The Impact of Marketing Channels on On-Farm Food Loss for Producers of Fruit and Vegetables in Québec and Ontario

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Abstract:

Food loss and waste is an issue in Canada. The over production of agricultural products can lead to declining land fertility, deteriorating sustainable environment, and wastage of energy. In comparison with other categories of agricultural products, the loss rate of fruit and vegetables is much higher because they cannot be stored for a long time and easily. Like other developed countries, most food is lost in Canada at the retailing and consuming level, which researchers tend to pay more attention to than other stages of the supply chain. In developing countries, food loss and waste occur primarily at the post-harvest stage, where the local food system is dominant. Recent studies suggest that on-farm food loss could be more severe than estimated before. Producers in some studies suggested that high cosmetic standards set by retailers and distributors lead to higher on-farm food loss rates than local marketing channels. Therefore, it is necessary to understand if it is true that producers selling through local marketing systems have lower food loss rates than producers selling through other marketing channels. We conducted a survey of fruit and vegetable producers in Québec and Ontario about their food loss rates at farmgate, the composition of marketing channels, and other factors that potentially impact the on-farm food loss rate. We found out that, compared to local channels, selling more directly to retailers statistically significantly reduces the on-farm food loss rate, but the absolute value is quite small. Small-scale farms have lower on-farm food loss rates than larger farms. Processing on farm also significantly reduces food loss on the farm. This study suggests that local marketing channels may not necessarily mean a lower on-farm food loss rate and that selling more directly to retailers could reduce on-farm food loss. However, producers need to consider their own situation to take measures to reduce on-farm food loss without compromising their income and welfare.

Résumé

Les pertes et le gaspillage alimentaires sont un problème au Canada. La surproduction du produit agricole peut causer une baisse de la fertilité des terres, une détérioration de l'environnement durable et un gaspillage d'énergie. En comparaison avec d'autres catégories de produits agricoles, le taux de perte de fruits et légumes est beaucoup plus élevé, parc qu'ils ne peuvent pas être stockés longtemps et sont faciles à périr. Comme les autres pays développés, la plupart des aliments sont perdus au niveau de la vente au détail et de la consommation, où les chercheurs ont tendance à accorder plus d'attention qu'aux autres étapes de la chaîne d'approvisionnement, tandis que dans les pays en développement, les pertes et le gaspillage alimentaires se produisent principalement au stade post-récolte, où le système alimentaire local est dominant. Des études récentes suggèrent que les pertes alimentaires à la ferme pourraient être plus graves qu'on ne l'estimait auparavant. Dans certaines études, les producteurs ont suggéré que les normes cosmétiques élevées établies par les détaillants et les distributeurs entraînent un taux de pertes alimentaires à la ferme plus élevé que les canaux locaux. Par conséquent, il est nécessaire de comprendre s'il est vrai que les producteurs qui vendent par l'intermédiaire de systèmes de commercialisation locaux ont un taux de perte alimentaire inférieur à celui des producteurs qui vendent par d'autres circuits de commercialisation. Nous avons mené un sondage auprès des producteurs de fruits et légumes du Québec et de l'Ontario sur leurs taux de pertes alimentaires à la ferme, la composition des circuits de commercialisation et d'autres facteurs susceptibles d'avoir une incidence sur le taux de perte d'aliments à la ferme. Nous découvert que la vente au détail réduit de manière statistiquement significative le taux de pertes alimentaires à la ferme, mais la valeur absolue est assez faible. Les petites exploitations agricoles ont un taux de pertes alimentaires à la ferme inférieur à celui des grandes exploitations. La transformation à la ferme réduit également considérablement les pertes alimentaires à la ferme. Une découverte inattendue est que les fermes des femmes participantes ont des taux de perte de nourriture à la ferme plus faible que les fermes des hommes participants. Cette étude suggère que les canaux de commercialisation locaux ne signifient pas nécessairement un taux de perte alimentaire plus faible à la ferme. Dans notre étude, vendre plus directement aux détaillants pourrait réduire les pertes alimentaires à la ferme. Cependant, les producteurs doivent tenir compte de leur propre situation pour prendre des mesures visant à réduire les pertes alimentaires à la ferme sans compromettre leur revenu et leur bien-être.

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1. Introduction:

Food loss and waste is a problem faced by both developing and developed countries. Globally, it is estimated that one-third of the food produced is lost or wasted (FAO, 2011). When comparing developing countries and developed countries, the main source of loss and waste occurs at different stages of the food supply chain. For developing countries, due to a lack of infrastructure and technology such as cold chain transport, refrigeration storage facilities, and the high proportion of the population in agriculture, the local market is their main source of selling. Much food must be discarded due to inappropriate post-harvest handling, storage and/or transport. As for developed countries like Canada, agricultural production is an industry rather than subsistence, so fewer people are needed and more machines and technology are applied, leading to large-scaled farms and long-distance transport to fewer retailer stores. As a result, more food was discarded at retailing level and at home than at earlier stages in the supply chain. If it is possible to combine the advantages and exclude the disadvantages of the two different marketing systems, i.e., selling primarily through local marketing systems, it may be possible to reduce food loss and waste significantly.

In modern agricultural production, food loss and waste suggest wastage of land fertility and energy, including energy to produce and transport (Abbott and Murphy, 2007). Among all categories of agricultural products, the loss rate of fruit and vegetables is outstanding, because of the nature of horticultural products. Except for a few fruits and vegetables, such as carrots, tomatoes, potatoes, apples, and pears, most fresh fruit and vegetables are fragile, perishable, labour-intensive and of short storage period. Tomatoes are a little special, because they are chromatic fruits, i.e., tomatoes can continue the ripening process after picking up. Therefore, tomatoes sold through the regular commercial market are harvested when the fruits are still green

and ripen in the buyers' facilities. In addition, appearance is an important feature for fruit and vegetables to be marketable. In comparison with other agricultural commodities, many fruit and vegetable producers must discard or even not harvest quite a quantity of edible produce.

The terms food loss and waste are often used interchangeably for all food produced within the system that does not reach the designed destination, but academia has not agreed on a common definition of food loss and food waste. A few researchers use food loss and waste as a wholesome and food loss and food waste are interchangeable. Some researchers considered food waste as a subset of food loss. Other researchers distinguish food loss from food waste by the stage of the food supply chain: food loss is food lost occurring before retailing level; food waste is food lost occurring at retailing and consuming level. In this paper, we define food loss and waste the same as the last one mentioned above, and we focus only on food loss at farmgate.

Owing to the characteristics of food loss and waste in developed countries, researchers in North America have tended to focus more on food wasted at the retailing and consuming stages rather than at the production stage. In this paper, we focused on the food loss rate at the farmgate. Apart from marketing channels, other factors are also potential to impact the on-farm food loss rate. Fruit and vegetable production does not involve machines as heavy as other agricultural products; thus, human labour is critical in the entire process of production, from planting to harvesting. Many producers plant more than one horticultural crop, and most crops are harvested from May to November. Such conflict during the period of harvesting could lead to a conflict of assignment of labour, which causes an inability to harvest all produce in time. Agriculture is traditionally considered dominated by males. It is interesting to know if females' role in decision-making in agricultural production could influence the on-farm food loss rate.

All these raise a question: can changing marketing channels alter the on-farm food loss rate of fruit and vegetables? First, it is necessary to know if it is true in the context of Canada's fruit and vegetable market, the on-farm food loss rate for farms selling through local marketing channels is smaller than those selling through other marketing channels. Québec and Ontario are the two provinces where nearly 50% of Canada's agricultural land of fruit and vegetable situates and over 50% of Canada's population dwell. We surveyed fruit and vegetable producers in Québec and Ontario online through growers' associations and individual contact. In the survey, we asked producers about their personal information, their composition of marketing channels, on-farm food loss rate, crops planted and other issues concerning farm operation and management. These primary data allow us to establish a model to explore the relationship between on-farm food loss rate and marketing channels, as well as other potential factors that may impact on-farm food loss and waste.

2. Literature review

2.1 General View of Food Loss

While the loss of edible food is an issue throughout the agricultural and food supply chains, there is not a universally accepted definition of food waste and loss. Precise definitions of the terms vary from one researcher to the other. The Food and Agricultural Organisation of the United Nations (FAO) initially defined food waste and loss as "wholesome edible material intended for human consumption, arising at any point in the food supply chain after harvest that was discarded, lost, degraded, or consumed by pests" (FAO, 1981; Parfitt et al., 2010). With further development, FAO considers food loss as decrease of quantity or quality of food caused by food suppliers from post-harvest up to but excluding retail level and food waste as the decrease of food quantity and quality at the stage of retailers and consumers (FAO, 2011). This definition distinguishes food loss from food waste, where food waste is defined as edible food that is not consumed after it has reached food retailers (i.e., food wasted in grocery stores, restaurants, or within households). Stuart (2009) extends the definition of food waste and loss by adding animal consumption and by-products of food processing to the purpose of the food, such that food products used for these purposes are not considered waste. Food waste is sometimes considered a subset of food loss: all food lost in the supply chain is called food loss, and food waste starts once the produce leaves farms (Minor et al., 2020). In addition, whether to include inedible parts is also argued among institutions.

Food waste and loss is a global issue. In a 2011 report, the FAO estimated that one-third of food produced for human consumption is either lost or wasted (FAO, 2011). Waste and loss of edible food occur in both developing and developed countries; however, different percentages of food waste and loss at different stages of the supply chain and for different reasons. In developing

countries, most food waste and loss take place at the early stages of the supply chain, namely production and distribution. These countries generally lack the infrastructure to store and ship agricultural products with minimized loss, as cold chain transportation and cooling storage facilities are not widely available (FAO, 2011). Therefore, the produce in developing countries is distributed mainly through small supply chains (FAO, 2011).

A report by Gooch et al. (2019) estimated that Canada wastes or loses 35.5 million metric tonnes (i.e., 40%) of food produced each year, of which 32% is avoidable. In Canada, like other developed countries, most food is wasted in retailer's stores and on the consumer's table, which is estimated to be as much as 60% of total food lost in the entire food supply chain (CEC, 2017); a relatively small portion of edible food is lost on the farm and within the distribution channel (FAO, 2011). This leads Canadian researchers and governments to focus more on retailing level and consumer side than the production side, i.e., food waste rather than food loss. Researchers found that food waste increases along with food availability and income; in a case study of southern Ontario, on average, a household threw away 2.4kg of food every week, which compromised 35.4% of the total waste thrown by a household; and in another case study conducted in Guelph, Ontario, the 2.98kg food waste per household is avoidable; the waste rate of fruit and vegetables is higher than other categories of agricultural products, shockingly over 40% (Abdulla et al., 2013; van der Werf et al., 2018; von Massow et al., 2019; Government of Canada, 2022).

Researchers have argued over how accurate the estimated rate of food loss and waste is in comparison with the actual rate. Some studies have suggested that the percentage of food wasted and lost at the farm level may be higher than previously thought. In an on-field assessment of fruit and vegetable production in North Carolina, US, researchers found that the average portion of farmers' reported marketed yield is 56% (Johnson et al., 2018); and the figure in an assessment of

fruit and vegetable farms in northern and central California, US is 31.3%, excluding walk-by loss – produce never harvested (Baker et al., 2019). Meanwhile, some other studies think the overall food loss rate has been overestimated. The newer estimation in 2016 of all food loss and waste of all EU-28 countries was 9 million tonnes, much smaller than the estimated three million tonnes of food loss and waste in 2004 that occurred in the United Kingdom alone (Sheane et al., 2017). In general, the researchers agreed that on-farm losses were motivated by several common reasons: discarding or not harvesting produce that does not reach the grade requirement set by buyers, overproducing to hedge risk or maintain income (Gillman et al., 2019); the inability to harvest agricultural products in time due to bad weather conditions or lack of labour; and the inability to harvest due to farm management (for example farm owners assigning employees to harvest one field first, resulting late harvesting in the other field) (Johnson et al., 2019; Minor et al., 2020). Such loss of agricultural products results not only in a loss of edible produce that could be consumed, but also the loss of soil biological fertility (Abbott and Murphy, 2007) and a waste of inputs such as fertilizer and fossil fuels. In general, studies consistently find that food waste and loss is a problem that threatens global food security, causes environmental problems, and raises energy wastage (Environment and Climate Change Canada, 2019; Beausang et al., 2017). Therefore, if the rate of food waste and loss can be reduced, more resources can be saved for future generations.

