Low	Plastic*/ glass	While yogurt is typically less susceptible than milk to spoilage, it will spoil if not kept at low temperatures and in sterile conditions. Key reasons to package yogurt are extending shelf-life/quality, mitigating food safety risks, and preventing loss/leakage.
Fresh fish fillets	20%	Low	Plastic*	Species of fish differ in their perishability and the likelihood that natural internal compounds (such as histamine and scromboid) or external pathogens will impact their safe consumption. Key reasons to package fresh fish fillets are extending shelf-life/quality, mitigating food safety risks, and decreased leakage.

** Subject to it possessing the required mechanisms (damage prevention, microbial control, etc.), the term "plastic" includes bio-based plastics, such as those manufactured from starch or sugar cane.*

Common to all 12 items, additional reasons to package foods and beverages include convenience and cost efficiencies. Less convenience may impact consumers' propensity to frequent a store or foodservice operation, and purchase the product(s) in question. Lower cost efficiencies increase businesses' operating costs and overheads, which are passed on to consumers in the form of higher prices.[192]

5.6. Reducing Packaging Materials' Environmental Footprint

Primary research respondents' views on the most effective means for reducing the environmental impact of the four materials commonly used to package foods and on which the study primarily focused are listed in the table below. The viability and effectiveness of these approaches is supported by findings identified during the literature review.[193] The reuse of paper, plastic, glass, and tin prior to recycling further reduces their environmental footprint.

Table 5-9: Minimizing Packaging Materials' Environmental Footprint

Packaging type	Reduce environmental impact
Paper	Recycling and composting†
Plastic	Light-weighting and recycling*†
Glass	Reuse
Tin (incl. steel and aluminum)	Recycling

** Or, in the case of bio-based plastics, composting.*
† The option of composting is dependent on the required systems being available.

Minimizing the environmental impact of packaging requires the entire packaging and food value chain to strategically align their operations. This includes resin/polymer/fibre manufacturers, packaging convertors/designers, food industry, municipalities, MRFs, and recyclers. For reasons discussed in the literature review, businesses manufacturing packaging associated products (incl. inks, adhesives, coatings) also need to align their operations with the entire value chain. A key reason for why this has not occurred on a broader scale is the lack of regulations, standards, and specifications required to create the economic incentives that will, in turn, drive change from a systems' perspective.[194]

6.0 SCENARIO ANALYSIS

The secondary and primary research both identified that means do exist to simultaneously reduce food loss and waste (FLW) and its carbon equivalent footprint (CO_2E), and the CO_2E footprint of packaging. A scenario analysis approach was utilized to compare the environmental impact of reducing FLW, combined with modifying waste management practices.

The scenarios are range finders. They convey the extent to which the environmental emissions associated with FLW and packaging can be reduced through various means. Given that they are range finders for guiding decisions and subsequent analysis by individual stakeholders, the scenarios included two extremes. While these extremes as described (for example, 100 percent FLW composted and 100 percent packaging recycled) may be unlikely to occur in reality, they provide added direction in terms of what product and packaging decisions will have greatest impact on overall CO_2E emissions.

Conducted in three phases, the analysis assessed various combinations of environmental trade-offs associated with 1) having improved packaging design and utilization; 2) having increased the recycling, reuse, or composting of packaging materials; and/or 3) having reduced FLW: for example, through utilizing more effective packaging, consumers buying loose/bulk foods in volumes that suit their needs — then taking these foods home and storing them in reusable packaging. Encompassing all 12 foods described in the previous section of the report and their primary packaging produced conclusions that extend beyond one food or packaging material in isolation.

The concepts explored in the first phase of the scenario analysis could largely be implemented in the short to medium term with existing resources and technology. They included decreasing FLW, directing various proportions of the FLW that do occur from landfill to composting, and recycling various percentages of packaging materials.

The second phase of the analysis assessed the CO_2E trade-offs associated with the elimination of prepackaged foods or beverages, and consumers using reusable containers to take home items sold loose or in bulk. Based on the literature review, the 200 responses to the online survey, and the 20 interviews, this scenario assumed that the widespread sale of loose/bulk items led to a 30 percent increase in FLW.[195]

The third phase of the analysis assumed a 50 percent reduction in FLW, all FLW is composted, and all food packaging is recycled. This is a stretch goal that reflects Canada's SDG commitments to reduce food waste in retail and consumer FLW by 50 percent, and overall GHG emissions. This outcome could be achieved through strategic industry and government collaboration, responsible consumer behaviour, along with the utilization of more effective and environmentally sensitive packaging.

6.1. Food and Packaging Combinations

The scenario analysis began by establishing a CO_2E baseline of individual foods and their primary packaging. The comparative CO_2E emissions of 12 representative food products and their packaging[m] were recorded. Each product, along with the pack size and weight, the primary packaging material associated with each product, and the weight of that packaging, is listed below in Table 6-1.

Table 6-1: Food Items and Packaging Used for Scenario Analysis

Item	Material	Pack size (kg)	Weight of Packaging (g)
Leafy greens	PET clamshell	0.45	48
Berries	PET clamshell	0.25	25
Apples	LDPE bag	1.5	9
Liquid milk	Cardboard	1 litre (1.03kg)	33
Yogurt	PP	0.75	29
Beef burgers (frozen)	Cardboard box Plastic bag (LDPE)	1.02	85 (cardboard) 4 (bag)
Granulated sugar	Paper	2.0	14
Shrimp-frozen	Plastic LDPE	0.454	28
Bread	Plastic LDPE	0.406	9
Dried pasta	Cardboard	0.375	46
Fresh chicken	Polystyrene tray & wrap	0.452	11 (tray) 20 (pad and wrap)
Fresh fish fillets	Polystyrene tray & wrap	0.300	11 (tray) 20 (pad and wrap)

m While these foods can come in a variety of packaging material combinations and pack sizes, the items were chosen because they represent common packaging types and sizes, and encompass a variety of packaging materials.

For the next stage of the analysis, we assumed one metric tonne of each of the 12 foods, making 12 tonnes of food in total. We then calculated the weight of packaging associated with these 12 tonnes of food, if packaged in the typical packaging types listed above. The total packaging would weigh 0.75 tonnes. The Environmental Protection Agency's WARM Model[196] was used to calculate the amount of CO_2E that was emitted during the life-cycle of this "basket" of packaged foods. As California has a similar sized population and environmental standards/sentiments to Canada, California was used as the proxy for Canada in the WARM model. The WARM calculator is a respected model used by researchers, NGOs such as ReFED, industry, and government.

6.2. Scenario Baseline

The WARM model was used to establish the difference in CO_2E emissions for the 12 foods studied and the materials in which they are packaged under a variety of scenarios. The scenarios include reducing FLW and different end-of-life waste management options for FLW and packaging.

Shown below in Table 6-2 are the metric tonnes of CO_2E ($MTCO_2E$) emissions associated with the life-cycle of the 12 tonnes of food and the 0.75 tonnes of packaging being investigated. As indicated, the CO_2E of packaging manufactured from virgin materials equates to five percent of the total CO_2E footprint of the whole product (food and packaging). If using recycled materials, the percentage of total CO_2E footprint for which packaging accounts would be lower than that presented below.

Table 6-2: Food Item and Packaging $MTCO_2E$ per Metric Tonne (MT) of Food

Food Item	Food $MTCO_2E$	Material in Which Food Packaged	Packaging Mass	Virgin Material Packaging $MTCO_2E$	Total $MTCO_2E$ (food & packaging)	Packaging $MTCO_2E$ as % of total CO_2E of Product
Leafy greens	0.49	Clamshell (PET)	0.11	0.260	0.75	35%
Berries	0.49	Clamshell (PET)	0.10	0.244	0.73	33%
Apples	0.49	Plastic bag (LDPE)	0.01	0.012	0.50	2%
Liquid milk	1.93	Cardboard (carton)	0.03	0.270	2.20	12%
Yogurt	1.93	PP (lid & container)	0.04	0.065	2.00	3%
Beef burgers (frozen)	33.16	Cardboard	0.08	0.702	33.87	2%
		Plastic bag	0.004	0.008		
Granulated sugar	4.03	Paper	0.01	0.059	4.09	1%
Shrimp-frozen	4.03	Plastic bag	0.06	0.119	4.15	3%
Sliced bread	4.03	Plastic bag (LDPE)	0.02	0.044	4.08	1%
Dried pasta	0.68	Cardboard	0.12	1.034	1.72	60%
Fresh chicken	2.70	Polystyrene tray	0.02	0.067	2.86	5%
		Wrap and pad	0.04	0.088		
Fresh fish fillets	4.03	Polystyrene tray	0.04	0.101	4.27	5%
		Wrap and pad	0.07	0.132		
TOTAL	**58.01**		**0.75**	**3.20**	**61.21**	**5%**

Source: Adapted from EPA-WARM model (converted to metric measure)

The food where this CO_2E footprint of packaging represents the highest percentage of that product's total CO_2E footprint is dried pasta at 60 percent. This is almost twice that of the next highest item, leafy greens, which is at 35 percent. The reasons why the packaging represents this high percentage of dried pasta's overall CO_2E footprint are 1) cardboard packaging has the highest carbon footprint of the materials listed above, 2) the packaging is the heaviest of those analyzed, and 3) dried pasta itself has one of the lowest CO_2E footprints.[n] The same reasons lie behind why the CO_2E footprint of the materials in which leafy greens and berries are packaged, as a percentage of total CO_2E footprint, are considerably higher than the other 9 items studied.

The total CO_2E footprint of the 12 tonnes of food (excluding packaging) is 58.01 metric tonnes. If the 0.75 tonnes of packaging is manufactured from virgin materials, their emissions would be 3.2 $MTCO_2E$. Together, their combined CO_2E footprint totals 61.21 metric tonnes. The CO_2E footprint of the packaging is five percent of the combined CO_2E footprint of the food and packaging.

Throughout the scenario analysis, the CO_2E footprint of the "basket" of food does not change. What does change is the amount of FLW that is associated with this basket of food and its associated environmental footprint. The specific emissions associated with FLW change according to destination: compost versus landfill. The environmental footprint of the primary packaging also changes, due to 1) elimination of packaging, 2) utilization of more readily recyclable packaging materials, and 3) increased utilization of PCR in the manufacture of those packaging materials.

[n] For example, the CO2E footprint of one tonne of dried pasta is 49 times less than the CO2E footprint of one tonne of beef burgers (0.68 vs. 33.16 MTCO2E), and 6 times less of the CO2E footprint of one tonne of granulated sugar (0.68 vs. 4.03 MTCO2E).

Based on the FLW data estimated by VCMI,[197] we estimate that the baseline FLW for these 12 tonnes of food is 3.37 tonnes. In 2019, VCMI conducted an extensive study that estimated the volume of FLW that occurs throughout the value chain for six food categories.[o] The percentage of FLW that VCMI estimated to occur in the 12 foods during distribution to consumers through retail, within individual households and within foodservice, were used to calculate the baseline FLW of this basket of food. Any FLW and associated CO_2E emissions that occur during production, processing, and packaging of the food are not factored into the scenarios.

As presented in Table 6-3 (below), when this 3.37 tonnes of FLW is put through the WARM model, its CO_2E emissions equates to 14.65 $MtCO_2E$. If all of this FLW goes to landfill, as we are assuming for the baseline scenario, an additional 2.02 $MtCO_2E$ of emissions would occur. This equates to a total of 16.67 $MtCO_2E$.

For the scenario baseline, all of the packaging is considered "waste" and sent to landfill. The column in Table 6-3 titled "Packaging" shows the 3.2 $MtCO_2E$ associated with the 0.75 tonnes of packaging if manufactured from virgin materials, and the additional 0.03 $MtCO_2E$ of emissions that result from all packaging waste going to landfill. The total emissions created from the 0.75 tonnes of packaging going to landfill is therefore 3.23 $MtCO_2E$.

The WARM model takes into consideration that there is some anthropogenic carbon capture associated with landfill, meaning that a percentage of carbon emissions produced by the FLW and packaging is captured back in the ground and not emitted into the atmosphere.

Table 6-3 also indicates that the total CO_2E footprint of the baseline scenario produced by 3.37 tonnes of food and 0.75 tonnes of packaging going to landfill is 19.90 $MtCO_2E$.

---

[o] Field crops, produce, meat/poultry, marine, diary/eggs, sugar/syrups.

6.3. Scenario Analysis: Phase One

The first phase examined the extent to which a moderate reduction in FLW, composting of FLW, and changes to packaging recycling alter the emission baseline of 19.90 $MtCO_2E$ established in Section 6.2. The far right-hand column "TOTAL ($MtCO_2E$)" shows the reduction in total CO_2E emissions below the baseline that are associated with each scenario. The results illustrate the effect of FLW prevention on CO_2E emissions. They also allow the comparative effects of composting FLW and the recycling of packaging to be compared to the reduction in emissions that can be achieved by reducing FLW. As identified in the literature review, the composting of FLW represents a considerably smaller reduction in CO_2E emissions than achieved by preventing FLW.

Two of the scenarios presented below reflect that a third of Canadian organic waste is currently diverted to compost.[198] Due to the lack of empirical research on the CO_2E footprint and lifecycles of compostable packaging, the scenarios did not investigate the use of compostable packaging. The scenarios are listed in order of the highest to lowest CO_2E emissions associated with each option. Two subsequent scenarios (#9 and #10) explore system-wide changes to FLW and packaging.

Table 6-3: Food and Packaging Waste Scenarios

		Food	Packaging	TOTAL ($MtCO_2E$)	
Baseline	Waste weight (tonnes)	3.37	0.75	4.12	
	Waste $MtCO_2E$	14.65	3.20	17.85	
	Waste management emissions (landfill)	2.02	0.03	2.05	
	Total waste emissions (MtCO2E)	**16.67**	**3.23**	**19.90**	
	Changes	**Incremental Change ($MtCO_2E$)**		**Total ($MtCO_2E$)**	**% below baseline**
Scenarios	30% of FLW composted, all packaging landfilled	-0.8	0	19.10	-4%
	Packaging reduced by 25% (e.g. light-weighting), all waste* landfilled	0	-0.81	19.09	-4%
	FLW reduced by 5%, all waste* landfilled	-0.84	0	19.06	-4%
	All FLW landfilled, all packaging recycled	0	-1.57	18.33	-8%
	FLW reduced by 5%, 30% of FLW composted, all packaging landfilled	-1.6	0	18.30	-8%
	All FLW composted, all packaging landfilled	-2.67	0	17.23	-13%
	FLW reduced by 20%, all waste* landfilled	-3.35	0	16.55	-17%
	FLW reduced by 20%, 30% of FLW composted, all packaging landfilled	-3.99	0	15.91	-20%

**All waste = FLW and packaging waste*

As indicated above, the scenario that generates the least emissions is where FLW is reduced by 20 percent below current levels and 30 percent of the remaining FLW is composted. The total emissions for this scenario (15.91 $MtCO_2E$) are 3.99 $MtCO_2E$ lower than the starting baseline of 19.90 $MtCO_2E$. As can be seen, these emissions are lower than having composted all FLW (at current levels).

The results confirm that the priority of CO_2E emission reduction efforts should be preventing the occurrence of FLW. This is where the greatest gains can be achieved. This does not detract from the importance of reducing CO_2E emissions by composting the FLW that does occur, pre-emptively reducing the environmental footprint of packaging through light-weighting or manufacturing packaging from recycled materials, and optimizing the post-use management of packaging by ensuring that it is recycled.

6.4. Scenario Analysis: Phases Two and Three

Based on the survey data, two further scenarios were explored to estimate the impact of extensive changes to packaging materials and formats on FLW and associated emissions. These scenarios are:

1. No primary packaging and moderate composting
    a. FLW increases by 30 percent
    b. 30 percent of FLW is composted
    c. 70 percent of FLW is landfilled
2. Significant reduction in FLW and zero packaging waste
    a. FLW is reduced by 50 percent
    b. All FLW is composted
    c. All packaging is recycled

6.4.1. No Primary Packaging and Moderate Composting

This scenario explored the impact of eliminating primary packaging. As mentioned previously, this range finder reflects the research having identified that the elimination of pre-packed foods and beverages could result in a 30 percent or more increase in FLW above current levels. This increase in FLW above the baseline established in Section 6.2 equals to a total of 4.02 tonnes of the 12 tonnes of foods analyzed going to waste.

The scenario presented below in Table 6-4 estimated the $MtCO_2E$ emissions that result from 30 percent of total FLW (4.02 tonnes) being composted and the remainder going to landfill. With no primary packaging and therefore packaging waste, packaging emissions are zero.

As the study’s focus is primary packaging, no emissions are included for secondary and tertiary packaging, both of which would likely need to alter due to the elimination of primary packaging. For example, plastic linings may have to be inserted into cardboard cartons to prevent contamination, spillage, etc. This could affect the CO_2E footprint and reusability/recyclability/compostability of secondary and tertiary packaging.

The only emissions included from this scenario are those associated with FLW and its waste management, which (reflecting findings contained in the literature review) are slightly reduced by 30 percent of the total FLW being composted. The additional 2.51 $MtCO_2E$ that results from a 30 percent increase in FLW is offset by the elimination of packaging. Compared to the baseline in Table 6-4, this results in an overall decrease of 0.72 $MtCO_2E$.

Table 6-4: Packaging Is Removed, FLW Consequently Increases by 30 Percent

FLW and Waste Management Practices		Food	Packaging	Total
Baseline	$MtCO_2E$ (Food waste and waste management)	**16.67**	**3.23**	**19.90**
Scenario	$MtCO_2E$ (Packaging removed, FLW increased by 30%, and 30% of FLW composted)	**19.18**	**0.00**	**19.18**
	Difference	**2.51**	**-3.23**	**-0.72**

In reality, consumers would still require packaging in the form of reusable containers and bags for transporting food and beverages from the place of purchase to their home. Therefore, the actual footprint of packaging would not be zero. This and the required changes to secondary and tertiary packaging means that the actual reduction in CO_2E emissions that resulted from the eradication of primary packaging could be less than presented above.

