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Canadian Produce Marketing Association

Literature Review and Stake Holder Interviews: Plastic Packaging Challenges as they Pertain to Food Safety, Food Quality and the Realities of the Fresh Produce Industry

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Canadian Produce Marketing Association (CPMA) Plastic Packaging Challenges as they Pertain to Food Safety, Food Quality and the Realities of the Fresh Produce Industry

Executive Summary:

- In today's society, packaging is ubiquitous and essential. It surrounds, enhances and protects the goods we buy, from processing and manufacturing, through handling and storage, to the final consumer. Without packaging, materials handling would be a messy, inefficient, and costly exercise and modern consumer marketing would be virtually impossible.
- Food packaging lies at the very heart of the modern food industry and very few foods are sold unpackaged. Good packaging prevents waste and ensures that the food retains its desired quality throughout its shelf life.
- Despite the important and key role that packaging plays, it is often regarded as an unnecessary cost. Furthermore, in the view of many consumers, packaging is, at best, somewhat superfluous, and, at worst, a serious waste of resources. Such views arise because the functions that packaging has to perform are either unknown or not considered in full. **By the time most consumers come into contact with a package, its job, in many cases, is almost over, and it is perhaps understandable that the view that excessive packaging has been used has gained some credence.** [1]
- Biopolymers and compostable polymers are most likely included in the ban.
- Not only retail bags, pouches and trays will be impacted but also food service packaging, case liners and even potentially pallet covers.
- Certain segments of the Canadian fresh-cut produce market may be eliminated, i.e., fresh cut baby carrots, berries, fresh cut salads and bananas.
- Not only will the safety, shelf life and quality of Canadian fresh produce be severely impacted by the topics and detail outlined in this report, but financial impact may also be acutely felt by:
    - Canadian companies including:
        - Fresh produce companies that use plastic bags and trays for fresh and fresh cut produce
        - Indoor agriculture companies who use plastic trays to package tender leafy greens.
        - Packaging companies who supply plastic packaging to the Canadian market
        - Retailers, hotels, restaurants, schools and institutions, who buy fresh cut produce instead of paying for liability insurance to cut and process produce on site.

[1]Robertson, Gordon L. Food Packaging. Available from: VitalSource Bookshelf, (3rd Edition). Taylor & Francis, 2016 Robertson, Gordon L. Food Packaging. Available from: VitalSource Bookshelf, (3rd Edition). Taylor & Francis, 2016 Food Packaging 3rd edition | 9781439862414, 9781439862421 | VitalSource

- Food waste and the corresponding environmental issues created will increase dramatically.
- Value added produce = produce that is cut, washed and packaged; value added produce is a $1.3b category in Canada; hundreds of SKU's across tens of suppliers. To achieve shelf-life and quality acceptable for commerce, value added produce requires both modified atmosphere packaging (MAP) and a supply chain with temperatures between 1 and 4.5°C; due to the decreased shelf-life of cut-produce. Today, modified atmosphere packaging can only be achieved through the combined use of breathable plastics and integrated equipment that creates the desired atmosphere inside the packaging. This technology can also include a nitrogen backflush (commonly referred to as Active MAP) to displace oxygen and lessen the possibility of pinking (oxidation) for a more marketable product.
- As of now, there is no alternative to plastic modified atmosphere packaging; elimination of plastic primary packaging in value added produce would result in the inability of the industry to provide 100% of the current value-added produce product assortment sold in the Canadian market.
- An exemption, for fresh produce items, from any plastic ban is required until alternatives are developed. The Canadian government should consider funding this research and development efforts.
- The vision of the future of packaging is one in which the package will increasingly operate as a smart system incorporating both smart and conventional materials and adding value and benefits across the packaging supply chain. For smart materials to be adopted in packaging, they need to be inexpensive relative to the value of the product, reliable, accurate, reproducible in their range of operation, and environmentally benign and food contact safe. Often these materials are currently cost prohibitive.

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Detail:

Project:

Using published, peer reviewed, scientific documents (literature review), and in excess of a dozen stake holder interviews including, processors, growers, distributors, packaging companies, industry experts, technology companies, recycling companies, trade associations and food safety experts, the project will generate a report addressing the following:

1. Explain how plastic packaging protects fresh produce vs. bulk (no packaging) or other package alternatives (i.e., fibre, cloth, etc.).

2. Illustrate the benefits of modified atmosphere packaging on quality and shelf-life extension for produce items such as bagged salads

3. Demonstrate how food quality is protected, and how shelf-life is extended, when plastic packaging is used vs. bulk (no packaging) or other package alternatives (i.e., fibre, cloth, etc.).

4. Demonstrate how food safety risks are lowered when plastic packaging is used vs. bulk (no packaging) or other package alternatives (i.e., fibre, cloth, etc.).

5. Extrapolate on the potential food quality and food safety impacts if plastic packaging was eliminated as an option for fresh produce.

6. Discuss how the elimination of plastic packaging could impact Canadian consumers in the context of food quality, food safety, and food availability.

7. The impact on food waste and the subsequent environmental issues, if plastic packaging is eliminated.

8. Potential sustainable options in lieu of a complete plastic packaging elimination

1. EXPLAIN HOW PLASTIC PACKAGING PROTECTS FRESH PRODUCE VS. BULK (NO PACKAGING) OR OTHER PACKAGE ALTERNATIVES (FIBRE, CLOTH, ETC.)

As Morya and Sharma (2019. researchgate.net) state; packaging functions range from those that are technical in nature to those marketing oriented. The functions of packaging are as follows:

- **Contain:** to hold the products and keep them secure until they are used. This is essential for the efficient transportation, storage and distribution of the product. The containment part of the function following points are to be consider:
    - portion control
    - company reputation
    - consumer expectation
    - consumer convenience
- **Protect:** protection and preservation are the next most important functions, after containment. The packaging protects the food from physical, chemical and microbial hazards along with microbial encroachment from the exterior, all significantly impacting product quality. The packaging protects the product from contamination, maintains quality and consistency, satisfies legislative needs (Codex recommendations, national and provincial legislation), and protects company reputation.
- **Inform:** to identify the product and assist in selling the product, some packages also inform the user about method of opening and/or using the contents. The following considerations may be part of this function; nature of the contents, legislation, Codex, and other codes, nutrition panels and claims, instructions for use, limitation of fraud, storage conditions pre and post opening.
  Unitization: The assembly or grouping of a single entity of a number of individual items of products or packages that can be easily distributed, marketed, or purchased as a single unit. Unitization reduces the number of handlings required for physical distribution, thus reducing the potential for damage. Physical distributions are significantly reduced by unitization, also reducing distribution costs.
- **Attraction:** Packaging plays an important role in marketing and business. It is an indispensable part of marketing. Packaging is the first impression and experience a customer has with the brand. Advertisement is the most important part of the attraction function.
- **Economy:** Packaging costs, including the materials as the packaging machinery, are a significant part of the cost of manufacturing foods. In many cases, these costs can be greater than the cost of the raw ingredients used to make the food. Therefore, packaging materials must be cost-effective, given the value of the food product. Packaging must be made of materials which are rugged enough to provide protection during distribution but be of low enough cost for use with foods.

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A new report by researchers at Michigan State University's (MSU's) School of Packaging (2023) found that many U.S. consumers don't fully understand how different types of packaging can preserve food and stretch household food budgets. Many consumers are unaware that reducing food waste helps combat climate change by cutting the amount of methane gas emitted into the atmosphere from decomposing food in our nation's landfills. If consumers knew more about the extensive economic and ecological benefits of packaging, they would factor it into their purchasing decisions at the grocery store, according to the research.

"There's a need to design packaging for produce that is currently not packaged; most of the produce in this study that was wasted, stemmed from using no packaging at all,"

- Michigan State University School of Packaging (2023)

- Researchers concluded in the white paper that "some food products, especially produce, would benefit from packaging technologies designed to extend their shelf lives and thereby reduce food waste."
- "There's a need to design packaging for produce that is currently not packaged; most of the produce in this study that was wasted, stemmed from using no packaging at all," Fennel said during the webinar, also noting the importance of "intelligent packaging" that could indicate the shelf life of food products. Going forward, education could be most strategically targeted to certain population segments, researchers also concluded.

2. ILLUSTRATE THE BENEFITS OF MODIFIED ATMOSPHERE PACKAGING ON QUALITY AND SHELF-LIFE EXTENSION FOR PRODUCE ITEMS SUCH AS BAGGED SALADS

Beaudry, (2007. researchgate.net) states that the aim of MAP (passive, active, or intelligent in design) is to take advantage of physiological responses of the enclosed plant material and/or included plant or human pathogens to the respiratory gases O2 and CO2. Presumably, MAP use is intended to maintain product quality, thereby ensuring appropriate value to the consumer and adequate cash flow back through the marketing and handling chain such that the production and marketing system is sustainable (Fig. 2).