The causes of food waste and loss must be analysed in multiple dimensions: political, economic, cultural, and social, because none of them is independent of the other. Because of this, there is no single simple perfect solution. Foods that are commonly consumed in some regions are considered by-products in others. For example, organ meat (e.g., liver, heart, kidneys, etc.) is commonly consumed by humans in many countries, such as Scotland (Haggis, traditionally made

from the stomach of sheep), China (pan-fried pork liver), Japan (raw beef liver), etc. (Sietsema, 2015; TasteAtlas, 2023), but most of the organ meat is not widely consumed in North America. Some parts of plants are also edible, such as sweet potato leaf and pumpkin leaf, but they are not accepted by consumers in the North American market. The FAO in 1981 specified such a special situation that food should be defined as the edible material that is widely accepted and consumed by a large population (FAO, 1981). Therefore, in the global context, these should be considered as food loss as there are edible foods, but there is no suitable market in North America.

Most residents of developed countries have enough income to afford food that meets high cosmetic standards, so the produce that does not meet these standards often fails to reach the table, even though there is no decline in its edibility or nutritional value (Yuan et al., 2019). In the economic aspect, for farmers afraid of having their produce rejected by buyers, it may be cheaper to leave crops unharvested or discard them. By leaving edible but cosmetically unappealing fruits and vegetables unharvested, they do not incur the additional costs of time, labour, and equipment for further sorting. This is the same for processors, as diverting produce to different production lines may require extra time, labour, and/or equipment than simply discarding (Minor et al., 2020; Johnson et al., 2019). In this paper, I consider food loss and food waste as two different subjects and only focus on food loss at the farmgate, defining food loss as edible food that is discarded, left unharvested, ploughed under, and/or composted before it reaches distributors, retailers, processors, or consumers.

One major difficulty of studying food waste and loss is that there are no precise data on the amount of consumable food that goes uneaten. The FAO and the United States Department of Agriculture (USDA) do not have specific data on food waste and loss, because such data collection is extremely expensive (Minor et al., 2020; FAO, 2019). Some researchers have conducted surveys

within a particular region, indicating that on-farm loss could be more severe than previously estimated, with calculations from sample farms much higher than producers' estimations of on-farm food loss (Johnson et al., 2018; Johnson et al., 2019; Baker et al., 2019). For example, Johnson et al. (2018) conducted a field measurement on farms in North Carolina, USA and found out that the loss rate of marketable vegetables ranges between 10% and 40% of the growers' marketed yield depending on the species. In comparison, producers in interviews conducted by Johnson et al. (2019) estimated on-farm food loss in the range of 10% to 20%. The figures of edible vegetables left on fields over first-harvested produce can reach more than 100% (i.e., more edible produce was left on the field unharvested than harvested).

Canada's agricultural system is relatively unique in comparison with other major agricultural-exporting countries. Canada is a significant exporter of cash crops such as wheat, canola, and soybeans but also a significant importer of fresh fruit and vegetables, mainly from the United States (AAFC, 2020). Some regions of Canada produce several fruit and vegetable crops in the warm summer months. In the province of Québec, growers produce over 70 species of fruit and vegetables, where the major production takes place in the Lanaudière (21%) and Montérégie (63%) regions, responsible for 84% of total fruit and vegetable production in Québec. Québec is also an exporter of fresh and processed fruit and vegetables to the United States (Québec, 2021). In the province of Ontario, there are over 125 different fruit and vegetable crops grown, concentrated in southern Ontario (OFVGA, 2021).

Canada's northern geography prevents Canadian farmers from massively producing fruit and vegetables all year round. This means that there is no significant competition for fresh fruit and vegetables between Canadian producers and foreign producers during the production season, except for the produce that can be stored for the long term, such as apples, onions, and carrots. For

simplification, the market of Canada's fruit and vegetable can be divided based on time: the summer market that can be supplied dominantly by Canadian farmers except for some tropical fruit, such as mangoes, bananas and dragon fruit; and the winter market, which on the other hand, is dominated by Canada's southern neighbours.

Among all types of agricultural products, the loss rate of fresh fruit and vegetables is more significant in comparison with other categories of agricultural products, no matter what kind of country. The UN estimates that over 40% of fresh fruit and vegetable do not reach their designated destination of consumption in the entire supply chain. In contrast, the proportion of grains that do not reach their consumption destination in North America and Oceania is less than 10% (Gustavsson et al., 2011; Gunders et al., 2017). The time-sensitive nature of fruit and vegetables causes a high rate of food loss and waste throughout the entire system. One significant feature of horticultural production is that it is labour-intensive. Most fruit and vegetables still need hand handling (e.g., harvesting, sorting, or packaging) rather than machines to avoid damage. Leafy greens and most fruits are very fragile and must be handled by hand. Most of them are hand-grown, hand-harvested, hand-sorted, and hand-packaged (OFVGA, 2022; Minor et al., 2020). Except for a few species, such as potatoes, pears, tomatoes, carrots, carrots, apples and sweet tomatoes capable of sustaining rough treatment and processing, most fruits and vegetables are very perishable and not able to store over a long period (Bachmann and Earles, 2000).

Canada heavily depends on temporary foreign workers in horticultural production, who work in the industry for a limited number of months each year. In Canada, temporary foreign workers represent 16% of the total agricultural labour force (CAHRC, 2014). Forty-three per cent of the total labour employed in horticultural production are foreign workers, and 61% of horticultural farmers hire them (CAHRC, 2014). This number is much larger than the proportion

of temporary foreign workers in other categories of Canadian agricultural production. The demand for labour in the horticultural section is facing a crisis, as the producers cannot find enough Canadian workers to fulfil the labour gap while maintaining the cost (CPMA, 2020). There are two ways to pay the workers: by time (i.e., the number of hours worked) and by quantity (i.e., the quantity of produce harvested). Some researchers indicate that manners of payment could partially impact the waste and loss at the harvest stage. If workers are paid based on length of work, some produce could be harvested would not be harvested; if workers are paid by unit, such as by per bushel, or per bag, the workers may ignore quality to reach quantity, that workers harvest the produce which should stay on the plant longer. In the latter case, the produce harvested too early may be discarded (Hill, 2019; Stevens, 2017).

The strict cosmetic requirement is another reason for food waste and loss of horticultural products, which further impacts farmers' decision-making (Johnson et al., 2019; Beausang et al., 2017). Cosmetic requirements include the size, colour, and shape of the fruit and vegetables. The requirement from both distributors and consumers may force some farmers to make decisions to discard or leave produce in the field during the harvest season, as produce that does not meet cosmetic standards will fetch a lower price and may therefore not be profitable to harvest. A farmer's decision of when to stop harvesting mainly depends on the market. Unlike cash crops like corn and wheat, many horticultural crops do not have uniform growth processes. This means that crops ripen at different times of the harvesting period, requiring multiple harvests (Minor, 2020). Farmers usually stop harvesting when the revenue of additional produce cannot cover the cost of harvesting, when the weather does not allow for harvesting, or when they think the quality of the agricultural products is too bad to be accepted by the processors and distributors. As for the

distributors, the consumer's conception shapes the standard requirement for the produce, so the produce that consumers dislike is discarded (Magalhães et al., 2021).

Canada's retail market for fresh fruit and vegetables may be described as an oligopoly system (Beingessner and Fletcher, 2020), with grocery sales dominated by three major national chains (Loblaw, Metro, and Empire (Sobey's)). Producers are not as powerful as the buyers on the markets to negotiate prices, which could be a reason for the high food loss rate at farmgate and the waste rate at the retailer level. This is one of the reasons why contract farming has become more and more popular among Canada's horticultural producers. It is considered a form of vertical integration so that retailing firms can better control the production process and final agricultural products (Prowse, 2012). In a particular case of contract farming introduced by a canning food company in Québec in a seminar addressed in a class at McGill University, processing firms provide seeds for farmers and set a fixed price of purchase before the season, which provides producers with a guaranteed income (Glover, 1987). After harvesting, firms usually provide trucks to ship the produce, which reaches the standard to the processing facility. Contract farming is a common approach for farmers to hedge financial risk, so it is easy for contract farmers to determine the time to stop harvest, because for those whose income is primarily from contracting buyers only need to fulfil the quantity notified on the contracts. The firms also could have more advantageous storage facilities than farmers do, which may reduce loss due to improper handling and storing. Meanwhile, the contract buyers or processors apply strict standards to the produce, which potentially causes loss and waste. For example, when there is a large harvest in a good year, the buyers simply cannot buy additional products that exceed the quantity agreed on the contract, so they only purchase the best of the best (Glover, 1987).

Currently, there are more and more forms of contracts that buyers and producers can determine whether to pay before or after the delivery, to set a fixed price or follow the market price, to set a penalty or not (Alberta, 2021), which makes contracting very complex and requires farmers to master more knowledge to maximize their income. This is also why the firms may overproduce, as buyers set high penalties for suppliers' incapability to completely deliver the order, leading to huge wastage (Parfitt et al., 2010). In the past, it was considered a type of guarantee of income for small-scale farmers (Glover, 1987), but now, ironically, some farmers consider it as a form of exclusion of local farmers from the agricultural land as they cannot expand production since it pushes the price of land high (NFU, 2013). Standards set by the distributors and retailers prohibit the entry of some marginal farmers, not only due to their relatively small size of farming but also the cultivars they grow, as the firms usually determine which cultivars farmers should grow by providing seeds (Prowse, 2012). The cultivars that are not capable of bearing long-distance shipping cannot massively enter the main supply chain and reach the retail store. Even for retail stores that sell produce with the "local" label, retailers prefer to cooperate with large commercial farms that produce commercial cultivars. The standard basically separates fruit and vegetables into two categories, where the first grade goes to the consumer's table, and the second-graded goes to food processing. The standards are different for different purposes; for example, the export standard is usually the highest to avoid corruption during cross-board shipment.

It seems that the public and governments regard the reduction of food waste and loss rate as beneficial to all agents in the food supply chain: food insecurity could be solved or improved; the resources are saved for the future; and farmers' incomes could increase because more products are sold (Lee et al., 2017; UN, 2021; Waste Reduction and Management Division, 2020). Therefore, from the federal to the individual level, there are several measures and campaigns to

reduce food waste and loss. Some provincial governments in Canada have introduced a food donation tax credit, which rewards producers for donating unsold produce. For example, in Québec, since 2015, individuals can claim a tax credit equal to 150% for an eligible amount of food donation, while the regular donation rate is 25% (Revenue Québec, 2020); in Ontario, farmers receive a tax credit valued at 25% of the fair market value of their produce donation (OMAFRA, 2016). Some non-government organizations (NGOs) and/or non-profit organizations (NPOs), like food banks, carry out food recovery programs to provide low-income families with fresh and nutrient-rich fruits and vegetables. One manner is called gleaning that NGOs and NPOs gather volunteers to go to the farm and collect the leftover produce after farmers finish harvesting.

In addition, there is a trend to promote the sale of ugly produce to reduce food waste and loss rate in the entire system. Ugly produce often refers to agricultural products that do not meet cosmetic standards, particularly their shapes are misfit, abnormal, or sub-optimal, but there is no decline in the nutritional quality of the produce (Yuan et al., 2019). Baby-cut carrots, or what is marketed as "baby carrots" (different from real baby carrots, which are carrots harvested before reaching maturity, so they are small), are one of the by-products of ugly produce. To reduce the loss of imperfect carrots, Mike Yorusek, a farmer from California, cut and peeled the imperfect carrots into 2 inches long, which later became extremely popular in the market. Ironically, the market for baby-cut carrots became so popular that the breeders bred carrots especially for cutting (Weise, 2004).

For farmers, when they cannot sell the edible produce, the fresh produce is usually ploughed into the land, composted as organic fertilizer, or used to feed animals (Weise, 2004; Gillman et al., 2019; Minor et al., 2020; Diaz-Ruiz et al., 2019). Animal feed is not a common practice in European countries nowadays, because of the monotony of the current agricultural

system and regulations concerning animal health (Salemdeeb et al. 2017). In traditional farming, farmers produce first to feed themselves and then sell the rest to the market, so they cultivate both crops and animals. In the modern day and the modern agricultural system, along with the increasing size of farms, farmers in the region produce the same agricultural products that they cannot find someone nearby to accept edible produce as animal feed (Salemdeeb et al. 2017).