6.4.2. Significant Reduction in FLW and Zero Packaging Waste

Based on findings contained in the literature review, along with responses received from the online survey and interviews about what is possible, the third scenario shown in Table 6-5 is based on improved packaging, along with improved behaviour by public and industry, resulting in FLW reducing by 50 percent. This is consistent with SDG 12.3. The adoption of responsible behaviour and creation of circular economic systems results in all the FLW that does occur being composted and all packaging being recycled.[p]

Table 6-5: Fifty Percent Reduction in FLW, All FLW Composted, All Packaging Recycled

FLW and Waste Management Practices		Food	Packaging	Total
Baseline	MtCO_2E (Food Waste and Waste management)	**16.67**	**3.23**	**19.90**
Scenario	MtCO_2E (FLW reduced by 50%, all waste-composted/recycled)	**8.83**	**1.62**	**10.45**
	Difference	**-7.84**	**-1.61**	**-9.45**

As can be seen, this stretch scenario almost halves the net CO_2E emissions of our baseline estimate for the "basket" of 3.37 of FLW and 0.75 tonnes of packaging going to landfill. This outcome could not be achieved without having optimized packaging and its utilization to reduce FLW, and having established a circular economic approach to the management of FLW and post-consumer packaging.

[p] All plastic packaging was allocated to "mixed plastics" in the WARM model, which is 40 percent HDPE and 60 percent is PET, while all paper/cardboard stayed as such. This is because HDPE and PET are the only plastics that can currently be recycled in the WARM model. The EPA acknowledge that recycling of LDPE does occur, but there is not enough data to include this in the WARM model at present.

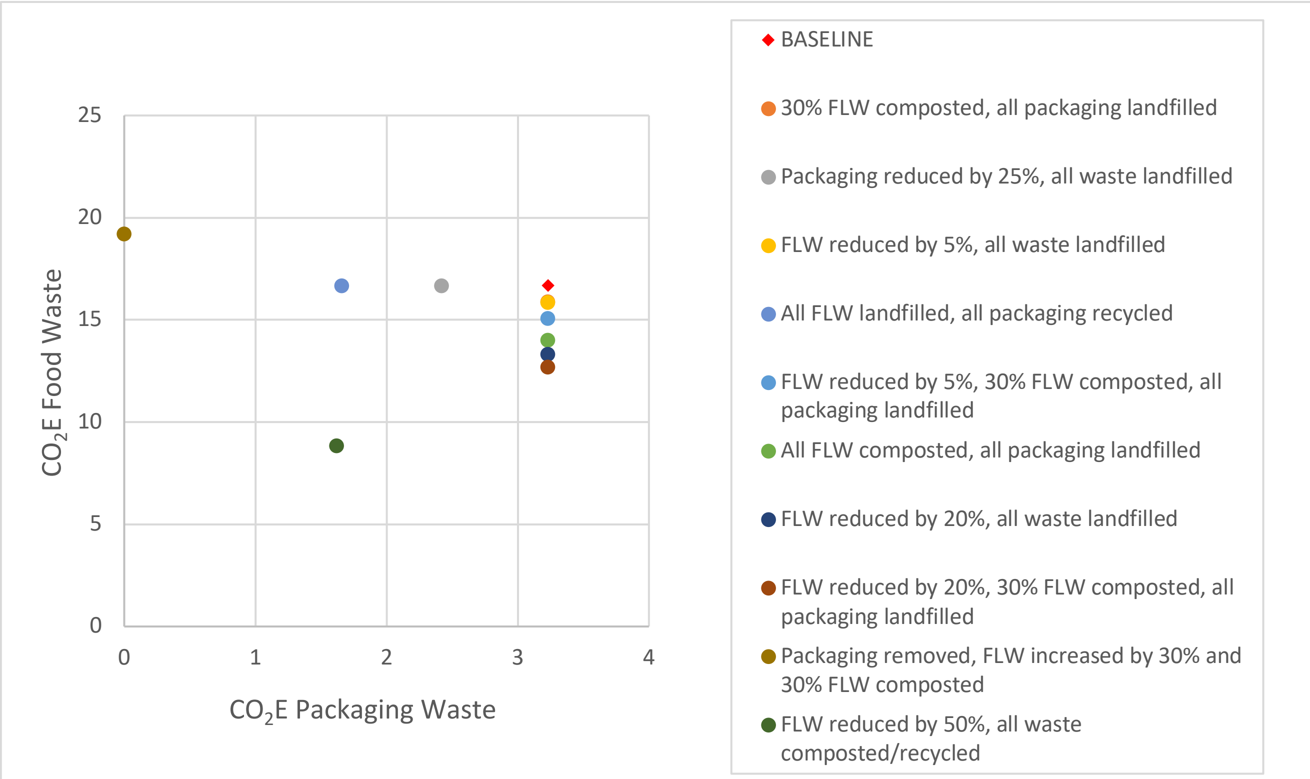
As shown by the literature review and primary research, choices that can lead to optimized packaging include simultaneously reducing its total volume, designing for recycling, and eradicating non-recyclable packaging solutions. Designing for recycling includes transitioning from multi-laminate to mono-polymer laminates. The ability to optimize packaging also rests on having 1) established the necessary recycling and composting infrastructures; 2) implemented the common standards/protocols/specifications required to ensure packaging material decisions reflect systems thinking; and 3) introduced the economic incentives required to drive purposeful behaviour amongst industry and consumers.

6.4.3. Scenario Analysis Summary

The scenarios presented in the proceeding sections are plotted below on the CO_2E matrix that forms Figure 6-1. It shows graphically that reducing FLW has the largest impact on reducing the environmental footprint of the food system. This is because food has a larger environmental footprint than packaging. While the percentage of total emissions represented by packaging differs quite markedly by food item, when aggregated across the 12 foods, packaging represents five percent of total CO_2E emissions. The 1.57 metric tonnes reduction in CO_2E emissions achieved by having recycled packaging illustrates that, the higher the utilization of PCR content in the manufacture of packaging, the less FLW must be reduced to offset CO_2E emissions of packaging.

Reducing FLW emissions through responsible behaviour by industry and consumers alike, combined with packaging innovation (not elimination), is key to minimizing CO_2E emissions. Reducing FLW by 50 percent, combined with utilizing fully recycled packaging and composting all remaining FLW, leads to net CO_2E emissions being close to half of the baseline estimate: 10.45 $MtCO_2E$ versus 19.90 $MtCO_2E$, respectively.

Figure 6-1: Scenarios and Associated Total CO_2E Emissions



Compared to the baseline, reducing FLW by five percent produced a four percent reduction in overall CO_2E. To achieve an equivalent reduction in environmental footprint without reducing FLW, packaging needs to be reduced by 25 percent. A reduction in FLW by 20 percent offsets the CO_2E emissions of the packaging currently associated with the 12 tonnes of food used in these scenarios. In contrast, the primary research identified that, without packaging, FLW could increase by 30 percent or higher.

Reducing FLW by 20 percent results in emissions that are 2.22 $MtCO_2E$ less than if all packaging was recycled. In the unlikely scenario that packaging was eliminated and FLW did not increase, the net result would be 16.67 $MtCO_2E$ emissions. This is very similar to the net emissions resulting from FLW having been reduced by 20 percent and all packaging going to landfill.

The hierarchy of priorities that flow from the scenario analysis for achieving measurable reductions in CO_2E emissions from food and packaging are therefore:

1. Reduce food loss and waste
2. Reduce packaging
3. Increase recyclability
4. Increase composting and anaerobic digestion

Means to reduce FLW in the home include encouraging consumers not to purchase beyond their needs and optimize the handling/storage/preparation of food in the home. For those foods and beverages that are suited to selling in loose/bulk, this method of sale may assist in reducing FLW by allowing people to only buy what they need. Tailoring pack size to specific markets, improved cool chain management, improving the effectiveness of packaging (e.g. damage prevention, modified atmosphere), and recovering then redistributing food to those in need can also reduce FLW.

Dried pasta was identified as suited to selling loose/bulk. That packaging accounts for 60 percent of dried pasta's total CO_2E footprint means that, if a reduction in FLW did occur from consumers purchasing according to their immediate requirements, this and no single use primary packaging would measurably reduce CO_2E emissions. If a small increase in FLW did occur due to its being sold in loose/bulk, the overall emissions could still be lower than those associated with pre-packaged. For similar reasons, certain leafy greens, such as whole heads of lettuce, is another food in which overall emissions could be reduced by selling loose versus pre-packaged. For most of the other foods studied, the reduction in CO_2E emissions achieved by not pre-packaging are insufficient to offset even a minor increase in FLW. Such foods include sugar and apples, both of which are suited to selling loose/bulk.

For those foods not suited to selling loose/bulk, means to reduce the CO_2E footprint of the packaging in which they are sold include light-weighting, eliminating problematic and unnecessary packaging, manufacturing the packaging from recycled materials, and designing the packaging for reuse, recycling, or composting. Even a marginal reduction in FLW, achieved by having improved the effectiveness of packaging from any of the three perspectives described in the literature review (product protection, extended shelf life, promoting behavioural change), would reduce CO_2E emissions more than eliminating primary packaging. Optimized packaging and its post-consumer management would achieve the largest reductions in CO_2E emissions, by having reduced both FLW and the CO_2E footprint of packaging. The composting and anaerobic digestion of any FLW that does occur would also reduce overall CO_2E footprint. The ultimate solutions therefore rest on systems-wide (systemic) innovation.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The recommendations that form this concluding section of the report reflect the research having identified that establishing an equilibrium between FLW and packaging—by having created the products, processes, and infrastructure required to prevent FLW and establish a circular economy for food and packaging—requires industry and multiple levels of government to collaboratively tackle the two issues concurrently from a systems perspective. Timelines for implementing the proposed recommendations and the stakeholders that we suggest are responsible for leading their implementation form Section 7.2.

While some foods and beverages are more amenable to selling loose/bulk than other foods and beverages, and there is a demand for foods and beverages that can be purchased loose/bulk, the elimination of packaging tends to lead to an increase of FLW. Of the 12 foods and beverages analyzed during the primary research, dried pasta, apples, certain leafy greens, and granulated sugar are most suited to selling in loose/bulk form. The ultimate viability of selling any loose/bulk products is, however, contingent on the purchasing preferences of those consumers who frequent a specific retail store or foodservice operation. The viability of selling loose/bulk also hinges on consumers' behaviour in the home — the most important of which is how they store foods and beverages prior to their preparation and consumption. This is because the environmental benefits of selling loose/bulk versus prepackaged foods and beverages hinge on FLW considerations and the percentage of their total CO_2E footprint for which packaging accounts.

The prevention of FLW, by means which include the recovery and redistribution of excess edible food, is the most effective way to reduce CO_2E emissions. The widespread elimination of primary packaging will require changes to tertiary and secondary packaging that could increase their own environmental footprint. This would in turn impact the extent to which packaging related emissions can be reduced by selling a higher proportion of foods and beverages loose or in bulk. Identifying the comparative environmental and economic opportunities, benefits, and challenges of changing packaging and merchandizing arrangements, then implementing and monitoring the effectiveness of subsequent changes, can only be achieved by having conducted holistic life cycle assessments (LCAs).

Holistic LCAs will guide the development of sustainable solutions that address the current fiscal and public policies that support the current linear economic model and obstructs the transition to a circular model. There is a lack of incentives for the food industry to modify its marketing practices to proactively reduce FLW along the value chain, and motivate consumers to more responsibly purchase and manage food and packaging in the home. There is also a lack of incentives for companies to design products for recycling and composting, and for municipalities to collect certain types of organic waste and packaging materials. The economic incentives required to establish efficient and effective material recovery, recycling, and composting/AD systems are also lacking. Changing this situation requires priority to be given to a mix of economic tools that stimulate new markets and engender behavioural changes required to drive systemic innovation along the entire packaging and food value chain.

7.1. Recommendations

The following recommendations have been categorized into five groups. Together, they reflect the FLW and packaging waste hierarchies for minimizing CO_2E emissions and valorizing resources. In order of priority, these are: 1) prevent/reduce, 2) reuse/repurpose, and 3) recycle, compost.

The categories into which the recommended interventions have been grouped are:

1. FLW prevention — this includes optimizing the sale of loose/bulk vs. prepackaged
2. Address problematic and unnecessary packaging
3. Improve recycling infrastructure
4. Improve composting/anaerobic digestion (AD) infrastructure
5. Accelerate development of new packaging materials and solutions

FLW Prevention: Optimizing Sale of Loose/Bulk Vs. Prepackaged
Implementation by food businesses
• Research the demand and viability of increasing the sale of loose or bulk foods within specific stores, foodservice operations, and markets served. • Proactively inform consumers on current options offered to purchase loose/bulk foods and beverages, and encourage the wider use of reusable packaging. Means to encourage the reuse of packaging include removing individual lightweight single-use bags from the produce department. • Conduct holistic chain life cycle analysis (LCA) of representative food/beverage products and their associated packaging solutions to gauge their potential impact on FLW along the value chain and in the home. Encompass primary, secondary, and tertiary packaging in the LCA, and use the findings to guide procurement, distribution, and merchandizing decisions. • Where demand appears sufficient and analysis shows that the sale of loose/bulk foods or beverages is economically and environmentally viable, implement proof of concept pilots. Where pilots are successful, design and implement a rollout plan in conjunction with vendors. • Guided by LCA results, in collaboration with vendors, establish and communicate standard operating procedures (SOPs) for determining packaging decisions including pack size and design. • Ensure on-pack communication to consumers regarding how to minimize FLW in the home by using packaging appropriately. • Communicate with consumers on how to minimize FLW when utilizing reusable packaging. This would occur via instore messaging and electronically via the internet and social media.

Implementation by packaging manufacturers, MRFs[q] and recyclers
• Assist the food and beverage industry to transition to increased sale of loose or bulk foods and beverages by producing reusable primary packaging for consumers that is fit for use in terms of its durability and ability to mitigate food safety/quality issues, and is fully recyclable. • Assist the food and beverage industry to transition to increased sale of loose / bulk foods and beverages by producing tertiary and secondary packaging that is fully recyclable or compostable, and reusable wherever circumstances allow.
Implementation by food industry bodies[r]
• Promote collaborative approaches that result in reduced FLW by having improved the flow of foods and beverages along the value chain. • Research the relationship between the purchase of specific loose/bulk foods/beverages and household FLW. The resulting insights and conclusions will enable retailers and foodservice to tailor loose/bulk programs to suit specific foods/beverages and their target consumer market. • Assist businesses to undertake effective and efficient holistic LCAs by producing a standardized framework and implementation methodology that users can tailor to their needs, then benchmark their own findings against as part of industry-wide continual improvement programs. • Research and communicate best practices for retailers and food service to determine in which circumstances the sale of loose/bulk foods and beverages constitutes an economically viable and environmentally sustainable alternative to prepackaged foods without contravening FLW and CO2E emission reduction efforts. • Research and communicate to industry best practices (and benefits achieved) by optimizing packaging solutions to minimize FLW and the CO2E emissions of packaging solutions by food/beverage type. This will include examining pack size, packaging mechanics, post-use, etc.

[q] Material Recovery Facilities
[r] Advocacy groups representing commercial businesses and associated stakeholders

- Lead pre-competitive collaboration between food and packaging industry in the design and utilization of fully-recyclable and reusable tertiary, secondary, and primary packaging, purposely employed where items are sold to consumers loose or in bulk.

Implementation by packaging, MRF, and recycling industry bodies[s]

- Collaborate with food industry bodies and businesses to optimize the design and utilization of packaging purposely employed to ensure the effective and efficient distribution, merchandizing, and storage (incl. in the home) of foods and beverages purchased by consumers loose or in bulk.

Implementation by government

Support research designed to identify in which unique circumstances specific foods and beverages can be sold loose/bulk without it leading to increased FLW, along with how risks associated with the sale of loose/bulk foods and beverages can be mitigated at the point of purchase and in the home.

Support the undertaking of holistic LCAs by industry. A portion of EPR levies (see below) will be used to establish and promote the use of common methodologies and reporting practices.

Support community-based social marketing to encourage consumers to purchase foods or beverages loose or in bulk without it leading to increased FLW.

Support development of innovative solutions that extend foods' and beverages' shelf life without the need for primary packaging: for example, edible coatings.

Ensure cost/benefit economic (commercial, social, environmental) analysis of FLW factored into packaging related policy, legislative, and regulative decision processes.

[s] Advocacy groups representing commercial businesses and associated stakeholders

Address Problematic and Unnecessary Packaging
Implementation by food businesses
• Guided by holistic LCA results, in collaboration with customers and vendors, establish and communicate standard operating procedures (SOPs) for packaging solutions, including minimum PCR content and designing for reuse, recycling, and/or composting. • Guided by the holistic LCA results, investigate opportunities to reduce the combined mass of tertiary, secondary, and primary packaging by lightweighting or other means. • Ensure packaging SOPs apply to the combined tertiary, secondary, primary packaging solution (materials, inks, adhesives, additives, labels, coatings, barrier layers) associated with each food and beverage product, not individual materials utilized in the manufacturer of each packaging solution. This includes labels applied directly to fresh produce. • Establish and communicate PCR goals and progress in achieving those goals to consumers, potentially in collaboration with the appropriate food industry association(s).
Implementation by packaging manufacturers, MRFs, and recyclers
• Collaborate with food industry stakeholders and government on the formation of a trusted source of objective unbiased, science-based information and guidance on packaging solutions (materials, inks, adhesives, additives, labels, coatings, barrier layers) and optimize their use within a circular economy. • In conjunction with food industry, industry bodies, and government, establish and communicate common standards, processes, and protocols for ensuring PCR materials are suited to inclusion in food-grade packaging or other uses that optimize materials' value and utility. • Establish processes and timelines for minimizing the existence of non-recyclable and non-compostable packaging materials from the food packaging system. This includes packaging designed for reuse, such as food containers and shopping bags. • Establish best practice guidelines, standards, and protocols that assist the food industry to optimize packaging material decisions from packaging mechanics and post-use perspectives.