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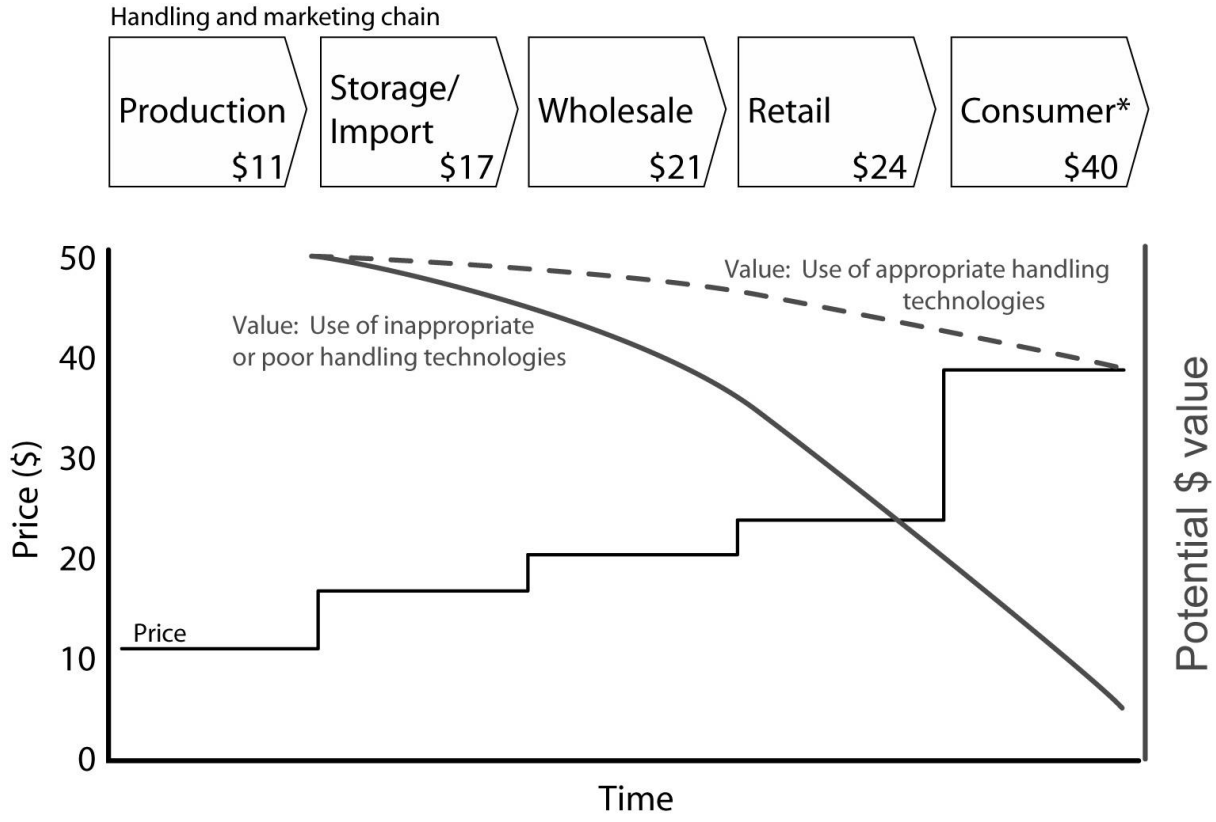


Figure 2. Diagram representing the flow of product through the handling and marketing chain (upper portion of figure) and its value, based on changing quality over time, and the concomitant reverse flux of cash (price) from the consumer to the various links in the market chain (lower portion of the figure). *Consumer decisions drive the flow of cash to all members in the supply chain; the amount of money the consumer is willing to pay will reflect perceived value in the product. (Beaudry, 2007)

Modification of the oxygen and carbon dioxide partial pressures in the atmospheres alters the physiology of harvested fruits and vegetables in a desirable manner, resulting in an improvement in quality maintenance relative to air storage. The determination whether oxygen and/or carbon dioxide modification is appropriate is dependent on the biology of the harvested plant organ and those components of physiology and pathology that comprise biological limiting factors. It is also important to note that each produce item and respective cut size may needs its own unique Modified "Atmosphere.

Brandenburg and Zagory (2009 Taylor Francis) also state modified atmosphere packaging, when combined with proper post-harvest handling procedures and temperature control, can have a positive impact on the quality and shelf -life of fresh produce. Packaging atmosphere control involves the balancing of key components: O2, CO2, other (to confirm). Considerations for each are outlined below.

Brandenburg and Zagory (2009. Taylor Francis) also state modified atmosphere packaging, when combined with proper post-harvest handling procedures and temperature control, can have a positive impact on the quality and shelf -life of fresh produce.

Oxygen Composition Control

Reducing O2 concentrations below about 10% for many fresh fruits and vegetables slows their respiration rate and indirectly slows the rates at which they ripen, age and decay. Reducing the O2 concentration can, in some cases, reduce oxidative browning reactions which can be of particular concern in precut leafy vegetables. Reduced O2 can delay compositional changes such as fruit softening, pigment development, toughening of some vegetables (such as asparagus and broccoli), and development of flavor (Kader, 1986. scirp.org). Finally, there is a great deal of interest in the use of low O2 as a quarantine treatment to disinfest fresh produce of insects and insect larvae. Proper combinations of low O2, low temperature and time may be effective against some of the most troublesome insect pests of concern in international commerce (Ke & Kader, 1992 234-451.pdf ucanr.edu).

CO2 Composition Control

Carbon dioxide (CO2) also has a minor suppression effect on the respiration of some fresh fruits and vegetables and thus can help extend their shelf life. At concentrations above 1-2%, CO2 reduces the sensitivity of plant tissues to the ripening hormone ethylene. Ethylene can cause premature ripening, fruit softening, yellowing of leafy vegetables, increased respiration rate and senescence of many fruits and vegetables. The prevention of these ethylene effects is important in the maintenance of quality attributed to MAP. Elevated CO2 (>~2%) can help reduce the damaging effects of ethylene by rendering plant tissues insensitive to ethylene (Herner, 1987 . CiNii Research; Kader et al., (1988. tandfonline.com). This may be one of the primary benefits of modified atmospheres for many commodities. CO2 at relatively high concentration (> 10%) has been shown to suppress the growth of a number of decay-causing fungi and bacteria.

Toivonen, Brandenburg, and Luo (2009. taylorfrancis.com) add that greater exploration of combined treatments should be encouraged as the current data clearly show synergistic effects on quality of fresh-cut produce. However, the fundamental shift in research will likely relate to greater focus on flavor, nutritional, and functional quality of fresh-cut products and how they can be better managed with MAP technologies. The

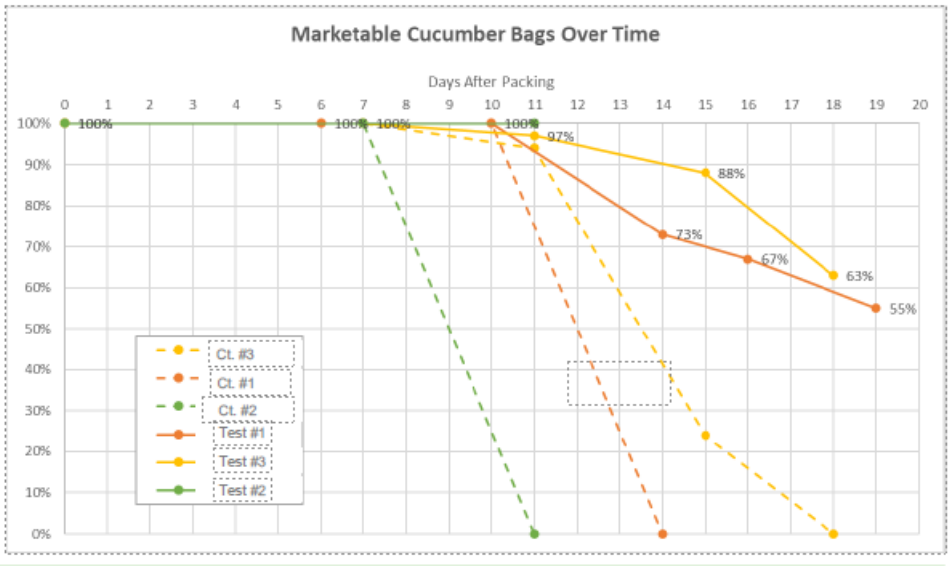
reason for this shift is that the category title (i.e., fresh-cut) brings with it an implicit expectation that the product be in a condition which approximates the initial quality at the time of cutting.

Other Considerations

Ščetar*, Kurek, and Galić (2010. researchgate.net) state that polymetric films have been used to package fresh products for over 35 years, with a number of benefits, including control of water loss, protection from skin abrasion and reduced contamination of the produce during handling. They also provide a barrier to the spread of decay from one unit to another (Kader, 1980. FT51.JPG (ucanr.edu)).

The vision of the future of packaging is one in which the package will increasingly operate as a smart system incorporating both smart and conventional materials and adding value and benefits across the packaging supply chain. For smart materials to be adopted in packaging, they need to be inexpensive relative to the value of the product, reliable, accurate, reproducible in their range of operation, and environmentally benign and food contact safe. Often these materials are cost prohibitive.

A packaging technology company adds that with respect to weight loss in cucumbers specifically, the non-MAP lost up to 9% (45 g) of the initial weight, whereas the MAP bags showed negligible weight loss: from 0% to 0.2%, which equates to more marketable fruit.



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As stated by a North American fresh produce processor; “thanks to our advancements and innovation in MAP, our products have exponentially increased in shelf life compared to previous generation packaging. With today’s highly developed breathable packaging, we have achieved an average shelf life of 16 days (about 2 and a half weeks).” “Without breathable packaging, fresh-cut produce has 1-2 days of marketable shelf-life due primarily to rapid dehydration. All of our films and bags are breathable and specially designed to meet the respiration requirements of the specific raw ingredients within each package.” Without innovative packaging, 1-6 days would virtually eliminate any remaining shelf life for bulk or non-packaged products. Improvements in MAP have allowed us to ship finished products to end destinations and still provide the consumer with an average of 10-15 days of remaining shelf-life after purchase.

3. Demonstrate how food quality is protected, and how shelf-life is extended, when plastic packaging is used vs. bulk (no packaging) or other package alternatives (i.e., fibre, cloth, etc.).