Despite these measures, the perception that providing farmers with incentives for donating unsold produce is an efficient way to address food loss and food insecurity is perhaps somewhat naïve. All the measures look good and indeed could reduce the food loss and waste rate, but they do not consider the farmer's thoughts about their views of the impact of reduction of food loss. According to a report published by Food Banks Canada in 2016, it claimed that the introduction of the food donation tax credit raised Québec farmers' enthusiasm for donating food. Québec food banks received over 460,000 kg more of fresh produce in 2015 (Food Banks Canada, 2016). However, producers do not always consider such incentives advantageous for themselves. In interviews with farmers in Ontario, many farmers did not consider the 25% tax credit enough to encourage them to donate fresh food. It was already difficult for producers to survive relying only on farming that they do not have the capability to donate food since they must incur the costs associated with harvesting without revenue from produce sales (Kinach et al., 2020). As for gleaning, some studies showed that some farmers consider it as a liability in consideration of sanitary requirements (i.e., there is no professional training of the volunteers that they could bring contamination to the agricultural products waiting for harvesting) (Johnson et al., 2019). Further, some farmers even dislike gleaning because they think such measures decrease the value of their products as there may already be an oversupply in the market (Soma et al. 2021). In addition, many food donations are likely to be the produce rejected by buyers that farmers do not donate on

purpose (Johnson et al., 2019). Some workers are also worried about so-called cannibalization, described by Berkenkamp and Nennich (2015), stating that if producers consider effective methods to reduce food loss, more produce will enter the market and reduce the price and value of the products already on the market.

This is also the reason for some farmers not welcoming the idea of ugly produce. Some retailers also expressed that they wasted loads of ugly produce because the customers were not willing to buy the not-good-looking produce at the retail stores (Soma et al., 2021). Some farmers argued that it is better to lose the agricultural products on the farm rather than at the later stages of the supply chain because the produces then can be ploughed into the land or composted, which returns the organic matter to the soil, improving the soil quality (Gillman et al., 2019). Farmers facing low-profit margins may find the cost of reducing food waste and loss too high to be affordable. These reasons mentioned above lead producers to be reluctant to carry out food recovery measures or participate in such programs to reduce food waste and loss. In some farmers' views, the best way to reduce on-farm food waste and loss is to expand the market by introducing alternative markets for farmers; for example, farmers sell the not-good-looking produce to processors or increase the price of produce (Johnson et al., 2019).

The concerns surrounding the reduction of food loss and waste brought up by producers come from their experience and knowledge of the agricultural market but are not clearly and precisely elaborated by economic theory or model. Food loss and waste occur all over the supply chain, but how a reduction of food loss and waste in one part of the supply chain impacts loss and waste rates in other stages is not clear. de Gorter et al. (2020) developed a model to better understand how the rate of food waste and loss in the entirety of the food system is affected by the reduction of the waste and loss rate at a particular stage in the supply chain (i.e., at the farm level,

at intermediaries and the consumer level). According to their model, halving the rate of food waste and loss at the farm gate does not necessarily translate into a reduction in the entire system, because the other stages of the supply chain may respond by increasing purchase and rate of food waste and loss, while a reduction at the consumer level greatly impacts the entire supply chain and producer behaviour. The most important factor in determining the effect on total food waste and loss is the elasticity of consumer food demand. When consumer food demand is inelastic, the effective price received by farmers is reduced when the waste and loss rate at the farmgate declines (de Gorter et al., 2020). The situation is reversed if the demand is elastic (de Gorter et al. 2020). Their results showed that it may not be economically beneficial for the system to reduce the rate of food waste and loss, because the total waste could increase because of increased waste at other stages of the supply chain, and the total quantity of production could either increase or decrease. The ambiguous outcome leads to concerns about the economic feasibility of reducing food waste and loss and farmers' willingness to implement measures to reduce food waste and loss at the production level. An economic review from the US showed that the demand for fruit and vegetable is inelastic (Andreyeva, 2010). This could be a negative indication when applying the estimates from the paper to the model developed by de Gorter et al. (2019), because it suggests that farmers may not benefit from reducing food waste and loss and even be worsened. However, the model's assumption should be examined because, in the short run, the demand for food cannot change solely due to the price. Unlike other commodities, food is essential for self-perseverance; and as rational people assumed in the economic theory, they will not buy food more than they can eat and simply throw them away.

2.2 Local food markets

From the past literature, one common factor often cited as contributing to on-farm food loss is the strict cosmetic standards of retailer buyers or wholesale buyers whose ultimate destination is retail stores (Gillman et al., 2019; Berkencamp and Nennich, 2015; Baker et al., 2019). Many edible fresh fruit and vegetables are discarded even before reaching the market, as farmers and intermediate buyers worry about being unable to sell the imperfect produce after a long period of transportation (Minor et al., 2020). Another reason is the customers. Customers buy fruit and vegetables more by eyes rather than by taste (Gillman et al., 2019). In most Canadian retailers' stores, there are few opportunities for tasting fresh fruit, so it is very common in winter, when there are not many significant Canadian competitors in the market, that the customers buy fruit that looks good (i.e., meets the cosmetic standard), rather than tastes good.

It appeared that the major cause of such a large quantity of food waste and loss of fresh fruit and vegetables is specific appearance standards in Canada. Therefore, if farmers can sell the perishable fruit and vegetables to a market where consumers are willing to accept those that do not meet the strict cosmetic standard set by the retailers, it may be more likely to reduce food loss while increasing farmers' income at the same time, which is just what producers expressed in the interviews – expanding the market (Johnson et al., 2019; Soma et al., 2021). The local market may be a good alternate market other than the current dominant agricultural market characterized by accepting small numbers of cultivars, setting high cosmetic standards of agricultural products, and long-distance shipping (Johnson et al., 2019).

The 2021 Canadian Census of Agriculture reported that 13,918 farms in Canada produce fruit and vegetables, and there are 3,155 fruit and vegetable farms in Québec and 3,298 in Ontario[1]

[1] The figures only include numbers of vegetable and melon farming (1,112), fruit and tree nut farming (1,113), other food crops grown under cover (111,419) under the section of Greenhouse, nursery and floriculture production and fruit and vegetable combination farming (111,993) from Statistics Canada.

(Statistics Canada, 2022a). The two provinces represent 46.4% of fruit and vegetable producers in Canada. By area, Québec plants 37% area of Canadian field vegetables planted and 34% of Canadian cultivated fruit; Ontario plants 49% of Canada's field vegetables and 14% of the country's cultivated fruit by area (Statistics Canada, 2022b; Statistics Canada, 2022c). Data from Statistics Canada (2022) suggests that roughly 6% of total planted vegetables did not reach the stage of harvesting (Statistics Canada, 2022c). There is no nationwide data of the unharvested area of fruit, nor food loss and waste along the supply chain of Canada, but we can have a look through another angle at fruit and vegetables incapable of reaching consumers' tables. Agriculture and Agri-Food Canada (AAFC) reported that in 2019, fresh vegetables (excluding potatoes) available per capita was 70.86kg and fresh fruit available per capita was 76.54kg (both figures include the quantity of imports). However, these figures declined to 36.1kg and 36.27kg when fruit and vegetables finally entered people's digestive systems, suggesting that the difference accounts for post-farm loss, including waste at home. Based on these figures from Statistics Canada and AAFC, the loss rate of fruit and vegetable in Canada is shockingly around 50%.

It is important to define local in a study. There is no precise and widely accepted definition of local and local food (Martinez, 2010; Dunne et al., 2011; Onozaka et al., 2011). Different institutions and studies use different definitions for their research. The US Congress defined "local" as the total distance that a product can be transported, such that local foods must travel less than 400 miles (approximately 644 km) from their origin or within the state in which it is produced (Food, Conservation and Energy Act, 2008). In Canada, the Canadian Food Inspection Agency (CFIA) recognizes local as food produced in the province or territory in which it is sold or across provincial borders within 50 km of the originating province or territory (CFIA, 2019). Apart from the definitions from the governments, geopolitical boundaries also appear to influence consumers'

concept of local as well (Willis et al., 2016). Farmers may also have their own perception of the concept of local food. Like the customers, they define local in both geopolitical and geographical manners. However, the way that some other agents in the agricultural system define "local" may vary from commodity to commodity, or local food should travel through as few intermediaries as possible (Beingesnner and Fletcher, 2020). This study also described that if one province cannot produce one type of agricultural products, then the customers would consider the nearest province where the produce grows to be local. For example, if some fruits can only be produced in British Columbia or are not widely planted in Saskatchewan, then these fruits would be considered "local" for Saskatchewan producers. In Canada, on average, 20% of food is consumed within the province in which it is produced; on the provincial level, among all food, residents of Québec consumed about 29% and residents of Ontario consumed 24% (Edge, 2013). However, there is no precise data specifically for fruit and vegetables.

Researchers have various reasons to study local food systems. From the agricultural aspect, local food systems allow for the preservation of cultivar genetic diversity (Brain, 2012). In the dominant market, in order to make fruit and vegetables endure the long distance of logistics, the buyers prefer the cultivars that are stiff and hard but usually not that tasty (e.g., tomatoes). Other cultivars are relatively fragile and unable to bear long-distance transportation in comparison with those displayed on the shelf of supermarkets. As a result, large distributors and retailers often refused to buy such cultivars, preventing these products from entering the dominant market over the past decades. However, local markets may be able to accept these fragile but delicious cultivars as they are not ruined by being transported long distances.

The local food system also assists local communities and local small-holder farmers. This allows farmers to obtain a higher share of the price and may further develop agrotourism, which

adds more value to their income (Gale, 1997). There are debates about whether short supply chains or local food systems are environmentally sustainable. For simplification of this study, the criteria are usually relatively simple by employing food miles or greenhouse gas (GHG) emissions to measure sustainability. Some studies found out that in terms of these two criteria, the short supply chain is worse than the commercial supply chain involving long-distance shipping, because non-local producers may be able to produce more efficiently (i.e., with lower GHG emissions) and customers may travel a longer distance on their own to reach the locally-produced food, further contributing to GHG emissions (Malak-Rawlikowaska et al. 2019). However, the conclusion drawn from these types of calculations may sometimes be too simple to account for the entire benefit of the local food system.

A general trend in developed countries after World War II was increasing the size of farms while decreasing the number of farms. This led to a concentrated mass-marketing system in which food products travelled a long way to reach consumers (Guptill and Wilkins, 2002; Rucabado-Palomar and Cuéllar-Padilla, 2020). In Canada, food on average needs to travel 2,500 km to reach consumers' tables (Hotton, 2016), especially in winter for fruit and vegetables, which mainly contribute to this number. As the aggregation of farms continues, farmers who participate in the dominant commercial markets are forced to either become larger and larger or exit the market. In such way, producers are able to obtain enough market power and enough income with relatively low marginal profit in comparison with other industries (Beingesnner and Fletcher, 2020).

This is the reason why local food markets provide such small-holder farmers with the opportunity to survive, as they can produce specialized produce for which consumers are willing to pay a higher premium price (Gale, 1997). In the context of Canada's agricultural market, local marketing is basically in three forms. The first is direct selling to customers. Some farmers open

farm shops or have stalls in the local farmers' market, so that they can sell fresh produce directly to the consumers. The second is community support agriculture, or CSA in short (Adam, 2006). There are two distinct types of CSA models – subscribers and shareholders. In a farmer-oriented system, farmers usually execute subscriber CSA that farmers cooperate to deliver CSA baskets to subscribers directly. As for shareholder CSA, people in the community grow fruits and vegetables in community gardens. Subscriber CSA is more popular than the shareholder model at present (Adam, 2006). These two methods allow producers to sell their agricultural products directly to the consumers, receiving a much higher share of dollar paid by the customers than those who sell to the retailers (Malak-Rawlikowaska et al., 2019; Beingesnner and Fletcher, 2019). The higher marginal profit of direct selling without intermediaries allows small-holder farmers to continue in the agricultural market. The third way that local food marketing channels operate is by selling to local distributors, whose retailers would proudly label them as "produced here" or "local". The retailer is possibly as picky as those distributors whose destination is far away from the production site. For some farms, there is another possible way to sell their produce – pick-your-own. This could be regarded as agritourism, which adds the value of service to agriculture (Malak-Rawlikowska et al., 2019).