Implementation by food industry bodies
• Establish then communicate to the food and packaging industries, common science-based standards and specifications of whether packaging is recyclable, biodegradable, bio-based, compostable, etc. • Collaborate with packaging industry stakeholders and government on the formation of a trusted source of objective unbiased, science-based information and guidance on packaging materials and optimizing of their use within a circular economy. • Establish and communicate minimum PCR content goals. Monitor and report progress to industry, consumers, and government, annually. • Collaborate with the packaging manufacturer and recycling industries on establishing processes and timelines for identifying non-recyclable packaging materials, and driving solutions through material and technology innovations or alternative recyclable design choices. • Establish common language that is used on packaging, at the point of purchase, and via social media to inform consumers about how to responsibly handle and dispose of packaging materials.
Implementation by packaging, MRF and recycling industry bodies
• Collaborate with the food industry on the creation and implementation of common science-based standards and specifications of whether packaging is recyclable, biodegradable, compostable, etc. • Revise the ISO 14021 standard so that “compostable” and “biodegradable” are no longer self-declared environmental claims that can be used to market packaging materials. • Collaborate with packaging industry stakeholders and government on the formation of a trusted source of objective, unbiased science-based information and guidance on packaging materials and optimize their use within a circular economy; • Collaborate with food industry bodies and government on establishing processes and timelines for identifying non-recyclable and non-compostable packaging materials, and minimize their use in the food packaging system through material and technology innovations or alternative packaging choices. • Establish a strategic roadmap, along with the enabling standards and specifications, for ensuring packaging manufacturers and recyclers collaborate to establish an economically viable circular economy for packaging that does not contravene FLW and CO2E emission reduction efforts.

Implementation by government

- Support the formation and operation of a trusted source of objective unbiased science-based information and guidance on packaging materials, and optimize their use within a circular economy.
- Mandate minimum PCR content through enforceable legislation. Monitor and report progress to industry and consumers.
- Encourage the use of holistic LCAs to optimize food and beverage packaging solutions in terms of their effectiveness in reducing FLW and their reusability, recyclability, and compostability.
- Ensure all legislative and regulatory decisions relating to packaging materials and their use are based on proven objective science and are national in scope. The impact of legislation should be regularly monitored and publicly communicated at a municipal, provincial, and federal level.
- Mandate minimum PCR content for all food and beverage packaging. To ensure that the systems and infrastructure required to meet increased demand exist, mandated minimum PCR levels would initially be relatively low (e.g. 10%), rising to a higher percentage over a pre-defined timeframe.
- Establish a common national EPR scheme that reflects entire packaging solutions' ease of recyclability or compostability/AD, along with the necessary standards/specifications (see below).
- Ensure that municipalities are responsible for monitoring and reporting their material management performance in terms of the packaging hierarchy: recycled, composted, and landfilled. The contribution of EPR levies to municipalities for investment in local material management infrastructure and programs will be based on performance.

Improve Recycling Infrastructure
Implementation by food businesses
- Ensure common, standardized on-pack communication to consumers regarding how to minimize packaging waste by recycling correctly.   - Ensure that entire packaging solutions (incl. materials, inks, adhesives, additives, labels, coatings, barrier layers), not individual materials utilized in the manufacturer of that solution, are designed to optimize their recyclability.   - Ensure that actions taken to streamline and optimize recyclable packaging solutions align with the requirements, capabilities, and infrastructure possessed by MRFs and recycling facilities.   - Retailers should position bins at store level where consumers can return flexible packaging, which is a challenge for curbside collection programs and MFRs to handle.
Implementation by packaging manufacturers and recyclers
In conjunction with food industry, industry bodies and government, establish and communicate common standards, processes and protocols for ensuring packaging solutions (materials, inks, adhesives, additives, labels, coatings, barrier layers) are suited to the creation and operation of effective and efficient national recycling infrastructure.
Implementation by food industry bodies
Lead collaboration between food/beverage, packaging manufacturing, recycling industries, and government in establishing economically and environmentally sustainable EPR systems.
Implementation by packaging and recycling industry bodies
- Identify and communicate best practices for optimizing the recyclability of packaging solutions.   - Research and communicate best practice EPR systems. Communicate results to industry, government, and consumers in the form of a measurable strategic roadmap for implementation.   - Recycling targets established, monitored, and reported at the municipal, provincial/territorial, and federal level.   - Establish common national quality standards and specifications for post-consumer recycled (PCR) resins and polymers.

- Develop alternative markets for recycled material. While ideally, recycled packaging is introduced back into the food system to close the loop, this might not always be possible.
- Collaborate with food industry and government on the establishment of EPR systems to which producing levels of the value chain (polymer producers, packaging manufacturers/converters and food industry) contribute financially.

Implementation by government

- Encourage private investment in MRFs and recycling infrastructure. This would include tax incentives or grants to enable businesses to invest in the equipment required to recycle packaging, and utilize packaging containing high levels of PCR.
- Support community-based social marketing to encourage consumers to act responsibly, thereby optimizing the utilization of current and future recycling programs.
- Establish EPR systems to which producing levels of the value chain (polymer producers, packaging manufacturers/converters and food industry) contribute.
- Ensure investment in establishment and enhancement of recycling facilities are driven by purpose, not politics. Municipal, provincial/territorial, and federal governments to collaborate strategically to establish of best practice recycling programs that are uniform across Canada. Performance is monitored and reported in ways that are designed to drive continual improvements in the utilization of recyclable packaging in ways that do not contravene FLW reduction efforts.
- Ensure EPR levies are proportionate to the difficulty of recycling each tonne of individual packaging solutions. In plastics, for example, stakeholders would pay lower levies for mono polymer PET that does not contain materials (inks, adhesives, additives, labels, coatings, barrier layers) that negatively impact its recyclability. The levies would rise to being much higher levies for multi-polymer laminates/films, etc. Levies would also reflect packaging materials’ PCR content.
- Support the development and commercialization of chemical recycling technologies.
- Ban the landfilling of packaging materials that have gone through a comparative LCA. The process of banning the landfilling of packaging materials would commence with EPR levies applied to landfill fees, with bans coming into force over a predetermined timeframe. Levies would be strategically invested into the creation and operation of recycling and composting/AD infrastructure *(see below)*.

Improve Composting/Anaerobic Digestion (AD) Infrastructure
Implementation by food businesses
• Conduct holistic chain LCA of representative food/beverage products and their associated compostable packaging solutions for the purpose of guiding packaging procurement, distribution, and merchandizing decisions. Encompass primary, secondary, and tertiary packaging that is considered biodegradable or compostable. • Ensure common standardized on-pack communication to consumers regarding how to identify compostable packaging and then dispose of it and organic waste appropriately. • Ensure that entire packaging solutions (incl. materials, inks, adhesives, additives, labels, coatings, barrier layers), not individual materials utilized in the manufacturer of that solution, are designed to optimize their compostability. • Ensure that actions taken to streamline and optimize composting packaging solutions align with the requirements, capabilities, and infrastructure possessed by composting and AD facilities.
Implementation by packaging manufacturers and composters/AD facilities
• In conjunction with food industry, industry bodies and government, establish and communicate common standards, processes, and protocols for ensuring packaging solutions (materials, inks, adhesives, additives, labels, coatings, barrier layers) are suited to the creation and operation of effective and efficient composting facilities or AD systems.
Implementation by food industry bodies
• Lead collaboration between the food and beverage, packaging manufacturing, recycling industries, and government in establishing economically and environmentally sustainable composting or AD systems and programs. • Research and communicate best practice composting and AD systems. Communicate results to industry, government, and consumers in the form of a measurable strategic roadmap that is implemented nationally.
Implementation by packaging and composting/AD industry bodies
• Establish a framework and strategic roadmap for ensuring packaging manufacturers, the food industry, MRFs, and composters collaborate on the establishment of economically and environmentally sustainable national composting facilities and AD systems. • Conduct research to identify best practice de-packaging of food, thereby ensuring that the effects of non-compostable packaging on the amount of FLW composted or sent to AD are minimized.

- Collaborate with food industry and government on establishing EPR systems to which producing levels of the value chain (polymer producers, packaging manufacturers/converters, and food industry) contribute. EPR levies are strategically directed to the creation and operation of the infrastructure and systems required to establish a sustainable circular economy for the composting and AD of organics and packaging.

Implementation by government

- Encourage private investment in composting and AD infrastructure. This would include tax incentives or grants to enable businesses to invest in composting facilities and AD technologies.
- Establish clear and enforceable national standards and protocols pertaining to compostable and biodegradable materials and their utilization (including inks, adhesives, additives, labels, coatings, barrier layers). Ensure certification is aligned with the needs and operations of existing and foreseeable new composting and AD facilities.
- Support extensive communication efforts that use psychology to motivate consumers to act responsibly, thereby optimizing the utilization of current and future composting/AD programs.
- EPR levies applied to compostable and biodegradable packaging material are determined by rigorous science-based standards and specifications. This includes stickers applied directly to fruits and vegetables.
- Compostable and biodegradable packaging material certifications are nationally recognized and aligned to composting and AD facilities' needs and operations.
- Ensure investment in establishment and enhancement of composting and AD facilities are driven by purpose, not politics. Municipal, provincial/territorial, and federal governments collaborate strategically to establish of best practice composting and AD programs that are uniform across Canada. Performance is monitored and reported in ways that are designed to drive continual improvements in the development and utilization of compostable, bio-based, and biodegradable packaging in ways that do not contravene FLW reduction efforts.
- Ban the landfilling of organics. The process of banning the landfilling of organics would commence with levies applied to landfill fees, with organic bans coming into force over a predetermined timeframe. Landfill levies would be invested in the creation and operation of composting and AD infrastructure.

Accelerate Development of New Packaging Materials and Solutions
Implementation by food businesses
• Collaborate with food and packaging industry stakeholders on pre-competitive packaging, recycling and composting/AD research and development efforts.
Implementation by packaging manufacturers and recyclers
• Collaborate with food and packaging industry stakeholders on pre-competitive packaging, recycling and composting/AD research and development efforts.
Implementation by food industry bodies
• Establish then facilitate strategic partnerships with packaging industry and broader stakeholders that are designed to foster the development and piloting of innovative packaging solutions.
Implementation by packaging industry broader stakeholder bodies
• Establish then facilitate strategic partnerships with food industry and broader stakeholders that are designed to foster the development and piloting of innovative packaging solutions.
Implementation by government
• Support development of innovative packaging solutions that show promise in terms of simultaneously reducing FLW and packaging waste. • Support the establishment of accelerators for developing, testing, and commercializing new forms of packaging that support the formation of a circular economy for food and packaging. • To address contamination issues that impact the percentage of packaging that is recycled or composted/AD, support research to identify best practice de-packaging technologies. • Support the research, development, and commercialization of best practice chemical recycling solutions.

7.2. Timelines

The recommendations described above are summarized below in Table 7-1 below. The table is a matrix of timelines for implementing the proposed interventions: "Do now" (1-2 years), "Do soon" (3-4 years), "Build a plan" (5+ years). The most pressing and readily implementable interventions are categorized as "Do now." Interventions that will require more planning and may require moderate investment are categorized as "Do soon." Interventions that require extensive collaboration and are expected to require considerable investment to implement have been categorized as "Build a plan." Listed in the left-hand column is the stakeholder group that we suggest should lead the implementation of each of the interventions listed.

Table 7-1: Summary of Recommendations

	Do now (1-2 years)	**Do soon (3-4 years)**	**Build a plan (5+ years)**
Food industry	• Determine viability of increasing the sale of loose/bulk foods • Educate consumers on buying loose/bulk • Conduct LCAs on FLW and packaging • Establish packaging material SOPs • Establish collection points for flexible packaging	• Mandate minimum PCR requirement • Ensure all packaging is fully recyclable or compostable • Invest in organic material (OM) collection with private or municipal hauler • Where OM volumes are sufficient, invest in AD facilities	• Monitor, benchmark, and report performance according to targets contained in recycling and composting/AD strategies
Packaging manufacturers	• Introduce common science-based communications with the food industry • Increase use of PCR materials	• Implement certification of recyclable or compostable packaging based on common standards	• Ensure materials are optimized in relation to EPR programs • Incorporate greater usage of PCR than virgin materials

MRFs and recyclers	• Develop strategy to implement common minimum PCR standards	• Ensure PCR materials meet common minimum standards • Invest in infrastructure	• Ensure industry has fully adopted minimum standards and specifications for PCR;
Composters/AD	• Develop strategy to implement common minimum composting/AD standards	• Invest in infrastructure	• Ensure industry has fully adopted minimum standards and specifications for PCR
Food industry bodies	• Implement best practice selling of loose/bulk foods; • Implement best practice on-pack communication on material disposal • Establish recycling targets	• Communicate EPR best practices to industry • Monitor and report performance in meeting PCR and recycling targets	• Implement monitoring, benchmarking and reporting of industry performance in relation to EPR programs
Packaging industry bodies	• Establish common science-based framework for determining packaging solutions recyclability and compostability	• Communicate EPR best practices to industry • Communicate best practice usage of PCR content to industry • Monitor and report industry performance	• Audit industry to verify that manufacturers are operating in accordance with minimum common national standards and specifications
Recycling and compost/AD industry bodies	• Establish common minimum standards to determine packaging solutions' recyclability and compostability • Establish common minimum standards for post-consumer, recycled (PCR) resins	• Begin implementing national recycling and composting/AD strategy • Monitor and report performance of recycling and composting/AD sectors according to targets	• Audit industry to verify that facilities are operating in accordance with minimum common national standards and specifications

	• Establish common communication on best practice material disposal • Create national recycling and composting/AD infrastructure strategy	contained in national strategy	
Government[t]	• Establish science-based standards to categorize packaging materials • Program to assist LCA implementation • Create national EPR implementation strategy • Establish and support packaging material R&D accelerators • Invest in promising FLW reduction technologies • Provide a standard FLW quantification method for ICI and municipalities	• Establish a FLW reduction target/goal • Establish national EPR program • Introduce legislation that mandates minimum PCR content • Encourage private investment in recycling and AD infrastructure	• Ban packaging materials from landfill • Ban organics from landfill • Monitor, benchmark and report EPR program performance

[t] This industry stakeholder group includes the Canadian Council of Ministers of the Environment (CCME)

8.0 ENDNOTES

[1] Gooch et al, 2019a

[2] UNDP, 2019a;

[3] GC, 2018; CBC, 2018

[4] Blake, 2020; Éco Enterprises Québec & RECYC-QUÉBEC, 2020

[5] Gooch et al, 2019a

[6] Valiante, 2019; Ellen MacArthur Foundation, 2019; UNEP, 2018; Saley, 2009

[7] Institut EDDEC and RECYC-QUÉBEC, 2019

[8] Institut EDDEC and RECYC-QUÉBEC, 2019; Garcia, 2019; Ellen MacArthur Foundation, 2017

[9] National Zero Waste Council's *Food Loss and Waste Strategy for Canada*, 2018:14

[10] Ellen MacArthur Foundation, 2019 a/b/c; 2017

[11] Ellen MacArthur Foundation, 2019c

[12] City of Guelph, 2019:5

[13] WRAP, 2015c

[14] ReFED, 2020

[15] Colicchio Goertz, 2018; Denkstatt, 2017; Grill, 2017; WWF, 2014

[16] Paben, 2018; Hillman et al, 2015; Resource Polymers, 2011; Franklin, 2010; Staley, 2009; EPA 2006

[17] Ellen MacArthur Foundation, 2019b/c; Lendal & Wingstrand, 2019; City of Guelph; 2019; NZWC, 2018; WWF, 2014

[18] UNDP, 2019a; Garcia, 2019; Schroeder et al, 2018

[19] UNDP, 2019a; GC, 2018; CBC, 2018

[20] CGRi, 2020; RECYC-QUEBEC, 2019

[21] Lendal & Wingstrand, 2019; NZWC, 2018; UNDESA, 2018

[22] UNDP 2019a/b

[23] Marchal et al, 2011

[24] Benson Wahlén, 2019; Hausfather, 2018

[25] Flanagan et al, 2019; UNDP 2019a; IPCC, 2019; Ellen MacArthur Foundation. 2019b/c; Marchal et al, 2011

[26] Askew, 2020; Lendal & Wingstrand, 2019; EIA & Greenpeace, 2019; Flanagan et al, 2019

[27] Askew, 2020

[28] Lockrey et al, 2019; Gooch et al, 2019b; Gooch et al, 2018; Aspalter, 2015; Neff et al, 2015; Holdway, 2011; AAFC 2010

[29] Buchanan, 2019; Suggit, 2018; Aschemann-Witzel, 2015a

[30] ReFED, 2020; Morrison, 2019c; Madox, 2019; Gooch et al, 2019a/b; Morrison, 2019b; Colicchio & Harrold, 2918; WWF, 2014

[31] Koelsch Sand & Robertson, 2019

[32] Lockrey, 2019; Flanagan et al, 2019; Gooch et al, 2018; NZWC, 2018; WRAP, 2015a/2017a; Suggitt, 2018; French Packaging Association, 2011; Daggett, 2017; IFT, 2007; IGD, 2017a/b; AMERIPEN, 2019; PAC, 2019 & PAC 2017; and the World Wildlife Fund, 2014

[33] Lockrey et al, 2019; Dagget, 2017; WRAP, 2017a; Aspalter, 2015; ReFED, 2015; Neff et al, 2015; Verghese et al, 2013

[34] EIA & Greenpeace, 2019; Buchanan, 2019; Gooch et al, 2019a/b; Aschemann-Witzel et al, 2015b; Verghese et al, 2013

[35] Lendal & Wingstrand, 2019; Ellen MacArthur Foundation, 2019 b; EIA & Greenpeace. 2019; Gooch et al, 2019a; WRAP 2017a

