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Alternative Solutions for Fruit and Vegetable Price Look-Up Stickers Generating Waste in the Environment

by

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Abstract

Waste generation impacts the environment, energy, economy, and society. Price Look-Up stickers used on the fresh produce become environment litter, can cause compost contamination, and contribute to climate change. This research was conducted to identify alternative and sustainable solutions for Price Look-Up stickers. Two surveys were conducted for the purpose of this research. Survey I was geared towards identifying the potential for adoption of alternative solutions among produce processors and distributors . Survey II was intended for analysing sticker waste disposal practices and attitudes among end consumers. Representatives from the sticker manufacturing industry were interviewed to gain information for analysing the prospects for innovation, availability, and adoption of alternative solutions. I consulted with officials at the Canadian Produce Marketing Association to understand their position on need for alternatives. Findings from the surveys and industry consultations were used to develop recommendations for The City of Calgary.

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Chapter 1: Introduction

Plastic has found its way into our daily lives since its invention in the early 1900s and is an integral part of thousands of products in our homes, kitchens, and grocery stores (Science History Institute, n.d.). The use of plastic including single-use plastic is unavoidable for several reasons including non-availability of affordable alternatives to plastics. Plastic used for packaging comes by default with the products we buy. Plastic used in food and fresh produce packaging is essential for maintaining hygiene and integrity of food items. Plastic is used for making labels that carry food or product information. One such example of a small plastic product widely used is the Price Look-Up (PLU) sticker, used on produce like fruits and vegetables, which are sold loose or bunched, by individual units or by weight. The PLU sticker carries the Price Look-Up code and information like the name, country of origin, and price of the product (International Federation for Produce Standards, n.d.-b). The stickers are not mandated by the government but required by businesses like supermarkets for product identification and tracing. The PLU stickers on the produce are scanned and used by cash registers for billing purpose (Chung, 2020).

For the purpose of this research, the words 'sticker' and 'label' are used interchangeably. The PLU sticker has three primary components: face stock, adhesive, and ink. Conventional and widely used stickers are primarily made up of polyethylene and adhesives which are not compostable (Nosowitz, 2018). In addition to the plastic, the face stock of some stickers can also contain paper. PLU stickers in fruit and vegetable waste including peels and rinds create contamination in the compost. Sorting of the stickers at the composting facility is highly time, labour, and cost intensive, as a result of which the food waste contaminated with PLU stickers may be diverted to landfills. The stickers are small and thin and can pass through the screens designed to detect foreign materials during the screening process at the composting facility. The plastic from the stickers can

potentially break down to form microplastics. Composting facilities consider the PLU stickers as one of the major and common contaminants in the entire chain. Presence of large amounts of contaminant or foreign matter can make the compost unmarketable. While the stickers appear to be relatively small and insignificant, thousands of stickers used every day combined, compound to a large number of contaminants. Producing high quality compost is essential as several municipalities supply bulk compost to local farms, landscape companies, and soil blenders. Therefore, this research investigates, "How to minimize the use of conventional PLU stickers on produce by finding alternative solutions and developing recommendations for advocacy with local producers in Calgary?" This research was conducted in collaboration with The Waste and Recycling Services at The City of Calgary.

1.1 Multidisciplinary Aspects

Production of stickers consume large amount of resources like water, energy, paper, plastic, adhesive, and ink during different stages like manufacturing, transportation, application, and end of life. Stickers have a short life span and at the end of life can become environmental litter if and when not disposed appropriately. Since multiple industries, resources, and environmental dimensions are involved, my research on PLU stickers was multidisciplinary and anchored to the three dimensions of sustainability: energy, environment, and waste management behavior.

1.1.1 Environment

In 2017, vegetable and fruit waste accounted for 30% and 15% of all food waste in Canada respectively (National Zero Waste Council, 2019). Food waste is either sent for composting or diverted to landfills, depending on the waste management capabilities and practices at different municipalities across the country. Food and plastic waste impact the environment. Contamination of compost results in production of low grade compost which can be potentially diverted to

landfills. The decomposition of organic food waste in landfills releases greenhouse gases (GHG), primarily composed of methane and carbon dioxide. Methane has 25 times greater global warming potential than carbon dioxide. Landfill emissions account for 20% of Canada's total methane emissions. In the year 2015, 30 Megatonnes of CO2 equivalent (eCO2) were produced from the landfills, of which 11 Mt eCo2 was captured and 19 Mt eCO2 was eventually emitted into the atmosphere (Government of Canada, 2017).

Craig Speirs, a councillor in Maple Ridge City in British Columbia, in 2017, had put forth a proposal to replace plastic-based PLU stickers, after recognising the critical contamination issue arising from the stickers. The councillor acknowledged that stickers were contaminating the compost which ultimately contaminated the soil used for agriculture. Craig Speirs's suggestion was to have non-compostable stickers replaced with compostable stickers or food stamps made from vegetable-based ink. Interestingly, his proposal garnered mixed reviews and opinions. The response received from people in general was not completely in support of his proposal. The common opinion was that the sticker contamination was relatively an insignificant issue and the councillor was suggested to focus on larger problems (CBC News, 2017). While the issue of contamination is being recognized by the City officials, there is an evident lack of awareness among people at large, about the serious environmental complications caused by the stickers. On March 06, 2018, the City of Calgary tweeted to inform Calgarians that PLU stickers should be taken off before discarding fruit and vegetable waste in green carts, as the stickers are not compostable (Dormer, 2018). In February 2020, CBC news carried an article about produce stickers being an environmental hazard and contributing to climate change in Canada. Composting plant managers find manual sorting and removal of stickers at the composting facility to be cost and labour intensive, and practically infeasible (Chung, 2020). Plastic remains in the compost from

the sticker adds microplastic in the environment. Taking into account the numerous news articles and statements from City officials, it can be inferred that recycling facilities and councils across the country are facing similar challenge with the PLU stickers.

1.1.2 Energy

Tremendous amount of energy is consumed for waste management, waste transportation, waste diversion, and development and maintenance of landfills that store the diverted waste. Most of the energy consumed in Alberta is generated from fossil fuels (AESO, 2019). The burning of fossil fuels dissipates GHG emissions and heat into the atmosphere, which subsequently contributes to climate change. Methane from landfills can be collected for energy production. However, not all municipalities that operate and manage landfills across Alberta and Canada have infrastructure and systems for methane collection. Consequently, methane is released into the atmosphere as a greenhouse gas. Incineration of waste is another way of generating energy. However, incineration creates harmful gaseous waste like particulate matter, sulphur and nitrogen oxides, volatile organic compounds, carbon monoxide, and ammonia. These gases when released into the atmosphere cause air pollution. In 2009, municipal incineration released 4,343 tonnes of all the gases combined, in Canada (Statistics Canada, 2015). Reduction of contamination in the compost helps to reduce waste diversion to landfills. This in turn will reduce the requirement for processes like gas collection and incineration for managing waste in the landfills.

1.1.3 Environment to Waste Management Behaviour

Compost produced from food and biomass waste is a stable humus-like substance which provides structure to the soil and helps to hold water. Stable and healthy compost is also beneficial in preventing diseases in plants. Additionally, compost helps to replenish the nutrients in the soil

(Ashrap & Cathey, 2019). Foreign matter and substances are screened and removed from the organic waste at the composting facilities to lower the contamination in the final compost.

Presence of large quantities of contaminants in the compost can degrade compost quality, and subsequently transfer contamination and toxicity into the soil upon integration. Presence of contaminants in food waste is one of the leading causes for food waste diversion to landfills (Government of Canada, 2019). Fruit and vegetable waste with PLU stickers create contamination in the composting stream. Plastic from PLU stickers remains in the compost. Plastic pieces can further breakdown to form microplastics. Plastic from produce and food packaging including labels like PLU stickers is one of the major contributors of plastic pollution, especially when not discarded in compliance with the best practices and processes implemented by the municipalities. United Nations Environment Programme estimates that nearly one-third of all plastic waste ends up in the oceans or in the soil. Half of the topsoil has been lost in the last 150 years owing to several causes including plastic pollution (United Nations Environment Programme, 2018). According to the Interactive Soil Quality Assessment Report published by the Institute for European Environmental Policy, the potential of microplastic pollution and contamination on land is 4 to 23 times greater than in the oceans (Gionfra, 2018). Plastic waste breaks into nanoparticles and has been observed to have entered our food chain through sea organisms and topsoil (Wang, Lee, Chiu, Lin, & Chiu, 2020).

Chapter 2: Literature Review

2.1 The Purpose of PLU Stickers

A global standard for the use of the PLU numbers or codes was set up in 2001 by a consortium of fruit and vegetable associations across the globe. The aim was to create a standardized numbering system for produce identification and management. The Price Look-Up codes are used on produce like fruits and vegetables, that are sold in bulk or loose, to achieve a harmonized and efficient supply chain system. The International Federation for Produce Standards (IFPS) publishes the PLU codes for different items to distinguish them effectively. The codes are issued for items that are available to the entire global produce markets. These PLU codes are globally used by all the members of the IFPS, including the Canadian Horticulture Council and Canadian Produce Marketing Association (International Federation for Produce Standards, n.d.-a). The PLU code contains four to five digits and is used as a key at the billing registers in the stores to retrieve the price of the product. There are over 1400 codes assigned globally to produce items.

The IFPS issued code system was first introduced in Canada and in the United States. Countries like Norway, United Kingdom, Mexico, New Zealand, Sweden, and Australia also became members of the IFPS and use the PLU codes (International Federation for Produce Standards, 2015). The PLU code is printed on small stickers, usually the size of a thumbnail, and the sticker is stuck on individual items. For smaller fruits like grapes and berries, the PLU code is printed on the bags that carry the fruit. The IFPS recognized additional benefits of using these codes. The codes enable efficient scanning and help maintain price integrity. Produce departments in the store can effectively manage their inventory with the help of the PLU coding system. Codes also help in easy compilation of sales data, making it simpler for retailers to add more items in their inventory (International Federation for Produce Standards, 2014).