Some farmers pointed out that they discarded more when selling directly to retailers than selling to local markets (Beingesnner and Fletcher, 2020), because the standard of retailers is strict, and they can find nowhere to resell the unfavourable produce. In addition, with more intermediaries, the proportion of the price consumers pay enters the producer's pockets is lower (Malak-Rawlikowska et al., 2019). In developed countries, the absolute quantity of fruit and vegetables sold to retailers or intermediaries still dominates the food retail market. If more produce can be sold in the local food system, producers may be able to obtain more income than through

the regular marketing channels, because consumers have a higher willingness-to-pay for local produce (Carpio and Isengildina-Massa, 2009) and farmers selling produce through direct or shorter marketing (Gale, 1997). This also suggests that for producers, local means restricting the number of intermediaries and selling directly to consumers to maximize the farmers' dollar share paid by customers.

A recent survey has shown that demand for fresh fruit and vegetables is declining in Canada, in which the proportion of potatoes continues to increase (Tugault-Lafleur and Black, 2019). Nevertheless, as immigration from other countries continues, the population of Canada will continue to rise into the foreseeable future, and immigrants may significantly change the current demographic pattern. This may further alter the demand for fruit and vegetables in the Canadian agricultural market. This indicates that there could be a wider market and more opportunities for Canadian farmers. With little change by shifting from the dominant market to the local market, farmers will be able to obtain more share from the current market. As for public servants and ministers in the agriculture section, this could be another strong support for promoting the local food system, together with reducing food waste and loss and self-sufficiency in the post-pandemic era.

2.3 Research question

Despite the claims of the positive impacts of local marketing channels, there is limited evidence that on-farm fruit and vegetable loss is impacted by farmers' choices over marketing channels. A study of farmers in Saskatchewan claimed that they lose less food in short supply chains than selling to retailers or other commercial buyers (Beingessner and Fletcher, 2020). However, there has not been a systematic investigation into whether local food systems result in less rate of food loss, particularly for fruit and vegetables. To obtain more precise data, it is

necessary to gather information directly from fruit and vegetable producers on their rate of food waste and loss when producers sell to different channels. If there indeed exists a significant difference in on-farm food loss among farmers who supply different distribution channels, it is also important to understand whether, by shifting more produce to sell in the local market, the overall food waste and loss rate of the system can be reduced. As mentioned above, the role of contract farming is ambiguous in food waste and loss. There are not many journal articles or academic papers digging into contract farming in Canada, although it is a common practice in the system. Through surveying producers in Québec and Ontario, it is possible to understand what roles contract farming plays in the current system, which fulfils the current blank.

Farmers have limited market power in comparison with both buyers and consumers in the agricultural market (Sexton, 2012). They also bear the brunt of risks brought by climate change and obtain less than intermediaries in comparison with their efforts devoted to horticultural production (Johnson et al., 2019). As such, when policymakers endeavour to reduce food waste and loss, it is important not to undermine producers' income and welfare. Farmers should not be the groups to bear the cost of reducing food waste and loss. In this respect, shifting the marketing channels to local food systems is, potentially, a suitable and feasible market-based solution to reduce food waste and loss while not jeopardising farmers' interests and welfare. However, it requires economic theory to support such reformation of the current system. This study aims to determine whether a Pareto improvement of the current agricultural system is possible, such that no agents are worse off while trying to solve the problem of food waste and loss. To do so, the study examines whether the local food system and other variables can reduce food loss at the farm level.

To investigate the role of distribution channels on rates of on-farm food loss, we collected data from surveys distributed to fruit and vegetable producers in Québec and Ontario. Following Ogoudedji et al. (2019), who studied maize storage loss in Benin, the Fractional Response Model (FRM) was employed to estimate how farmers' sales to different distribution channels influenced their on-farm food loss rates. The results suggest that farmers selling directly to retailers has a lower food loss rate at the farmgate than those who sell through marketing channels, although the magnitude of this reduction was rather small.

3. Conceptual Framework

The theoretical framework follows de Gorter et al. (2020). He and his colleagues were interested in how the change of rates of food loss and waste in different stages of the supply chain influences the entire supply chain and overall food loss and waste. They considered the rate of food loss and waste to be exogenous. To simplify the model, they divided the supply chain into three stages – producers, intermediaries (including distributors, processors and other buyers) and consumers. They established a model of estimation of food loss and waste at each stage and combined them to examine the scale and direction of each stage's direct and indirect impact on the other stage (i.e., how a lower loss rate at the farm level affected total loss and waste in the entire system). In order to test their model, they utilised observed market data from the United Kingdom to simulate how the reduction in food loss and waste in one sector impacted loss and waste in other sectors.

The model from de Gorter et al. (2020) focused on the relationship between food loss and waste rate and supply quantity in each stage. For example, on the farm level, the total quantity of supply that farms sell and enter the food supply chain is the total quantity produced in the farm (q_F) after accounting for the rate of on-farm food loss. This is shown in Equation (3.1), where q is the quantity of agricultural products; α is the food loss rate; F indicates the farm level; and TS is the total supply that the farm sells.

$$q_{TS} = (1 - \alpha_F) q_F \tag{3.1}$$

As mentioned before, research and reports on food loss and waste worldwide are mostly estimations. It is the same for the de Gorter et al. (2020) model. Their model differentiated the food supply chain from the point of view of customers for the reason of simplification: at home or

away from home, so that the number of stages of the food supply chain is the same. This method of distinguishing did not consider the differences in the supply chain length owing to different marketing channels. For example, direct selling to customers involves only two agents: farmers and customers, while selling to processors involves at least four agents: farmers, processors, retailers and customers. With more agents participating in the process of shipping from field to table, it is possible that the overall rate of food loss and waste of the latter one is higher than the previous one. In addition, it is possible that different marketing channels have different cosmetic standards and other factors that impact the loss rate on farms. Moreover, they reduced the loss and waste by 50% for simulation to investigate how a reduction in food loss rate at one stage of the food supply chain would impact system-wide food loss/waste. This rate of change seems rather aggressive in consideration of the real-world situation and the measures proposed in this paper.

The interest of this study is the quantity of loss and loss rate at the farm level instead of the supply quantity at each stage of the food supply chain. Thus, the quantity of on-farm food loss can be written in Equation (3.2), where L_F is the quantity of loss at the farm level, q_F is the total amount produced by the farm, and α_F is the rate of on-farm loss.

$$L_F = \alpha_F \times q_F \tag{3.2}$$

The loss rate at the farm level (α_F) is the average rate of all farms. After introducing different marketing channels, the on-farm food loss rate can be rewritten as the combination of loss rates based on different marketing channels, as shown in Equation (3.3). It is the weighted average of on-farm food loss rate, where *L* is selling through local marketing channels; *R* is selling directly to retailers; *P* is selling directly to processors, *D* is selling to distributors and *O* is selling

to buyers none of the above, such that q_{F_L} is the total amount of produce produced for the local market, α_L is the loss rate of produce for the local market, etc.

$$\alpha_F = \frac{\alpha_L q_{F_L} + \alpha_R q_{F_R} + \alpha_P q_{F_P} + \alpha_D q_{F_D} + \alpha_O q_{F_O}}{q_F} \tag{3.3}$$

Equation (3.3) presents the relationship between the average on-farm food loss rate and the proportion of sales through each marketing channel. This formula highlights the impact of marketing channels on the loss rate at farmgate, which was not specific in the model of de Gorter et al. (2020). If there exist differences between different marketing channels, then α_F changes in accordance with the proportion of production sold to different channels, even though the sum of the total supply does not change. If the hypothesis is correct, i.e., the on-farm loss rate of selling through local marketing channels is lower than that of selling through other marketing channels, increasing the quantity of selling through local marketing channels (q_{F_L}) will decrease the overall food loss rate at the farmgate. Therefore, under the expected condition, simply changing the composition of marketing channels can reduce the overall on-farm food loss rate.

The premise is to know if it is true that the on-farm loss rate of local marketing channels is lower than those of other marketing channels, which trigger the need to establish a model to estimate the different on-farm food loss rate of different marketing channels.

4. Methods

The objective of this study is to examine on-farm food loss and to determine the impact of distribution channels on the rate of on-farm loss, using data collected from fruit and vegetable producers in Québec and Ontario.

4.1 Survey design and distribution

To determine whether rates of on-farm food loss differ according to farmers' mix of distribution channels, we developed a survey distributed to horticultural producers in Québec and Ontario. A copy of the survey is included in Appendix C at the end of this thesis. The survey was conducted online through the LimeSurvey platform (www.limesurvey.org).

The survey asked farm operators about their basic information, farm operation and farm management practices. For basic information, they were asked about age, gender, location of the farm and years in the agricultural industry. This allows us to establish an image of producers in engage in horticultural production at present. For farm operations, we asked farm operators about the types of crops they produced and the size of cultivation, as these two factors could influence farm operators' decisions on marketing channels. On-farm food loss rate was estimated and reported by farm operators themselves. In the survey, producers were informed that loss rate is defined by the percentage of produce discarded, left unharvested, ploughed under and/or composed over edible food.

The parts following asked producers about their portfolio of marketing channels. Based on the context of the Canadian agricultural market, the marketing channels were classified as directly to consumers, directly to processors, directly to retailers, to a distributor, or other marketing channels defined by producers. Survey respondents were asked the proportion of their output that

was sold to each of these channels. Producers could also indicate other types of marketing channels if they found the options mentioned above not applicable. As for farm management, farmers are asked if they are under the status of contract farming if they produced in an organic manner and if they employ foreign workers, as these all could impact food loss at farmgate. These characteristics were specified because contract buyers may be picky about the appearance of fruit and vegetables; organic farming requires practices quite different from commercial ones (for example, most herbicides and pesticides commonly used in commercial farming are forbidden in organic farming); and foreign workers may impact on production, as more than 50% horticultural farms employ foreign workers. If farm operators cannot recruit foreign workers, they probably face a labour shortage, which may worsen food loss on the farm.

The past three years were unique due to the COVID-19 pandemic, so we are also interested in the impact of the pandemic on the change of producers' choice of distribution channels. We asked producers whether and how their composition of marketing channels changed due to the pandemic and whether they thought any change would be lasting. The third section is a detailed extension of section two. It aimed to understand producers' feelings and thoughts towards the current agricultural market. The participants were given the option of completing this section or skipping to the end of the survey. In this part, participants were asked further questions about the practice in sales, personal views of their status in the current agricultural system, their bargaining power in the market, reaction to measures aiming to reduce food loss and waste, and the impact of the pandemic. They were also asked about their insights on the conception of "local". The survey is enclosed with thanks for their participation. In this part, the contact information of the academic team was available for participants once again for reminding.

It is not easy to reach every individual producer of all marketing channels, as some producers would not publish their contact information on the Internet. As a result, the survey was initially distributed through producer's associations. Initial contact with individual producers was made on our behalf by these associations. We reached out to regional commodity organizations (see Appendix A1 for a full list of organizations) to ask them to contact their members via email with a link to the survey or advertise the survey on our behalf in their newsletters and other outreach efforts. The regional producer's association of fruit and vegetable of Québec, Association des producteurs maraîchers du Québec (APMQ), represents 389 (it is the number during the survey, there are 450 members in May 2023) farm operators or owners of horticultural production and 80% horticultural production in Québec. The counterpart of the APMQ in Ontario is the Ontario Fruit and Vegetable Growers' Association (OFVGA) which represents the fruit and vegetable producers of all categories, consisting of Berry Growers of Ontario, Fresh Vegetable Growers of Ontario, and other associations. The participants were provided with a link either in a column in the monthly newsletter of the association or through the recruitment email forwarded to all members by the personnel responsible for communication or research. The participants of the survey are considered as farm operators who have a general view of on-farm loss and waste. The participation rate was expected to be low, because according to the coordinators of the associations, farmers are reluctant to fill in a long questionnaire, which would quickly exhaust their patience. In addition, one coordinator also mentioned that there were lots of academic researchers approaching farmers, which also contributed to the low participation rate.

The first round of recruitment was initiated in late November of 2021. Surveys were mainly distributed through representatives of producer's associations. A few associations distributed through both newsletters and emails. However, the participation rate was low, and a second

recruitment process must be introduced. The second recruitment was initiated at the end of April of 2022. In the second stage of recruitment, we introduced incentives to increase the participation rate. Participants had the option of entering a drawing to win one of 10 gift cards to a gas station of their choice worth 50$.

Some associations publish the contact information of their members on their websites (available in Appendix A2), so we were able to reach producers directly by email. In the third round of recruiting, we sent invitation emails directly to producers for whom contact information was publicly available. Some producers do not provide email addresses but provide contact forms on their websites. We left messages on the website to reach such producers.