[36] Gooch et al, 2020; Suggit, 2018; Verghese et al, 2013; Verghese et al, 2015

[37] IEA & Greenpeace, 2019

[38] WRAP, 2019; WRAP, FSA & DEFRA, 2019

[39] Gooch et al, 2019a; Uzea et al, 2014

[40] Askew, K. 2020; Sand, 2019; Ferguson, 2019; Gooch et al, 2019a

[41] Gooch et al, 2019a

[42] Gooch et al, 2019a; Gooch et al, 2016; Uzea et al, 2014

[43] Leigh, 2019; Sand, C. 2019a/b; Dyer & Simonson, 2019; Antler, 2019

[44] Dyer & Simonson, 2019; Koelsch Sand, 2019

[45] Leigh, 2019

[46] Greenpeace, 2019; Tesco, 2019a/b; Gooch et al, 2019a/b

[47] Leigh, 2019; Dyer & Simonson, 2019; Tesco 2019a/b; Lord et al, 2016

[48] Ross, 2019; Sand, 2019; Gooch et al, 2019; NAPCOR & APR, 2018

[49] Dilkes-Hoffman et al, 2018

[50] Marsh & Bugusu, 2007b:R47

[51] Leigh, 2019; Sand, 2019a/b, Koelsch Sand & Robertson, 2019; Dyer & Simonson, 2019; Gooch et al, 2019b; NAPCOR & APR. 2018; Marsh & Bugusu, 2007b

[52] Goldring, 2020; Camilleri et al, 2019; Brooks, 2019; Morrison, 2019b; Taylor, 2019; Audet & Brisbois, 2018; Neff et al, 2015

[53] Goldring, 2020; Philippidisab et al, 2019; Chandra et al, 2015; WRAP 2013a

[54] TRT World, 2019; Sweden, 2019

[55] Laboratory for Climate Action, 2019

[56] Abacus Data, 2019

[57] Goldring, 2020

[58] The Grocer, 2018

[59] BBC, 2019; Taylor, 2019; Abacus, 2019

[60] Wilson, 2019; Camilleri et al, 2019; WRAP, 2017b; WRAP, 2013A; March & Bugusu, 2007

[61] Goldring, 2020; Gooch et al, 2019a; Verghese et al, 2015/2013; Verghese et al, 2012

[62] WRAP, FSA & DEFRA, 2019; Gooch et al, 2019a; Neff, Spiker & Truant, 2015; Neff, 2015

[63] Audet & Brisbois, 2018

[64] Goldring, 2020; Aschemann-Witzel et al 2015a; Neff et al, 2015; WRAP, 2013a

[65] Morrison, 2019b; Burrows, 2018; Abacus Data, 2019

[66] Gooch, et al, 2019a; O'Sullivan, 2018; Second Harvest, 2017

[67] Gooch et al, 2019a

[68] Audet & Brisbois, 2018; WRAP, 2013a; Scott & Butler, 2006

[69] WRAP, FSA & DEFRA, 2019

[70] St. Goddard, 2019; Patel, 2018

[71] Goldring, 2020; Camilleri et al, 2019; Antler, 2019; Dyer & Simonson, 2019; Sand, 2019b

[72] Goldring, 2020; Lockrey et al, 2019 PAC, 2017 & 2019; IGD, 2017; ReFED, 2016; WRAP, 2015; and Denkstatt, 2015

[73] Gooch et al, 2019

[74] WRAP, 2017a; French Packaging Association, 2012

[75] Lockrey et al, 2019; Flanagan et al, 20119; Gooch et al, 2019a; Denkstatt, 2015; Gunders, 2012

[76] WRAP, FSA & DEFRA, 2019

[77] AAFC, 2010:17

[78] Goldring, 2020; NZWC, 2018; Gooch et al, 2018; Aschemann-Witzel et al, 2015b; WRAP, 2013a/2017e

[79] Neff et al, 2015

[80] Hanson & Mitchell, 2017; PAC, 2015; WRAP, 2013A; WRAP, 2010a; Koelsch Sand, 2019; Dennis, 2017

[81] Gooch et al, 2019; PAC, 2017/2019; CPMA, 2019; IGD, 2017; WRAP, 2015;

[82] UPS, 2016; Terracycle, 2019

[83] Staffer, 2019; Apeel, 2019

[84] WRAP, 2015a

[85] Gooch et al, 2019a; Euromonitor 2017b; EPA, 2015; IGD, 2017a/b

[86] EPA, 2019

[87] Gooch et al, 2018

[88] Gooch et al, 2019b

[89] McEwen Associates, 2014

[90] Plummer, 2018

[91] Grill, 2017

[92] Cotterman, 2018

[93] Koelsch Sand & Robertson, 2019; Gooch et al, 2019b; Marsh & Bugusu, 2007a

[94] Sand, 2019b; Dyer & Simonson, 2019; Gooch et al, 2019b; Marsh & Bugusu, 2007a

[95] Antler, 2019; Nosowitz, 2018

[96] Gooch et al, 2019b; Suggit, 2018; Colicchio & Goertz, 2018; Marsh & Bugusu, 2007

[97] Sand, 2019a; Ross, 2019; Baeini, 2019a/b; Ferguson, 2019

[98] Lau & Wong, 2000

[99] Koelsch Sand, 2019; Ross, 2019; Marsh & Bugusu, 2007a/b

[100] WRAP, 2019b; Gooch et al, 2019; Paben, 2018; Recyc-Quebec, 2017; Lord et al, 2016

[101] Zhou, 2013; Roco et al, 2010

[102] Brown & Kuzma, 2013

[103] Sand, 2019a; Blake, 2019; Marsh & Bugusu, 2007a

[104] Institute of Packaging Technology and Food Engineering, 2019; PAC, 2019 & 2017; Gooch et al, 2018; WRAP, 2017a/b/c; IGD, 2017a/b; French Packaging Association, 2011; Scott and Butler, 2006

[105] Kroger, 2019; Gooch et al, 2019; Koelsch Sand & Robertson, 2019; Sand, 2019; WRAP, 2015b; Verghese et al, 2013/2012; French Packaging Association, 2011

[106] Greenpeace, 2019; Gooch et al, 2019; Dyer & Simonson, 2019; Sand, 2019b

[107] Molina-Besch et al, 2019; Sand, 2019a; Verghese et al, 2013/2015; Verghese et al, 2012

[108] Molina-Besch et al, 2019:37

[109] Molina-Besch, et al, 2019; Goldsberry, 2018; EPA, 2019

[110] Abacus, 2019; Crossmark, 2016

[111] CPMA, 2019

[112] Koelsch Sand, C. 2019; Ferguson, 2019; Gooch et al, 2019b

[113] Gooch et al, 2019b

[114] WRAP, 2019a/2019b; Tita, 2019; Gooch et al, 2019a/b; Ferguson, 2019; Tesco, 2019a; Valiante, 2019

[115] PAC, 2019; Watson, 2019; AMERIPEN, 2019; Gooch et al, 2018; Sealed Air, 2015

[116] Askew, 2020; Rowan, 2019; Resource Association, 2015

[117] Gooch et al, 2019; PAC, 2019/2017/2014; Crawford Packaging, 2019

[118] Koelsch Sand, 2019; Unilever, 2019

[119] Koelsch Sand, 2019; Sealed Air, 2019; Baeini, 2019a/b; Murray & Meyer, 2019

[120] Walmart, 2019a

[121] Walmart, 2019b

[122] Kroger, 2019)

[123] Lendal & Wingstrand, 2019; Gooch et al, 2019b; Marsh & Bugusu, 2007a/b

[124] Sagan 2019

[125] Market Smor 2019

[126] Litwin, 2017

[127] Sobeys, 2019; Canadian Press, 2019

[128] Carrefour, 2019a/b

[129] Gooch et al, 2018

[130] Gooch et al, 2019b:22

[131] Gooch et al, 2018

[132] Morrison, 2020; Speare-Cole, 2019

[133] Gooch et al, 2019b; Cooman, 2018

[134] Canada Press, 2019

[135] Bulk Barn, 2019

[136] Abeego, 2019

[137] Recyc-Quebec, 2017; Summers, 2012; Edwards & Meyhoff Fry, 2011

[138] Gooch, 2020; BBC, 2019

[139] Taylor, 2019; CPMA, 2019

[140] Taylor, 2019

[141] St. Goddard, 2019

[142] EIA & Greenpeace, 2019

[143] MEFD, 2018; Klahre, 2017

[144] Koelsch Sand, 2019:114

[145] CIAC, 2019

[146] ECCC, 2019

[147] Lendal & Wingstrand, 2019; Howe, 2019; Valiante, 2019; Lord et al, 2016; Franklin, 2010; Staley, 2009

[148] Hillman et al, 2015:10

[149] Sand, 2019a; Gooch et al, 2019; Marsh & Bugusu, 2007a/b

[150] Perugini et al, 2005

[151] Paben, 2018; Resource Polymers, 2011; Franklin, 2010; Staley, 2009; EPA 2006

[152] Koelsch Sand, 2019; Gooch et al, 2019; Marsh & Bugusu, 2007a/b

[153] NAPCOR & APR, 2018; Source Polymers, 2011; EPA, 2006

[154] WRAP, 2019b; Gooch et al, 2019; Perugini et al, 2005; Staley, 2009; EPA, 2006

[155] CCME, 2019

[156] ECCC, 2019

[157] CIAC, 2019

[158] Sobeys, 2019

[159] Howe, 2019

[160] Sobeys, 2019

[161] Koelsch Sand, 2019; Koelsch Sand & Robertson, 2019; Marsh & Bugusu, 2007a/b; Baeini, 2019a/b

[162] Koelsch Sand, 2019; Vogt, 2019; Howe, 2019; Ross, 2019; Baeini, 2019a/b; Gooch et al, 2019; Marsh & 2007b

[163] Howe, 2019; Baeini, 2019a/b; Ross, 2019

[164] Blake, 2019; Koelsch Sand, 2019

[165] St, Goddard, 2019

[166] Vogt, 2019; St. Goddard, 2019

[167] Jarvis & Robinson, 2019

[168] Gooch et al, 2019: Vogt, 2019; St. Goddard, 2019; Baeini, 2019a/b

[169] Sand, 2019b

[170] St. Goddard, 2019; Antler, 2019; Dyer & Simonson, 2019

[171] Baeini, 2019a/b; Ferguson, 2019; Gooch et al, 2019; Dilkes-Hoffman et al, 2018

[172] Dyer & Simonson, 2019; Sand, 2019b

[173] Leigh, 2019; Dyer & Simonson, 2019; Antler, 2019; Sand, 2019b

[174] Dyer & Simonson, 2019; Blake, 2019; Antler, 2019; Sand, 2019b

[175] Leigh, 2019; Antler, 2019; Koelsch Sand, 2019

[176] Howe, 2019; Vogt, 2019; NAPCOR & APR, 2018

[177] Ross, 2019; Baeini, 2019a/b; Dilkes-Hoffman et al, 2018

[178] Ross, 2019; Lord et al, 2016

[179] Antler, 2019; Nosowitz, 2018

[180] Fresh Plaza, 2019b

[181] Cooke, 2019

[182] Blake, 2019; Antler, 2019

[183] EPA, date unknown; Fuqing, et al, 2018

[184] O'Sullivan, 2018

[185] Recycling Product News, 2018; City of Surrey Website, 2018

[186] Gooch et al, 2019a

[187] Second Harvest, 2018

[188] WRAP, FSA & DEFRA, 2019

[189] WRAP, 2015c

[190] Rulibikiye, 2019

[191] WRAP, FSA & DEFRA, 2019; BBC. 2019; Maddox, 2019; Goldsberry, 2018; Suggit, 2018; Aschemann-Witzel et al, 2015; Chandra Lal et al, 2015; EPA. 2015; Marsh & Bugusu, 2007a/b; WRAP 2013a; WRAP 2017a

[192] Lockrey et al, 2019; Gooch et al, 2019b; Gooch et al, 2018; EPA. 2015; Marsh & Bugusu, 2007a/b

[193] NAPCOR & APR, 2018; Smith, 2019; Hillman et al, 2015; Marsh & Bugusu, 2007a/b

[194] Ellen MacArthur Foundation, 2019a/b; Lendal & Wingstrand, 2019; Gooch et al, 2019b; OECD, 2016

[195] Plummer, 2018; Cotterman, 2018; Gooch et al, 2019b; Gooch et al, 2018;

[196] EPA, v15, 2019

[197] Gooch et al, 2019a

[198] Weber, 2019

9.0 REFERENCES

AAFC. 2010. The Canadian Consumer: Behaviour, Attitudes and Perceptions Toward Food Products; MARKET ANALYSIS REPORT; International Markets Bureau, Agriculture and Agri-Food Canada. Available from: http://www.gftc.ca/knowledge-library/file.aspx?id=ce8b6b48-c2b3-45f3-9c12-551975dd2706

Abacus Data. 2019. Single-use Plastics, Consumers, and Produce: Executive Summary; Presentation to CPMA Board of Directors; Halifax, NS, September 12, 2019; Abacus Data.

Abeego. 2019. Wrap Today. Save Tomorrow; Abeego: keep food alive. Accessible from: https://canada.abeego.com/

AMERIPEN. 2019. Unwrapping Ambitious Packaging Commitments in the U.S.; AMERIPEN and the U.S. Chamber of Commerce Foundation. Accessible from: https://cdn.ymaws.com/www.ameripen.org/resource/resmgr/docs/AMERIPEN-2018-commercefounda.pdf

Antler, S. 2019. Private communication; Compost Council of Canada.

Apeel. 2019. Freshness That Won't Go To Waste; Apeel Sciences. Accessible from: https://apeelsciences.com/

Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., Gustavsson, J. 2015a. Consumers and food waste – a review of research approaches and findings on point of purchase and in-household consumer behaviour. Paper prepared for presentation at the EAAE-AAEA Joint Seminar 'Consumer Behavior in a Changing World: Food, Culture, Society" March 25 to 27, 2015 Naples, Italy

Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., Oostindjer, M. 2015b Consumer-Related Food Waste: Causes and Potential for Action; Sustainability 2015, 7, 6457-6477; doi: 10.3390/su7066457

Askew, K. 2020. A Different Approach to Innovation: Putting Science, Regulation and Nutrition at the Heart of NPD; Food Navigator; William Reed; January 6, 2020. Accessible from: https://www.foodnavigator.com/Article/2020/01/06/Putting-science-regulation-and-nutrition-at-the-heart-of-NPD?utm_source=newsletter_daily&utm_medium=email&utm_campaign=06-Jan-2020

Audet, R., Brisebois, É. 2018. Le gaspillage alimentaire entre la distribution au détail et la consommation. Accessible from: https://chairetransition.esg.uqam.ca/wp-content/uploads/sites/48/2018/11/Le-gaspillage-alimentaire-entre-la-distribution-au-detail-et-la-consommation.pdf

Baeini, R. 2019a. Orora Fresh, Canada. Presentation at the CPMA Plastic Packaging Stakeholder Working Group: October 1, 2019, Toronto.

Baeini, R. 2019b. Private communication; Orora Fresh, Canada.

Barker, M. 2019 "Waitrose launches compostable banana bag", Fruitnet.com. March 2019. Accessible from: http://www.fruitnet.com/fpj/article/178145/waitrose-launches-compostable-banana-bag

BBC. 2019. Inside the Supermarket: Episode 3; British Broadcasting Corporation. Accessible from: https://www.bbc.co.uk/iplayer/episode/m000bhz0/inside-the-supermarket-series-1-episode-3

Bedford, E. 2019. Statistica. Annual Expenditure on Snack Foods. Accessible from: https://www.statista.com/statistics/724544/annual-expenditure-on-snack-foods-per-canadian-household/

Bedford, E. 2019a. Statistics. Forecasted Retail Sales of Sweet and Savoury Snacks. Accessible from: https://www.statista.com/statistics/481476/forecasted-retail-sales-of-sweet-and-savory-snacks-canada/

Benson Wahlén, C. 2019. 87 Companies Commit to Climate Targets for 1.5°C Future; International Institute for Sustainable Development; October 1, 2019. Accessing from: https://sdg.iisd.org/news/87-companies-commit-to-climate-targets-for-1-5c-future/

Berry, D. 2019. "How packaging innovation is changing the food industry", Food Business News. June 12, 2019. Accessible from: https://www.foodbusinessnews.net/articles/13930-how-packaging-innovation-is-changing-the-food-industry

Blake, A. 2020. Private communication; Director of PACNEXT and PAC Food Waste; Retired Executive of Package Development & Design covering Sustainability, Innovation and Digital Work Processes.

Blake, A. 2019. Private communication; Director of PACNEXT and PAC Food Waste; Retired Executive of Package Development & Design covering Sustainability, Innovation and Digital Work Processes.

Brooks, M. 2019. 'Single use' plastic bags are not single use; Frederick News-Post; June 21, 2019. Accessible from: https://www.fredericknewspost.com/opinion/letter_to_editor/single-use-plastic-bags-are-not-single-use/article_340d3370-51f5-5d57-ba65-ca2b2c4547ef.html

Brown J, Kuzma J. 2013. Hungry for information: public attitudes toward food nanotechnology and labeling. Rev Policy Res 30:512–548

Buchanan, E. 2019. THE SMART SUPERMARKET: How retailers can innovate beyond single-use plastics and packaging; Greenpeace. Accessible from: https://www.greenpeace.org/canada/en/publication/27357/the-smart-supermarket-how-retailers-can-innovate-beyond-single-use-plastic-and-packaging/

Bulk Barn Homepage (2019). Viewed: https://www.bulkbarn.ca/Reusable-Container-Program/

Burrows, D. 2018. The Grocer Vision Report: Beyond Plastics. Grocery Packaging in a Sustainable Future. Paid for by Price Waterhouse Cooper. Editor: Nick Hughes Writer: David Burrows. Estimated date: 2018.