The coding system is important and required by the retailers for point-of-sale identification. The system, however, is voluntary and not mandated by the government (Canadian Produce Marketing Association, n.d.). The Canadian Horticulture Council (CHC) is a national association representing over 25,000 fruit and vegetable producers in Canada and is involved in production of over 120 horticulture crops (Canadian Horticulture Council, 2018). The Canadian Produce Marketing Association (CPMA) represents companies that are involved in marketing of vegetables and fruits in Canada. CPMA represents national and international members who account for 90% of fruits and vegetables sales in Canada. The PLU coding system is not federally regulated or mandated. PLU stickers are simply required by medium and large retailers in the country (Canadian Produce Marketing Association, n.d.).

PLU stickers are commonly made of plastic which makes the stickers non-compostable. The stickers are tested by the health authorities to ensure they pose no harm if consumed accidentally. Plastic is the preferred material as it provides durability and can withstand spray, water, other liquids, and does not break during handling, packaging, and transit. While the stickers cause no physical harm to people, they cause environmental pollution due to the plastic content (Dormer, 2018).

2.2 The Green Cart Guidelines – City of Calgary

The City of Calgary recognizes PLU stickers in the food waste as a compost contaminant. The screens at the composting facility are used to detect presence of foreign matter like glass, plastic, metal, styrofoam, coffee cups, jars, and PLU stickers to name in a few (City of Calgary, n.d.-b). Food waste is screened, and detected foreign objects are removed before converting the waste into compost. The PLU stickers can remain undetected during the screening process as they are small and thin in size. When undetected the stickers break down in the compost affecting its quality.

Theoretically, highly contaminated compost may potentially have to be diverted to the landfill. Food waste with sticker contamination is also sent to the landfill as it is considered unfit for producing high quality compost. In the landfills, food and organic waste undergo decomposition by microorganisms through anaerobic digestion, which emits large amounts of greenhouse gases like methane and CO2 into the atmosphere.

The City of Calgary has published green cart guidelines on their website. The guidelines contain a list of all the items that are compostable and go into the green cart (City of Calgary , n.d.-a). The guidelines also include a list of non-compostable items which should not be added to the green cart. The PLU stickers are listed under the non-compostable items. The food waste received at the composting facility from numerous households and business have PLU stickers attached to the waste. As a result, the contaminated waste may be diverted to landfills. For the purpose of this research, The City of Calgary waste collection system scenario (green cart for organic waste, blue cart for recyclable waste, and black cart for garbage waste) will be considered as the appropriate waste collection practice.

2.3 PLU Sticker Alternatives

In 2009, research was carried out by the Agriculture Research Service (ARS) at the U.S. Department of Agriculture (USDA) and a group of scientists at the University of Florida (UFL) to test the application and feasibility of the laser tattoo technology as an alternative for PLU stickers (Durham, 2009). The technology was previously invented by a scientist, Greg Drouillard, at the UFL. The experiment conducted involved etching the PLU code in the form of a tattoo on the grapefruit. The outer few cells of the fruit were etched using a carbon dioxide laser beam and the lasered tattoo was then covered with wax. The wax covering was used to avoid any water loss and block entry for pathogens that could infect the fruit. The laser labelling technology has been

approved by FDA for citrus fruits and is being tested on other items like melons, kiwi, banana, coconuts, and pomegranates (Palmieri, 2017).

A Spanish company, LaserFood based out of Valencia, successfully tested a hi-tech laser technology in 2010, to engrave the logo, codes, and dates on the produce (Glotz, Zuke, & Shapley, 2010). The fruit is marked with a laser and then sprayed with a contrast liquid which reacts with the components present in the skin of the fruit, resulting in a permanent laser mark on the fruit. The technology has been tested on different fruits and vegetables. The laser labelling system promises to reduce the labelling cost by a huge margin as it eliminates the need for materials like paper, plastic, ink, and adhesive which are needed for production of the stickers. The laser mark system was developed with the support of the European Union's Eco-Innovation program (European Commission, 2020a). The system was showcased in 2015 at the international trade show for the fruit and vegetable industry (LaserFood, 2015). The technology gained legal approval by the European Union in 2013. Additionally, the technology lowers energy consumption by 35% in contrast to the standard sticker production methods (European Commission, 2020b). One of the challenges observed with the technology is lack of widespread acceptance by the producers and retailers. Optimum market penetration depends on public perception, adoption of new technology, and phasing out of conventional methods which appear to be convenient and easy to use. The degree of market penetration of the technology in Europe is not accurately known. Economic and social implications, barriers, and usability of the system among Canadian producers will help to determine the feasibility of adoption of this alternative in the country.

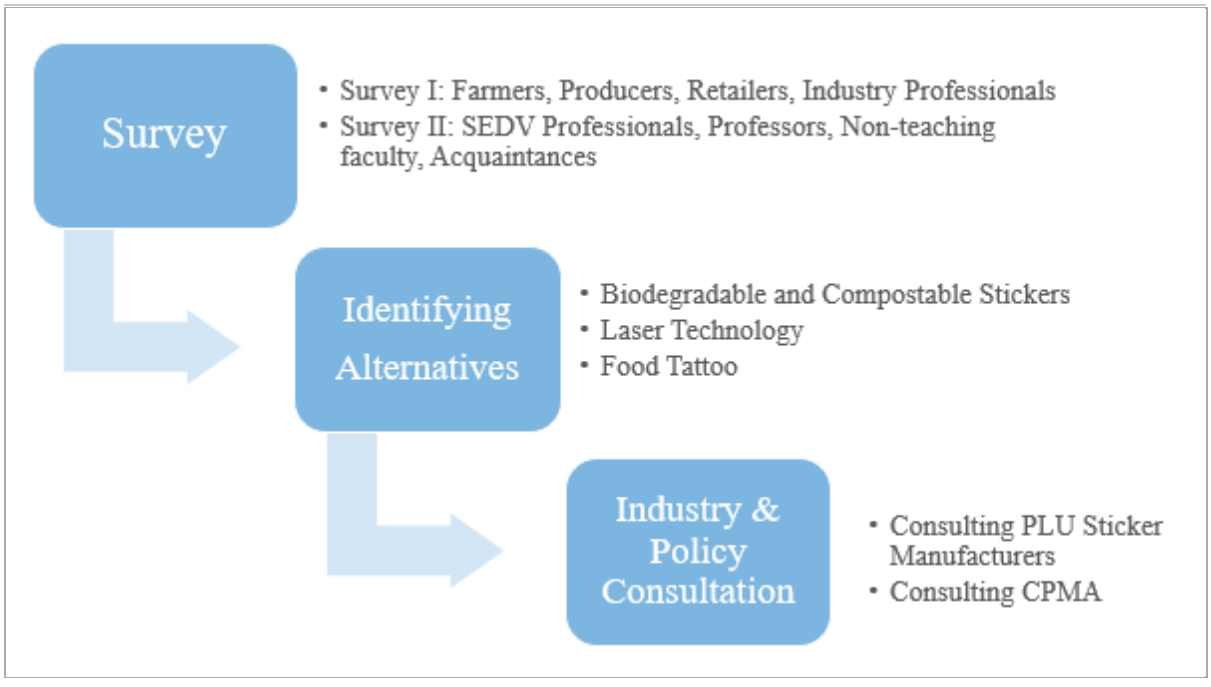
Rhodes Yespen, Executive Director at the Biodegradable Products Institute (BPI), recognized plastic contamination and waste diversion as one of the developmental and environmental issues that require sustainable solutions (Yepsen, 2016). BPI is considering achieving cost and waste

reduction, creation of new jobs, healthy communities and environment, through innovation in labelling of the produce. The goal is to manufacture stickers and other products associate with food using compostable materials so they would easily break and not contaminate the compost. This would reduce processing cost and energy consumption required for food waste processing and diversion. Compostable stickers are a meaningful alternative to plastic stickers as it helps to eliminate compost contamination and food diversion.

Chapter 3: Scope and Methodology

After conducting relevant research on the significance of use of PLU stickers and the associated environmental footprint, it was determined that there is a great potential for creating awareness about the environmental impact of the stickers. The literature review available on the subject of PLU stickers is limited. Therefore, I realized an opportunity to conduct two online surveys to further investigate the need for alternative solutions to conventional PLU stickers. The research was also geared towards identifying alternatives currently available in the industry. The final component of the research focused on consulting with PLU sticker manufacturers and with the Canadian Produce Marketing Association.

Figure 1 Research Methodology



Source: (Author, 2020)

3.1 Survey

Two surveys were conducted for the purpose of this research.

3.1.1 Survey I: Sustainable Alternatives for PLU Stickers

For the purpose of this research, the term 'produce processors and distributors' is used to represent fruit and vegetable farmers, producers, retailers, marketers, and all the stakeholders who use stickers on the produce they grow and/or sell. The survey was designed to capture and to observe the willingness among produce processors and distributors to adopt alternative and sustainable solutions. The first survey was conducted to estimate the level the awareness about the environmental impact of the stickers, among produce processors and distributors in the fresh produce industry, as they are primary stakeholders who use the PLU stickers on the produce they grow or sell. The survey also inquired about their interest in switching to alternative solutions. It was significant to determine if there was a collective interest for the need to adopt sustainable alternatives. Furthermore, the survey was designed to determine the challenges perceived by the stakeholders which could be potentially encountered while attempting to migrate to sustainable alternatives. Survey participants were also requested to provide examples of technical and financial support they would presumably endeavor to gain for transitioning to sustainable alternatives.

I reached out to organizations like YYC Growers, CPMA, CHC, Bassano Farms Ltd., Sunfresh Farms Ltd., Alberta Greenhouse Growers Association, and Edmonton Potato Growers, to circulate the survey among their network of farmers, producers, and retailers. The survey was also circulated among the PLU sticker manufacturers. The survey was designed to analyse the gaps and identify potential challenges and opportunities that need to be addressed for switching to sustainable alternatives.