The impact of plastic packaging is not just limited to the primary retail packaging, but also the packaging used by the industry to get the product to the retailer such as case liners and pallet bags As noted by a North American film producer, “climate plays a large role in the growing of fresh cut produce and therefore produce is sourced worldwide”. For instance, most lettuce, whether it is in bulk packaging or portioned sizing, is harvested in California, Arizona, and Mexico. Banana’s top producing country is India, Melon’s is in Turkey, and Berries are in China, Mexico, and USA. The transit from these locations to the point of purchase can take upwards of 6 days. At that time the product has exhausted its freshness cycle. Modified Atmosphere Packaging (MAP) is used to extend this shelf life and allow for extended point of purchase shelf life. MAP can be utilized in both fresh cut value add items as well as whole fresh produce. The extension in shelf life is often increased to 16-18 days, representing an increase of up to 8 days due to proper packaging.
Items most effective in MAP/OTR (Oxygen Transmission Rate)packaging include banana’s, apples, melons, baby carrots, berries, and lettuce.

A Canadian packaging company adds that plastic packaging, especially when designed for modified atmosphere packaging (MAP), helps **extend the shelf life of fresh produce** by controlling factors such as oxygen and moisture. Without this protective environment, the shelf life of many fruits and vegetables could be significantly shortened, leading to increased food waste as products spoil more quickly.

In addition, as stated by a leading fresh produce authority, **plastic packaging also serves as a structural barrier to physical damage which can accelerate tissue destruction**, alter respiration rates due to damaged cells, and

enhance microbial growth on the damaged plant tissues (spoilage and pathogens), all conditions that lead to reductions in shelf-life.

They go on to state that bulk sale of ready-to-eat fresh-cut fruit and vegetables will require a container for the product to be held in so a consumer can take it home. If such packaging is provided by customers, as is common with bring-your-own coffee mugs or with the use of reusable bags for shopping, considerations must be made to **improve education for consumers on proper cleaning and sanitation of these containers**, as well as proper storage of containers as they may present opportunities for pathogen exposure or growth.

A container provided by a customer could harbor microorganisms, chemical contaminants, etc. based on their handling, storage, and prior uses of the container. Current food handling assessments and studies indicate there are significant gaps in general food safety handling knowledge. If a container is contaminated, it can pose a risk to that customer, additional customers, and store employees, should poor handling practices be used.

For example, if a customer places product in their reusable container and decides they selected too much product, they may replace the excess back into the bulk container. If their container is contaminated, this **represents a cross-contamination opportunity along with a cross-contact allergen risk** that would endanger other customers.

White and Lockyer (2020. Nutrition Bulletin - Wiley Online Library) discuss that there is an important trade-off to consider when removing plastic packaging from fruit and vegetables, which is the resultant reduction in shelf life and subsequent increase in food waste. Fresh produce is estimated to be the most highly wasted type of food in the UK, and it is likely that food waste has an even greater environmental impact than the production and disposal of plastic.

Specifically with respect to berries an industry leader states in Use Case 1 - Impact of Packaging on Berries":

> The lateral movement of product that a bulk container allows would cause fruit damage. Damaged fruit leaks, causing an environment conducive to the spread of mold/decay onto otherwise healthy berries.
> Damaged fruit may not meet retailer specifications, which leads to rejection and food waste. Even if the retailer accepts it, damaged fruit is not attractive to consumers which can also lead to food waste. Bulk, as opposed to other types of packaging (paper or plastic), will also lead to the highest level of dehydration. Food was from damaged or dehydrated fruit increases greenhouse gas emissions.
> In pilot bulk strawberry shipments, their shelf life was found to be much lower than if they are packaged.
> Raspberries and blackberries are so delicate that the level of fruit waste in bulk shipments would increase substantially.

Fig 1

An industry expert added that berry and grape supply from the US and Mexico will most likely **cease, as the food loss during transit will negate the profitability for the suppliers.**

4. DEMONSTRATE HOW FOOD SAFETY RISKS ARE LOWERED WHEN PLASTIC PACKAGING IS USED VS. BULK (NO PACKAGING) OR OTHER PACKAGING ALTERNATIVES

A leading food safety expert adds that the sale of ready-to-eat fruits and vegetables offers an opportunity for intentional or accidental contamination by customers and retail store employees; human handling and hygiene have been identified as a source of food contamination. Studies have shown gaps in consumer food safety handling practices and bulk sale of susceptible ready-to-eat items could create potential opportunities for contamination. While retail employees can be trained and assessed over time on optimal food handling and hygiene practices, addressing the risk from customer handling is less straightforward or controllable.

Food handling within a retail grocery store introduces additional risk variables given the concurrent interaction with other products and tools in the store (e.g., carts, baskets). These interactions may introduce new contamination opportunities and increase the likelihood a customer or employee's hand could harbor pathogenic microorganisms. As an example, a Journal of Food Protection Paper 2018 study surveyed 35 retail stores and the surfaces of 105 packaged raw poultry products in Tennessee and found six were positive for shiga-toxigenic *Esherichia coli* (STEC), seven were positive for *Campylobacter*, three were positive for both STEC and *Campylobacter.* Since customers move throughout and between areas of the store and interact with

objects shared between customers (e.g., shopping carts, other products) and areas of the store, there is an increased opportunity to transfer pathogens during shopping.

A leading north American food safety expert also notes that "The US FDA Food Safety Modernization Act Final Rule on Produce Safety | FDA requires that food packing, including food packaging materials be "cleanable or designed for single use". Further, the rule states "if you reuse food-packing material, you must take adequate steps to ensure that food contact surfaces are clean, such as by cleaning food-packing containers or using a clean liner." The leading north American food safety expert adds given the determination that the US and Canada have comparable food safety systems, and in light of the US FDA PSR requirements, **a ban on single use plastic could jeopardize regulatory compliance with this major food safety rule,** since some surfaces in the produce supply chain are difficult to maintain in a sanitary condition, and single use plastic (e.g., bags and liners) helps maintain food safety and regulatory compliance."

"Plastic packaging also limits consumer contact with produce. Almost no one washes their hands upon entry to a retail establishment. Human pathogens such as Norovirus, Hepatitis A, Salmonella and pathogenic E. coli can be introduced by people touching produce and subsequently cross contaminate other products (when the consumer opts not to purchase)."

"Furthermore, in a study (William et al., 2011) observed 1/3 of consumers who use reusable shopping bags carry other non-grocery items, and approximately 75% of consumers used those same bags for raw meat and other foods. A move away from single use plastic bags, whether for transportation of groceries to the home, or for storage within the home, could risk food safety issues based on inadequate consumer cleaning and sanitizing of alternative reusable materials."

A North American fresh produce company adds that most importantly for food safety, especially with value-added fresh cut vegetables and fruit, packaging provides a protective barrier to protect it from cross contamination. With most of our products, packaging also provides a modified atmosphere to help prevent the growth of microorganisms.

Without packaging, it becomes especially vulnerable to harmful pathogens such as E. coli, Salmonella, and Listeria and even more so when cut or trimmed and exposed to the elements. Packaging is a great tool to help reduce these risks. Yes, there are fresh produce items that can be shipped and sold in bulk but beyond the quality benefits of packaging, the **opportunity for cross contamination spreads across each step of the handling chain.**

On top of this, the ability to trace potential food vehicles for foodborne illness is reduced greatly as traceability on non-packaged items is extremely difficult. While it is known that packaged salads have been linked to foodborne outbreaks it is the very packaging that has allowed this.

Health officials will acknowledge that non-packaged, bulked produce are involved in produce outbreaks just as much, if not more, but the ability to identify the vehicle is virtually non-existent and even when they do, the illness outbreaks are long over." Imagine eliminating the packaging for cheese, cereal, yogurt, etc. that could be provided bulk in a grocery store and trying to identify if these items were the source of a foodborne illness outbreak! "

Impact on Traceability

This is just another aspect of food safety traceability in which packaging provides the ability of advanced, detailed traceability. Similarly, packaging allows for labeling that helps communicate to the consumer about different food safety certifications and farm source.

As stated by Alchemy Systems Consulting (2023. Alchemy), plastic packaging is widely used to contain food products as it provides the necessary protection from external factors that cause spoilage. Plastic works as a protective barrier between the external gases and the food products, thus saving it from reactions such as oxidation and ensuring the food item remains fresh. Plastic packaging is used in the food supply chain because it supports the safe distribution of food over long distances and minimizes food waste by keeping food fresh for longer.

It is also important to remember that the Canada strictly regulates substances that come in contact with our food, which include plastic packaging products. Each food item, as well as the packaging used for it, undergoes stringent evaluation before receiving the necessary approvals.

5. EXTRAPOLATE ON THE POTENTIAL FOOD SAFETY IMPACTS IF PLASTIC PACKAGING WAS ELIMINATED AS AN OPTION FOR FRESH PRODUCE

Food Safety Magazine (2023. Food Safety) states that Cross Contamination throughout the entire supply chain and even in the retail stores is the greatest concern. The opportunity for cross contamination spreads across each step of the handling chain. Retail contact surfaces in whole cantaloupe areas that were cleaned and sanitized on a regular basis (e.g., daily) had lower Listeria spp. prevalence than those surfaces that were cleaned and sanitized on a variable schedule (or as needed basis). Foam had the highest prevalence of

Listeria–positive samples (100%) and is not recommended for use in whole cantaloupe displays (despite its ability to cushion product.

Craig Casillas Food Processing, (2013. Food Processing) adds when we think and talk about food safety, an important factor is often ignored. Consumers, media, regulators and industry tend to focus on the product, but packaging is a critical component in the overall food safety process. Now more than ever, as food distribution networks globalize, packaging plays a vital role in ensuring the final product is safe and secure for consumption.