4.2 Empirical Framework

The dependent variable in this study is the rate of on-farm food loss. It is measured by the proportion of total production that was unsold or left unharvested, reported by survey respondents. This variable is bounded by 0 and 1; the Fractional Response Model was employed to investigate whether individual farmers' rates of on-farm loss are associated with their main distribution channel. Ordinary Least Squares (OLS) was not employed, because it is possible that OLS would deliver a negative prediction while our dependent variable is strictly between 0 and 1. Tobit model is not applicable as well, as our data are not censored.

The Fractional Response Model uses the Quasi-Maximum Likelihood Estimation method (QMLE) to estimate the non-linear model, because we do not know the distribution of dependent variables; and the fractional response model likely implies heteroskedasticity (Wooldridge, 2010). However, a Wald Test can be used to test if the coefficients of heteroskedasticity are significantly different from 0 (Wooldridge, 2011; Williams, 2019). Ogoudedji et al. (2019) utilised Fractional

Response Model to assess maize storage losses in southwest Benin, whose purpose is similar to our goal. Nevertheless, their explanatory variables contain endogenous variables, so they utilised the fractional logit model instead of the fractional probit model (Ogoudedji et al., 2019; Wooldridge, 2011). In this paper, I use the fractional probit model for analysis.

The empirical Fractional Response Model specification of storage losses employed in this study is adapted from Papeke and Wooldridge (1996) and is shown in Equation (4.1) below. The index k is the number of independent variables in the regression as well as the number of coefficients to be estimated.

$$E(Y_i|\boldsymbol{X}_i, \boldsymbol{Z}_i) = G(\boldsymbol{X}_i\beta, \boldsymbol{Z}_i\gamma) = \Phi\left(\beta_0 + \gamma_0 + \sum_{k=1}^{4} \beta_k \boldsymbol{X}_{ik} + \sum_{k=1}^{7} \gamma_k \boldsymbol{Z}_{ik} + \varepsilon_i\right) \quad (4.1)$$

The variable Y_i is the individual farmer i's proportion of food loss, while $\boldsymbol{X}_i$ is a vector of farm-specific characteristics. $G(X_i\beta, Z_i\gamma)$ in Equation (4.1) is a standard normal cumulative density function to bound fraction response in [0,1]. It specifies conditional mean. Given the conditional mean, using QMLE, we are able to estimate fractional probit regression. There would be only one constant shown in the regression table as the sum of those of the main explanatory variable and controlling variables as presented in Equation (4.1).

Independent variables were classified into two categories: main explanatory variables and control variables. The main explanatory variables are where this study is interested. The main explanatory variables $\boldsymbol{X_i}$ are presented in Equation (4.2) and the controlling variables $\boldsymbol{Z_i}$ are presented in Equation (4.3).

$$\boldsymbol{X}_i = [Retail_i, Processor_i, Distributor_i, OtherChannel_i]^{\mathrm{T}} \quad (4.2)$$

$$\boldsymbol{Z}_i = [MFV_i, LFV_i, Other_i, Overlap_i, Gender_i, FarmProcessing_i, Small_i]^{\mathrm{T}} \quad (4.3)$$

The dependent variable is the percentage of fruit and vegetables discarded, ploughed under or unharvested or more than two over total edible produce reported by each participant. The index i indicates the individual producers. The main variables of interest are the distributional channels, X_i: $Local_i, Retail_i, Processor_i, Distributor_i,$ and $OtherChannel_i$. They are reported as a percentage of total produce sold to each marketing channel, locating in a closed interval [0,1]. $Local_i$ refers to the proportion of producer i's produce sold directly through local marketing channels (e.g., farmer's shop, farmer's market, pick-your-own and community-supported agriculture (CSA)). $Retail_i$ is the proportion sold directly to retailers; $Processor_i$ refers to the proportion sold to processors of all kinds (e.g., manufacturers of juice, sauce, etc.); $Distrbutor_i$ refers to the proportion sold through distributor channels; $OtherChannel_i$ refers to other marketing channels that do not belong to all distribution channels mentioned above. The variable $Local_i$ was excluded from the model due to collinearity, so the coefficients of other variables are interpreted as the effect of selling more through the other distribution channels compared to the proportion sold through local distribution channels.

The nature of crops produced was treated as control variables, including variables *FFV* (fragile fruit and vegetables), *MFV* (medium storage fruit and vegetables), *LFV* (long storage fruit and vegetables), and *OTHER* (produce other than fruit and vegetables). These variables were created to describe the length of storage period for the fruit and vegetables in retailer's stores, i.e., shelf life. The longer the storage period of fruits and vegetables is, the longer the window period allows farmers to find a buyer. For example, leafy greens, strawberries and herbs were categorized into *FFV*; beets and peaches were categorized into *MFV*; carrots and apples were categorized into *LFV*; *OTHER* are crops of soybeans, cash crops and Ginseng. A detailed description of the variables is presented in Appendix B1. The assignment method of horticultural crops is to be seen

in Appendix A2. They are calculated by the area of crops of the category over the total area of planting. These three variables are also perfectly collinear, so *FFV* was dropped from the model.

To control for the potential impact of overlapping harvest times of horticultural crops on rates of on-farm food loss, the variable $Overlap_i$ was included. This variable was generated from our survey data and available harvest information. In the survey, we asked producers about their top five crops grown on their farms. Using the Ontario harvest calendar published online on pickyourown.org (see Appendix A4), I created a variable to indicate whether individual farms had crops harvested concurrently. It is a binary variable to indicate whether a farm that has at least two crops with the same harvest window. It is equal to 1 when there are at least two crops harvested at the same period, and 0 otherwise. This variable is included because farms with overlapping harvest activities may have limitations on their harvesting abilities which may result in higher rates of loss.

$FarmProcessing_i$ is a binary variable to indicate whether producers undertake any processing activities on the farm (for example, farmers make jam or juice on their farm). *GENDER* is the sex of participants, where female is 1 and male is 0.

$Small_i$ is an indicator of a small-scale farm. In this study, farm size smaller than 10 acres is regarded as a small-scale farm and assigned as 1; otherwise, they are assigned as 0. In Canada, the scale of a farm is decided based on operating revenues. Small-scale farms are those whose annual operating revenue is smaller than $50,000 (Statistics Canada, 2022d). Fruit and vegetables are of higher value than other crops of agricultural commodities, so the size of small-scale farms of horticultural production is smaller than farms of other produce. In our survey, 10 acres are the 25th percentile of all reported farms. Size is an important controlling variable for potential heteroskedasticity in the model. Therefore, a Wald test was used to verify if there exists heteroskedasticity.

The various marketing channels (i.e., $Local_i, Retailers_i, Processors_i$ and $Distributor_i$) are our main variables of interest in the formula, which represent the impact of marketing channels on food loss at farm-gate, mainly due to standards and grading set by buyers. The nature of different crops also influences farm food loss. For example, consumers or buyers set quite strict cosmetic standards for colourful peppers, and colourful peppers do not have many selling channels other than fresh eating, so it may be that on-farm loss rate for fruits and vegetables like this (with shorter storage times or more fragile produce) is higher than apples. Apple is a popular fruit, and there are many products manufactured by not first-grade apples, such as apple juice and apple sauce. Together with a long storage lifespan, apples have a lower loss rate than many fruit and vegetables.

In addition, to study the role of distribution channels, it is also interesting to understand the relationship between the destination of agricultural products and the on-farm food loss rate. Therefore, another Fractional Response Model, where another main explanatory variable $\boldsymbol{W}_i$, as shown in Equation (4.4), variables of destinations of produce, is created, named $InRegion_i$, $InProvince_i$, $InCanada_i$ and $Export_i$. Producers were asked about the proportion of their agricultural products to each destination over total produce. $InRegion_i$ is the proportion of their produce sold within the producer's region or county; $InProvince_i$ is the proportion of produce sold within the province; $InCanada_i$ is the proportion of produce sold inside Canada; and $Export_i$ is the proportion of the produce sold to foreign countries. Similar to variables of marketing channels, $InRegion_i$ is removed due to collinearity.

$$\boldsymbol{W}_i = [\, InProvince_i \; InCanada_i \; Export_i \,]^{\mathrm{T}} \tag{4.4}$$

Therefore, the new fractional response model, Equation (4.5) was established similarly to Equation (4.3) and k is the numbering of variables.

$$E(Y_i|\boldsymbol{W}_i, \boldsymbol{Z}_i) = G(\boldsymbol{W}_i\theta, \boldsymbol{Z}_i\iota) = \Phi\left(\theta_0 + \iota_0 + \sum_{k=1}^{3} \theta_k \boldsymbol{W}_{ik} + \sum_{k=1}^{7} \iota_k \boldsymbol{Z}_{ik} + \varepsilon_i\right) \quad (4.5)$$

4.3 Hypotheses

I hypothesize that growers who sell through local marketing outlets have a lower on-farm rate of loss and waste. From the model of marketing channels, since *L* is dropped due to collinearity, the coefficient of other marketing channels indicates the change to on-farm food loss in comparison to local marketing channels. Therefore, I expect the coefficients on these variables to be positive, i.e., $\beta_k > 0\ \forall k$. As for controlling variables, MFV_i, LFV_i and $OtherType_i$ have longer storage periods than FFV_i, so they are expected to have lower food loss rates on farms ($\gamma_1, \gamma_2, \gamma_3 < 0$). $Overlap_i$ indicates potential conflicts of labour allocation between produce that have coincided harvest period. As a result, I hypothesize that farms with the phenomenon of overlapping have higher loss rates than farms without this phenomenon, so it was expected that the coefficient would be positive ($\gamma_4 > 0$). $FarmProcessing_i$ is expected to deliver a negative coefficient as it is regarded as an on-farm activity to reduce on-farm food loss ($\gamma_6 < 0$). The effect of gender is ambiguous; thus, the direction of the coefficient of $Gender_i$ is uncertain, as we do not know how and what females impact the food loss at farmgate, so is the variable $Small_i$ as the size that we are uncertain about the impact of size over farmer's decision-making ($\gamma_5, \gamma_7 \neq 0$). The model of destination of produce is similar to the model of marketing channels, so that coefficients of variables of destination are hypothesized as positive (i.e., $\theta_k > 0$) and coefficients of controlled variables are expected to be the same as in the model of marketing channels.

Model of marketing channels ($k = 1,2,3,4$):

H_{01}: $\beta_k = 0$

H_{11}: $\beta_k > 0$

H_{02}: $\gamma_k = 0$

H_{12}: $\gamma_1, \gamma_2, \gamma_3, \gamma_6 < 0; \gamma_4 > 0; \gamma_5, \gamma_7 \neq 0$

Model of destinations of produce (k = 1,2,3):

H_{03}: $\theta_k = 0$

H_{13}: $\theta_k > 0$

H_{04}: $\iota_k = 0$

H_{14}: $\iota_1, \iota_2, \iota_3, \iota_6 < 0; \iota_4 > 0; \iota_5, \iota_7 \neq 0$

5. Results:

5.1 Summary statistics

The online survey is relatively easy to distribute. However, the participation rate was lower than desired. This is potentially due to the busy farming season and relatively limited exposure to producers (producers may just ignore the newsletter). In total, we collected 100 responses of which 61 are eligible for analysis in the fractional response model.

Summary statistics on farmers' demographics and general farm statistics are shown in Table 1 below. People working in the agricultural industry are ageing in comparison with other industries; however, producers in this sample were younger than the average age of Canadian farmers. Participants were 45 years old on average, with a median age of 42 years old, compared to the average of 56 for farmers in Canada in 2021 (Statistics Canada, 2022). Participants have been in agricultural production for 23 years on average, with a median of 20 years of experience. Among 80 producers, there were 14 farmers reported that they worked in agriculture for less than ten years, and 12 of them were younger than 30 years old. According to their ages and years in the agricultural industry, many producers started to work in agricultural production since they were teenagers. The numbers of observations are different, because participants can choose to quit or not to answer at any time they want.

Farm size ranged from less than one acre to more than 3,000, averaging just under 162 acres. Most participating farms are between 10 to 100 acres. Farmers employed an average of 14 employees during the non-harvest season and 40 during the harvest season, although these numbers ranged quite substantially as well. Foreign workers are important sources of fruit and vegetable production in Canada. According to our survey. 57.35% of fruit and vegetable farms in

our samples employ foreign workers, and in terms of absolute quantity, foreign workers represented 52.01% of the total labour force (including permanent workers) in fruit and vegetable production. In comparison, foreign workers represent 47.32% of total workers in the production of field fruit and vegetable, tree fruit and vine (CAHRC, 2017) and 63.1% of farms reported employing temporary foreign workers (TFWs). (See Table 1).