CCME (Canadian Council of Ministers of the Environment). 2019. Canada-Wide Action Plan On Zero Plastic Waste: Phase 1. June 27, 2019. Accessible from: https://www.ccme.ca/files/Resources/waste/plastics/1289_CCME%20Canada-wide%20Action%20Plan%20on%20Zero%20Plastic%20Waste_EN_June%2027-19.pdf

Camilleri, A., Larrick, R., Hossain, S., Patino-Echeverri, D. 2019. Consumers Underestimate the Emissions Associated With Food But Are Aided By Labels; Nature Climate Change; January 2019; Vol. 9: 53-58. Accessible from: https://www.nature.com/articles/s41558-018-0354-z.epdf?author_access_token=ZXWI0btyZIWQwj7rLOmtntRgN0jAjWel9jnR3ZoTv0NsSCbRFysgh2dTg6tP9Ljh3ZPfMqfetXSOGIC-loyi9eSLPa_3h1Oh2J4xrzN9fuDn2ABJwxsSNwutYvhREct9TXGhEj9cBajpa94vlPahBw%3D%3D

Canadian Press. 2019. “Metro to allow reusable containers in effort to cut waste”, Canadian Grocer. Published April 16, 2019. Accessible from: http://www.canadiangrocer.com/top-stories/headlines/metro-to-allow-reusable-containers-in-effort-to-cut-waste-86813

Carrefour. 2019a. Carrefour is taking action against plastic packaging; Our Commitments; Carrefour. Accessing from: http://www.carrefour.com/current-news/carrefour-is-taking-action-against-plastic-packaging

Carrefour. 2019b. Anti-food waste; Our Commitments; Carrefour. Accessible from: http://www.carrefour.com/combating-waste/anti-food-waste

CBC. 2018. Canada will meet climate targets despite emissions gap: environment minister; Canadian Broadcasting Corporation; March 6, 2018. Accessible from: https://www.cbc.ca/news/politics/emissions-gap-mckenna-2030-target-1.4563801

CDBQ. 2019. Réduction du gaspillage de viandes fraîches dans le secteur du commerce au detail (Reducing fresh meat waste in the retail sector); Centre de développement bioalimentaire du Québec. Accessible from: https://www.recyc-quebec.gouv.qc.ca/sites/default/files/documents/fiche-aide-financiere-cdbq.pdf

CGRi. 2020. The Circularity Gap Report: 2020; Circularity Gap Reporting Initiative. Accessible from: https://www.circularity-gap.world/2020

Chandra Lal, R; Yambrach, F., McProud, L. 2015. "Consumer Perceptions Towards Package Designs: A Cross Cultural Study," Journal of Applied Packaging Research: Vol. 7: No. 2, Article 4. DOI: 10.14448/japr.04.0004; Available at: http://scholarworks.rit.edu/japr/vol7/iss2/4

Chemistry Industry Association of Canada (CIAC) 2019. "The Role of Chemistry in a Circular Economy for Plastics". February 2019. Access via: https://canadianchemistry.ca/wp-content/uploads/2019/02/CIAC_circular_economy_for_plastics.pdf

Chevalier, J 2018. "In your blue box, not all plastics are created equal", CBC News. Published Sep 12, 2018. Accessible from: https://www.cbc.ca/news/canada/ottawa/plastic-valuable-ottawa-recycling-1.4818980

City of Guelph. 2019. 50x50x50 by 2025: Creating Canada's First Circular Food Economy; City of Guelph and the County of Wellington. Accessible from: https://guelph.ca/wp-content/uploads/SmartCities_Booklet.pdf

City of Surrey Website 2018. North America's First Closed-Loop Waste Management System Opens in Surrey. Posted March 9, 2018. Accessible from: https://www.surrey.ca/city-government/26297.aspx

Colicchio, I., Goertz, H. 2018. How smarter plastic packaging helps to reduce food waste; DSM Engineering Plastics; November 23, 2018. Accessible from: https://www.dsm.com/markets/engineering-plastics/en/blog/how-smarter-plastic-packaging-helps-reduce-food-waste.html

Cooke, H. 2019. Government moves to ban plastic fruit stickers, cutlery, and cotton buds; National, Politics, Stuff.co.NZ; December 8, 2019. Accessible from: https://www.stuff.co.nz/national/politics/118018134/government-moves-to-ban-plastic-fruit-stickers-cutlery-and-cotton-buds

Cooman, S. 2018. "Packaging Fresh Produce in Cardboard trays with top seal", Fresh Plaza. November, 1, 2018. Accessible from: https://www.freshplaza.com/article/9038127/packing-fresh-produce-in-cardboard-trays-with-top-seal/

Cotterman, R. 2018. Private communication; Vice President, Sustainability; Sealed Air.

CPIA AND CIAC Press Release. 2019. Canada's chemistry and plastics industries share federal government's concerns about mismanagement of plastic waste. June 10, 2019.

CPMA (Canadian Produce Marketing Association). 2019. Produce Industry Plastic Packaging Stakeholder Working Group; July 9, 2019; Toronto.

Crawford Packaging. 2019. Going Green with Top Seal Packaging, case study. Accessible from: https://crawfordpackaging.com/case-studies/top-seal-financing

Crossmark. 2016. Consumer Preferences: The Reality; CPMA Consumer Engagement Program Results; Crossmark Canada.

Daggett, D. 2017. Global Perspectives on Food Waste and Packaging; Sustpack 2017, April 24-26, 2017; Scottsdale, Arizona

Deloitte. 2019. Economic Study of the Canada Plastics Industry, Markets and Waste; Summary report to Environment and Climate Change Canada.

Dennis, A. 2017. Packaging and Food Waste; Director, Technical Packaging & Environmental Officer, Nestle Canada; Presentation at Canada's 2017 Food Loss and Waste Forum; Mississauga, April 12, 2017

DEFRA. 2009. "Making the most of packaging. A strategy for a low-carbon economy". Department for Environment, Food & Rural Affairs; Published 30 March 2011. Accessible from: http://www.defra.gov.uk/environment/waste/topics/packaging/strategy.htm

Dilkes-Hoffman, L, Lane, J., Grant, T., Pratt, S., Lant, P., Laycock, B. 2018. "Environmental impact of biodegradable food packaging when considering food waste", School of Chemical

Engineering, The University of Queensland, St Lucia, QLD, Australia, Journal of Cleaner Production. June 2018

Dillon, N. 2016. “Are Tote Bags Really Good for the Environment?” The Atlantic. Sept 2, 2016. Accessible from: https://www.theatlantic.com/technology/archive/2016/09/to-tote-or-note-to-tote/498557/

Dyer, L., Simonson, W. 2019. Compostable Packaging: Understanding the What, Why, and Where; PAC and AMERIPEN Webinar; September 19, 2019.

Éco Enterprises Quebec & RECYC-QUÉBEC. 2020. How Can We Improve Our Recycling?; RECYC-QUÉBEC; Accessible from: http://recreer.recyc-quebec.gouv.qc.ca/en/how-can-we-improve-our-recycling

Edwards, C., Meyhoff Fry, J. 2011. Life cycle assessment of supermarket carrier bags: a review of the bags available in 2006; Environment Agency, Bristol, UK. Accessible from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291023/scho0711buan-e-e.pdf

EIA & Greenpeace. 2019. Checking Out on Plastics II: Breakthroughs and backtracking from supermarkets; Environmental Investigation Agency and Greenpeace. Accessible from: https://eia-international.org/wp-content/uploads/Checking-Out-on-Plastics-2-report.pdf

Ellen MacArthur Foundation 2019a. Circular Economy; Ellen MacArthur Foundation. View web page: https://www.ellenmacarthurfoundation.org/circular-economy/concept

Ellen MacArthur Foundation. 2019b. Food initiative: Igniting a food system transformation; Ellen MacArthur Foundation. Accessible From: https://www.ellenmacarthurfoundation.org/our-work/activities/food

Ellen MacArthur Foundation. 2019c. Cities and Circular Economy for Food; Ellen MacArthur Foundation. Accessible from: file:///C:/Users/Martin/Documents/Projects%20-%20VCMI/NZWC/Background%20Info/Cities-and-Circular-Economy-for-Food_280119.pdf

Ellen MacArthur Foundation. 2019d. Chile joins Plastics Pact network; Ellen MacArthur Foundation. April 15, 2019. Accessible from: https://www.ellenmacarthurfoundation.org/news/chile-joins-plastics-pact-network

Ellen MacArthur Foundation. 2017. What is the circular economy?; Ellen MacArthur Foundation. Accessible from: https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy

EPA. 2019. Waste Reduction Model (WARM): Version 15; United States Environmental Protection Agency. Accessible from: https://www.epa.gov/warm/versions-waste-reduction-model-warm#15

EPA. 2015. Reducing Wasted Food & Packaging: A Guide for Food Services and Restaurants; United States Environmental Protection Agency. Accessible from: https://www.epa.gov/sites/production/files/2015-08/documents/reducing_wasted_food_pkg_tool.pdf

EPA. 2017. Sustainable Management of Food Basics; United States Environmental Protection Agency; last updated March 8, 2017; Available from: https://www.epa.gov/sustainable-management-food/sustainable-management-food-basics

EPA (2006) Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks Report; United States Environmental Protection Agency. Accessible from: Exhibit 2-2, pg. 24

EPA. Date unknown. “The Benefits of Anaerobic Digestion of Food Waste At Wastewater Treatment Facilities”. United States Environmental Protection Agency. Accessible from: https://www.epa.gov/sites/production/files/documents/Why-Anaerobic-Digestion.pdf

Euromonitor 2017a. Food Waste: Implications and Opportunities. Nov 2017 Accessible from: https://www.euromonitor.com/food-waste-implications-and-opportunities/report

Euromonitor 2017b. Global Packaging Sustainability: Turning Necessity into Opportunity. September 2017. Accessible from: https://www.euromonitor.com/global-packaging-sustainability-turning-necessity-into-opportunity/report

Euromonitor 2018 Plastic Packaging in Foods: Untangling the Waste Issues. May 2018. Accessible from: https://www.euromonitor.com/plastic-packaging-in-foods-untangling-the-waste-issues/report

Euromonitor 2018b. Global Food Packaging: Innovating for the Consumer of the Future. May 2018. Accessible from: https://www.euromonitor.com/global-food-packaging-innovating-for-the-consumer-of-the-future/report

European Environmental Agency 2016. "Case Study 2: Sweden. Sweden: Agreement on Producer Responsibility for Packaging". Published April 20, 2016. Accessible from: https://www.eea.europa.eu/publications/92-9167-052-9-sum/page005.html

European Union 2018. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: A European Strategy for Plastics in a Circular Economy {SWD (2018) 16 final}

European Union 2018a. "Proposal for a Directive of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment", European Commission 28th May 2018. Accessible from: https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A52018PC0340

Ferguson, I. 2019. Chantler Packaging, Ontario; Private communication.

Flanagan, K., Robertson, K., Hanson, C. 2019. Reducing Food Loss and Waste: Setting a Global Action Agenda; World Resources Institute. Accessible from: https://www.wri.org/publication/reducing-food-loss-and-waste-setting-global-action-agenda

FPA. 2015. Food Waste Reduction: Flexible Packaging Extends Shelf Life; Flexible Packaging Association; Annapolis, MD. Accessible from: https://www.flexpack.org/sustainable-packaging/food-waste-reduction/

Franklin. 2010. Life Cycle Inventory of 100% Postconsumer HDPE and PET Recycled Resin From Postconsumer Containers and Packaging: Final Report; Franklin Associates, a Division of ERG Prairie Village, Kansas. Accessible from: https://plasticsrecycling.org/images/pdf/PE_PP_Resins/Life-Cycle-Inventory-Study/Life_Cycle_Inventory.pdf

French Packaging Association Conseil National De L'Emballage). 2011. Prévention du gaspillage et des pertes des produits de grande consommation: Le rôle clé de l'emballage; Paris, France. Accessible from: https://conseil-emballage.org/la-prevention-du-gaspillage-et-des-pertes-des-produits-de-grande-consommation-le-role-cle-de-lemballage/

Fresh Plaza. 2019a. "93,000 tonnes of packaging waste for fresh fruits and vegetables", Fresh Plaza. Published Feb 26, 2019. Accessible from: https://www.freshplaza.com/article/9075982/93-000-tonnes-of-packaging-waste-for-fresh-fruits-and-vegetables/In Germany

Fresh Plaza. 2019b. Major UK supermarkets to ditch apple labels: "Plastic Pledge' spells end of the apple sticker; Fresh Plaza; December 18, 2019. Accessible from: https://www.freshplaza.com/article/9174180/major-uk-supermarkets-to-ditch-apple-labels/

Fuqing, X., Yangyang, L, Xumeng, G., Liangcheng, Y., Yebo L. 2018. "Anaerobic digestion of food waste – Challenges and opportunities", Bioresource Technology. Volume 247, January 2018, Pages 1047-1058. Accessible from: https://www.sciencedirect.com/science/article/pii/S0960852417315687

Garcia, C. L. 2019. Circular Economy and Sustainable Development Goals in the Americas; Circular Economy Platform; May 17, 2019. Accessible from: https://www.cepamericas.com/single-post/2019/05/17/Circular-Economy-and-Sustainable-Development-Goals-in-the-Americas

George, S. 2018. “Are the days of recycling with a clear conscience over?” The Guardian. Oct 22, 2018. Viewed online: https://www.theguardian.com/commentisfree/2018/oct/22/recycling-fuels-consumption-plastic

Goldring, N. 2020. The Relationship Between Fresh Produce Packaging, Food Waste And Recycling In The Home; Australian Fresh Produce Alliance. Accessible from: http://www.freshproduce.org.au/resources/

Goldsberry, C. 2018. “Glass or plastic? Study profiles changing consumer attitudes”, Plastics Today. Aug 30, 2018. Accessible from: https://www.plasticstoday.com/packaging/glass-or-plastic-study-profiles-changing-consumer-attitudes/188152184759378

Gooch, M. 2020. Store Visits and Examination of Packaging and Loose/Bulk Food Merchandizing Initiatives Undertaken by UK Retailers; January, 2020.

Gooch, M., Bucknell, D., LaPlain, D. 2020. Estimating the Greenhouse Gas (GHG) Footprint of Household Food Waste in Oakville; Halton Environmental Network. Accessible from: https://haltonenvironet.ca/

Gooch, M., Bucknell, D., LaPlain, D., Dent, B., Whitehead, P., Felfel, A., Nikkel, L., Maguire, M. 2019a. The Avoidable Crisis of Food Waste: Technical Report; Value Chain Management International and Second Harvest; Ontario, Canada. Accessible from: https://secondharvest.ca/research/the-avoidable-crisis-of-food-waste/

Gooch, M., Bucknell, D., Laplain, D., Whitehead, P. 2019b. A landscape review of plastic packaging in the Canadian fresh produce industry; Canadian Produce Marketing Association. Accessible from: https://cpma.ca/docs/default-source/corporate/2019/cpma-executive-summary-of-technical-report.pdf

Gooch, M., Bucknell, D., Whitehead, P. 2018. "Quantifying the Value of Packaging: As a Strategy to Prevent Food Waste in America, AMERIPEN". Accessible from: https://c.ymcdn.com/sites/www.ameripen.org/resource/resmgr/files/AMERIPENWhitePaper-FoodWast.pdf

Gooch, M., Dent, B., Felfel, A.S., Vanclief, L., Whitehead, P. 2016. "Food Waste: Aligning Government and Industry within Value Chain Solutions". Value Chain Management International. Accessible from: http://vcm-international.com/wp-content/uploads/2016/10/Food-Waste-Aligning-Government-and-Industry-VCMI-Oct-4-2016.pdf

Gooch, M., Felfel, A. 2014. $27 Billion Revisited: The Cost of Canada's Annual Food Waste. Value Chain Management International. Accessible from: http://vcm-international.com/wp-content/uploads/2014/12/Food-Waste-in-Canada-27-Billion-Revisited-Dec-10-2014.pdf

GC (Government of Canada). 2019. Ocean Plastics Charter (main webpage); Government of Canada.. Accessible from: https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/international-commitments/ocean-plastics-charter.html

GC (Government of Canada). 2018. Canada's Implementation of the 2030 Agenda for Sustainable Development; Government of Canada. Accessible from: https://sustainabledevelopment.un.org/content/documents/20033CanadasVoluntaryNationalReviewENv6.pdf

Green Dot BioPlastics. 2019. A Better BioPlastic For a Better World. Accessible from: https://www.greendotbioplastics.com/

Greenpeace. 2019. Throwing Away The Future: How Companies Still Have It Wrong On Plastic Pollution "Solutions". Greenpeace. Accessible from: https://www.greenpeace.org/canada/en/publication/26745/throwing-away-the-future-how-companies-still-have-it-wrong-on-plastic-pollution-solutions/

Gov UK. 2018. Packaging waste: producer responsibilities: Guidance; United Kingdom Government. Accessible from: https://www.gov.uk/guidance/packaging-producer-responsibilities

Grand View Research 2019. Global Plastics Market Data. Viewed online: https://www.grandviewresearch.com/industry-analysis/global-plastics-market

Gray, A 2017. "Germany recycles more than any other country", World Economic Forum. December 2017. Viewed online: https://www.weforum.org/agenda/2017/12/germany-recycles-more-than-any-other-country/

Grill, T. 2017. Food Waste Reduction Opportunities and Solutions through Packaging; Director, Sustainability Americas; Sealed Air; Presentation at Canada's 2017 Food Loss and Waste Forum; Mississauga, April 12, 2017

Gunders, D. 2012. Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill; National Resource Defense Council. Accessible from: https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

Hall, D 2019. "Why replacing plastics is a complicated task", Food Manufacture. June 17, 2019. Accessible from: https://www.foodmanufacture.co.uk/Article/2019/06/17/Food-expert-tackles-plastics-issue

Hanson, C., Mitchell, P. 2017. The Business Case for Reducing Food Loss and Waste. Champions 12.3, (March), 1–24. Accessible from: https://champs123blog.files.wordpress.com/2017/03/report_-business-case-for-reducing-food-loss-and-waste.pdf

Hausfather, Z. 2018. UNEP: Limiting warming to 1.5C requires 'fivefold' increase in climate commitments; Carbon Brief; November 27, 2018. Accessible from: https://www.carbonbrief.org/unep-limiting-warming-to-1-5c-requires-fivefold-increase-in-climate-commitments

Hillman, K., Damgaard, A., Eriksson, O., Jonsson, D., Fluck, L. 2015. Climate Benefits of Material Recycling: Inventory of Average Greenhouse Gas Emissions for Denmark, Norway and Sweden; Nordic Council of Ministers. Accessible from: https://backend.orbit.dtu.dk/ws/portalfiles/portal/113053358/2015_Norden_Climate_Benefits_of_Material_Recycling.pdf

Howe, C. 2019. Ice River Springs. Presentation at the CPMA Plastic Packaging Stakeholder Working Group: October 1, 2019, Toronto.