Kasza, Veflen, et al (2022. mdpi.com) state food-related consumer decisions have an impact on the environment. However, trending patterns of sustainable consumption often pose a challenge for food-safety authorities: these initiatives may unintentionally compromise food safety. Environmentally conscious but risky behaviors aimed at the reduction of food waste and plastic packaging were chosen for discussion and scrutinized based on expert opinions. Those expert opinions clearly indicated that a significant part of environmentally conscious behaviors, such as removing mold, eating expired perishable food, overstoring leftovers, **avoiding single-use plastic packaging even when cross-contamination is a threat**, and using reusable bags without cleaning for a long time, often contribute to food-safety risks.

Those expert opinions clearly indicated that a significant part of environmentally conscious behaviors, such as removing mold, eating expired perishable food, overstoring leftovers, **avoiding single-use plastic packaging even when cross-contamination is a threat**, and using reusable bags without cleaning for a long time, often contribute to food-safety risks.

According to public health statistics, more than 40% of foodborne illnesses were linked to households where practices originated due to sustainability reasons, contributing to the number of food-safety incidents. The presence of the most common foodborne pathogens can lead to problems for healthy consumers only if food-handling behavior promotes pathogen reproduction or does not inhibit pathogen growth (such as saving leftovers and ready-to-eat foods for too long or fostering cross-contamination through lack of packaging).

Packaging has a multifaceted role in the life cycle of food; it is a physical protective barrier and a communication and marketing platform. It also provides resistance to tampering as well as enabling convenient handling, transportation, and storage.

Reduction of plastic packaging also raises challenges at the consumer level because misperceptions and bad practices can lead to food-safety risks in daily use of reusable packaging materials. Management of these

complex areas (especially minimizing use of plastic) demands continuous research and innovation and requires communication across different industry sectors.

The European Paper Packaging Alliance (2020. eppa-eu.org) Professor David McDowell, Emeritus Professor of Food Studies at Ulster University, indicated that banning single-use packaging without radically altering food hygiene practices would result in increased persistence and circulation of food-borne pathogens. Single-use paper packaging can reduce food contamination, ensuring that food arrives intact and unspoiled during transport. It also plays a role in minimizing food waste by controlling portion size and extending shelf life.

In addition, a review of the impact of the COVID-19 pandemic on Europe's environment in 2020, the European Environment Agency stated that disposable packaging played a central role in preventing the virus from spreading among the European population.

Professor David McDowell, Emeritus Professor of Food Studies at Ulster University, **indicated that banning single-use packaging without radically altering food hygiene practices would result in increased persistence and circulation of food-borne pathogens**.

6. DISCUSS HOW THE ELIMINATION OF PLASTIC PACKAGING COULD IMPACT CANADIAN CUSTOMERS IN THE CONTEXT OF FOOD QUALITY, FOOD SAFETY, AND FOOD AVAILABILITY.

Allergens

A leading North American Food Safety specialist states: Some produce items can cause allergic reactions (allergy-symptoms.org) and may be wrapped in plastic either individually or during transportation (e.g., in larger bags) to reduce cross contact with the allergen.

Quality

In addition, packaging improves produce quality, and our understanding of the implications of quality defects on produce safety **is increasing (see item 12 RFP 2024 Hazard Statement Tables_FINAL090623.pdf** (centerforproducesafety.org). Product that is bruised, damaged, or has begun to deteriorate may make a more hospitable environment for spoilage bacteria and potentially pathogen growth. Thus, the quality that is retained by virtue of single use plastic also may have a food safety benefit.

Availability

An industry expert states that in 2022, Canada imported $1,715M worth of fresh fruit and $2,104M of fresh vegetables from the US. In fact, 42% of fresh fruit exported from the US, and 75% of fresh vegetables exported from the US are shipped to Canada, according to USDA.
As indicated by a North American association, in some cases, moving to a bulk-only model is not possible. For example, shipping raspberries in bulk rather than in a clamshell of some type is difficult to imagine without the shipments degrading into pulp. In fact, the current production practice for berries is to harvest in the field and pack into containers immediately. In the case of berries being shipped any distance (as opposed to local production) containers are enclosed to protect the fruit and ensure quality, shelf life and food safety. Likewise, it is difficult to imagine selling bagged salad without a bag. Salad, in particular, is highly prone to wilting and would be unsaleable in <2 days without proper storage.

The association goes on to say that by requiring American producers to bear the cost of a separate Canadian production line could well lead to the elimination of U.S. sales into Canada. For many of our growers, the Canadian and U.S. markets are completely integrated – so much so that when we ask, “Do you export?” many respond “No, I only sell in the United States and Canada.” Requiring a completely different packaging regime for the Canadian market will begin to separate our two marketplaces and begin to force serious questions about continuing to stay in the Canadian market. In our discussions with a variety of our major growers with business in Canada, we have gotten a very stark picture. In speaking with them, after overcoming the shock of this regulation many have said that, if forced to switch to non-plastic packaging, they likely would **not** sell into Canada because no alternatives exist, and they don’t see selling in bulk as viable.

For those that cite the existence of alternatives, they note that if retailers do not bear the cost switching to these non-plastic alternatives, then they too would likely **not** sell into Canada because prices for non-plastic packaging are two or even three times higher than plastic. Most growers are incredibly doubtful that retailers will absorb increased costs, and grocery store retail history in both the United States and Canada tells us their

doubt is warranted. As such, Canada faces a very real possibility of either a reduction in supply of fresh produce or Canadian consumers will face increased costs, if the notice as written is not significantly modified. As the Ministry knows, the United States is Canada's No. 1 fruit and vegetable supplier.

One grower added that: "We can put 30 days on a processed carrot easily. Whereas if you were to peel and polish a carrot, …put it in bulk, you are looking at less than a week."

In addition, one US peach grower says, "almost **certainly won't sell to Canada if this was implemented**"

A processor interviewed pointed to a study from University of Toronto, that estimates over 15% of Canadians live in food insecurity (Gov CAN) – defined as the inability to acquire or consume an adequate diet quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so. Creating further complexities in the use of packaging would adversely affect efforts to reduce food insecurity in the country.

The Market

Per Nielsen IQ Canada reporting (ending March 2023), Value-Added (VA) Salad and Vegetables are $1.3B in $ Sales, +4% vs one year ago. It is estimated that VA Salad and Vegetables account for 12.5% of the total produce market in Canada. Per Nielsen IQ Canada reporting,

The Impact

The elimination of plastic packaging would eliminate close to 100% of value-added products currently being provided to the Canadian market today.
For some processors, their entire product portfolio utilizes plastic and the technology alongside it (Modified Atmosphere Packaging (MAP)) to distribute safe and healthy fresh cut produce, salads, fruit and ready-to-eat meals to grocery stores, foodservice outlets like restaurants, foodbanks, schools and convenient stores.
The elimination of plastics will also decrease the consumption of healthy fresh foods and increase health care costs for the government and the population. We recognize that packaging is critical for fresh cut produce. We want to minimize packaging where we can and look to new technologies that can drive that minimization further without degradation/quality/safety of a necessary, health forward food. We have invested in research and already implemented actions to reduce plastic where we can. We ask that value-added produce and fresh foods in Modified Atmosphere Packaging be exempt from this legislation. One industry expert opined that the pending packaging regulations in Canada will decimate choice for Canadian consumers as US exporters will likely look at other markets, or at other uses for their land.

Given the volume of US exports to Canada, and given the fact that for some categories of fresh, around 50% comes from the US or Mexico, plotting out basic supply and demand curves can reasonably accurately predict that prices for fruits and vegetables may increase up to double from their current levels. Canadian domestic production can make up deficiencies in some categories, but it will come at a higher cost, due to the temperature and light conditions in Canada, and a carbon footprint associated with the need to provide artificial lighting and temperature control.

> For some processors, their entire product portfolio utilizes plastic and the technology alongside it (Modified Atmosphere Packaging (MAP)) to distribute safe and healthy fresh cut produce, salads, fruit and ready-to-eat meals to grocery stores, foodservice outlets like restaurants, foodbanks, schools and convenient stores.

In addition, it was stated that food safety incidents will increase with a plastic packaging ban. Shelf life for certain commodities such as English Cucumbers will drastically reduce resulting in an increase in food waste and a decrease in consumption. Overall purchases will decrease as alternate non-plastic packaging will not give consumers visibility to determine the quality of the produce at the point of purchase.

Fresh cut fruits and vegetables, bagged/pre-made salads and berries will have very short shelf-lives in non-plastic packaging, making these items scarce in Canada. Berries and grape consumption will decrease as non-plastic packaging will increase food waste. Berry and grape supply from the US and Mexico will cease as the food loss during transit will negate the profitability for the suppliers.

Brennan, Langley et al. (2021. ScienceDirect) in the Journal of Cleaner Production state that Food packaging is often viewed as having a negative impact on the environment. However, packaging can protect food, prolong shelf life, and **reduce environmental impact by reducing food waste.**

Food packaging plays a vital role in food waste reduction through functional measures (Lindh et al., 2016 ScienceDirect). The existing literature shows that food packaging is continually advancing in shelf-life extension and waste reduction.

Existing designs and integrated technologies include:

- physical,
- chemical,
- sensory,
- microbiological protection innovations

(Gutierrez et al., 2017; Manfredi et al., 2015; Møller et al., 2016; Verghese et al., 2014; Wikström et al., 2018; Yildirim et al., 2018; Zhang et al., 2015 (ScienceDirect).

There is well-established research on packaging features that extend the shelf-life of food by using physical-chemical and microbiological protection. However, research specific to packaging functions that save food from waste (also called 'save food packaging') is an under-developed field (Wikström et al., 2018; Wikström et al., 2019. ScienceDirect).