Table 1 Survey I Questionnaire

	Question	Answer Options
1	Please provide your location (city)	*Option to add name*
2	Do you use PLU Stickers on your products/produce?	Yes No
3	Name a few products (fruits/vegetables) that you use PLU Stickers on.	*Option to add names*
4	Are the PLU stickers made of plastic? If no, what are they made of?	Yes No *Option to add comments*
5	Are you aware of the plastic contamination in compost and the environment arising from PLU stickers?	Yes No Maybe
6	Do you think PLU stickers are good and sustainable for the environment?	Yes No Maybe
7	Would you be interested in learning about alternative and sustainable options for PLU stickers?	Yes No
8	Would you be open to adopting alternative solutions?	Yes No
9	Mention some of the challenges you might face while switching to alternative and sustainable options.	*Option to add comments*
10	Mention in a few words what kind of support would you like to receive from the government.	*Option to add comments*

Source: (Author, 2020)

Question #1in the survey, ***"Please provide your location (city)",*** aimed at gathering information about the regions where the participants are located. The purpose was to identify the regions in Canada where the produce processors and distributors were interested in learning about sustainable technologies and solutions. Question #2, ***"Do you use PLU Stickers on your products/produce?"***, was important to help make a clear distinction in the responses received from the produce processors and distributors, and the sticker manufacturers. The purpose was to investigate and understand the needs of different stakeholders and study their perspective about the need for sustainable alternatives.

The survey was shared with different groups of produce processors and distributors across Canada. Presumably, the survey might have also reached produce processors and distributors who do not necessarily use PLU stickers on their produce. Question #3, ***"Name a few products (fruits/vegetables) that you use PLU Stickers on"***, helped to make the distinction in responses from different groups of produce processors and distributors.

The research on PLU stickers revealed that different materials are and can be used for making the face stock of the stickers. Currently, the market has different variations of the PLU stickers. While a majority of the stickers used are made of plastic, plastic and paper combined, paper lined with a thin layer of plastic, and stickers made only of paper, are different variants used for the produce. Question #4, ***"Are the PLU stickers made of plastic?",*** was about estimating the number of responses that came from produce processors and distributors that used stickers made of plastic and segregating these responses from the ones that came from produce processors and distributors who use compostable stickers.

Question #5, ***"Are you aware of the plastic contamination in compost and the environment arising from PLU stickers?"*** was an important question geared towards examining the

participants' knowledge about the environmental impact of the PLU stickers, specifically, the impact on compost contamination. Presence of knowledge and awareness are critical drivers for change.

Question #6 which is, ***"Do you think PLU stickers are good and sustainable for the environment?"***, focused on inquiring the participants' awareness about the impact of the stickers on the environment. Having awareness is critical for ensuring responsible production and consumption.

Question #7, ***"Would you be interested in learning about alternative and sustainable options for PLU stickers?"***, and question #8, ***"Would you be open to adopting alternative solutions?"***, were asked to further understand and study the participants' interest using and manufacturing sustainable products. For successful transition to sustainable alternatives, it is crucial to reason the need for transition. Based on the responses, presence of need for alternatives can be determined. Analysing the need for change was important as demand can potentially create the scope for change.

Question #9, ***"Mention some of the challenges you might face while switching to alternative and sustainable options",*** was a suggestive question asking the participants to state the challenges they foresee to likely encounter while adopting alternative solutions. The final question, question #10, ***"Mention in few words what kind of support would you like to receive from the government",*** was intended to collect information that highlights the support required by the participants for adopting alternative technologies or solutions.

3.1.2 Survey II: PLU Stickers Disposal

The second survey was conducted among a different group of stakeholders. These were people who presumably consume fruits and vegetables on regular basis. The purpose of this survey was to study the PLU sticker disposal practices. Appropriate disposal of the stickers can help avoid sticker contamination in the compost. Compost contamination from stickers can be avoided by ensuring that the stickers are not disposed in the green carts from where the waste reaches the composting facility.

The participants of this survey were M.Sc. Sustainable Energy Development (SEDV) 2019- 2020 and 2020- 2021 cohort students at the University of Calgary, teaching and non-teaching staff at the University of Calgary, and other known acquaintances across Canada. I selected a diverse group of participants with the intent of studying the waste disposal practices among sustainability professionals and non-professionals, to find similarities and differences in waste disposal behavior. The severity of the environmental impact of waste in several situations can be lowered by behavioral shift in routine waste disposal and management practices.

Table 2 Survey II Questionnaire

	Question	Answer Options
1	Are you a M.Sc. student/alumni at the University of Calgary?	Yes No
2	Which cart do you discard the PLU stickers in?	Black Cart Blue Cart Green Cart
3	Did you know that PLU Stickers are made using plastic?	Yes No
4	Did you know that the plastic in the PLU stickers contaminates the compost during composting of organic waste?	Yes No
5	Do you think the PLU Stickers are compostable or biodegradable?	Yes No

Source: (Author, 2020)

Question #1, ***"Are you a M.Sc. student/alumni at the University of Calgary?",*** was aimed to make the distinction in responses received from SEDV participants and non-SEDV participants. The purpose was to study PLU sticker waste disposal behavior differences and similarities between sustainability practitioners and non-practitioners.

Question #2, ***"Which cart do you discard the PLU stickers in?"***, aimed at collecting data on the participants' choice of cart for disposing the PLU sticker. Through conversations with my colleagues and acquaintances during the initial phase of my research, I discovered that many of them were either not aware that the PLU stickers were not compostable or did not seem to be cognizant about the environmental impact of the stickers. Therefore, I was motivated to ask this question and record the responses.

Question #3, ***"Did you know that the PLU Stickers are made using plastic?"*** , question #4, ***"Did you know that the plastic in the PLU stickers contaminates the compost during composting of organic waste?"***, and question 5#, ***"Do you think the PLU Stickers are compostable or biodegradable?",*** were aimed at identifying the participants' grasp of the potential impact of the PLU stickers on the environment. Studying behavior aids in identifying the gaps and the scope for areas of improvement and education dissemination for generating awareness and sensitizing people on issues facing our environment.

3.2 Identifying Alternatives

3.2.1 Biodegradable or Compostable PLU Stickers

The face stock of conventional stickers is made of plastic, or a combination of paper or plastic. Commonly used plastic types for PLU stickers are vinyl or polyethylene. While paper is biodegradable, the plastic in the face stock is not biodegradable or compostable. This can create plastic and subsequent microplastic residue in compost, soil, and the environment. Additionally, the adhesive used in the PLU stickers can also release contaminants and toxic substances in the soil. The stickers being thin, small, and pliable can and do easily pass through the screens and are not segregated from the rest of the organic waste. Therefore, the final compost produced can be contaminated with sticker residue. Efficient sticker disposal practices can promote diversion of stickers to the landfills directly without them reaching the composting facility. While this is one of the best practices for managing sticker waste, it is not entirely conducive to environmental stewardship. Sticker waste remains in the landfills for several decades as plastic accumulates in the environment rather than readily decompose (World Wildlife Fund, n.d.).

Use of alternative biodegradable or compostable materials for manufacturing stickers offers a sustainable solution for sticker production, consumption, and disposal. Compostable stickers must

be tested and certified to ensure high quality and safety for soil integration. Making 100% compostable stickers will foster reduction in use of fossil hydrocarbons used for making plastic monomers, elimination of compost contamination from stickers, reduction of waste diversion to landfills, reduction in energy consumption for waste management and diversion, and end sticker waste accumulation in landfills and environment. The research was intended to identify alternative solutions for PLU sticker production.

3.2.2 Laser Labelling Technology

Laser labelling of PLU codes on fruits and vegetables is a promising technology with relatively far less environmental impact and sustainable application. The technology has gained wider acceptance and application in Europe. The European Union (EU), through its Eco-innovation initiative that branched from the EU's Entrepreneurship and Innovation Programme, extended support for the development of laser technology for marking of information on fruits and vegetables, by contributing 50% of the overall project budget of 1.273.411 €, between June 2010 – June 2013. The outcome of the programme was the development of laser labelling technology, which employs the use of a substance that catches color when activated by a laser.

The laser technology eliminates the need to use paper, plastic, ink, and adhesive, all of which are essential components of PLU stickers (European Commission, 2020a). The Spanish company, LaserFood, which innovated the laser mark technology estimates 35% reduction in energy consumption to the standard sticker production (European Commission, 2020a). The technology has been promoted by the EU citing evident environmental and economic benefits including decreased labelling cost and increased labelling efficiency. At the same time, EU recognises the lack of confidence among produce processors and distributors and their reluctance in adopting the technology due to uncertainty about reactions of the consumers.

The focus in this research was to study the challenges and opportunities of adoption of the laser labelling technology in North America as a potential sustainable alternative to PLU stickers. This technology showcases enormous potential for optimizing resources and reducing waste generation.

3.2.3 Food Tattoo Labelling

Tattoos etched on fruits and vegetables using food-grade inks have been used in small pockets in Spain, Japan, Sweden, Australia, and the UK (Cluff, 2017). This development was a result of the farmers catering to consumers' demand for reduced packaging and use of plastic. Vegetable ink-based tattoo are considered safe and do not pose any health concerns. Printing ink on the fruit or vegetable directly, eliminates the need for face stock resources and adhesives. However, ink labels are not entirely moisture resistant and can potentially rub off on coming in contact with water or moisture for a longer period. This technology adds more options to labelling alternatives. I have researched the opportunities and limitations of this alternative to analyse the feasibility of its application.

3.3 Consulting with CPMA and PLU Sticker Manufacturers

3.3.1 CPMA

The Canadian Produce Marketing Association is actively involved in advocating for reduction of plastic consumption and use in the produce industry. The association is working to collaborate with the government to identify and create innovative solutions while upholding and promoting food safety and food security. Promoting transition to sustainable alternatives from single-use plastic has been at the forefront of the association's agenda while developing and providing suggestions and recommendations to political parties in Canada (Canadian Produce Marketing Association, 2019b), for creating environmentally favorable options. In May 2019, the CPMA created Plastics Packaging Working Group to work towards creating a roadmap for addressing the

use of plastic in the produce sector (Canadian Produce Marketing Association, 2019a). One of the objectives of the working group is to identify opportunities for reducing plastic waste by promoting innovation to ensure plastics used in the produce sector are recyclable, reusable or compostable. Successful implementation of such objectives will directly contribute towards the Canada-wide strategy on Zero Plastic, and the Oceans Plastics Charter.