Variable	Mean	Median	Min	Max	Number of Observations
Age (Years)	45.3	42	20	80	80
Years in Agricultural Industry	23.3	20	3	60	80
Size of Farms (acres)	161.9	45	0.057	3,325	67
On-farm Food Loss (%)	7.8	5	0	35	65
Number of Harvest Season Workers	40	20	0	425	68
Number of Non-Harvest Season Workers	14	3	0	130	69
Number of Temporary Foreign Workers Employed (among those who employed TFWs)	37	16	1	400	63

Table 1 General Information of Participants and Their Farms Among 63 participants, 39 reported that they employed temporary foreign workers

The majority (68.35%) of survey respondents produced fruit and vegetables in Québec, with the remaining coming from Ontario. Only 12% of our participants were greenhouse producers, or their dominant production field takes place in the greenhouse, and just over 15% were organic producers. Although organic farming has been thriving in recent years (Bialais, 2020), it is still a minor farming measure compared to commercial farming in our samples. Among 70 participants, 11 are currently certificated as organic farming, and five were in the process of the transition or plan to convert to organic farming in the next few years. Most farmers conducting commercial farming do not consider switching to organic farming shortly (see Table 2).

	Number of Observations	Total Observations (Frequency)
Location		79
Ontario	25	(31.65%)
Québec	54	(68.35%)
Main Production in Greenhouses		65
Yes	8	(12.31%)
No	57	(87.69%)
Organic Farming		70
Yes	11	(15.72%)
No, and no plan to convert to organic production	54	(77.14%)
No, but have plan to convert to organic production (or currently transitioning the operation)	5	(7.14%)
On-Farm Activities		76
Sorting	48	(63.16%)
Packaging	47	(61.84%)
Shipping	43	(56.58%)
Processing	19	(25.00%)
Employment of Foreign Workers		68
Yes	39	(57.35%)
No	29	(42.65%)
Participation in Contract Farming		70
Yes	8	(11.43%)
No	62	(88.57%)

Table 2 General Information of Farms and Farm Operation

Summary statistics of variables applied in the model are presented in Table 3. In our sample, many farms sell their produce dominantly through a particular marketing channel, and most agricultural products are sold within the province. The types of fruit and vegetables cultivated by producers from Québec and Ontario do not have great variance, except that only producers from Ontario reported that they grow Ginseng (see Appendix A1 for all reported crops).

Food loss rates reported by producers mostly fall in the range of 1% and 10%, and a few producers reported 0% food loss rates at farmgate (Figure 1). The mean of all participants is 8.3%. Figure 2 demonstrates our participants' choices of selling their fresh produce. A few producers

reported that they sell through other marketing channels, but they did not specify the marketing channels. Some producers and representatives of grower's associations mentioned that some small-scale farms do not package themselves, so they sell their produce to large farms which will be responsible for the following handling and shipping process; some producers also sell their produce to marketers.

VARIABLES	**N**	**Mean**	**Standard Deviation**	**Min**	**Max**
Explanatory Variable					
Distribution Channel (main explanatory variables of Model 1)					
% sold locally	61	47.32	42.53	0	100
% sold to retailers	61	24.45	32.17	0	100
% sold to processors	61	5.51	17.94	0	99.50
% sold to distributors	61	18.41	33.18	0	100
% sold to other buyers	61	4.31	17.14	0	100
Types of Produce					
Fragile fruit and vegetables	61	0.361	0.333	0	0
Medium Storage fruit and vegetables	61	0.348	0.321	0	1
Long storage fruit and vegetables	61	0.253	0.323	0	1
Other produce	61	0.040	0.168	0	0.952
Destination of Produce Channel (main explanatory variables of Model 2)					
% sold in region/county	39	52.95	45.46	0	100
% sold within province	39	36.31	38.03	0	100
% sold within Canada	39	3.64	7.21	0	30
% export	39	7.10	18.30	0	97
Controlling variables					
Female	61	0.525	0.504	0	1
Small-scale farm	61	0.295	0.460	0	1
Processing	61	0.262	0.444	0	1
Dependent variable					
On-farm food loss rate	61	0.083	0.079	0	0.350

Table 3 Summary Statistics % sold locally and % sold in region/county are omitted due to collinearity

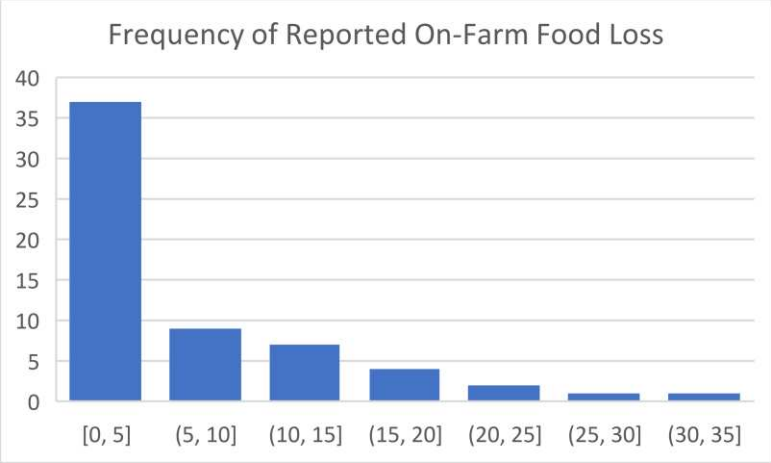

Figure 1 Distribution of reported on-farm food loss rate

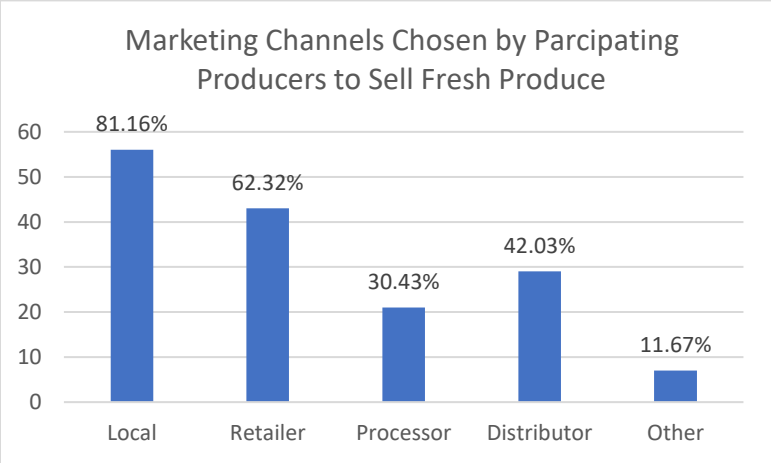

Figure 2 Marketing channels chosen by participating producers to sell their fresh produce
The figure above is the number (bar) and proportion (number) of participants reporting selling any of their produce through the various marketing channels. For example, 56 of 69 participants (81.16%) reported selling produce through local marketing channels. It should be noted that one producer can sell through multiple marketing channels, so the sum of choices of marketing channels exceeds 69.

Producers indeed took measures to reduce on-farm food loss. As shown in Table 3, 39.68% of our participants reported conducting at least one measure to reduce food loss. It is a little surprising that many producers can find an outlet for animal feed, which is an enormous difference found by Salemdeeb et al. (2017). We did not ask about the ownership of the animals, so it is unclear to us whether the animals were grown by producers themselves or producers sent the food to external animal farms. As mentioned by producers, transformation of produce is conducted in

several manners to reduce food loss, including making juice, jam, and freezing and some of them sell processed fruit and vegetables to customers. Producers indeed donate their produce to food banks. Two producers mentioned two non-profit organisations of second harvest or gleaning in Québec: Artha récolte[3] and Maski récolte[4]. However, one of them did note his concern over food safety. Such concern about food safety is partially revealed in other measures taken by other producers as well. In other measures conducted, some producers emphasized that they gave only to family or friends, or the produce processed is for self-usage only. One producer stated that she also sold second-grade strawberries at a lower price at a farmer's shop, which was exceedingly popular among customers. This is an example of ugly produce.

	Number of observations	**Total Observations (Frequency)**
Manners applied by producers to reduce on-farm food loss		63
Sold to another outlet	18	(28.57%)
Donation	25	(39.68%)
Give to friends, relatives and employees	24	(38.10%)
Animal feed	18	(28.57%)
Discarded/Composted	24	(38.10%)

Table 4 Buyers' and Producer's Marketing Behaviour

According to producers' description (see Table 4), cosmetic standard indeed matters during the process of purchasing. Most farmers (34 among 56) reported that their produce is rarely or sometimes rejected by buyers because of its appearance. It seems that producers would consider the cost and time of looking for a new buyer, so in most cases, producers would follow their "inertia", i.e., they accept the lower prices from the same buyers instead of looking for a new one. In terms of producers' feeling towards their power in the current agricultural market, most of them

[3] Artha récolte website: https://www.artharecolte.com/
[4] Maski récolte website: https://www.maskirecolte.com/

(55.36%) in fact felt that they obtained a fair price from buyers, but there are still some farmers feeling powerless against the buyers, as producers expressed that their dollar share of the price paid by customers are low, where many shares were taken by distributors or other intermediaries, although producers faced the stroke of bad weather conditions and unstable market price directly. One producer clearly stated that producers must be equivalent to buyers in order to be able to negotiate with them. This leads us to ask another question about the role of the institution. In the context of the agricultural industry, the institution usually refers to grower's associations. In Québec and Ontario, there exist several associations of participants in the food supply chain, such as producers, distributors and marketers. Producers' associations are more common than those of other stakeholders. It is rarely known for outsiders the role of the producer's association in terms of marketing, so we asked producers if the associations that the producers joined negotiated the price for them with buyers. Only a few farmers (8 among 55 reported participants) reported that their associations represented them to negotiate price, and all of them reported that they were either "satisfied" or "extremely satisfied" about the price they received. This may suggest the importance of the role of institutions when coming to obtaining market power.

	Number of observations	**Total Observations (Frequency)**
Do cosmetic standards impact prices received		49
Yes	32	(65.31%)
No	17	(34.69%)
Frequency of rejection		56
Never	17	(30.36%)
Rarely	18	(32.14%)
Sometimes	16	(28.57%)
Often	5	(8.93%)
Reaction to rejection		39
Accept the lower price	27	(69.23%)
Look for another buyer	12	(30.77%)
Fair Price Received		56
Do not negotiate	18	(32.14%)

Yes	31	(55.36%)
No	7	(12.50%)
Unions represent for price negotiation		55
Yes	8	(14.55%)
No	47	(85.45%)

Table 5 Buyers' Behaviour reported by producers

Producers were also asked about the impact of the shock of the COVID-19 pandemic. The pandemic brought a sudden shock to the supply chain at the beginning of March 2020, leading to disruptions in the food supply chain. It was a question if the pandemic brought a permanent change or if it brought a long-term effect. In this project, we focused on the change in producers' marketing channels and on-farm food loss, so producers were asked about the impact of COVID-19 on these two aspects. Most producers did not change their marketing channels due to the pandemic. Ten producers reported the change in the proportion of marketing channels, among whom five regarded it as permanent. For all the changes, producers follow the "inertia" as well, i.e., instead of developing a new marketing channel, producers prefer to sell to existing buyers and to sell more proportion to one of the buyers. All participants who answered that there were changes in marketing channels chose to sell to the buyers who bought most before the pandemic. It was noticed that five producers who reported selling more in local marketing channels had had significant proportion through local marketing. Besides, farmers were asked if their ability to harvest was impacted due to the pandemic. The producers who confirmed that their deteriorated harvesting ability also confirmed that their on-farm food loss was impacted by the pandemic. This indicates the potential correlation between the labour force and on-farm food loss.