Importance of consumer education and understanding

Throughout the literature it is evident that consumer knowledge, levels of awareness, interest, and appreciation are major factors in their refusal or acceptance of emerging packaging techniques (whether those technologies are specifically directed at reducing food waste or not). This complex relationship consumers have with food packaging creates a barrier to efficient food saving practices (ARCARDIS, 2019. (ScienceDirect). Consumer education on the benefits of packaging technologies is a repeated recommendation across the literature (Aday and Yener 2015; Barska and Wyrwa 2016; Licciardello 2017; Verghese et al., 2015; Williams et al., 2012).

Vocabulary used to communicate to consumers has also been recognised as a concern. Licciardello (2017) states that the focus should be on the way the product and packaging work together as a system, rather than just the packaging. This approach aims to expand consumers' awareness that packaging is an actor in the broad food system and is not the only determining factor relating to environmental impact.

Consumer education on the benefits of packaging technologies is a repeated recommendation across the literature (Aday and Yener 2015; Barska and Wyrwa 2016; Licciardello 2017; Verghese et al., 2015; Williams et al., 2012).

Edmund K. Mupondwa (2009) states packing material innovations is an integral part of MAP.
It is clear from this discussion that the economic impact of these storage innovations is significant. The impact on the food distribution chain is considerable especially when one considers the increased demand by supermarkets for safe foods and for traceability of each lot of fruits and vegetables. This places additional demands on growers and packinghouses.

The economic value of symmetric information is also clear from the labeling information provided in new packaging technologies as consumers increasingly seek clear and unambiguous information to enable them to

make informed decisions that have implications for health. In the past, nutritional information was never obligatory for fresh fruits and vegetables in all markets.

Less handling of prepackaged produce contributes to consumer perceptions that this produce is more. sanitary and safer. These consumer perceptions were confirmed by retailers who noted that consumers associate quality with fresh, and convenience and cleanliness with packaged.

Packaging Performance

Certain factors such as package design have also been shown as important in influencing this trend. Over 80% of consumers in a U.S. study expressed preference for a transparent design that allowed them to see what they are purchasing (PMA June 2004). Smaller, more flexible packages were also identified as preferable over larger, rigid packages both because they allow ease of storage and give the consumer the ability to see and feel the produce (PMA, June 2004).

There are clear global benefits that arise from a truly global fresh produce international trading chain in which CA and MA innovations enable fresh products to be transported efficiently and safely over wide distances and through an array of climatic zones. Future research can quantify these trends in terms of their commercial and socioeconomic impact, including an assessment of industry conduct, structure, and performance, in particular, the degree to which CA and MA have facilitated the creation of a competitive food trading environment while extending the produce supply window and shelf life, enhancing quality, minimizing product loss, ensuring affordability by consumers, and greatly reducing business operating costs, especially in light of high investment costs that are entailed by such a distribution system.

In a food security article, This Is Plastics: it is stated that in 2020, over 3 billion people worldwide faced food insecurity. This is due in part to spoilage or improper packaging, a problem made worse by the COVID-19 pandemic as supply chains crumbled and access to basic goods declined. However, with plastic packaging, food insecurity and food waste can be significantly reduced. Plastic packaging extends the shelf life of perishable products and is lighter and more durable than alternatives.

Sustainability

Furthermore, plastic packaging is the most sustainable option compared to alternative materials and contributes to environmental goals while reducing costs for consumers across the globe. Affordable plastics increase consumer access, consumer prices can be reduced with the use of more economical plastic products. PET plastic bottles, for example, cost less than half as much as glass bottles—savings that are generally passed

on to consumers. With rising inflation in the United States pushing these costs even higher, boosting consumer access to basic goods is now more important than ever.

Not only does replacing alternatives with plastic packaging reduce costs for consumers and manufacturers, it also extends the shelf life of products. Americans throw out about 20% of groceries due to spoilage every year, pushing them to purchase replacement items. However, flexible and rigid plastic packaging are more durable than alternatives and maintain product integrity during and after transit, extending sell-by dates and giving consumers more time to use products.

Food Waste

In a food security article, This Is Plastics: goes on to state that in 2020 with plastic packaging extending shelf life, consumers are less likely to throw spoiled items away, and less likely to "throw away" the money they spent on that product. The affordability and increased security that plastic packaging provides is particularly critical for consumers in rural areas and food deserts where poverty rates might be higher and grocery store commute times are longer. By increasing the use of plastic packaging for food products to create much needed shelf-life extensions, all consumers can access basic food products while also saving money.

Flexible plastic packaging not only prolongs shelf life, but also makes food look fresher for longer. Plastic packaging also reduces contamination and spoilage during manufacture and transport by using thermo-sealing techniques, making food safer for consumers.

Safer food reduces food waste both during manufacture and after purchase, further increasing consumer access.

In addition, as stated by Alchemy Systems Consulting (2023. Alchemy one of the primary roles of food packaging is to protect food products from damage and degradation while allowing for easy transportation. While there are multiple types of packaging options, plastic packaging is one of the most popular options. This is because one of the major advantages such type of packaging offers is its flexibility in terms of functionality. Plastic also offers biological protection by way of protecting the food products from the millions of microorganisms present in its surroundings.

Plastic packaging reduces food waste by extending shelf life and keeping our food fresher for longer. This valuable material also increases access and affordability for consumers across the globe and drives environmental goals by reducing emissions at every step of the life cycle. Industry is already investing in new ways to ensure that plastic packaging is even more environmentally friendly, like Eco-Product's line of recycled

plastic packaging. By using more plastic packaging, we can continue to reduce food waste and increase food security.

This Is Plastics: (2023) also states certain policies can have unintended negative consequences. These include efforts to ban or tax products such as plastic bags. While these initiatives likely arise from a sincere effort to prevent litter and help the environment, officials often overlook the negative economic impact, and overstate the environmental impact, of these policies.

Plastic packaging reduces food waste by extending shelf life and keeping our food safer and fresher for longer.

A study by the National Center for Policy Analysis shows that plastic bag bans have a negative effect on retail sales in areas where bans are in place, as they encourage shoppers to take their business to areas neighboring the ban regions. A better option for states and municipalities working to combat plastic pollution without hurting both the economy and people who are poor is to promote plastic bag and film recycling instead. The recycling of these materials in the United States has been on the rise in recent years.

Obersteiner, Cociancig, Luck and Mayerhofer (2021. Sustainability) point out that the function of packaging is often overlooked when considering waste; however, food packaging is indispensable for hygienic protection during transport and distribution within the supply chain. An important way to prevent the premature spoilage of a variety of different food product groups is to use specially optimized packaging systems. These are able to provide a high level of protection and actively extend shelf life.

However, even if novel packaging systems theoretically have great potential for waste reduction, it remains uncertain whether they will also be accepted at the consumer level and actually contribute to waste reduction within households.

The function of packaging is often overlooked when considering waste.

In discussing packaging and food waste, Verghese, Lewis, Lockrey, Williams, and Simon, (2013. CHEP Australia (diva-portal.org)) state that over 4.2 million tonnes of food waste is disposed to landfill in Australia each year. Around 1.5 million tonnes of this is from the commercial and industrial sector (the focus of this report), costing around $10.5 billion in waste disposal charges and lost product. The largest single contributor in the commercial and industrial sector is food service activities (e.g., cafes, restaurants, fast food outlets), which generate 661,000 tonnes of food waste per year, followed by food manufacturing (312,000 tonnes) and food retail (179,000 tonnes).

Verghese, Lewis, Lockrey, Williams, and Simon, (2013. CHEP Australia (diva-portal.org) add that a number of opportunities to reduce food waste through packaging improvements were identified, including:

1) Distribution packaging that provides better protection and shelf life for fresh produce as it moves from the farm to the processor, wholesaler or retailer. This may require the development of tailored solutions for individual products.

2) Distribution packaging that supports recovery of surplus and unsaleable fresh produce from farms and redirects it to food rescue organisations.

3) Improved design of secondary packaging to ensure that it is fit-for-purpose, i.e., that it adequately protects food products as they move through the supply chain. Packaging developers need to understand the distribution process and where and why waste occurs.

4) A continuing shift to pre-packed and processed foods to extend the shelf life of food products and reduce waste in distribution and at the point of consumption (the home or food services provider). The packaging itself also needs to be recoverable to minimize overall environmental impacts.

5) Adoption of new packaging materials and technologies, such as modified atmosphere packaging and oxygen scavengers, to extend the shelf life of food

6) Education of manufacturers, retailers and consumers about the meaning of use-by and best- before date marks on primary packaging to ensure that these are used appropriately. Confusion about date marking results in food being thrown away when it is still safe to eat.

7) Product and packaging development to cater for changing consumption patterns and smaller households. Single and smaller serve products will reduce waste by meeting the needs of single and two person households.

8) Collaboration between manufacturers and retailers to improve the industry's understanding of food waste in the supply chain. Greater attention to be given to where and why this occurs, tracking over time, will reduce the costs and environmental impacts of waste.

9) More synchronized supply chains that use intelligent packaging and data sharing to reduce excess or out-of-date stock.

10) Increased use of retail ready packaging to reduce double handling and damage and improve stock turnover, while ensuring that it is designed for effective product protection and recoverability (reuse or recycling) at end of life.

Discussing the impact of removing plastic packaging from fresh produce White, and Lockyer (2020. wiley.com), add that plastic packaging of food causes a significant proportion of the UK's plastic waste, and manufacturers and retailers are exploring alternatives to single-use plastics, particularly in relation to fresh produce, including increasing the availability of loose items in supermarkets. However, there is an important trade-off to consider when removing plastic packaging from fruit and vegetables, which is the **resultant reduction in shelf life and therefore potential increase in food waste.**

Fresh produce is estimated to be the most highly wasted type of food in the UK, and it is likely that food waste has an even greater environmental impact than the production and disposal of plastic.