The PLU stickers are not considered or declared as single-use plastic by the authorities in Canada. However, the stickers are similar in function and use to that of single-use plastics and single-use packaging. There is sufficient cause and motivation for sticker manufactures and associations like the CPMA to be proactive in investing and researching for alternative solutions. As the impact of the stickers is evident, further proliferation of environmental impact can be combated by timely prevention through promotion and implementation of alternative solutions. CPMA through its well-positioned presence in the produce industry can use its resources, expertise, and influence to advocate for adoption of sustainable alternatives among the government, sticker manufacturers, and produce processors and distributors.

Consulting with CPMA was an important component of my research. Reaching out to produce processors and distributors within CPMA's network through CPMA, enabled circulation of Survey I among a wide group of participants. This was helpful in collecting more responses. Interviewing and consulting with senior officials at CPMA was also undertaken to research their position on the need for sustainable alternatives to conventional PLU stickers.

3.3.2 Sticker Manufacturers

Companies like Sinclair Systems International and Accu-Label Inc. have been at the forefront of design and innovation, investing in research and manufacturing of ecological and sustainable products. Accu-Label is an industry leader in labelling technology, manufacturing labels and high-

speed labelling systems renowned for exceptional performance and efficiency. Food safety and produce traceability sits at the heart of label manufacturing at Accu-Label. The company has achieved exceptional feat in producing labels with high-quality biodegradable paper, recyclable plastic (PET) liner, FDA-complaint adhesive, and water-bases ink (Accu-Label, n.d.). While the company pumps approximately 1.5 billion stickers every year across Canada, Mexico, and The United States, the environment friendly labels have gained demand and popularity among fruit and vegetable processors in countries like New Zealand, Holland, and Australia.

Sinclair, in partnership with Zespri International Limited, the world's largest marketer of kiwifruit, has been invested in creating and trialling prototypes of compostable stickers sine 2008. Zespri has been committed to fostering environmental sustainability and has a strategized plastic packaging optimization goal and plan. Stemming from the successful partnership, Sinclair produced its first 100% certified compostable sticker in 2019, called the EcoLabel (Zespri, 2019). All the components of the EcoLabel: the face stock, adhesive, and ink passed testing with an accredited third party laboratory to show compliance with EN 13432:2000 , and is certified by TÜV Austria under the OK Compost – Industrial and Seedling certification (Sinclair-International, n.d.). This was a great milestone in development of compostable stickers, for which the company earned the AE50 award for outstanding innovation by ASABE in 2020 and a nomination for the prestigious Fruit Logistica Innovation Award 2020.

To conduct an effective research, consulting with leading sticker manufacturers was imperative to understanding the market scenario, demand, need for, and the future of biodegradable and compostable sticker alternatives in North America.

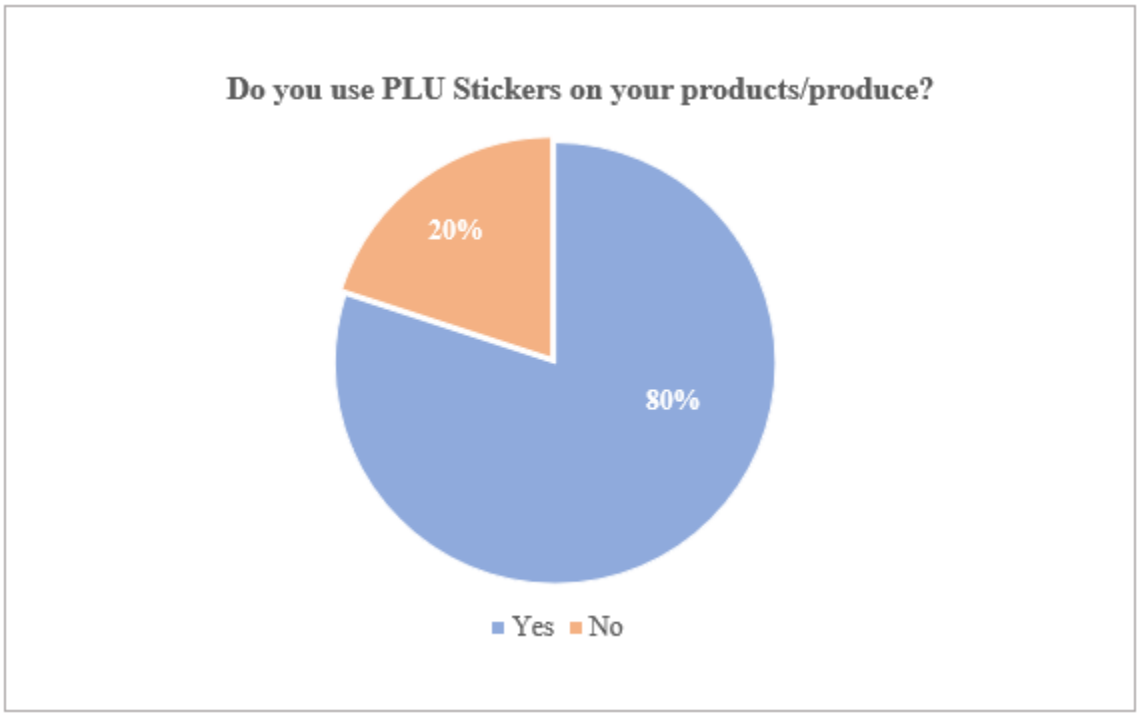
Chapter 4: Findings and Analysis

4.1 Awareness Precedes Change

Responses for Survey I were anonymously received from participants in Calgary, Alberta, Edmonton, Toronto, Ontario, British Columbia, Vancouver, Ottawa, Manitoba, and Nova Scotia.

Participants included a mix of produce processors and distributors and stakeholders from the produce industry presumably like fruit and vegetable marketers, importers, and sticker manufacturers. As indicated in Figure 2, 80% of the responses were received from fruit processors and 20% of the responses were received from various stakeholders and sticker manufacturers. While reaching individual group of farmers was challenging, it was rewarding reaching out to organizations and associations with a network of produce processors and distributors and produce industry stakeholders. All the survey responses received were complete. In all, 63 survey responses were received over a period of three months.

Figure 2 Survey I Participant Mix

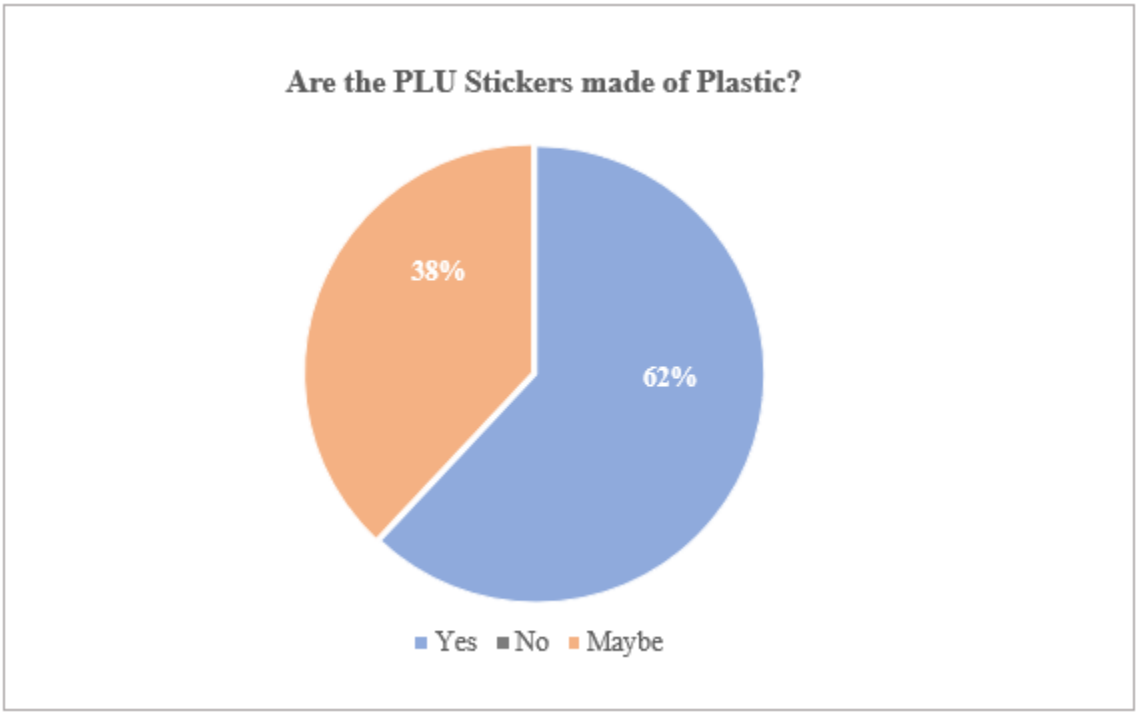


Source: (Author, 2020)

The produce processors and distributors who participated in the survey reported that they used the PLU stickers on produce like cucumbers, apples, mangoes, lemons, bananas, peppers, tomatoes, onions, mandarins, carrots, and berries.

Figure 3 indicates 62% of the participants who used stickers on the produce reported the PLU stickers they used were made of plastic. The remaining 38% reported the stickers were probably made of plastic. 3 participants from the 38% category mentioned the stickers were made up of plastic and paper. No participant reported absence of plastic in the stickers. This data reflects that the stickers used by the participants are mostly of the conventional type which are made of plastic or a combination of paper and plastic.