IGD 2017a. Case study: Northern Foods - Goodfella's pizza box re-design; Institute of Grocery Distributors (IGD). Accessible from: http://igd.com/Research/Supply-chain/Waste-prevention/Six-to-fix-to-prevent-waste/Design/Northern-Foods---Goodfellas-pizza-box-re-design/

IGD. 2017b. Case study: Tesco - New pack format for chickens; Institute of Grocery Distributors (IGD). Accessible from: http://igd.com/Research/Supply-chain/Waste-prevention/Six-to-fix-to-prevent-waste/Design/Tesco---New-pack-format-for-chickens/

IÖGO website (viewed July 2019). https://www.iogo.ca/en/products/greek-0-plain-750g/

IPCC. 2019: Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.- O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. Accessible from: https://www.ipcc.ch/srccl/download/

Jarvis, C., Robinson, M. 2019. "The losing economics of recycling: Canada's green industry is deep in the red", Global News. May 28, 2019. Accessible from: https://globalnews.ca/news/5207256/economics-of-recycling-canada/

Jenkins Packaging (viewed July 2019). Accessible from: https://www.jenkinsfps.co.nz/top_seal_packaging_the_way_of_the_future

Johnson, K. 2018. "Milk bags avoid anti-plastic environmental backlash", The Western Producer. August 16, 2018. Viewed online: https://www.producer.com/2018/08/milk-bags-avoid-anti-plastic-environmental-backlash/

Klahre, A. 2017. Here's What to do With all Your Recyclable Shopping Bags; Kitchn. December 18, 2017. Accessible from: https://www.thekitchn.com/heres-what-to-do-with-all-your-reusable-shopping-bags-252560

Koelsch Sand, C. 2019. The Dynamics of Recycling Food Packaging; Food Technology; Institute of Food Technologists; July, 2019. Accessible from: https://www.researchgate.net/publication/333968934_The_Dynamics_of_Recycling_Food_Packaging

Koelsch Sand, C., Robertson, G. L. 2019. How to Reduce Packaging Waste, Food Technology; Institute of Food Technologists; February, 2019. Accessible from: https://www.ift.org/news-and-publications/food-technology-magazine/issues/2019/february/columns/packaging-how-to-reduce-packaging-waste

Kroger. 2019. A Sustainable Future: Zero Hunger, Zero Waste; Kroger's 2019 Environmental, Social & Governance (Esg) Report. Accessible from: http://sustainability.kroger.com/2020-goals.html

Kummu M, de Moel H, Porkka M, Siebert S, Varis O, Ward PJ. 2012. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. Science of The Total Environment. 2012; 438: 477–489. doi: 10.1016/j.scitotenv.2012.08.092 PMID: 23032564

Lacey, P., Spindler, W. 2019. "Sustainable packaging is good for profits as well as the planet", World Economic Forum. Viewed online: https://www.weforum.org/agenda/2019/01/most-plastic-packaging-is-unrecycled-that-has-to-change/

Lau OW, Wong SK. 2000. Contamination in food from packaging materials. J Chrom. A 882(1–2):255–70.

Leigh, S. 2019. Okay, What's Up With Compostable Plastics?; Key Information To Know Before Choosing Your Products; Quest University Canada. Accessible at: https://www.creativebc.com/2019/01/25/okay-whats-up-with-compostable-plastics.php

Lendal, A., Wingstrand, S. L. 2019. Reuse: Rethinking Packaging; Ellen MacArthur Foundation. Accessible from: https://www.ellenmacarthurfoundation.org/assets/downloads/Reuse.pdf

Linde Gas. undated. The ultimate combination for freshness. MAPAX® modified atmosphere packaging; Linde Gas Division, Pullach, Germany; Linde AG. Accessible at: http://www.linde-gas.com/internet.global.lindegas.global/en/images/MAPAX%20brochure17_4683.pdf

Lipinski, B., Hanson, C., Waite, R., Saerchinger, T., Lomax, J., Kitinoja, L. 2013. Reducing Food Loss and Waste: Creating a Sustainable Food Future, Installment Two; World Resources Institute; http://www.wri.org/publication/reducing-food-loss-and-waste

Litwin, K. 2017. Montreal's Épicerie Loco Champions Zero-Waste Shopping; Montreal Gazette; March 9, 2017. Accessible from: https://montrealgazette.com/news/local-news/montreals-epicerie-loco-champions-zero-waste-shopping

Lockrey, S., Verghese, K., Danaher, J., Newman, L., Barichello, V., Gama, L., D. 2019. The role of packaging for Australian fresh produce; Australian Fresh Produce Alliance. Accessible from: http://freshproduce.org.au/__static/46a2ec4557d1f3fde09c35c70f57f8bf/afpa-report-2019-digital-book_(2).pdf?dl=1

Loop. 2019. Homepage; Loop. Accessible from: https://loopstore.com/

Lord, R., Kao, G., Joshi, S., Gautham, P., Bartlett, C., Bullock, S., Burks, B., Baldock, C. Aird, S., Richens, J. 2016. Plastics and Sustainability: A Valuation of Environmental Benefits, Costs and Opportunities for Continuous Improvement; TruCost Plc & American Chemistry Council; July 2016. Accessible from: https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf

Lucas, C. 2019. Recycling crisis: Inner-city council in trial of fourth bin for glass; The Age: Politics, Victoria, Recycling; April 28, 2019. Accessible at: https://amp.theage.com.au/politics/victoria/recycling-crisis-inner-city-council-in-trial-of-fourth-bin-for-glass-20190428-p51hw0.html

Marchal, V., Dellink, R., van Vuuren, D., Clapp, C., Château, J., Lanzi, E., Magné, B., van Vliet, J. 2011. OECD Environmental Outlook to 2050: Climate Change Chapter; OECD Environment Directorate and the PBL Netherlands Environmental Assessment Agency; Organisation for Economic Co-operation and Development. Accessible from: https://www.oecd.org/env/cc/49082173.pdf

Maddox, P. 2019. Removal of packaging must be done carefully to avoid food waste; The Grocer: Environment; November 4, 2019. Accessible from: https://www.thegrocer.co.uk/environment/removal-of-packaging-must-be-done-carefully-to-avoid-food-waste/599147.article

Market & Smor. 2019. Market & Smor Homepage. Accessible from: https://www.themarketsmor.com/

Marsh, K., Bugusu, B. 2007a. Food Packaging and its Environmental Impact; Journal of Food Science; Institute of Food Technologists; April, 2007. Accessible from: https://www.researchgate.net/publication/296867329_Food_packaging_and_its_environmental_impact

Marsh, K., Bugusu, B. 2007b. Food Packaging -- Roles, Materials, and Environmental Issues; Institute of Food Technologists; Journal of Food Science. April 2007. 72 (3), R39–R55. doi:10.1111/j.1750-3841.2007.00301 Accessible from: https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1750-3841.2007.00301.x

McCurry, J., 2019. “Japan's plastic problem: Tokyo spearheads push at G20 to tackle waste”, The Guardian. Published June 27, 2019. Accessible from:

https://www.theguardian.com/world/2019/jun/27/japans-plastic-problem-tokyo-spearheads-push-at-g20-to-tackle-waste

McEwen Associates. 2014. The Value of Flexible Packaging in Extending Shelf Life and Reducing Food Waste; Flexible Packaging Association, Annapolis, MD. Accessible from: https://www.flexpack.org/sustainable-packaging/food-waste-reduction/

Method Website viewed July 2019. https://methodhome.com/beyond-the-bottle/packaging/

MEFD: Ministry of Environment and Food of Denmark 2018. "Life Cycle Assessment of grocery carrier bags." February 2018. Accessible from: https://www2.mst.dk/Udgiv/publications/2018/02/978-87-93614-73-4.pdf

Mintz, C. 2018. "How one Toronto organization is saving good food from the garbage", The Globe and Mail. May 16, 2018. Accessible from: https://www.theglobeandmail.com/life/food-and-wine/food-trends/how-one-organization-is-saving-millions-of-pounds-of-food-from-the-garbage/article30058349/

Molina-Besch, K., Wikström, F., Williams, H. 2019. "The environmental impact of packaging in food supply chains—does life cycle assessment of food provide the full picture?", The International Journal of Life Cycle Assessment. January 2019, Volume 24, Issue 1, pp 37–50. Accessible from: https://link.springer.com/article/10.1007/s11367-018-1500-6

Morassutti, M. 2017. "Passport 2017: The Tale of Canada's Infamous Bagged Milk". May 5, 2017. Viewed online: https://passport2017.ca/articles/made-in-canada-milk-in-a-bag

Morrison, O. 2020. Iceland Launches Trial to Reduce Plastic Packaging on Fresh Produce by 90%; Food Navigator; William Reed; May 24, 2019. Accessible from: https://www.foodnavigator.com/Article/2020/02/05/Iceland-launches-trial-to-reduce-plastic-packaging-on-fresh-produce-by-over-90?utm_source=newsletter_daily&utm_medium=email&utm_campaign=05-Feb-2020

Morrison, O. 2019a. Morrisons to introduce plastic-free fruit and veg in 60 stores after positive trials; Food Navigator; William Reed; May 24, 2019. Accessible from: https://www.foodnavigator.com/Article/2019/05/24/Morrisons-to-introduce-plastic-free-fruit-and-veg-in-60-stores-after-positive-trials?utm_source=newsletter_daily&utm_medium=email&utm_campaign=28-May-2019&c=ETTNhvNBQU0I2whD7pakacssECn%2BjXbR&p2=

Morrison, O. 2019b. Consumer attitudes to plastic bordering on 'militant' but is food waste forgotten?; Food Navigator; William Reed; July 19, 2019. Accessible from: https://www.foodnavigator.com/Article/2019/07/18/Consumer-attitudes-to-plastic-bordering-on-militant-but-is-food-waste-forgotten?utm_source=newsletter_daily&utm_medium=email&utm_campaign=18-Jul-2019&c=ETTNhvNBQU2%2F0tYnLW1DQeX1ICbqkSDt&p2=

Morrison, O. 2019c. From plastics to plant based, businesses must find "intelligent ways forward" for sustainable foods. Food Navigator; William Reed; October 18, 2019. Accessible from: https://www.foodnavigator.com/Article/2019/10/18/Good-Business-CEO-Giles-Gibbons-discusses-totemic-issues-of-climate-change-and-equality/?utm_source=Newsletter_Subject&utm_medium=email&utm_campaign=Newsletter%2BSubject&c=ETTNhvNBQU0fyMArN2xDZ2%2BOpAXKcIsj

Murray, A., Meyer, D. 2019. Talking Trash With Dow's Jim Fitterling: CEO Daily; Fortune; June 26, 2019. Accessible from: https://fortune.com/2019/06/26/talking-trash-with-dows-jim-fitterling-ceo-daily/

NAPCOR & APR. 2018. Postconsumer PET Container Recycling Activity in 2017; National Association for PET Container Resources (NAPCOR), the Association of Plastic Recyclers (APR); November 15, 2018. Accessible from: http://www.plasticsmarkets.org/jsfcode/srvyfiles/wd_151/napcor_2017ratereport_final_1.pdf

NZWC. 2018. A Food Loss and Waste Strategy for Canada: National Zero Waste Council; May, 2018. Accessible from: http://www.nzwc.ca/focus/food/national-food-waste-strategy/Documents/NZWC-FoodLossWasteStrategy.pdf

Nature Fresh website: https://www.naturefresh.ca/

Nature Knows Website: https://www.natureknows.ca/

Neff RA, Spiker ML, Truant PL 2015a. Wasted Food: U.S. Consumers' Reported Awareness, Attitudes, and Behaviors. PLoS ONE 10 (6): e0127881. doi:10.1371/journal.pone.0127881

Neff, RA. 2015b U.S. Consumer Awareness, Attitudes, and Behaviors Related to Food Waste; Department of Environmental Health Sciences, John Hopkins Bloomberg School of Public Health; Baltimore, MA

Nielson 2019. Sustainability Continues to Drive Sales Across the CPG Landscape. May 1, 2019. Accessible from: https://www.nielsen.com/us/en/insights/article/2019/sustainability-continues-to-drive-sales-across-the-cpg-landscape/

Nosowitz, D. 2018. Those Little Stickers? They are a Big Waste Problem; Environment, Food and Drink; Modern Farmer; March 15, 2018. Accessible from: https://modernfarmer.com/2018/03/little-produce-stickers-are-big-waste-problem/

O'Dea, K. 2015. How packaging plays in the circular economy; Greenbiz; March 24, 2015. Accessible from: https://www.greenbiz.com/article/how-circular-economy-plays-out-packaging

O'Sullivan, C. 2018. The Food Waste Scorecard. Published June 2018 by FeedbackGlobal.org

OECD 2016. "Extended Producer Responsibility: Updated Guidance for Efficient Waste Management, OECD Publishing", Paris. Accessible from: https://www.oecd.org/environment/waste/extended-producer-responsibility-9789264256385-en.htm

Paben, J. 2018. Quantifying Environmental Benefits of Recycled Plastic; Resource Recycling; August 28, 2018. Accessible from: https://resource-recycling.com/recycling/2018/08/28/quantifying-environmental-benefits-of-recycled-plastic/

PAC. 2019. Executive Summary of Food Waste Reduction Case Studies; September 25, 2019; Accessible from: http://www.pac.ca/Programs/FW/Documents/foodwaste-case-study-summary-2019.pdf

PAC 2017. "PAC FOOD WASTE: Executive Summary of Food Waste Reduction Case Studies". Accessible from: http://www.pac.ca/Programs/FW/Documents/pacfood-execsum-2016.pdf

PAC 2014. Food Waste Reduction Case Studies; PAC Food Waste; PAC. Accessible from: http://www.pac.ca/assets/2014-foodwaste-casestudies.pdf

Patel, A. 2018. The Biggest Recycling Mistakes Canadians Continue to Make; Global News, April 24, 2018. Accessible from: https://globalnews.ca/news/4153053/biggest-recycling-mistakes/

Peake, L. 2020. Plastic promises: What the Grocery Sector is Really Doing About Packaging; Green Alliance. Accessible from: https://www.green-alliance.org.uk/resources/Plastic_promises.pdf

Perugini, F., Mastellone, M. L., Arena, U. 2005. Recycling options for management of plastic packaging wastes; Environmental Progress 24(2):137 – 154. Accessible from: https://www.researchgate.net/publication/229447045_Recycling_options_for_management_of_plastic_packaging_wastes

Philippidisab, G., Sartoria, M., Ferraria, E., M'Bareka, R. 2019 "Waste not, want not: A bio-economic impact assessment of household food waste reductions in the EU", Resources, Conservation and Recycling Volume 146, July 2019, Pages 514-522. Accessible from: https://www.sciencedirect.com/science/article/pii/S0921344919301788?via%3Dihub

Plummer. R. 2018. Plastic fantastic: How it changed the world; BBC News; British Broadcasting Corporation; January 11, 2018. Accessible from: https://www.bbc.com/news/business-42646025

Powell, C. 2019. "Ending the plastic age. Grocers are big contributors of plastic waste, but efforts are underway to curb it", Canadian Grocer. May 23, 2019. Accessible from: http://www.canadiangrocer.com/worth-reading/ending-the-plastic-age-87410?utm_source=EmailMarketing&utm_medium=email&utm_campaign=Newsletter

Recycling Produce News 2018. "First of its kind closed-loop waste management system opens in Surrey". March 12, 2018. Accessible from: https://www.recyclingproductnews.com/article/27765/first-of-its-kind-closed-loop-waste-management-system-opens-in-surrey

Recyc-Quebec. 2017. Faits saillants des résultats de l'analyse du cycle de vie environnementale et économique des sacs d'emplettes (Environmental and Economic Analysis of Shopping Bags); Recyc-Quebec. Accessible from: https://www.recyc-quebec.gouv.qc.ca/municipalites/mieux-gerer/informations-banissement-sacs-plastique

RECYC-QUEBEC. 2019. Circular Economy; RECYC-QUEBEC. Accessible from: https://www.recyc-quebec.gouv.qc.ca/sites/default/files/documents/feuillet-economie-lineaire-circulaire-english-version.pdf

ReFED. 2020. 27 Solutions to Food Waste: The benefits of each of these solutions outweigh the costs. Accessible from: https://www.refed.com/?sort=emissions-reduced

ReFED. 2016. A Roadmap to Reduce U.S. Food Waste by 20 Percent. Accessible from: http://www.refed.com/downloads/ReFED_Report_2016.pdf

Region of Peel Website viewed July 2019. How to sort your waste. Accessible from: http://www.peelregion.ca/scripts/waste/how-to-sort-your-waste.pl?action=search&query=Pizza%20box%20%28greasy%29

Resource Association. 2015. Survey Shows Strong Public Support for Recycling Content in Plastic Bottles and Legislation to Mandate Recycled Content: The Public Wants Our UK Plastics Recycling Industry; Resource Association, Otley, England. Accessible from: http://www.resourceassociation.com/news/survey-shows-strong-public-support-recycled-content-plastic-bottles-and-legislation-mandate

Resource Polymers. 2011. GHG Emission Reductions Verification Report; Resource Polymers Inc.; Accessible from: https://www.csaregistries.ca/files/projects/prj_7878_1007.pdf

Roco MC, Mirkin CA, Hesam MC. 2010. Nanotechnology research directions for societal needs in 2020: retrospective and outlook. WTEC Study on Nanotechnology Research Directions, World Technology Evaluation Center, Arlington

Ross, J. 2019. Private communication; rPlanet Earth; California; https://www.rplanetearth.com/

Rowan, J. 2019. Could Single-Use Plastics Actually be the Best for the Environment?; The Food Institute Blog; August 6, 2019: Accessible from: https://foodinstitute.com/blog/single-use-plastics-best

Rulibikiye, A. 2019. Private Conversation; Food Packaging Materials and Incidental Additives Section, Health Canada.