The definition of local is subjective, not only to customers but also to producers (Martinez, 2010; Dunne et al., 2011; Onozaka et al., 2011). In general, local is defined by an institution or

government based on geopolitical and/or geographical context (Dunne et al., 2011). In the survey, we asked producers about their own insight into the concept of "local" (shown in Table 6). It is obvious that for fruit and vegetable farmers in Québec and Ontario, local is majorly defined by geopolitical boundaries. For producers, local defined as "within 50km" was chosen less than "within the province" (12 vs. 23). Only four producers considered produce within Canada to be local. In terms of geopolitical aspects, "within the province" is the greatest common range acceptable for producers. In terms of geographical view, one more people agree on "within 100km" than "within 50km". This may be because of the special characteristics of Canadian agricultural production. Agricultural production nowadays still heavily relies on the natural environment, so most fruit and vegetable producers in Québec and Ontario concentrate on the southern border of Canada and the United States. As a result, for producers living near the border of two countries, 100 km could suggest that the origin of the produce is from the US. Therefore, the produce from the US, although the physical distance could be nearer than fruit and vegetables produced "within the province", the psychological distance is much further than produce from the province. However, geopolitical boundary naturally excludes produce from the US. Besides, the economy, agricultural production patterns and agricultural policies of both countries are quite distinguished, which leads to US farmers naturally becoming competitors of Canadian farmers. According to the representative from Ontario Apple Growers Association, the price of apples is not only influenced by domestic factors, such as total quantity produced, yields of the year, and popularity of the cultivars, but also influenced by apple export from the US. If the quantity of export from the US is high, the price received by Ontarian apple growers could be lower than expected. This partially revealed the rationality of the psychological distance between Canadian and US producers and the

reason why producers in our sample utilised geopolitical aspects rather than geographical aspects to define "local".

	Number of Observations
Within municipality	33
Within my county or region	38
Within my province	23
Within Canada	5
Within 50 km of my farm	12
Within 100 km of my farm	14
Within 500 km of my farm	2

The total number of observations = 57

Table 6. Definition of local by participants. The producers were asked to check all definitions applicable to them.

Since our sample size is relatively small, it is critical to know the representativeness. Table 7 compares our sample and the general population of fruit and vegetable producers. According to Statistics Canada (2022a), in the sector of fruit and vegetable production, there are 3,155 producers in Quebec and 3,298 in Ontario. According to the source of AAFC (2022a & 2022b), the total number of fruit and field vegetable growers were 2,900 in Quebec and 2,246 in Ontario, which is smaller than those of Statistics Canada, because it did not include non-field vegetable producer and greenhouse producer. Association des producteurs maraîchers du Québec (APMQ; the largest vegetable grower association of Quebec) stated on its website that it had 450 members; and Ontario Fruit & Vegetable Growers' Association (OFVGA) stated that it is a collective of fruit and vegetable production related associations or companies. Since we did not reach every fruit and vegetable producer in Quebec and Ontario, this suggested that not every farmer defined as fruit and vegetable was contacted. For example, Ontario Ginseng Growers' Association is a member organization of OFVGA; although ginseng is classified in the sector of fruit and vegetable production, it aimed mainly for medicine, diet supplement and export, which did not match the

purpose of this study. As a result, we did not contact this association to distribute our survey. In broad view, based on the data from Statistics Canada, our sample size covered only 0.93% of fruit and vegetable producers in Quebec and Ontario. In a narrow view, based on the number of members of APMQ, we expected that 1,800 fruit and vegetable producers in Quebec and Ontario were exposed to our survey. Therefore, our sample size covered 3.4% of strictly-defined fruit and vegetable producers.

	Sample	**Population**
Age of Farm Operators (Median)	42	58 (Statistics Canada, 2022d)
Number of Farms	61	6,453* (Statistics Canada, 2022a)
		5,146* (AAFC, 2022a; AAFC, 2022b)
		1800 (estimated number of members of associations reached out)
Average Size of Farm (acres)	161.9	75.6* (AAFC, 2022a; AAFC, 2022b)
On-Farm Food Loss Rate (%)	8.3 (reported by producers)	13 (estimation; Environment and Climate Change Canada, 2019)
Location of Participants (%)		
Quebec	68.35	56.35
Ontario	31.65	43.65
Proportion of Cultivated Land Used for Certificated Organic Produce (%)	7.87	8.04* (Statistics Canada, 2022e; AAFC, 2022a; AAFC, 2022b)
Percentage of Farms that Employer Foreign Workers (%)	57.35	63.1 (CAHRC, 2017)
Percentage of Foreign Workers of Total Labour (%)	52.01	47.32 (CAHRC, 2017)

Table 7. Compare and contrast of sample and population. The figure with the asterisk symbol (*) was calculated based on the data provided by reports.

As for other surveyed items, in comparison with the farm operators in Canada, the median age of those in our sample was 16 years younger. Neither the average nor the median size of farms in our sample is close to the average farm size of Canada, owing to the size and distribution of our sample. We had more Quebec producers participating than Ontario ones, with a higher proportion

of Quebec producers than the general population of fruit and vegetable producers. For the rest characteristics, the two numbers were close.

5.2 Regression Results

In our samples, there is a very large farm more than 3,000 acres, which is much larger than the other fruit and vegetable farms in the sample. The second largest farm is 715 acres. As a result, we present our results with and without the outlier. It is necessary to understand if each variable is correlated with the other, especially if farm size impacts producers' choices of marketing channels. None of the variables is highly correlated with the other (see Appendix B2). We did not include the variables related to contract farming, because they are in our sample, there are not many producers under contract farming.

Our sample size is relatively small (61 eligible responses for data analysis), so we assumed that there exists heteroskedasticity due to size. We used the Wald Test to verify if the coefficients of the heteroskedasticity function are significantly different from 0. The results are presented in Table 7. The coefficients of both models are not significant (i.e., we fail to reject the null hypothesis of homoskedasticity), so we used the fractional probit model instead of the fractional heteroskedastic probit model.

Wald Test (df = 1)

	χ^2 **statistics**	$p > \chi^2$
Models of Marketing Channels	0.02	0.877
Models of Destinations	2.34	0.126

Table 8 Wald Test for Heteroskedasticity The coefficients of the heteroskedastic function of both models are not significant

As shown in Table 9, without or without the outlier, the only significant variable of marketing channels is direct selling to retailers. It also shows that with and without the outlier, farms smaller than 10 acres have a lower on-farm loss rate than farms larger than 10 acres. Considering on-farm activities, farms that do process have a lower on-farm food loss rate than farms that do not process their produce. In addition, female participants reported a lower food loss rate than male participants. As expected, overlapping causes a higher food loss rate at farmgate.

The coefficients of the Fractional Response Model do not represent the numeric value change, but the direction of their impacts. However, the marginal effect delivers the average marginal value, which is easier to interpret. According to marginal effects, a 1% increase in the proportion sold directly to retailers shifted from local marketing channels is associated with a 1.8% decrease in on-farm food loss in comparison with local marketing channels. Small-scale farms usually have a lower loss rate by 5.1% without outlier and 5.0% with outlier. Farms, where producers do processing have a lower loss rate by 3.7% without outlier and 3.8% with outlier. Farms for whom a female completed the survey have rates of food loss 3.6% lower without outlier or 3.4% with outlier than the rest of the sample. Farms with overlapping harvesting activities had on-farm food loss rates 3.9% higher than those without overlapping phenomenon.

	Without outlier		**With outlier**	
	Regression coefficients	**Marginal effects**	**Regression coefficients**	**Marginal effects**
% sold to retailers	-0.006*	-0.018*	-0.006**	-0.019**
	(0.003)	(0.007)	(0.002)	(0.007)
% sold to processors	-0.003	-0.002	-0.003	-0.002
	(0.004)	(0.002)	(0.004)	(0.002)
% sold to distributors	0.001	0.003	0.001	0.003
	(0.002)	(0.008)	(0.002)	(0.008)
% sold to other buyers	-0.001	-0.001	-0.001	-0.001
	(0.003)	(0.001)	(0.003)	(0.001)

Small-scale farm	-0.344**	-0.051**	-0.337**	-0.050**
	(0.147)	(0.021)	(0.146)	(0.021)
Female	-0.242**	-0.036*	-0.246**	-0.034*
	(0.118)	(0.018)	(0.117)	(0.018)
Overlapping	0.267*	0.039*	0.294*	0.039*
	(0.140)	(0.022)	(0.144)	(0.021)
Processing	-0.259**	-0.038**	-0.248**	-0.037**
	(0.119)	(0.019)	(0.107)	(0.017)
Medium storage fruit and vegetables	-0.055	-0.003	-0.055	-0.003
	(0.226)	(0.013)	(0.226)	(0.013)
Long storage fruit and vegetables	0.015	0.001	0.013	0.000
	(0.255)	(0.009)	(0.255)	(0.009)
Other produce	-0.013	-0.001	-0.118	-0.001
	(0.283)	(0.001)	(0.280)	(0.002)
Constant	-1.149***		-1.154***	
	(0.210)		(0.209)	
Observations	60		61	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9. Estimated fractional response model of marketing channels

In the survey, we asked not only about their combination of marketing channels, but also the destinations of their produce. Since this part is designed on the second part of the survey and participants can choose not to answer or quit the questionnaire any time they want, the sample size is much smaller than the model of marketing channels. There are only 39 eligible responses suitable for analysis. We asked producers to list destinations of their produce by the proportion of their total unprocessed produce consumed in their region, in their province, in Canada or outside Canada (i.e., export). Their sum is always 100%. As we would like to compare destinations within their region or county, we exclude this variable. In addition, like before, we exclude the variable for fragile fruit and vegetables from the model to avoid collinearity. Similar to the hypothesis of the model of marketing channels, we hypothesized that the explanatory variables of destinations

of produce are positive, and all other controlling variables are the same as before. The result of the model of destinations of produce is shown in Table 9.

With or without the outlier, farmers who sell more of their produce within Canada have significantly lower rates of on-farm food loss than selling within their region. Still, small-scale farms and on-farm processing have a negative impact on rates of on-farm food loss and overlapping is associated with higher rates of food loss. However, in this model, female participation is no longer statistically significant.

However, when looking at the marginal effect of destinations of produce, the marginal effect is much larger than those of marketing channels. For farmers with 1% more produce selling within Canada shifted from selling within their region or county, the on-farm food loss rate declined by 1.3%. Small farms have a 5.8% fewer on-farm food loss rate without outlier or with outlier than farms larger than 10 acres; processing on the farm indicates a reduction of about 2.9% without outlier and 3.2% with outlier. Overlapping increases the food loss rate at farmgate by 5.9% without outlier and 6.0% with outlier.

	Without outlier		**With outlier**	
	Regression coefficients	**Marginal effects**	**Regression coefficients**	**Marginal effects**
% sold within province	0.002	0.013	0.002	0.012
	(0.002)	(0.011)	(0.002)	(0.011)
% sold within Canada	-0.031***	-0.011***	-0.032***	-0.012***
	(0.009)	(0.002)	(0.009)	(0.002)
% export	0.002	0.002	0.002	0.002
	(0.002)	(0.002)	(0.001)	(0.002)
Small-scale farm	-0.397*	-0.058**	-0.397**	-0.058**
	(0.207)	(0.029)	(0.206)	(0.028)
Female	-0.195	-0.036	-0.181	-0.026
	(0.133)	(0.020)	(0.128)	(0.018)
Overlapping	0.402**	0.059**	0.395**	0.060**
	(0.180)	(0.027)	(0.177)	(0.026)

Processing	-0.196*	-0.029*	-0.217**	-0.032*
	(0.109)	(0.017)	(0.102)	(0.016)
Medium storage fruit and vegetables	-0.299	-0.015	-0.277	-0.014
	(0.191)	(0.009)	(0.189)	(0.009)
Long storage fruit and vegetables	-0.152	-0.006	-0.155	-0.006
	(0.270)	(0.001)	(0.270)	(0.010)
Other produce	-0.239	-0.001	-0.323*	-0.001
	(0.207)	(0.001)	(0.196)	(0.001)
Constant	-1.335***		-1.333***	
	(0.248)		(0.245)	
Observations	38		39	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10 Estimated fractional response model of destination of produce

The model of destinations of produce also showed that producers or farms selling through local marketing channels do not necessarily have a lower on-farm food loss rate than selling through other marketing channels. Therefore, it is interesting to know the relationship between marketing channels and destinations of produce.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Local	1.000								
(2) Retailers	-0.612	1.000							
(3) Processors	-0.303	-0.066	1.000						
(4) Distributors	-0.466	-0.134	-0.012	1.000					
(5) Other	-0.291	-0.169	-0.071	0.012	1.000				
(6) INMR	0.683	-0.439	-0.288	-0.404	0.011	1.000			
(7) INPRO	-0.479	0.251	0.237	0.296	0.044	-0.874	1.000		
(8) INCAN	-0.577	0.279	0.404	0.397	-0.055	-0.561	0.289	1.000	
(9) OUTCAN	-0.474	0.458	0.063	0.231	-0.097	-0.448	-0.022	0.398	1.000

Table 11 Matrix of correlation between marketing channels and destinations of produce.
INMR = in my region/county; INPRO = in my province; INCAN = in Canada, OUTCAN = outside Canada

As shown in the correlation matrix table (Table 10), selling within the region/county is relatively positively highly correlated with selling through local marketing channels (0.683), while others are not that highly correlated. This indicates that produce sold through local marketing channels is likely to be consumed within a short distance of the production site, while other marketing channels distribute produce much further. It revealed the relationship between marketing channels and destinations of produce.