International Cases and Lessons Learned

EuroNews (2021) states that with a ban on plastic wrapped fruit and veg expected in 2023 in Spain, manufacturers and retailers have concerns around its effect on food waste and the nation's health.

BBC) News (2021) adds that a new law banning plastic packaging on most fruit and vegetables comes into effect in France from New Year's day. Cucumbers, lemons and oranges are among the 30 varieties banned from being wrapped in plastic. Larger packs as well as **chopped or processed fruit will be exempt.**

The impact of eliminating plastic packaging on Canadian businesses including, fresh produce, processors, indoor ag market, and packaging companies, institutional and retail companies

One Canadian packaging company postulated that many consumers appreciate the convenience of pre-packaged options, which eliminate the need for weighing and bagging items individually. The absence of plastic packaging could result in a shift in consumer habits and preferences.

A North American produce expert interviewed predicted that:

- Retail fresh produce value added industry will be eliminated forcing the closure of the majority of fresh cut processing facilities.
- Canadian Greenhouse industry will experience a severe decrease in English Cucumber sales.

- Canadian Greenhouse industry will experience a decrease in pepper and tomato sales due to the visibility at retail and the increased cost for non-plastic packaging.
- Covered Environment Agriculture will experience a severe sales loss of leafy greens and herb sales.
- Retail stores will experience a decrease in sales due the lack of variety and increased retail prices for fresh produce.
- Canadian packaging companies supply plastic packaging to the fresh produce industry will suffer a significant volume decrease.

7. THE IMPACT ON FOOD WASTE AND THE SUBSEQUENT ENVIRONMENTAL ISSUES, IF PLASTIC PACKAGING IS ELIMINATED.

In a food security article (2020)it is stated that by extending product shelf life, plastic packaging reduces food waste and the need for consumers to "double-buy" food items. According to a report by the Waste and Resources Action Programme (WRAP), increasing the shelf life of food by just one day could reduce waste and result in cost savings of about $800 million a year.

Kasza, Veflen, et al (2022. mdpi.com)) state consumers tend to judge packaging in an extremist way; in general, they overestimate the negative environmental aspects of food packaging but underestimate its role in food safety. According to consumers' assumptions, more than half of the total carbon footprint of a food product is related to the packaging. In fact, the actual data on the carbon footprint **ratio of packaging compared to the total carbon footprint of the product is only 1/30**. Consumers tend to consider disposable packaging an enemy, even though it significantly contributes to maintaining food safety and, due to longer shelf life, even facilitates a more sustainable food chain.

Kasza, Veflen, et al (2022) state consumers tend to judge packaging in an extremist way; in general, they overestimate the negative environmental aspects of food packaging but underestimate its role in food safety.

According to the literature, estimated food loss due to lack of proper packaging has a bigger negative effect on the environment than the positive effect of simplification or complete abandonment of packaging.

Packaging is the most efficient physical barrier to protect food; unpacked food is prone to food-safety risks. Elimination of single-use packaging results in the spread of reusable packaging materials. Single-use plastic bags—used for bakery products, vegetables, and fruits—not only are convenient but also help to prevent cross-contamination by separating food products. Replacing single-use plastic bags with reusable shopping bags may deliver new types of risks; consumers are often not aware of their own responsibility in maintaining

the hygiene of these items (bags, boxes). Non-adequate washing and sanitizing of these containers can lead to cross-contamination.

Additionally, because packaging serves as the primary communication platform between food manufacturers and consumers, lack of packaging can easily imply a lack of risk-related information for consumers.

In the case of bulk products, bulk-food containers in the shop must be equipped with the food label required by legislation, or personnel of the shop should be able to provide information upon consumer request. However, all necessary food-safety information (e.g., expiration date, storage circumstances) vanishes after the product fills the consumer's own food container, resulting in a possible knowledge deficit before consumption. The deficiency in consumer knowledge can pose food-safety risks and trigger household food waste.

One association indicated that "On average, only 3-3.5% of the climate impact of packaged food comes from the packaging itself. This proportion can be significantly higher for certain kinds of foods and formats, but ultimately, packaging "pays off" if the protective features help to reduce food waste by at least ~4%."

A published article, in (theconversation.com) (2019) "Why some plastic packaging is necessary to prevent food waste and protect the environment" the authors state there has been a surge in awareness of the damage that plastic pollution does to our planet in recent years. It has spurred a number of campaigns to remove single-use plastics from our daily lives. This extends to food packaging, with a Waitrose supermarket in the city of Oxford recently launching a package-free trial.

Many people bemoan the large amount of packaging that supermarkets use, particularly for fruit and vegetables, most of which have their own natural protection. Nonetheless, a major reason that supermarkets use so much packaging is to protect food and prevent waste – particularly with fresh food. **Removing plastic entirely from our food supply may not be the best solution when it comes to protecting the environment and conserving valuable resources.**

Plastic packaging is used in the food supply chain because it supports the safe distribution of food over long distances and minimizes food waste by keeping food fresh for longer. A 2016 review of studies on food waste, by the EU Commission, (Food Safety europa.eu), found that 88m tons of food is wasted every year in the EU – that's 173kg per person and equals about 20% of food produced. Minimizing this

Removing plastic entirely from our food supply may not be the best solution when it comes to protecting the environment and conserving valuable resources.

wastage is crucial for environmental protection, as well as food security.

For example, the use of just 1.5g of plastic film for wrapping a cucumber can extend its shelf life from three days to 14 days and selling grapes in plastic bags or trays has reduced in-store wastage of grapes by 20%.

Plastic protects and preserves the freshness of a lot of fruit and vegetables. Recent estimates from Zero Waste Scotland suggest that the carbon footprint of food waste generated can be higher than that of plastic. Specifically, 456,000 tons of food waste produced in Scottish households were found to contribute to around 1.9m tons of CO_2, three times higher than that of the 224,000 tons of plastic waste generated.

Plastic packaging maintains food quality and safety. Food that is naturally wrapped in its own skin and can be safely transported and consumed without the need for single-use. But research shows that these products appear to be sustainable only where short food supply chains exist. When food is transported from further away, as a lot is, plastic can play an important role in protecting it from becoming waste. Furthermore, plastic packaging is more flexible and lighter than alternatives such as cardboard. This reduces transportation costs and the carbon emissions that come with them.

Simply removing plastic from food packaging is not as sustainable as one might think. There are lots of cases where plastic packaging can be beneficial at reducing waste. But food sellers need to think of ways to reduce and reuse the plastic where possible. Another solution is to develop a more circular economic model where plastic is reused and recycled a lot more. This makes economic as well as environmental sense.

Work is also being done on new, bio-based packaging that can perform the same role as conventional plastic in terms of protecting food and preventing food waste – and could also be biodegradable. But a lot of questions remain as to whether bio-based plastics are actually sustainable in the long term, especially if vast amounts of resources are needed to produce them.

A Canadian packaging company adds that with respect to environmental issues created by the elimination of plastic packaging:

- Greenhouse Gas Emissions: Food waste in landfills contributes to the production of methane, a potent greenhouse gas. Increased food waste resulting from the elimination of plastic packaging could exacerbate these environmental impacts.

- Resource Use: The production, transportation, and disposal of food require significant resources, such as water, energy, and agricultural inputs. Increased food waste places additional strain on these resources, contributing to environmental degradation.

- Wasted Agricultural Inputs: When food is discarded, the resources invested in its production, including water, fertilizers, and energy, become wasted. The elimination of plastic packaging without a suitable alternative could lead to a higher proportion of agricultural inputs being lost.

- Impact on Land Use: Landfill Expansion: The disposal of increased food waste in landfills may contribute to the expansion of landfill sites, which can have adverse effects on local ecosystems and communities.

A North American processor added, I would ask them to specifically mention the role packaging has in extending "shelf-life". For example, developments in plastic have extended shelf-life of baby carrots to 28 days today, compared to 14 days just 15 years ago. It's a good example, and useful illustration, that extending shelf-life obviously reduces food waste.

Discussing specific fruits and veg, one industry expert stated that food loss in transit for berries, English cucumbers and grapes will increase. Food waste at retail stores and at consumers will increase due to the shorter shelf life. Food loss on fresh cut and bagged salads will increase to the point that the categories may be eliminated at retail stores.

A second North American processor adds that The National Zero Waste Council. (2022 Love Food Hate Waste Canada) reported that the average Canadian household wasted 140 kg of food in 2022. Wasting this much food when totaled up for Canada amounts to over $20 billion of food thrown away annually. Globally, food waste has reached 40% of total production (WWF. 2022. WWF panda.org), with food loss and waste contributing to ~8% of global emissions (fao.org)But packaging design has been proven to be part of the solution (ReFED) through dramatically increased shelf life.

8. POTENTIAL SUSTAINABLE OPTIONS IN LIEU OF A COMPLETE PLASTIC PACKAGING ELIMINATION

As one processor stated, the elimination of plastic packaging has the potential to increase food waste, with cascading environmental consequences. Addressing these challenges requires a holistic approach that includes

the development of sustainable packaging alternatives, consumer education, and supportive policies to minimize the environmental impact of food waste.

Kasza, Veflen, et al., (2022. mdpi.com) observe that during consumer campaigns, it is important to note that most single-use packaging materials (e.g., PET, paper) can be recycled through selective waste collection and processing systems. Unfortunately, many food packaging materials cannot be easily recycled due to their multi-layer structure. During recent decades, development of novel packaging materials based on by-products and biodegradable materials has become an important research field that can alleviate this challenge.