Sagan, A. 2019. No-waste grocery stores not a garbage idea to help tackle food waste; Canadian Press; January 31, 2019.

Sand, C. 2019b. The Complexities of Compostable Food Packaging; Food Technology Magazine; Institute of Food Technologists; October 1, 2019. Accessible from: https://www.ift.org/news-and-publications/food-technology-magazine/issues/2019/october/columns/packaging-complexities-of-compostable-food-packaging

Saputo. 2019a. Our Australian Brand Sungold Works to Significantly Reduce its Plastic Use; Case studies: Packaging; Saputo. Accessible from: https://www.saputo.com/en/our-promise/case-studies/packaging

Scott, B., Butler, P. 2006. Packaging technologies with potential to reduce the amount of food thrown away; WRAP. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Pckg%20formats%20food%20waste%20tech%2018%20Dec%20MCB1.pdf

Sealed Air. 2019. Sealed Air Announces Bold 2025 Sustainability and Plastics Pledge; Sealed Air. Accessible from: https://sealedair.com/media-center/news/sealed-air-announces-bold-2025-sustainability-and-plastics-pledge

Sealed Air 2015. Taking Stock: Retail Shrink Solutions; Sealed Air Corporation, Charlotte, NC. Accessible from: https://sealedair.com/sites/default/files/White%20Paper%20Retail%20Shrink__040115%20revision.pdf

Sealed Air 2017. Private discussions with Sealed Air Corporation (Food Care Division), Charlotte, NC

Second Harvest. 2017. Toss or keep? A Guide: Best Before Dates vs. Expiry Dates; Second Harvest; June 30, 2017. Accessible from: https://secondharvest.ca/uncategorized/toss-keep-guide-best-dates-vs-expiry-dates/

Schroeder P., Anggraeni, K., Weber, E. 2018, "The Relevance of Circular Economy Practices to the Sustainable Development Goals". Journal of Industrial Ecology, V. 23; number 1; DOI: 10.1111/jiec.12732. Accessible from: https://onlinelibrary.wiley.com/doi/full/10.1111/jiec.12732

Skoda, E. 2018. "Getting ready for the German Packaging Law", Packaging Europe. Dec 14, 2018. Accessible from: https://packagingeurope.com/getting-ready-for-the-german-packaging-law/

Sloan, E., Adams Hutt, C. 2017. "Getting Ahead of the Curve: Sustainability (Gen 2)". Nutraceuticalsworld.com. Dec 4, 2017. Viewed online:

https://www.nutraceuticalsworld.com/issues/2017-12/view_trendsense/getting-ahead-of-the-curve-sustainability-gen-2/

Smith, L. 2019. Plastic Waste; House of Commons Library Briefing Paper Number 08515; 17 June, 2019. Accessible from: https://researchbriefings.files.parliament.uk/documents/CBP-8515/CBP-8515.pdf

Sobeys. 2019. Packaging and Materials: Plastic and Packaging; Sobeys Inc. Accessible from: https://corporate.sobeys.com/sustainability/packaging-and-materials/

Southey, F. 2019. "Plastic waste 'state of play' reveals just 9 countries have specific prevention targets", Food Navigator; William Reed; June 6, 2019. Accessible from: https://www.foodnavigator.com/Article/2019/06/06/Plastic-waste-state-of-play-reveals-just-9-countries-have-specific-prevention-targets?utm_source=newsletter_daily&utm_medium=email&utm_campaign=10-Jun-2019&c=ETTNhvNBQU1KuEmxzRGkzgoFfzXMXfkY&p2=

Speare-Cole, R. 2019. Iceland relaunches plastic-free packaging after first trials fail to resonate with shoppers; Evening Standard; July 22, 2019. Accessible from: https://www.standard.co.uk/news/uk/iceland-relaunches-plasticfree-packaging-after-first-trials-fail-to-resonate-with-shoppers-a4195831.html

Sprang, E. S., Moreno L. C., Pace, S. A., Achmon, Y., Irwin Donis-Gonzalez, I., Gosliner, W. A., Jablonski-Sheffield, M. P., Abdul Momin, Md, Quested, T. E. Winans, K. S., Tomich, T. P. 2019. Food Loss and Waste: Measurement, Drivers, and Solutions; Annual Review of Environment and Resources; 2019. 44:117–56. Accessible at: https://www.annualreviews.org/doi/abs/10.1146/annurev-environ-101718-033228

St. Goddard, J. 2019. Plastic Waste: The State of Recycling in Ontario; Recycling Council of Ontario; Presentation at the CPMA Plastic Packaging Stakeholder Working Group: July 9, 2019, Toronto.

Staffer, C. 2019. Are edible peels the new plastics?; Fresh Plaza; December 6, 2019. Accessible from: https://www.freshplaza.com/article/9170670/are-edible-peels-the-new-plastics/

Staley, S. 2009. The Link Between Plastic Use and Climate Change: Nitty-gritty; Stanford Magazine; November/December, 2009. Accessible from: https://stanfordmag.org/contents/the-link-between-plastic-use-and-climate-change-nitty-gritty

Stanford University. 2019. Contamination in Recycling. Accessible from: https://lbre.stanford.edu/pssistanford-recycling/frequently-asked-questions/frequently-asked-questions-contamination

Statistics Canada 2006. Waste Management Industry Survey: Business and Government Sectors, Catalogue no. 16F0023XIE

Statistics Canada viewed July 2019. Detailed food spending, Canada, regions and provinces. Date modified: 2019-07-26 Accessible from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110012501

Store Brands staff 2019. "Aldi expanding plastic-free produce pilot", Canadian Grocer. June 25, 2019. Accessible from: http://www.canadiangrocer.com/top-stories/headlines/aldi-expanding-plastic-free-produce-pilot-88047?utm_source=EmailMarketing&utm_medium=email&utm_campaign=Newsletter

Suggitt, J. 2018. The link between food waste and packaging; GreenBiz; November 23, 2018. Accessible from: https://www.greenbiz.com/article/link-between-food-waste-and-packaging

Summers, C. 2012. What Should Be Done About Plastic Shopping Bags?; Magazine; BBC News; British Broadcasting Corporation; March 19, 2012. Accessible at: https://www.bbc.com/news/magazine-17027990

Sunsetgrown.com viewed July 2019. https://www.sunsetgrown.com/products/eco-flavor-bowls/

Sweden (official website). 2019. The Swedish Recycling Revolution. Accessible from: https://sweden.se/nature/the-swedish-recycling-revolution/

Taylor, R, L, C. 2019. Bag leakage: The effect of disposable carryout bag regulations on unregulated bags; Journal of Environmental Economics and Management; Elsevier; Vol 93, PP. 254-271. Accessible from: https://doi.org/10.1016/j.jeem.2019.01.001

Technomic 2018 "Snacks Continue to Replace Meals" nutraceuticalsworld.com. March 13, 2018. Accessible from: https://www.nutraceuticalsworld.com/contents/view_breaking-news/2018-03-13/snacks-continue-to-replace-meals/2156

TerraCycle. 2019. Recycle Everything With Terracycle; Terracycle (Canada). Accessible from: https://www.terracycle.com/en-CA/

Tesco. 2016. An update on our Corporate Responsibility commitments; Tesco PLC; November 2016. Accessible from: https://www.tescoplc.com/media/391787/corporate-responsibility-update_nov-2016-final.pdf

Tesco. 2019a. Materials and Design; Tesco Sustainability. Accessible from: https://www.tescoplc.com/sustainability/packaging/topics/materials-and-design/

Tesco. 2019b. Tesco Preferred Materials. Accessible from: https://www.tescoplc.com/media/475041/preferred-materials-list-30818-website.pdf

Thackston, E. 2013. "The Effect of Packaging Material Properties on Consumer Food Quality Perception in Quick-Service Restaurants"; Graduate School, Clemson University, SC.

Thornton, T. 2018. "Here's how many times you actually need to reuse your shopping bags", Phys.org. August 6, 2018. Accessible from: at https://phys.org/news/2018-08-reuse-bags.html

Tita, B. 2019. Drink Makers Seek More Recycled Plastic; The Wall Street Journal; June 30, 2019. Accessible from: https://www.wsj.com/articles/drink-makers-seek-more-recycled-plastic-11561910599

TRT World. 2019. Swedish recycling so successful it is importing rubbish; TRT World; February 25, 2019. Accessible from: https://www.trtworld.com/europe/swedish-recycling-so-successful-it-is-importing-rubbish-24491

Udall, T., Lowenthal, A., Merkley, J., Clark, K. 2020. Break Free From Plastic Pollution Act of 2020; The Senate of the United States. Accessible from: https://www.tomudall.senate.gov/imo/media/doc/Bill%20Text-Udall-Lowenthal%20Break%20Free%20From%20Plastic%20Pollution%20Act.pdf

UNDP. 2019a. Sustainable Development Goals: Deadline 2030, The SDG Decade of Action; United Nations Development Program. Accessible from: https://www.undp.org/content/undp/en/home/sustainable-development-goals.html

UNDP. 2019b. Sustainable Development Goals: Goal 13: Climate action; United Nations Development Program. Accessible from: https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-13-climate-action.html

UNEP (date unknown). Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations; United Nations Environment Programme. Accessible from: https://www.unenvironment.org/resources/report/legal-limits-single-use-plastics-and-microplastics

UNEP. 2018 Single-Use Plastics: A Roadmap for Sustainability. https://wedocs.unep.org/handle/20.500.11822/25496

Unilever. 2019. Waste and Packaging; Rethinking plastic packaging – towards a circular economy; Unilever Global. Accessible from: https://www.unilever.com/sustainable-living/reducing-environmental-impact/waste-and-packaging/rethinking-plastic-packaging/

UNDESA. 2018. Webpage: Responsible Consumption and Production. United Nations Department of Economic and Social Affairs; Viewed online:

https://unstats.un.org/sdgs/report/2018/goal-12/ and https://unstats.un.org/sdgs/report/2018/goal-11/

Laboratory for Climate Action. 2019. Climate action barometer: Disposition of Quebecers facing climate challenges 2019; Laboratory for Climate Action; Unpointcing & Laval University. Accessible from: https://unpointcinq.ca/app/uploads/2020/01/BarometreUnPointCinq_FINAL.pdf

UPS. 2016. The Growth of the Circular Economy: A whitepaper. Accessible from: https://sustainability.ups.com/media/UPS_GreenBiz_Whitepaper.pdf

Uzea, N., Gooch, M., Sparling, D. 2014. Developing an Industry Led Approach to Addressing Food Waste in Canada; Provision Coalition. Accessible from: http://www.provisioncoalition.com/assets/website/pdfs/Provision-Addressing-Food-Waste-In-Canada-EN.pdf

Valiante, V. 2019. A Vision for a circular economy for plastics in Canada: The Benefits of Plastics Without Waste and how to get it right; Smart prosperity institute. Accessible from: https://institute.smartprosperity.ca/library/publications/vision-circular-economy-plastics-canada-benefits-plastics-without-waste-and-how

Venkat K. The climate change and economic impacts of food waste in the United States. International Journal on Food System Dynamics. 2012; 2: 431–446.

Verghese, K., Lewis, H., Lockrey, S., Williams, H. 2015. Packaging's Role in Minimizing Food Loss and Waste Across the Supply Chain; Packaging Technology and Science; DOI: 10.1002/pts.2127. Accessible from: https://www.worldpackaging.org/Uploads/SaveTheFood/Packagingroleminimisingwaste.pdf

Verghese, K., Lewis, H., Lockrey, S., Williams, H. 2013. The role of packaging in minimising food waste in the supply chain of the future: Final Report; Centre For Design; RMIT University. Accessible from: https://chepedia.chep.com/media/24874/RMIT-study_The-role-of-packaging-in-minimising-food-waste-in-the-supply-chain_June-2013_FINAL.pdf

Verghese, K., Lockrey, S., Clune, S., Sivaraman, D 2012. "Life cycle assessment (LCA) of food and beverage packaging", Emerging food packaging technologies: Principles and practice, Chapter: 19, Publisher: Woodhead Publishing, Editors: Kit L. Yam, Dong Sun Lee, pp.380-408. Accessible from: https://www.researchgate.net/publication/269819181_Life_cycle_assessment_LCA_of_food_and_beverage_packaging

Vogt, M. 2019. EFS Plastics Inc.; Presentation by Recycling Industry Stakeholders to Canadian Retailers; Recycling Council of Ontario; Etobicoke, Ontario; August 13, 2019.

Walmart. 2019a. Recycling Playbook: Optimize, Change, Advance; Walmart Inc.; October 25, 2019.

Walmart. 2019b. Sustainability Priorities (Walmart Recyclability Playbook); Walmart Inc. Accessible from: https://corporate.walmart.com/media-library/document/sustainable-packaging-playbook-deep-dive/_proxyDocument?id=00000169-15fc-dd5e-a3eb-75fc34d80000

Watson, A. 2019. Embracing Change to Help Reduce Food Waste and Remove Plastics; Nature Knows; Ontario Produce Marketing Association; June, 2019. Accessible at: https://www.theopma.ca/embracing-change-to-help-reduce-food-waste-and-remove-plastics/

Weber, B. 2019. Canadians creating more waste and lack co-ordinated way to deal with it: report; The Canadian Press; CTV News; March 9th 2019. Accessible at: https://www.ctvnews.ca/sci-tech/canadians-creating-more-waste-and-lack-co-ordinated-way-to-deal-with-it-report-1.3836304

Westervelt, A. 2012. "Can Recycling Be Bad for the Environment?" Forbes. April 25, 2012. Accessible from: https://www.forbes.com/sites/amywestervelt/2012/04/25/can-recycling-be-bad-for-the-environment/#59538d703bec

WestRock 2016. Packaging Matters™: Consumer Insights Study, June 2016; Norcross, GA. Available from https://www.westrock.com/en/insights

Willett, W., Rockstrom, J. 2019. Summary Report of the EAT-Lancet Commission; Food Planet Health: Healthy Diets from Sustainable Food Systems; AT-Lancet Commission. Accessible from: https://eatforum.org/content/uploads/2019/07/EAT-Lancet_Commission_Summary_Report.pdf

William Reed (date unknown). “Effects of Plastic Waste Diagram”. Accessible from: https://cdn-a.william-reed.com/var/wrbm_gb_food_pharma/storage/images/media/images/effects-of-plastic-waste-source-eea/9546698-1-eng-GB/effects-of-plastic-waste-source-EEA.png

Wilson, J. 2019. “Brands increase trust—and prices—through sustainability”. Nielson. July 11, 2019. Accessible from: https://www.nielsen.com/us/en/insights/article/2019/brands-increase-trust-and-prices-through-sustainability/

Woodward, A. 2019. “In some countries, people face jail time for using plastic bags. Here are all the places that have banned plastic bags and straws so far”, Business Insider. April 3, 2019. Accessible from: https://www.businessinsider.com/plastic-bans-around-the-world-2019-4#most-countries-are-taking-the-threat-of-plastic-pollution-seriously-according-to-a-un-report-127-countries-had-implemented-some-type-of-policy-regulating-plastic-bags-by-july-2018-1 and https://www.businessinsider.com/plastic-bans-around-the-world-2019-4#californias-new-rules-about-plastic-straws-went-into-effect-in-2019-16

World Economic Forum. *date unknown*. Toward the Circular Economy”, McKinsey & Company. Editors: Gilian Crowther and Terry Gilman. Viewed online: http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/the-limits-of-linear-consumption/

WRAP 2013a. Consumer Attitudes to Food Waste and Food Packaging: Summary of Research Findings. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Slides%20-%20Consumer%20attitudes%20to%20food%20waste%20and%20food%20packaging.pdf

WRAP 2013b. Thermochromic inks and reducing household food waste; WRAP. Accessible from:

http://www.wrap.org.uk/sites/files/wrap/Using%20thermochromic%20inks%20to%20reduce%20household%20food%20waste.pdf

WRAP 2013c. Analysis for Courtauld Commitment 3 targets: Analysis undertaken to determine the targets that are set under the third phase of the Courtauld Commitment. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Analysis%20for%20Courtauld%20Commitment%203%20targets.pdf

WRAP 2015a. Reducing food waste by extending product life; WRAP. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Product%20Life%20Report%20Final_0.pdf

WRAP 2015b. Reducing apple waste and loss in the Sainsbury's supply chain: a demonstration project. WRAP. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Sainsburys%20Apples%20Case%20Study.pdf

WRAP. 2015c. Strategies to achieve economic and environmental gains by reducing food waste; WRAP. Accessible from: http://www.wrap.org.uk/sites/files/wrap/WRAP-NCE_Economic-environmental-gains-food-waste.pdf

WRAP 2017a. Reduce waste by optimising secondary and tertiary packaging; Accessible from: http://www.wrap.org.uk/content/reduce-waste-optimising-secondary-and-tertiary-packaging

WRAP 2017b Cardboard packaging optimisation: best practice techniques; Accessible from: http://www.wrap.org.uk/sites/files/wrap/Cartonboard%20Case%20Study.pdf

WRAP 2017c. Courtauld Commitment 3: Delivering action on waste. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Courtauld_Commitment_3_final_report_0.pdf

WRAP 2017d. Improving the quality of food grade recycled PET. Accessible from: http://www.wrap.org.uk/node/14242

WRAP 2019b. A Roadmap to 2025 – The UK Plastic Pact. Accessible from: http://www.wrap.org.uk/sites/files/wrap/The-UK-Plastics-Pact-Roadmap-v2.pdf

WRAP, FSA & DEFRA (2019) Label better, less waste: Fresh, uncut fruit and vegetable guidance; Waste Resources Action Program (WRAP), Food Standards Agency (FSA), Department for Environment, Food and Rural Affairs (DEFRA); November 2019. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Food_labelling_guidance_uncut_fruit_and_vegetable.pdf

WRAP. 2010a. Courtauld Commitment 1 (2005-2010): Case Studies. Accessible from: http://www.wrap.org.uk/sites/files/wrap/CC%20Case%20Studies,%2019%20Aug%202010%20final.pdf

WRAP. 2010b. Packaging optimisation for whole, fresh chicken, (July 2010).