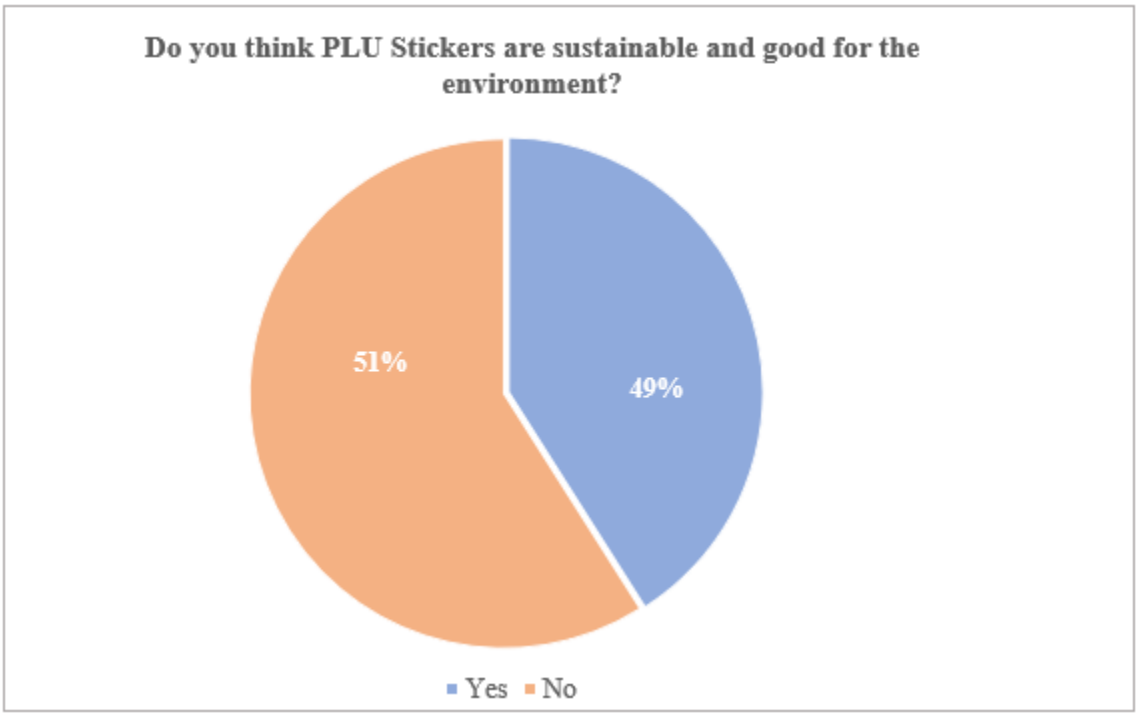
Figure 3 PLU Stickers Type



Source: (Author, 2020)

When asked if the PLU stickers are good and sustainable for the environment, 51% of the participants were of the opinion that the stickers are not good for the environment, while 49% said that they think the stickers are good for the environment. This data was interesting as it reflected small difference in the opinions of two different groups as seen in Figure 4. While there is awareness about the impact of the stickers within the larger group, there is also a great opportunity for generating awareness among the other half of the participants.

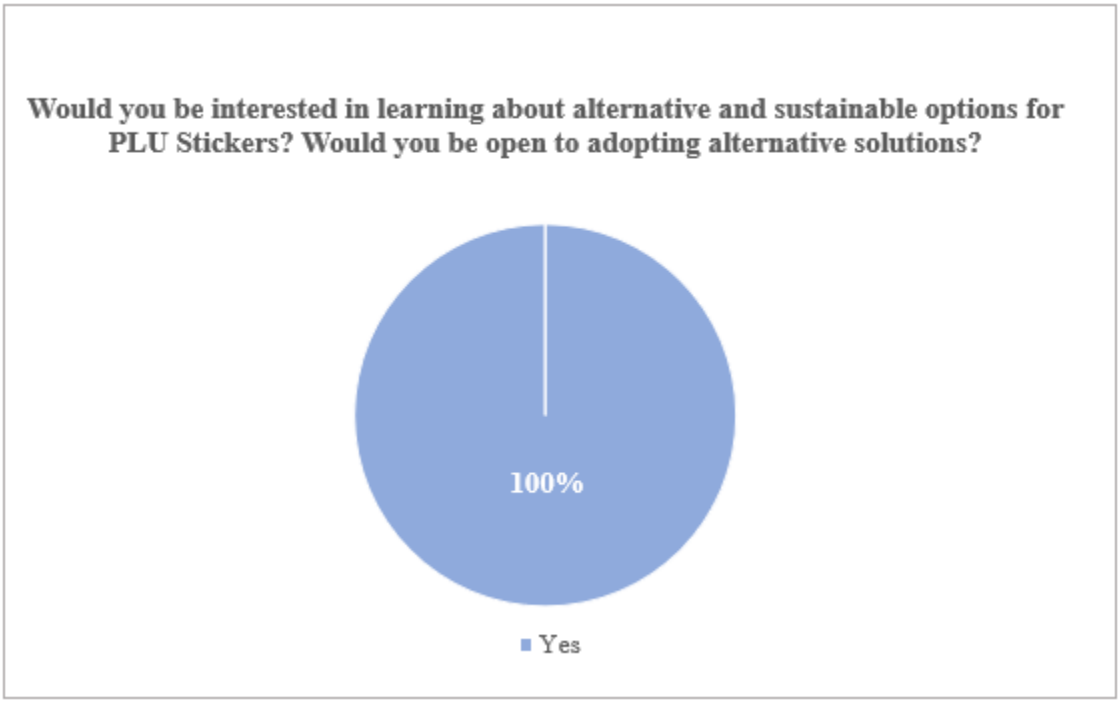
Figure 4 Opinion on PLU Sticker Impact on Environment



Source (Author, 2020)

Responding to the next question in the survey, 100% of the participants indicated that they are interested in learning about sustainable alternatives and are also open to adopting sustainable solutions, as indicated in Figure 5. It was interesting to learn that 49% of participants who said they thought the stickers are good for the environment were also open to learning about alternative and sustainable solutions. In retrospection, it would have been useful and interesting to add a follow-up question asking the participants to state their rationale behind the answer, as all the participants indicated interest in learning about alternative solutions, including those who reported thinking that the conventional stickers are good for the environment.

Figure 5 Willingness to Adopt Alternative Solutions



Source: (Author, 2020)

Table 3 List of Challenges

Mention some of the challenges you might face while switching to alternative and sustainable options.	Financial assistance
	Product durability
	Infrastructure, machinery
	Lack of demand
	Product efficiency, large-scale application

Source: (Author, 2020)

Financial assistance was the most common response received from the participants when asked to state some of the challenges they foresee in making the transition. One of the participants put forth an important view stating that farmers alone should not be at the forefront of bearing all the related costs. Financial investment should be a shared responsibility lead by the government in this case, as the transition to alternatives is for the larger environmental good and consideration, which will benefit the entire community at large. A few participants reported that plastic in the stickers offered longevity, durability, and resistance to moisture. They reported being apprehensive about an all-paper sticker fearing it may not survive shipping and transit durations and environment. Some participants reported that there may not be an immediate interest in adopting other technologies or alternatives as they have not faced any demand for biodegradable or compostable stickers and have not received complaints about pollution and contamination arising from stickers. Furthermore, 4 participants mentioned they were not aware of any alternatives available in the market. In their opinion, lack of demand is complemented by lack of supply and availability. One of the other challenges reported was the uncertainty of the potential of large-scale application of the alternatives. Conventional products offer a certain speed and application efficiency. Participants reported that the new alternatives must offer at least the same efficiency if not higher.

Table 4 Government Support List

Mention in a few words what kind of support would you like to receive from the government.	Subsidy, grants for cost equalization
	Technical assistance
	Infrastructure, machinery
	Public awareness and education
	Policy and regulations mandate

Source: (Author, 2020)

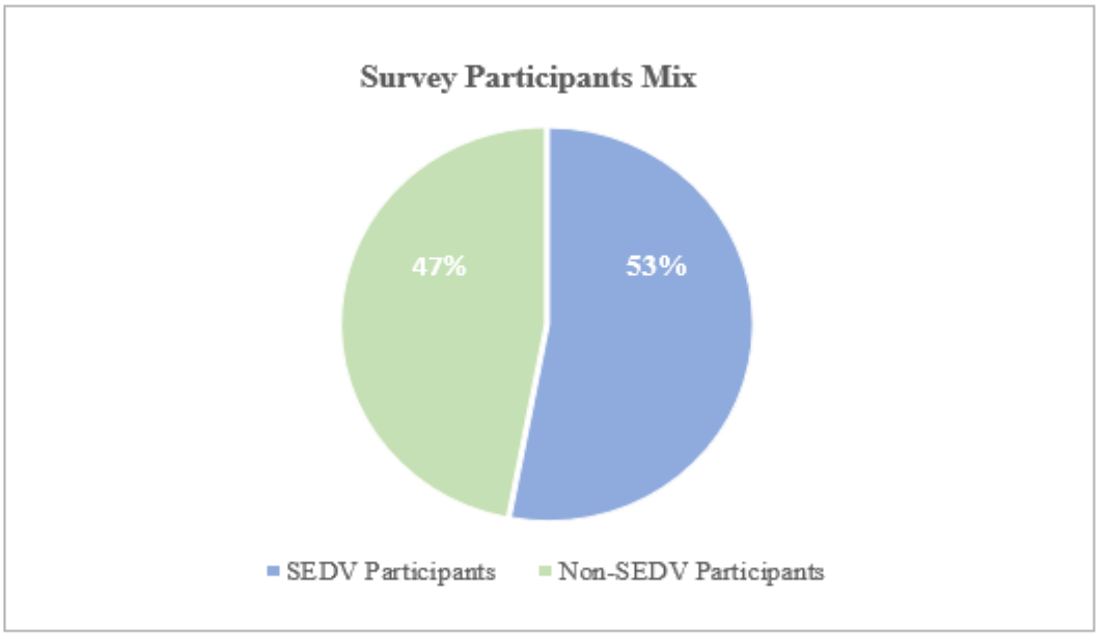
Migration to new technologies or alternatives can be challenging and potentially involve several risks. Support from provincial and federal governments can supplement the transition and aid in lowering risks. Responding to the final question in the survey, the participants reported the need for financial assistance in the form of subsidy or grant for cost equalization and faster transition. One participant stated and which may hold true for others too, that he/she would want to avoid any potential impact on the finances and income that may result from decreased efficiency or lower product quality projected by the alternatives. Therefore, having financial backing and protection is critical in making the transition effortless. Of the respondents, 13 participants reported a need for a policy and regulations mandate for alternative solutions that foster sustainability. Policy will help to create demand leading to mass production which can cumulatively help in lowered cost and increased affordability. However, it is significant that policy creation is initiated after sufficient and effective consultation with the stakeholders to ensure risk and impact minimization on all the stakeholders. Policy plays a significant role especially when technology and equipment must be imported from other countries when not available locally. Finally, increased demand for ecological products from people can greatly encourage governments to implement strategies and plans for introducing sustainable products and technologies while reasonably supporting the cost and impact of the transition.