The novel packaging solutions increasingly indicate that **total rejection of single-use plastic is not the only path for a more sustainable food packaging.** Therefore, sustainable communication messages should focus on sharing knowledge and consumer engagement in proper recycling, rather than elimination of protective packaging. Use of simple, well-designed packages and their selective collection and recycling might help to find the balance between protecting consumers' health and sustainability.

Challenges

A leading North American fresh produce processer cautions that there still are challenges, today plastics are a highly effective tool in improving quality and food safety and reducing food loss, all while at a highly competitive price. There are no alternatives or substitutions to plastic today. We have tested multiple bio-based resins such as PLA and other fiber-based materials that can't hit OTR, WVTR, and/or lack machinability (such as throughput speed and seal performance). Furthermore, performance restricted substitutions that do exist, cost 5-9X more than its plastic counterpart. In terms of functionality, most alternatives for plastic film are low strength and/or react poorly to micro-perforation, often making them susceptible to breakage or malfunction. Furthermore, most also lack the durability to perform in a constant 34–40-degree cold chain.

As one Canadian packaging company states; "the elimination of plastic packaging for fresh produce could lead to a range of challenges affecting both food quality and safety." Striking a balance between sustainable packaging alternatives and the necessary protection for fresh produce is crucial in addressing these potential impacts.

In discussing plastic reduction, a leading North American fresh produce processer states, we have successfully reduced plastic by 3.5 million pounds per year through utilizing Peel & Reseal packaging technology for our many of our clamshells. The plastic reduction is a result of replacing the rigid lid with a resealable lidding film, while also eliminating a top and bottom label. The new design maintains a recyclable tray made from 100% recycled plastic and improves the shopper experience with a printed film while ensuring the finest quality

greens. Our packaging is extremely popular with consumers, with over 75% of consumers surveyed stating they are happy with it and over 92% stating that they love it citing “freshness, ease, and convenience” as the reasons for satisfaction. This peel reseal format cannot be used on all vegetables or vegetable blends due to OTR constraints.

It is important to also note that work is ongoing and ramping up in the packaging industry as evidenced by the move of one processor into late stage trials loading 30% pcr in its retail flexible packaging, a move that could replace over 400,000 pounds of virgin plastic per year with recycled content, and make this processor one of the first consumer facing brands to roll out pcr in its plastic bags.

That being said a leading food safety expert cautions that as the produce industry, governments, and societies evolve to incorporate a growing diversity of more sustainable packaging options, careful consideration must be made to ensure the advancements in food safety, quality, and portability are not lost, and that with each new material introduced, we ensure that appropriate research is conducted to assess that non-plastic alternatives provide comparable, if not improved upon, advancements to food safety and public health.

Use of recycled PET in thermoforms and bottles reduces the, Green House Gases, GHG, footprint by ~70% vs. virgin PET plastic usage (plasticsrecycling.org)

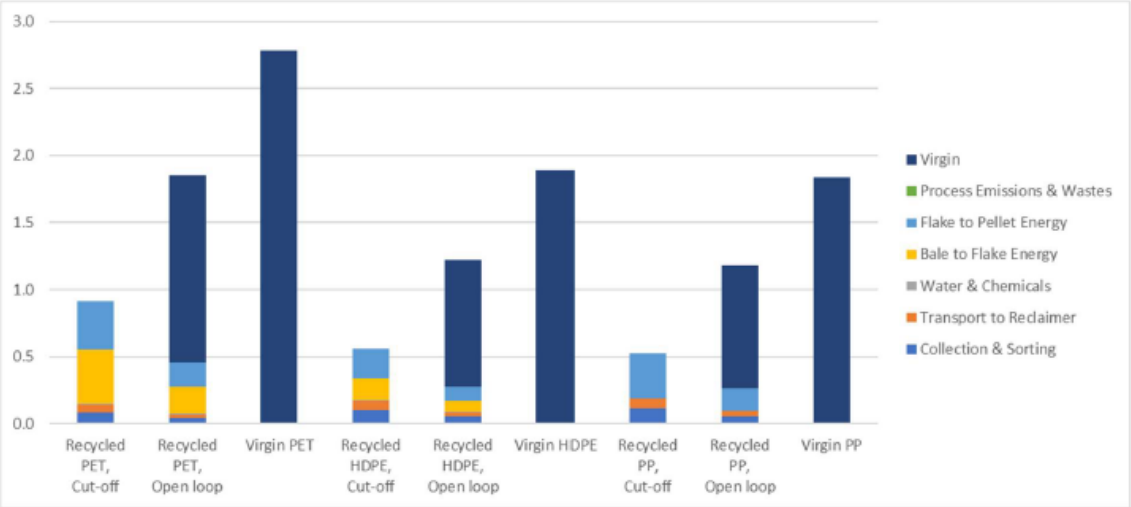
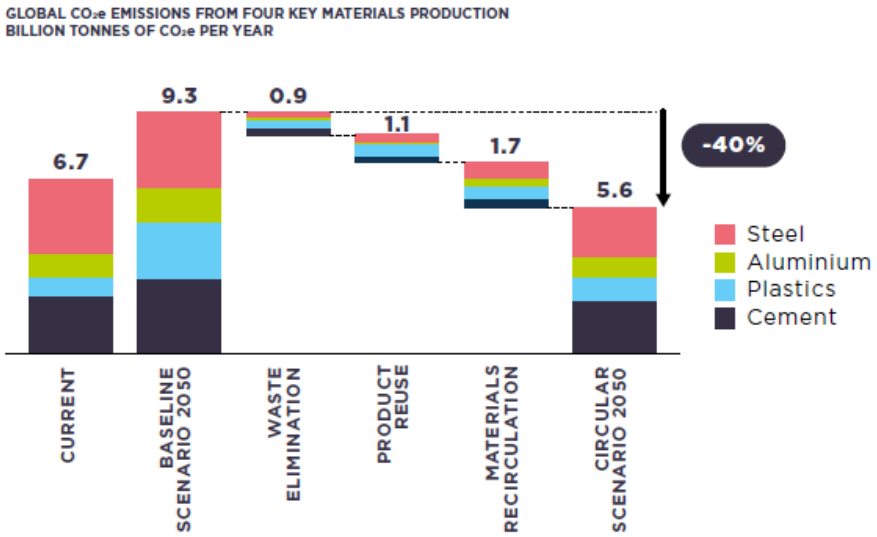


Figure 3-6. Global Warming Potential Results for Recycled and Virgin Resins (kg CO_2 eq/kg resin)

Sustainable Packaging

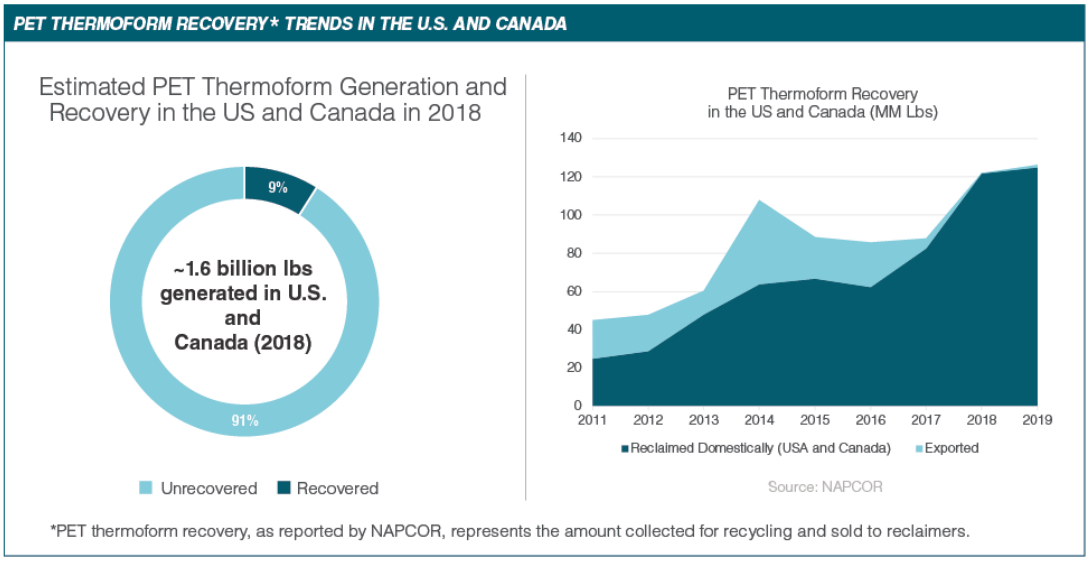
There is a greater opportunity to reduce Green House Gases, GHG, by recycling materials than by either reduction or reuse. Ellen MacArthur Foundation, Completing the picture: How the circular economy tackles climate change (2021. ellenmacarthurfoundation.org)



In discussing case liners and pallet bags a large North American manufacturer states that the bulk of the packaging utilized withing this group are Polyethylene (PE/LDPE) based. These structures are 100% recyclable and fall within the #4 recycle code (LDPE). This allows them to be mechanically recycled and used back within a circular economy.

Recycled Content Post Industrial (PIR) and Post Consumer (PCR)

As stated by an industry organization over the last decade, the produce packaging industry has made significant strides in reducing packaging as well as reformulating packaging to lower the environmental impact of plastics used. Reports & Resources - NAPCOR



They go on to state that almost all clamshells today contain recycled plastic. In some categories like spinach, the clamshells are made from 100 percent rPET, or recycled polyester. By contrast, PCR for flexible packaging (e.g., bags) has only become widely available in recent years.

PCR now makes up about 5 to 10 percent of every polyethylene package that some packaging companies are making. Part of the constraint is that it is expensive to set up factories to manufacture PCR, as the Ministry no doubt knows. PCR itself is also more expensive than virgin plastic by a factor of two, but blending PCR with virgin plastic reduces the cost, making it more affordable. Packaging manufacturers in the United States and produce companies are working together to push the use of PCR in flexible packaging.