WRAP. 2017e. Tesco Help Customers to Love Food Hate Waste. Accessible from: https://www.lovefoodhatewaste.com/article/tesco-help-customers-love-food-hate-waste

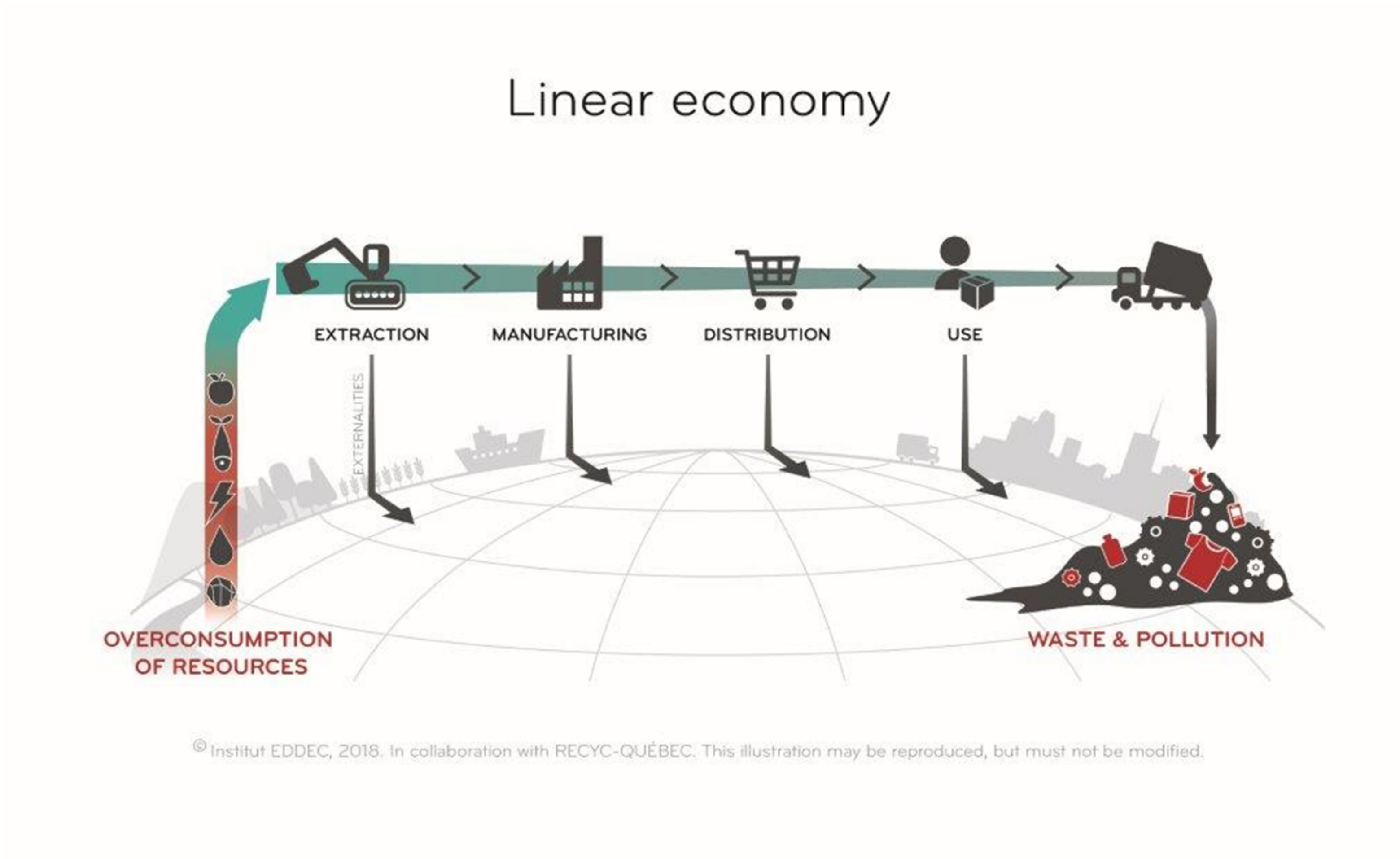
WRAP. 2019a. Circular Economy Review; WRAP. Accessible from: http://www.wrap.org.uk/content/wraps-vision-uk-circular-economy-2020

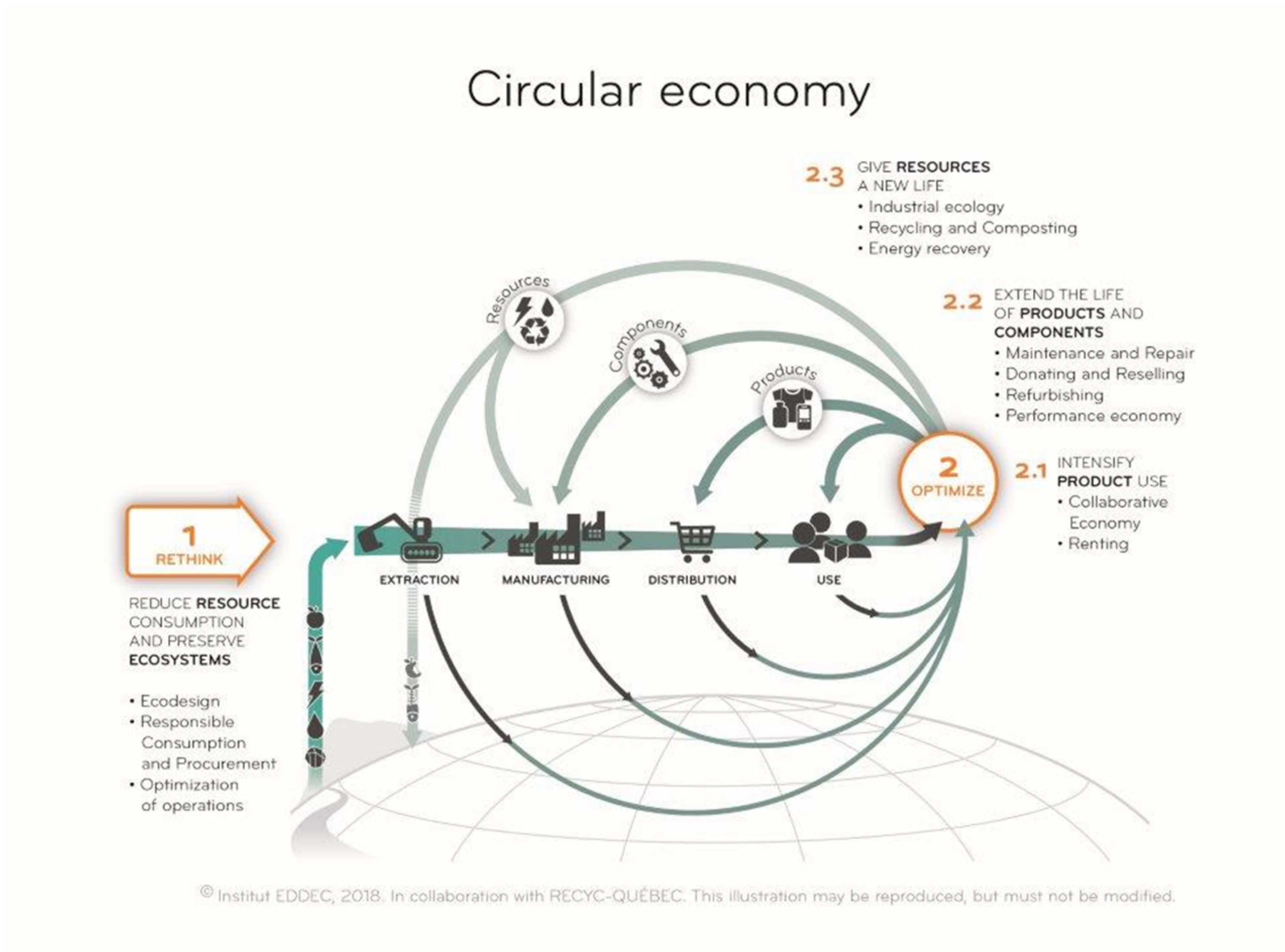
WRAP. 2019c. Understanding plastic packaging and the language we use to describe it; WRAP, The UK Plastics Pact. Accessible from: http://www.wrap.org.uk/sites/files/wrap/Understanding%20plastic%20packaging%20FINAL.pdf

WWF. 2014. Pack it in; World Wildlife Magazine; World Wildlife Fund; Fall 2014. Accessible at: https://www.worldwildlife.org/magazine/issues/fall-2014/articles/pack-it-in

Zhou, G. 2013. Nanotechnology in the food system: consumer acceptance and willingness to pay. Theses and Dissertations- Agricultural Economics, Paper 10

10.0 APPENDIX A:
GRAPHICAL COMPARISON OF LINEAR VERSUS CIRCULAR ECONOMIES




Circular economy
2.3 GIVE RESOURCES A NEW LIFE
• Industrial ecology
• Recycling and Composting
• Energy recovery
2.2 EXTEND THE LIFE OF PRODUCTS AND COMPONENTS
• Maintenance and Repair
• Donating and Reselling
• Refurbishing
• Performance economy
2.1 INTENSIFY PRODUCT USE
• Collaborative Economy
• Renting
2 OPTIMIZE
Resources
Components
Products
1 RETHINK
REDUCE RESOURCE CONSUMPTION AND PRESERVE ECOSYSTEMS
• Ecodesign
• Responsible Consumption and Procurement
• Optimization of operations
EXTRACTION
MANUFACTURING
DISTRIBUTION
USE
© Institut EDDEC, 2018. In collaboration with RECYC-QUÉBEC. This illustration may be reproduced, but must not be modified.

11.0 APPENDIX B: EXTENDED PRODUCER RESPONSIBILITY

Improving the design and management of the packaging value chain is critical to the establishment of a circular model.[199] Extended producer responsibility (EPR) is one specific form of legislation that has been proven to incentivize industry to adopt practices that reflect the concept of circular economies. This includes the utilization of readily recyclable packaging and the establishment of sustainable circular packaging economies.

The use of EPR as an environmental policy tool emerged within a number of OECD countries in the late 1980s, its primary purpose being to encourage the attitudes and behaviours required to engender the responsible management of packaging by industry and consumers from a lifecycle perspective. In 2001, the OECD published a guidance manual on EPRs, which was updated in 2016. Legislation has been a major driver, and most EPRs appear to be mandatory rather than voluntary. The OECD policy guide provides examples from around the world of EPR policies and recommendations on developing a robust and effective EPR policy. Of the approximately 400 EPR global systems in operation, three quarters of them have been established since 2001, and packaging accounts for 17 percent of these programs.[200] Legislative efforts aimed at establishing EPR programs, and which have been enacted since the OECD analysis, include those introduced in the United States in February 2020.[201]

Despite limited data and some methodological challenges of assessing and comparing EPRs around the world, the OECD has concluded that this policy measure has led to decreased waste production and increased recycling. For an EPR to be effective, the OECD recommends that the objectives and scope of the EPR are clearly defined, including the setting of targets. The roles of producers and the products that are included within the program need to be clearly established, and the programs need to be transparent. Therefore, there needs to be mechanisms for reporting and monitoring, as well as clearly stated sanctions for transgressions.

Europe is at the forefront of implementing EPR initiatives to reduce the amount of all types of packaging materials going to landfill, by legally requiring businesses to pay towards the cost of recycling. In the UK, all businesses handling over 50 tonnes of packaging per year and/or with an annual turnover of £2+ million (~CA$3.4 million) and deemed a "packaging producer" must contribute to the Packaging Producer Compliance Scheme. Packaging producers include resin and packaging manufacturers or converters, food processors and packers, and any businesses whose logo or trademark appears on the packaging.[202] Increasingly, EPR payments reflect specific materials' ease of recyclability and PCR content.

In January 2019, Germany introduced an enhanced dual waste collection program. Their original law and program started in 1991, and has been replaced with a strict new law as of January 2019. Any company, including online sellers, must comply or face fines up to 200,000 euros. Companies or packaging providers arrange for the collection and the recovery of the packaging after use; and it is collected alongside regular household waste. Companies register and pay a license fee to have their products and packaging identified with a "Green Dot" logo. These items are collected, sorted, and recycled at the dual system facilities. Targets to recover and recycle 90 percent of plastics were set for January 1, 2019, and 90 percent of all metal, glass and paper by 2022.[203]

It is worth noting that an increasing number of stakeholders believe that the fees paid by brand owners —those that determine product specifications and therefore packaging materials used in the food industry—do not cover the full cost of recycling programs and initiatives. Multiple jurisdictions are therefore planning to introduce significant changes to their EPR programs over the coming years.[204]

The table below summarizes the impact of EPRs that have recycling targets in place, but that differ by the fee structure of the program.

Impact of Various EPR Fee Structures

EPR Fee Structure	Impact on production/ consumption?	Impact on virgin material use?	Impact on product design?	Impact on recycling?	Comment/ other considerations
Fees based on sales			If PRO fee is weight based, downsizing, light-weighting No impact on recyclability		Cost-effectiveness depends on how the PRO operates
Tradeable credits assigned to producers	Yes, direct from producer responsibility organizations (**PRO**) fees	Yes, substitution effect reduces use	The more recyclable a firm's product, the more credits it earns (against paying full EPR fees)	Yes	Could be costly sorting requirements and high admin costs, but credits add flexibility
Tradeable credits assigned to recyclers			If PRO fee is weight based, downsizing, light-weighting No impact on recyclability because no brand sorting		No sorting by brand, so lower costs, but less impact on recyclability

Source: OECD, 2016

Reflecting what has occurred in other jurisdictions (such as the UK and Europe), in June 2019, the Canadian Council of Ministers of the Environment (CCME) set out a national Canadian action plan that promotes adapting to a circular economy for plastics.[205]

Key areas in their three-year plan include:

6. Extended producer responsibility
7. Single use and disposable products
8. National performance requirements and standards
9. Incentives for a circular economy
10. Infrastructure and innovation investments

11. Public procurement and green operations

The CCME action plan places greater emphasis on reduction, reuse, and refurbishments than on recycling, composting, or energy recovery (e.g. anaerobic digestion).

12.0 APPENDIX C:
ECONOMIC VIABILITY OF PLASTIC RECYCLING

The following frequency tables detail online survey respondents' views regarding the comparative economic viability of recycling specific forms of food grade plastic packaging.

PET – polyethylene terephthalate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	4	2.0	9.1	9.1
	2	4	2.0	9.1	18.2
	3	8	4.0	18.2	36.4
	4	8	4.0	18.2	54.5
	5	20	10.0	45.5	100.0
	Total	44	22.0	100.0	
Missing	System	156	78.0		
Total		200	100.0		

LDPE – low-density polyethylene

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	8	4.0	18.2	18.2
	2	8	4.0	18.2	36.4
	3	7	3.5	15.9	52.3
	4	10	5.0	22.7	75.0
	5	11	5.5	25.0	100.0
	Total	44	22.0	100.0	
Missing	System	156	78.0		
Total		200	100.0		

Polystyrene

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	5.5	26.8	26.8
	2	7	3.5	17.1	43.9
	3	14	7.0	34.1	78.0
	4	1	.5	2.4	80.5
	5	8	4.0	19.5	100.0

	Total	41	20.5	100.0	
Missing	System	159	79.5		
Total		200	100.0		

Q7-PLA - polylactic acid

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	20	10.0	46.5	46.5
	2	6	3.0	14.0	60.5
	3	13	6.5	30.2	90.7
	5	4	2.0	9.3	100.0
	Total	43	21.5	100.0	
Missing	System	157	78.5		
Total		200	100.0		

Q7-Complex or multi-layered laminates / films

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	22	11.0	50.0	50.0
	2	9	4.5	20.5	70.5
	3	8	4.0	18.2	88.6
	4	1	.5	2.3	90.9
	5	4	2.0	9.1	100.0
	Total	44	22.0	100.0	
Missing	System	156	78.0		
Total		200	100.0		

Q7-HDPE – high-density polyethylene

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	5	2.5	11.6	11.6
	2	4	2.0	9.3	20.9
	3	7	3.5	16.3	37.2
	4	9	4.5	20.9	58.1
	5	18	9.0	41.9	100.0
	Total	43	21.5	100.0	
Missing	System	157	78.5		
Total		200	100.0		

Q7-PP – polypropylene

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	5	2.5	11.6	11.6
	2	4	2.0	9.3	20.9
	3	13	6.5	30.2	51.2
	4	8	4.0	18.6	69.8
	5	13	6.5	30.2	100.0
	Total	43	21.5	100.0	
Missing	System	157	78.5		
Total		200	100.0		

13.0 APPENDIX ENDNOTES

[199] PAC, 2019/2017/2014; Sand, 2019; Gooch et al, 2019b/2018; Colicchio & Harrold, 2918; DEFRA, 2009; WRAP, 2006; WRAP, 2015c

[200] OECD, 2016

[201] Udall et al, 2020

[202] Gov UK, 2018

[203] Skoda, 2018

[204] Smith, 2019; CCME, 2019

[205] CCME, 2019

zeroWASTE

NATIONAL ZERO WASTE COUNCIL

An Initiative of Metro Vancouver