4.2 Behavioral Shift and Adherence to Best Practices Can Reduce Environmental Impact of PLU Stickers

Implementation of alternative solutions may not be feasible in the immediate future as transition is a time-intensive process. In the meantime, finding other opportunities to combat compost pollution and waste generation from PLU stickers can be exceptionally useful. One way of reducing the environmental impact is by implementing best practices in waste disposal, diversion,

and management. Responses from the Survey II were useful in analysing PLU sticker waste disposal practices and in developing recommendations for adoption of best practices.

Figure 6 Survey II Participant Mix



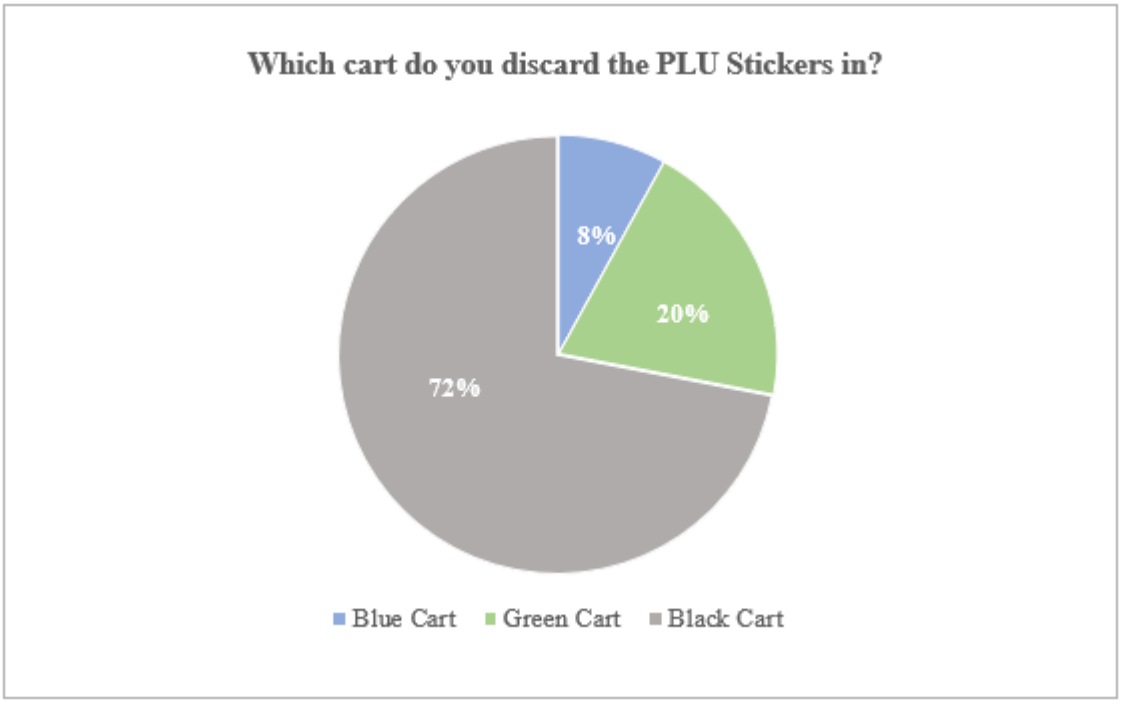
Source: (Author, 2020)

The total of 72 responses were recorded for Survey II. SEDV participants constituted 53% of survey responses and 47% of responses were received from non-SEDV participants.

Of those taking the survey, 72% of participants reported they discarded the PLU stickers in the black cart, which is also the right choice in the case of The City of Calgary scenario. Non-biodegradable stickers in the green cart can contaminate the compost. The stickers when disposed in the blue cart can cause contamination at the recycling plant, and therefore, is most likely to be diverted to the landfill. As indicated in Figure 7, 20% of the participants reported discarding stickers in the green cart and 8% reported using blue cart for PLU stickers. Of the 20% of

participants who reported using the green cart, 15% were non-SEDV participants or practitioners. It can be inferred that awareness about the best disposal practice is high among SEDV participants who are also sustainability practitioners.

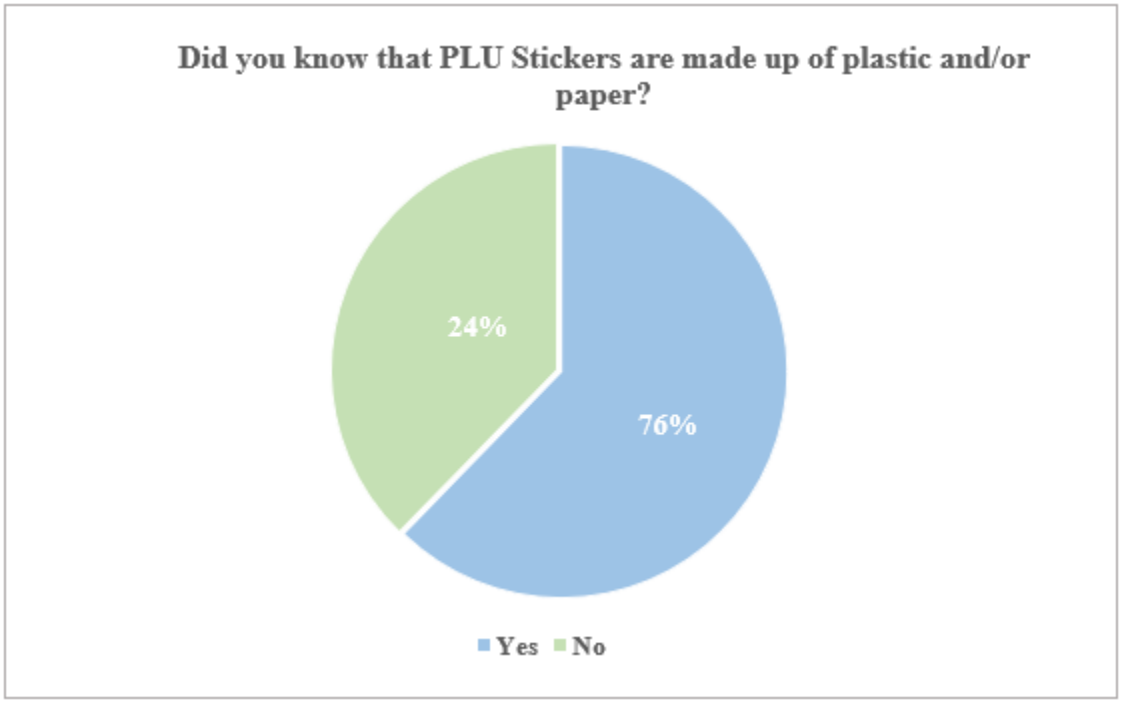
Figure 7 Choice of Cart for Sticker Disposal



Source: (Author, 2020)

The following survey question inquired if the participants were aware of presence of plastic in the PLU stickers, as this could inform and influence their sticker disposal practice. Of all the respondents, 76% of participants reported being aware and a relatively smaller group making up the remaining 24% reported not being aware of plastic being one contents of the sticker. Out of the 76%, 55% of participants were from the SEDVgroup . The data in Figure 8 is useful in substantiating that sustainability practitioners have an edge over the non-practitioners with regard to the knowledge about PLU stickers.

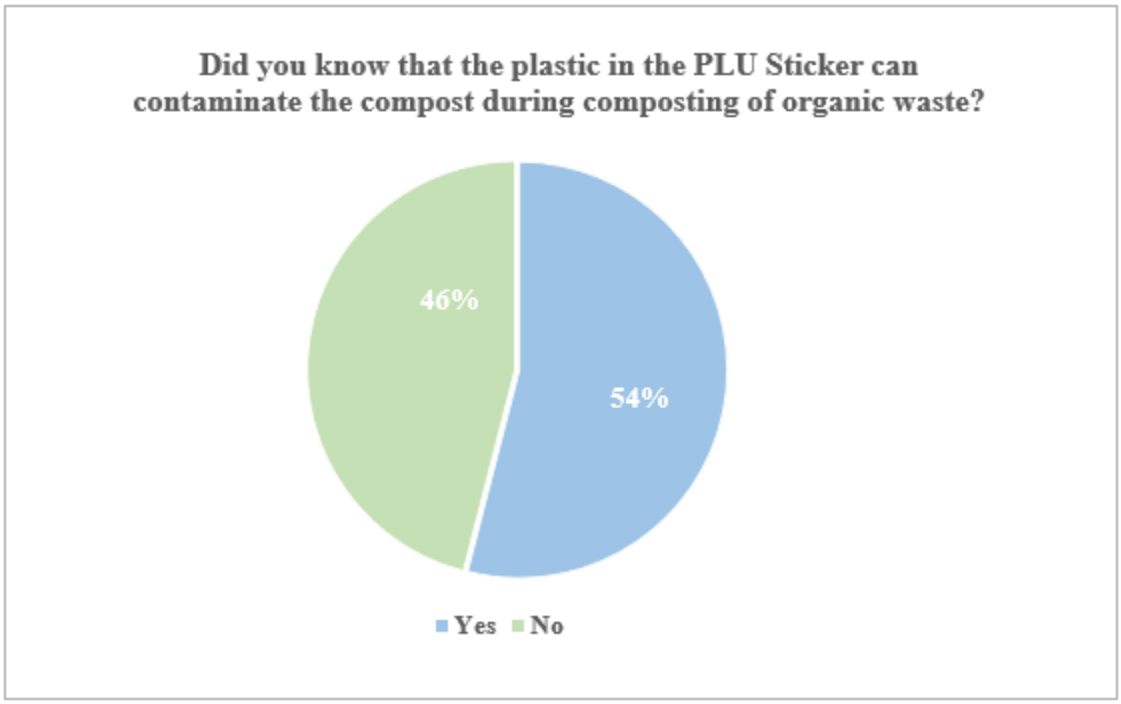
Figure 8 PLU Sticker Components



Source: (Author, 2020)

Question #4 focused on the knowledge among the participants about the potential of the stickers to contaminate the compost during composting of organic waste. The cognizance of the impact on compost is again useful in informing adoption of best practices by individuals. As shown in Figure 9, 54% of participants reported being aware of presence of plastic in PLU stickers that can cause compost contamination. Of this, 49% were SEDV participants.