A North American processor adds that although recycled content both PCR and PIR can be utilized in the manufacturing process in creating the MAP/OTR controlled package, it does not support the chemistry of the tight tolerances needed to control the OTR of the package within the retail space. However, PCR and PIR can be utilized when the process of controlling the MAP/OTR is controlled by Micro, Macro, Laser, and Mechanical Perforations. Another alternative to Perforations is a Punch and Patch Breathability System.

Canadian Government should provide more recycling infrastructure to increase the availability of recycled content to manufacture recycled materials. (2021. ellenmacarthurfoundation.org)

Table 1: Summary of output (unchanged from 2022)

Packaging category	Evidence found that a 'system for recycling' exist in practice and at scale today[4]	Countries/Regions where responses provide evidence for a 30% recycling rate being achieved[5]	Total population for which survey responses provide evidence of a 30% recycling rate being achieved[6]
PET bottles	Yes	**Regions:** EU+3 **Countries:** Argentina; Australia; Austria; Belgium; Bolivia; Brazil; Bulgaria; Canada; China; Costa Rica; Cyprus; Czech Republic; Denmark; Ecuador; El Salvador; France; Germany; Guatemala; India; Indonesia; Italy; Japan; Mexico; Netherlands; New Zealand; Norway; Panama; Paraguay; Peru; Poland; Portugal; Russia; South Africa; Spain; Sweden; Switzerland; United Kingdom	4.6 billion
PET Thermoforms	No	**Countries:** Australia; Canada; New Zealand	68 million

Life Cycle

White and Lockyer (2020. wiley.com) state full life cycle analysis is currently unavailable for some alternative types of packaging (such as edible films and coatings), which means the relative effect of these on the environment compared to plastic is unclear, and may in fact be worse. More research is required to fully ascertain the best solution for this complex issue. However, communicating strategies to the general public to minimize household wastage of fresh produce, including optimal storage conditions for different varieties of fruit and vegetables, is likely to be of benefit.

Using recycled materials collected by these PCR manufacturers reduces the amount of single-use plastic going into landfills and repurposes it so it gets used again and again, up to eight times by current usage metrics. Eliminating single-use plastics as the notice suggests would kill this industry just as it has begun to take off.

White and Lockyer (2020) state full life cycle analysis is currently unavailable for some alternative types of packaging (such as edible films and coatings), which means the relative effect of these on the environment compared to plastic is unclear, and may in fact be worse.

With respect to Life Cycle and efficiency, in a food security article, it is stated that in 2020, while plastic packaging is clearly the best choice for increasing consumer access, plastics are also the best option for reaching environmental goals according to Life Cycle Assessments (LCAs).

Not only is plastic packaging more durable, it is up to 20 times lighter than alternatives, allowing more products to be packed into fewer shipments. Lighter shipments increase fuel efficiency for trucks and aircrafts that are delivering products to far-off destinations.

A longer shelf life also means that less food is wasted, and the emissions associated with decomposition are also reduced.

In addition to reducing the emissions produced by decaying food alone, innovative and durable plastic packaging also prevents wasting all of the resources that were spent producing a product.

As stated by Alchemy Systems Consulting https://www.alchemysystems.com/ Recently, a life cycle study was conducted to measure the viability and safety of plastic in today's market compared to other packaging materials. This included plastic packaging, plastic caps, plastic containers and flexible plastics as well as shrink wrap. While analyzing the samples, it was ascertained that alternatives materials took up about 4.4 times as much weight after manufacturing had completed. The manufacturing process itself used twice the amount of energy used to create plastic. This only goes to show that the nature of plastic—the production process as well as its life cycle—have shown significant improvements over the years.
One sustainable packaging expert agrees that the total impact over the life of the packaging needs to be assed and considered.

Compostable

Compostable alternatives though available to the market have similar downfalls as the PCR and PIR materials.

These materials show very poor breathability as well as poor mechanical properties which can cause failures within the distribution chain.

One of the major challenges of compostable packaging is the ability to design when the competing process begins and how quickly it compost.

As Robertson, (2016. Food Packaging. 2016) states it is also important to understand that there are two key steps that must occur in the biodegradation of polymers.
First, a **depolymerization or chain cleavage step** (hydrolysis and/or oxidation may be responsible) converts the polymer chain into smaller oligo-meric fragments. The hydrolytic or oxidative processes may be promoted biotically (in biological pathways) and abiotically (in nonbiological pathways), with oxidation usually a slower process than hydrolysis.

The second step (**known as mineralization**) occurs inside the cell, where oligomeric fragments are converted into biomass, minerals and salts, water and gases such as CO2 and CH4. The biodegradation of plastics depends on both environmental factors (i.e., temperature, moisture, oxygen and pH) and the chemical structure of the polymer or copolymer.

Complete biodegradation of the product is commonly measured through respirometric tests such as in ASTM D5338, which is equivalent to ISO 14852.

It comes as a surprise to many people to learn that certain natural materials do not meet these standards, for example, a leaf will not naturally biodegrade within the time frame allotted by either D6400 or EN13432.

Economics

The recycling industry data suggests that investments in thermoform-specific sortation from the Recycling Partnership including at Merlin Plastics, Delta, British Columbia, 100% rPET Thermoforms are produced at scale by Klöckner Pentaplast, rPlanetEarth, Merlin Plastics and others. available on the market.

When properly designed (APR guidance to be updated soon), thermoforms can be incorporated up to 10 wt.% in PET bottle stream and at higher levels in PET thermoforms and fiber stream.

North American recycling capacity for rPET thermoforms is continuing to increase.

Going Forward

The fresh produce industry currently selects the packaging type that addresses food safety requirements and balances the shelf life, food loss/waste and cost factors. Any change to the current regulations will result in an increased cost to Canadian consumers.

Finding sustainable packaging alternatives involves a nuanced consideration of various factors, from the type of materials used to their end-of-life options and economic feasibility. Striking the right balance is essential for effective and widespread implementation. An exemption from any plastic ban is required until the alternatives are developed.

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APPENDIX

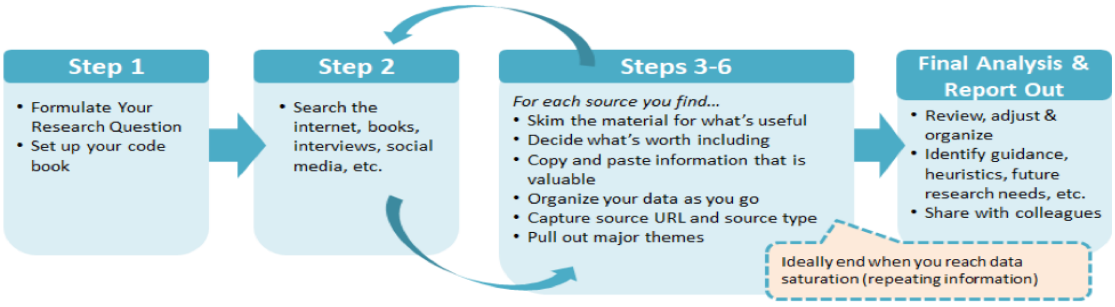
Problem

The consultation document frames several legislative requirements which would have a drastic impact on how Canadian consumers are able to purchase fresh fruits and vegetables and would severely restrict how plastic packaging could be utilized across the Canadian produce supply chain.

In response to the Pollution Prevention Plan Notice for Primary Food Packaging (P2) proposal, CPMA (Canadian Produce Marketing Association) is looking to substantiate the role packaging plays from a food quality and food safety perspective for fresh produce.

Methodology

Our literature search will follow the six basic steps of literature research as outlined by (Pare & Kisiou, 2017);



Research Process

To facilitate the research, Qfresh has:

- Compiled a list of relevant databases and texts searched.
- Made a list of relevant keywords and phrases.
- Made notes from each database.

Qfresh Lab has

- Read the selected articles thoroughly and evaluated them.
- Compared the literature against practical/commercial applications. Highlighted key sections of literature and studies that deviate from practical applicability.
    - For example: many times, studies overlook a key component of packaging technology.
- Organized the selected papers by looking for patterns and by developing subtopics.
- Breakdown of sources:

  - **Primary:** books, chapters, reviewed articles
  - **Secondary:** newspapers, magazine articles
  - **Tertiary:** social media, industry owned research and interviews with relevant companies and individuals
- Reviewed the literature and compiled all the results into a report.
- Expanded and revised our original research question.

An expanded literature search also includes

- The impact of eliminating plastic packaging on Canadian businesses including, fresh produce processors, indoor ag market, and packaging companies, institutional and retail companies.
- The impact on food waste and the subsequent environmental issues, if plastic packaging is eliminated.
- Potential sustainable options in lieu of a complete plastic packaging elimination:
  - "Sustainable Packaging"
    - Recycling vs. compostability
    - Differences between conventional polymers and biopolymers
    - Fit for use challenges.
    - Life cycle comparisons
    - Economics

The report formatting is such that any information, data, or analysis discovered will be listed under the relevant project topic heading. This will streamline findings; which information discovered is related to each relevant question.

Literature searches/interviews were conducted on:

- Peer reviewed scholarly papers.
- Peer reviewed books and book chapters
- Trade journals and publications
- Industry companies', personnel, and executives
- The general internet

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The consultation document frames several legislative requirements which would have a drastic impact on how Canadian consumers are able to purchase fresh fruits and vegetables and would severely restrict how plastic packaging could be utilized across the Canadian produce supply chain.

In response to the P2 proposal, CPMA[2] is looking to substantiate the role packaging plays from a food quality and food safety perspective for fresh produce.