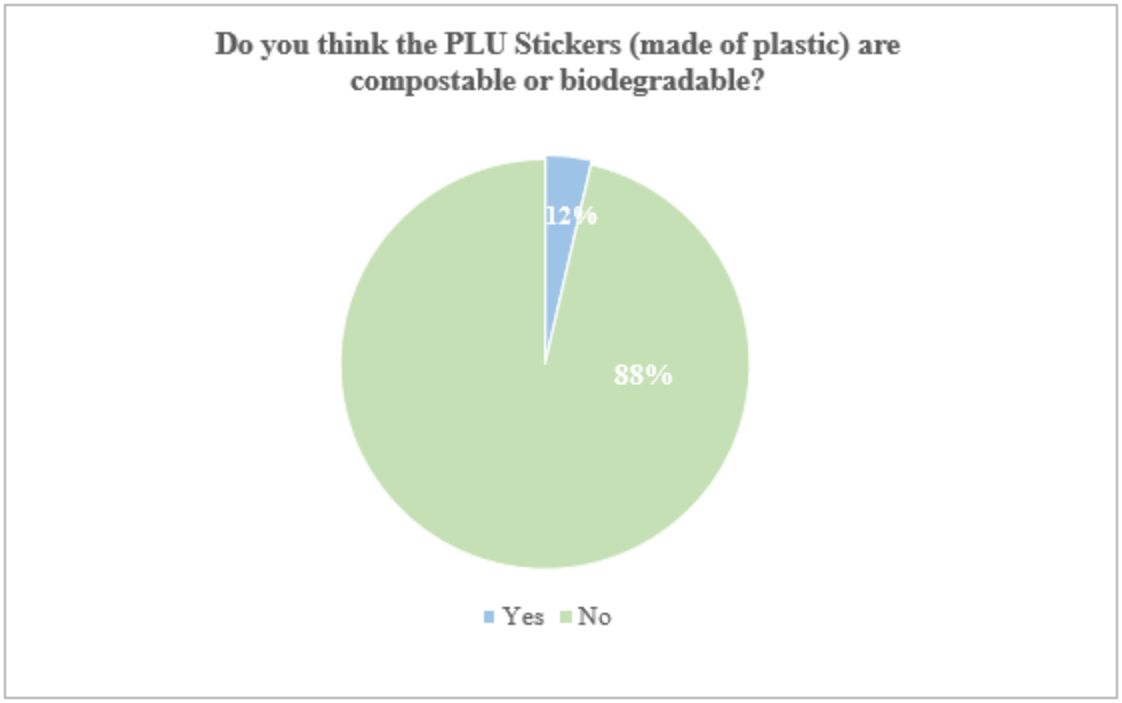
Figure 9 PLU Sticker Impact on Compost



Source: (Author, 2020)

Responses for the final question of the survey indicate that 88% of the participants, as shown in Figure 10, think PLU stickers are not compostable or biodegradable. Knowing this is important as this can help people keep the stickers out of their backyard compost and out of the green cart to avoid contamination at industrial composting facilities. Out of the 12% who said that stickers are compostable, 8% were non-SEDV participants. Analysing data from question #4 and question #5 informs that while a larger group of people are aware that the stickers are not compostable, many of them are unaware of the impact of the stickers on the compost. This again indicates an opportunity for making more information available about compost contamination in the public domain.

Figure 10 PLU Sticker End of Life



Source: (Author, 2020)

4.3 Opportunities and Challenges with Biodegradable and Compostable Alternatives

Biodegradable stickers are being currently used by produce processors and distributors on a relatively smaller scale. However, use of these stickers is growing at a fast pace due to environmental and regulatory considerations. Responding to Survey I, fruit processors have indicated lack of demand as being one of the factors that has not created the need for use of biodegradable or compostable stickers.

Shubh Singh, Business Development Head at Accu-label International, during an interview pointed out that regulations on use of single-use plastics are more stringent in places like Europe than in North America. This also reflects on the use of products like PLU stickers which function as single-use packaging item. Therefore, fruit processors are more inclined towards adopting

alternative solutions like biodegradable stickers made of all biodegradable components (ink, adhesive, face stock including liner). Accu-Label manufactures stickers with face stock made up of recyclable plastic (PET) liner and, paper that is sustainably sourced from suppliers that are FSC Certified. The paper in the face stock biodegrades in about six to eight weeks.

Presence of high percentage of paper in the face stock of the sticker exponentially reduces the release of sticker residue in the compost, if or when the sticker is wrongly discarded in the green cart and then enters the composting stream. Release of plastic can also be substantially reduced as the PET liner is recyclable. However, due to the limitations in the overall composting and recycling infrastructure, the stickers are not recommended for industrial composting yet. Diversion of these stickers to the landfills has reduced environmental impact a large part of the sticker would biodegrade leaving behind a small percent of the plastic reduce. The company is currently heavily invested in testing and producing 100% home compostable stickers to reduce release of plastic waste in the environment.

Singh added that public perception of stickers also potentially plays a role in creating demand for biodegradable stickers. People's choices can be driven by aesthetics making the shiny plastic stickers on the fruit more appealing. Hence, creating awareness on the use and benefits of paper labels will be helpful in promoting use of biodegradable labels. While the cost of these labels is the same as the plastic labels, there are several factors like lack of supply of alternatives, contract obligations, desire to avoid switching costs, which perhaps make plastic stickers more favourable among the customers. On the other hand, compostable labels suited for industrial composting are believed to have a 50% higher markup than the average cost of conventional plastic stickers (S.Singh, personal communication, July 22, 2020).

A 100% certified compostable label, EocLabel, manufactured by Sinclair is suited for industrial composting and certified compostable in compliance with internationally recognized EN 13432 Standard. The sticker is also food safe and available in a wide range of shapes and sizes. Compostable stickers are manufactured and supplied to the customers on request. **Director of Research and Development at Sinclair Systems International, M. Scott Howarth**, was directly involved in the creation of Ecolabels, driven by passion and personal desire to produce earth-friendly products. Sinclair was invested in relentless research for over ten years to innovate functional sustainable labels ideal for industrial composting. Dr. Howarth informed in an interview conducted for this research, that majority of customers requesting for EcoLabels cater to the European markets, as they are backed by stringent regulations and restrictions on use of single-use plastics. Demand for the EcoLabel is relatively higher in European Countries. The need for sustainable labels is less perceived in North America resulting in lower demand for the product.

The price of EcoLabel is about two times that of standard labels manufactured by the company, as high-quality components are used for making the labels. However, the price can be potentially lowered with increase in volume of production and sales. Hence, higher demand for sustainable labels can aid in regulating the price. Standardized regulations can also aid in timely migration to sustainable products. Dr. Howarth also shared insight on the need for education and awareness for enabling implementation of best disposal and waste management practices. As the labels are suited for industrial composting, it is critical that labels are appropriately discarded and sent for composting. Additionally, presence of efficient industrial composting infrastructure is critical for suitable end of life treatment across all regions where labels are used (S. Howarth, personal communication, July 21, 2020).

4.4 Opportunities and Challenges with Laser Labelling Technology and Food Tattoo

The European Commission ruling has paved way for application of the laser technology for etching product information and PLU codes directly on the skin of the produce. The laser mark technology invented by LaserFood S.L., offers several environmental benefits like reduction in use of resources like water, energy, paper, ink, adhesive, and plastic, as recognized by the European Union. In addition, large scale application of laser technology will enable reduction of GHG emissions. Laser technology is also efficient in attaining greater flexibility in changing the shape and size of logos and codes (European Commission, 2020a). The technology has been tested for high efficiency and is promoted by the European Union in partnership with the parent company.

The challenges with this technology lie in addressing the perception and uncertainty among people regarding the use of laser directly on the produce. The Food and Drug Administration in the United States has approved the use of laser marking on citrus fruits with thick skin that provides extra protection to the fruit (FDA, 2019). Carbon dioxide laser light is used for etching information on the produce. The emitted infrared radiation must be of the wavelength 10.6 micrometers and the maximum energy output of the laser must not exceed 9.8 * 10-3 (J/cm 2). The area of the etching surface on the citrus fruit is required to not exceed 0.122 cm2. Laser etching increases the amount of natural wax used to coat the fruits. A layer of natural wax coating is required before and after laser etching to protect the integrity of the fruit. Research at the University of Florida raised concerns about destruction of the natural protective layer of the fruit caused by the laser beam. Destruction of the layer could open up perforations that could serve as entry path for pathogens, specially in fruits with thin outer layer or skin (Etxeberria, Miller, & Achor, 2006). The high energy of the laser beam is likely to cause temporary vaporization of natural and added wax coatings, exposing the protective layer of the fruit. These challenges reveal opportunities for further research

and advancement in laser technology for generating confidence among produce processors and distributors and consumers. Additionally, sufficient data on wide-scale application of the laser technology and its impact on the produce in Europe is not available.

Food ink-based tattoos are used by small pockets of farmers in Sweden, the UK, and Spain. A banana farmer who tried using ink-based tattoo for printing product information, noticed that the food ink rubs off when fruit is stored in cold room or when the fruit comes in contact with moisture. The farmers are more inclined towards adopting the laser labelling technology for more robust and efficient application. Branding done with laser does not penetrate through the thick skin. Hence, the shelf life or the quality of the fruit is not affected. However, the efficiency and safety of use of laser for produce with thin skin is relatively undetermined requiring further research and development (Cluff, 2017).

4.5 Need for Regulations and Uniform Waste Management and Composting Capabilities

The Canadian Produce Marketing Association plays a significant role in advocating for policies, regulations, and adoption and implementation of best practices in the produce sector. Researching CPMA's position on various aspect of the PLU stickers was of prime importance for successful conduct and completion of this research.

Shannon Sommerauer, Director, Government Relations at CPMA, expressed that the fresh produce industry was already deeply engaged in efforts to develop a sustainable sticker. Sustainability is one of the IFPS' Focus Areas and addressing sustainability of PLU stickers is a key part of this work. She further added that intensive research is underway across the global industry to support the development of home compostable/industrial compostable stickers, including looking at the adhesive used.

In the Canadian context, CPMA has deliberately taken a proactive leadership role in a broader industry effort to address problematic, single-use plastics used in the industry, and stickers are one component of this work. CPMA is also actively engaged in advocacy efforts to share this work with government in order to support the development of effective measures to reduce the use of problematic plastics while also taking into account important industry considerations around food waste and food safety.

Sommerauer highlighted the need for infrastructure in order to advance sustainability efforts. As industry is increasingly moving to more sustainable packaging, such as compostable or recyclable packaging, unfortunately, a significant challenge that we are seeing globally is the inconsistent availability of industrial composting or even consistent recycling systems across municipalities. Shannon Sommerauer in her concluding statement reiterated that even if all packaging is made entirely recyclable/compostable, that won't make a difference unless the infrastructure is in place to do the recycling/composting (S. Sommerauer, personal communication, July 09, 2020).

Vice President of Policy & Issue Management at CPMA, Jane Proctor added value to this research by sharing her profound knowledge about the role of the PLU stickers in the produce sector and the wide array of challenges connected with transition to alternatives. Proctor informed that maintaining integrity of the PLU codes was important for successful scanning and traceability of the produce at the retail stores. Lack of advancement in alternative technologies like Laser Labelling may not offer robust application of the PLU codes and bar codes on the produce, thus affecting the scannability of the product information. Introduction of sustainable alternatives by the sticker manufacturers might not necessarily solve the issues emerging from PLU stickers unless uniform and efficient composting and recycling capabilities and infrastructure is developed across all municipalities. Alternative solutions must also comply with food safety standards and

regulations. Proctor further added that adding to the challenges is the issue of public perception and acceptance of alternative technologies, stemming from safety concerns and lack of information about these technologies. People may not be comfortable consuming food that is etched with laser, at least until there is more information available in the public domain about the technology. Addressing the larger plastic packaging issue in the produce sector, Proctor emphasized on the challenges of achieving alignment in use of packing across several countries as Canada imports food from around 150 countries to meet the food demand of its citizens. It is perhaps not easy or even possible to have control over all the packaging including PLU stickers that come from other countries given different regulations and practices. While concluding, Proctor stressed on the need to focus on best outcomes that are beneficial to the society at large, while maintaining reasonable costs and high food safety standards (J. Proctor, personal communication, July 14, 2020).

Chapter 5: Conclusion

PLU stickers guarantee access to product information, provide traceability, and promote harmonized supply chain operations in the produce sector. The relevance of PLU stickers and coding is well established. While researching for alternatives solutions to reduce use of conventional stickers on the produce, my research revealed that there are efforts being made by the stakeholders in the produce sector including sticker manufacturers to innovate and introduce sustainable alternatives to conventional PLU stickers. However, wide-spread and faster adoption of alternatives rests on several factors like cost, infrastructure, public perception leading to higher demand for alternatives, and policy being a few significant drivers.

At present, there are varying kinds of PLU stickers in the market. While the majority of stickers are conventional type or plastic-made, some alternatives like compostable stickers are also being used. The end of life treatment requirements for conventional stickers and compostable stickers are different. Conventional stickers are suited for diversion to landfills and compostable stickers are ideal for industrial composting so they can break down in a systematic fashion and be converted from waste to a part of the compost. This may create confusion in the minds of the consumers when choosing the respective bin for disposal. Being adept at differentiating between compostable and non-compostable stickers could be challenging as people may not be as observant while disposing the stickers.

The laser labelling technology takes away the need for use of any material in printing product information. Use of this technology can eliminate compost contamination, waste, and plastic pollution challenges arising from use of PLU stickers. Compliance with GS1 standards will help gain buy-in and amplify people's confidence in laser marking and combat doubts related to food safety.

During several instances, this researched has revealed the need for continued dissemination of information and education on the impact of plastic waste and waste at large to foster sustainable practices and create demand for sustainable products.

5.1 Call to Action

On analysing data of the two surveys conducted, and interviewing all the experts during the research, I analysed there is an opportunity to create awareness among people in order to empower and enable them, to make right choices in managing and disposing waste. Change in behavior can substantially decrease environmental impact of our production and consumption practices.

Campus as a Learning Lab (CLL) is a unique initiative by the University of Calgary that focuses on experiential learning using campus as a lab to promote sustainability (University of Calgary, n.d.). I have collaborated with the Office of Sustainability and the Facilities Management Department at the University, to run an awareness and education campaign on the environmental impact of PLU stickers, while emphasizing on their relevance and use. This campaign will tie into a larger CLL project on single-use plastics. The purpose of the campaign will be help inform people's decision on PLU sticker disposal practices. Since produce items are presumably used by most people, the campaign will benefit everyone who encounters the campaign on the campus.

The campaign is expected to run online and on campus through Fall 2020.

5.2 Recommendations

Waste is best managed by collaboration and synergy between different stakeholders. Production, consumption, and end of life treatment processes need to be complementary of one another, supported by polices and regulations. For an ideal scenario, alternatives can be selected in compliance with the available waste management and end of life treatment processes. This helps to ensure reduction of waste in the environment. Furthermore, enhanced waste processing,

composting, and recycling capabilities are useful in managing and treating waste that is generated from the produce and products imported from other countries.

5.2.1 The City of Calgary

The research indicated lack of sufficient awareness among people regarding disposal of PLU stickers. The small size of the stickers gives out the perception of insignificant impact on the environment, not brining the cumulative effect to the forefront. In addition to the published green cart guidelines on the City of Calgary website, running information and education campaign for a certain period can be beneficial and impactful to bring about the much needed shift in disposal practices. It is also important to educate people on the rationale behind the disposal of stickers in black carts in Calgary. Individual municipalities may have different waste collection systems and may employ use of different colored waste collection bins. Knowing the exact reason will help people make informed decisions and enable them to dispose waste in accordance to the purpose of the bin and waste collection and processing capabilities in respective cities and provinces. Creating awareness on the difference between home composting and industrial composting is also essential, especially in cold regions like Canada, where ideal composting temperature may not be attainable outside of industrial composting facilities. Currently available compostable stickers are ideal and certified for industrial composting only which informs that home composting of the stickers must be avoided. Similarly, people can also be educated about contaminants from other sources that reach composting and recycling facilities, due to lack of adherence to best waste disposal practices.

Advocating for conventional PLU stickers to be considered as single-use plastic can be beneficial in changing the perception and creating opportunity for favorable policies, for making alternative solutions economically and technologically viable. However, the relevance and need for PLU coding and stickers must be maintained. While PLU stickers are similar in function and use to

single-use plastic, any type of ban on the product is not recommended. The opportunity can be utilised to advocate for production and use of sustainable products.

5.3 Limitations and Opportunities

5.3.1 Limitations

Reaching out to a large group of participants for Survey I was challenging. The rapidly evolving Covid-19 situation delayed the prospects of reaching out to targeted participants from March through early June 2020. Several stakeholders play an important role in successful operations of produce sector. I was unable to get through to an intended large number of produce processors and distributors to gain their participation in the survey. Reaching out to a larger group producing and selling a wider range of products in different regions of the country would have enabled collection of more data and opinions. Stakeholder consultation is crucial for discussing relevant subjects that have the potential of creating a large impact.

Literature available on PLU stickers and coding application is limited. Information about PLU sticker pollution and contamination is mostly available on and restricted to media and news platforms.

All municipalities deal with produce waste. I was unable to reach out to many municipalities to understand their waste collection processes and compost contamination challenges including mitigation measures. Collective expression of similar waste management issues by municipalities can be a driving force for provincial and federal governments to introduce stringent measures.

5.3.2 Future Research Opportunities

The subject of sustainable alternatives for PLU stickers and PLU coding on produce can be explored further in the future as follows:

- Research the developments in the laser labelling technology and compliance with food safety standards and regulations. The technology is promising in reducing waste generation and compost contamination, with presumably lower impact on resource utilization.
- Collection of detailed statistics by municipalities to record waste diversion to landfills due to plastic contamination will be useful as this data can be used to measure the exact impact and advocate for effective government regulations. Estimating accurate contribution of produce plastics to environment waste, litter, and GHG emissions is required. Canada's commitment to the IPCC agreement must be supported by recording and further combating GHG emissions from specific sectors and products.
- When selecting alternatives, life cycle assessment of materials and technology must be conducted to determine the footprint of the alternatives. Life cycle assessment tool can be used as of the methods in selecting and promoting best alternatives with relatively reasonable environmental footprint. Analysing impact of products and technology from extraction to end of life is critical in determining the required resource consumption and long term environmental impact. This in turn can help in resource optimization
- Measure the impact of the Call to Action campaign at the University of Calgary through survey and other assessment methods. Analysing change in behavior, practices and potential domino effect beyond the campus, will be useful in determining the impact of the campaign.

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