6. Discussion:

6.1 General review

Our survey asked farmers to self-report their rates of on-farm food loss. The median reported on-farm food loss is 5% and the average is 7.8%; this differs from estimates of the government of Canada, which estimated that 13% of fruit and vegetables are unharvested or discarded following harvest (Environment and Climate Change Canada, 2019). While self-reporting is a common way in the study of food loss and waste (Kaminski and Christaensen, 2014), the value reported by farm operators is usually smaller than the estimation generated by the government. Self-reporting is subjective, so different people have different definitions of food loss and edible produce, and although our wording tried to neutralize the negative impression of loss, farmers may tend to report a lower rate of on-farm food loss, because humans tend to overstate their good and understate their wrong (Johnson, 2018; Ogoudedji et al., 2019; Kaminski and Christaensen, 2014). This could be the reason that some farmers report zero on-farm loss of fruit and vegetables. Another interesting finding is the difference between other sources and producers' reporting. In personal communication, representatives from apple grower's associations of both provinces said that the on-farm food loss of apples is near zero because apples have many more marketing channels than other horticultural crops. However, according to our survey responses, producers who produced apples do not necessarily report a low loss rate. Apple producers reported on-farm food loss in the range of 1% to 10% of total production. According to our data, these apple producers did not sell their apples through that many marketing channels as mentioned by the representatives. It is unclear to us whether the producers cannot sell their second-grade apples or that they do not have access to market channels.

Based on the model of marketing channels, with or without the outlier, producers who sell more directly to retailers had lower rates of on-farm food loss in comparison to selling through local marketing. However, the impact of this was relatively small in comparison with the controlling variables – a 1% increase in the proportion sold directly to retailers suggests a 0.1% lower food loss rate. Therefore, even considering the impact of strict cosmetic grading from retailers, based on our survey and model, selling directly to retailers may reduce rates of on-farm food loss compared to selling through local marketing channels. Smaller farms tend to choose to sell through local marketing channels in our sample, as shown in the correlation matrix. The size of farms may indicate the producer's capacity to adapt their operation or ability to integrate technological advancements. The larger the size of the farm, the more revenue the producers can divert to investment into technologies that could reduce rates of on-farm food loss. For example, the larger the size of the farm is, the more highly possible that producers invest in on-field cooling or on-farm refrigerating facility, which may reduce the amount of uneaten produce. These adaptions could be too expensive for small farms.

When we included the destinations of farmers' fruits and vegetables in the empirical model, despite a smaller sample size, it still provided some interesting insight. Instead of the distribution channel, with or without outliers, farmers who sold produce within Canada had a significantly lower food loss rate than those who sold more within the producers' region. Although not significant, selling within the province and for export outside Canada is associated with higher loss rates than selling through local marketing. Selling produce over a short distance is relatively highly correlated with selling through local marketing channels, but produce needs to travel a longer distance to reach the destination, mainly through non-local marketing channels. The two models mutually confirmed that producers selling through local marketing channels in our sample do not

necessarily mean that they have a lower on-farm food loss rate. In addition, selling in Canada could suggest that they sell to nearby provinces. Based on the population density of Canada, the geographical distance between selling within the province does not necessarily means shorter than selling within Canada (for example, the distance from Ontario's easternmost point to its westernmost point is over 1,500 km [5], while significant populations in Ontario and Québec live within short distances of each other). Another possible reason is the technology that the further the produce travel, the more widely preservation technology is applied during transportation. As mentioned above, size could impact the adaption of technology and choices of buyers, so for producers able to sell within Canada, on-farm food loss and rate could be smaller.

Models of distribution channels and destinations of produce share similar patterns. No matter with or without outliers: small-scale farms, processing on farms and overlapping harvest time all have a significant impact on on-farm food loss. Small-scale farms, in this study, are farms smaller than 10 acres. The model suggested that small-scale farms have a lower on-farm food loss rate. It is possible that small size may limit the operator's capacity to adapt common technology to reduce on-farm food loss, such as on-field cooling and refrigerated storage facilities. However, as mentioned by a few participants, they can process their second-grade or unmarketable produce in the farm or family kitchen to reduce their on-farm loss. In addition, if they have local marketing channels, they can sell processed products as value-added products, which not only reduces food loss at the farmgate but also increase on-farm income. It is also possible that with the application of machines, the harvesting frequency of larger farms is lower than smaller farms due to the cost of using machines such as harvesters and collectors. Fruit and vegetables do not grow in a uniform process like cash crops such as soybeans, wheat and barley, and for large farms, they tend to sell

[5] https://www.ontario.ca/page/about-ontario#section-3

through marketing channels other than local marketing channels. As a result, produce that does not meet buyers' requirements is discarded, leading to a higher on-farm food loss rate unless producers can find other channels to sell the produce.

There are slight differences between the two models regarding the significance of some explanatory variables, but they did not impact the main results. Processing on the farm statistically significantly reduces on-farm food loss. This is not surprising, as it is a manner to diversify marketing channels by farmers themselves acting as processors. This could be regarded as a shortcut to the food supply chain in that producers recovered the food loss by themselves, and it prevented the loss caused by processors. Producers also obtained additional income, and their welfare was not compromised. We expected that the size of farms would show a pattern of natural distribution. However, our survey attracted small and medium-sized farms rather than super-size farms (>1,000 acres). It is probable that our incentive cannot attract super farms. We expected that the super-size farms would sell more through non-local marketing channels, so if we were able to recruit more large farms, our model would be able to estimate the role of distribution channels more accurately on the current fruit and vegetable market and the nature of crops.

In comparison with the average age in the entire agricultural industry, reporting participants in this study are ten years younger than the average age of farmers in Canada and closer to the general age of the entire Canadian population (Statistics Canada, 2021). This phenomenon may be the result of the nature of fruit and vegetable production. In our preliminary analysis, neither age nor experience is statistically significant in the rate of on-farm food loss. The marginal profit of fruit and vegetables is relatively high in comparison with other crops, while the level of mechanization of most fruit and vegetable production is low. Therefore, the barrier of entry for young farmers is not very high in comparison with other crops (such as corn, soybeans, wheat, etc.,

that require more land and capital investment), as producers can start with a small area of land without buying equipment. This may be partially reflected in our sample, as five participants reported having only three years of experience in agriculture; 12 participants reported being younger than 30 years old; and 4 participants reported planting areas smaller than 1 acre. As mentioned above, only a few fruits and vegetables, such as potatoes, carrots, sweet potatoes and sweet corn, do not have high labour requirements, because the hardiness of these horticultural crops can sustain the application of machines from the stage of planting to shipping. Most horticultural crops still require heavy input of labour before leaving the farm. This requires a physical constitution for farm operators who also participate in agricultural production and wish to reduce labour costs. We assumed that the participants were the mainstay of the farm operation, so particularly for family farms, it is not surprising that the reported participant's age is similar to the average age of the entire population. The younger generation of agricultural producers may accept measures to reduce on-farm food loss more easily than the older generation. Therefore, it may be easier to introduce rational food rescue measures in fruit and vegetable production than in other sectors of the agricultural industry.

We only asked farm operators to report their top five fruit and vegetable crops. It is possible that producers plant more than five crops, but due to limits of space on the survey, they did not report all their horticultural crops. We asked producers to report estimated on-farm food loss based on all their agricultural products. Owing to the existence of unobserved crops, there may exist minor differences in the crop variable (i.e., fragile fruits and vegetables, medium storage fruits and vegetables, and long storage fruits and vegetables) from reality. As a result, it should only impact the coefficients of crop variables, which in our regression result, apparently does not have any statistical significance.

Owing to our relatively small sample size, we used a binary variable to indicate small-scale farms whose size is smaller than 10 acres. Small-scale producers possibly make their decision differently from other larger producers, because their scale limits the application of advanced technology, and they may tend to find a niche market to avoid direct competition with large commercial farms. This gives small-scale farms unique characteristics in agricultural production. Based on our models, small-scale farms have roughly 4% lower on-farm food loss rate than farms of more extensive scale. Producers of small-scale farms may prefer to choose crops of higher marginal profit, which demand more care and attention. For example, farmers need to prune fruit trees to make the fruit large and sweet. In addition, they need to handle a smaller absolute quantity of produce than larger farms, so many fruit and vegetables that may be wasted in larger farms can be rescued.

The gender variable shows that farms reported by women have a lower on-farm food loss rate than those with male participants. Agriculture has been considered a relatively conservative industry with males as the main participants. We assumed that the participants were farm operators or were essential to agricultural production. There is no absolute and clear explanation for our findings, but it is possible that farms with females significantly involved in the operation would favour sustainable measures to reduce on-farm food loss (Karami and Mansoorabdi, 2008). As expected, producing crops with overlapping harvest times increases on-farm food loss. If several crops need to be harvested during a similar period, producers then must decide how to assign their labour. If there is not enough labour, then producers must determine the priority of crops. If one crop is higher than the other, then they would assign more labour to this crop, leading to an on-farm loss in the field of the other crop.

6.2 Implications

Based on the report of Statistics Canada, most Canadians do not meet the recommendation for fruit and vegetable consumption from Health Canada (Statistics Canada, 2019). On the other hand, AAFC estimated that more than 50% of fruit and vegetables are wasted along the entire food supply chain (AAFC, 2019; AAFC, 2020). There are several reasons for significant food loss and waste in the section of fruit and vegetable production. On the supplier side, the cosmetic grade rejects many agricultural products from entering the food supply chain; in restaurants, institutions, and retailers, many prepared meals are thrown away due to food safety; at home, many families stock fruit and vegetables but do not eat them soon enough before they are spoiled. Naturally, we cannot recommend stakeholders reducing on-farm food loss of fruit and vegetables by shifting to planting non-fruit and vegetable imperishable agricultural products. In the current situation, we cannot change dramatically and immediately the behaviour of each stakeholder, especially consumers, but we can make some minor changes on the supply side.

Based on the models presented in this paper, producers who sell more produce directly to retailers rather than through other distribution channels have lower rates of on-farm food loss. However, this does not suggest that selling directly to retailers reduces the on-farm food loss rate or that retailers have a loose standard on fruit and vegetables. It could be because farms eligible to sell directly to retailers have more efficient measures to reduce on-farm food loss. Several producers emphasized that producers have relatively less market power than retailers. If they do not grow large enough to bargain with buyers, they would not obtain a fair price, even though customers pay a relatively high price at retailer's stores. The unfair price makes farmers barely survive and unable to afford technology or measures to reduce food loss at farmgate, even though they want to. Rome was not built in one day; farmers could not gain market power as they wished. It may not be a severe problem for large farms, but for small-scale farms, selling more to retailers

may not be a good option, because a lack of market power may let them not obtain a good and reasonable price. Local marketing enables small farms to survive in Canada's agricultural market where consolidation is still trending. Previous studies showed that consumers are willing to pay more for local food (Carpio and Isengildina-Massa, 2009; Beingessner and Fletcher, 2020). Direct selling to consumers shortens the steps of the supply chain between producers and customers, leading to more dollar share of price to producers (Beingessner and Fletcher, 2020). For intermediate-scale farm operators, organising a grower's association empowered to represent growers to bargain with buyers could be a good option. According to our survey, producers who have a union to negotiate the price for them are either satisfied or extremely satisfied with the result. If farm operators prefer, they can choose to process their unmarketable produce on the farm. This measure not only reduces on-farm food loss but also adds value to their produce, bringing additional on-farm income. However, farmers should consider whether it is worth based on their condition in terms of additional input and cost. If farmers are not capable of processing on their own, diversifying their marketing channels to sell second-graded produce, such as selling to consumers as "ugly produce" or selling to processors for processed food, may decrease rates of on-farm loss. A recent news article by the Canadian Broadcasting Company (CBC, 2022) discussed a case in Nova Scotia that a cauliflower farmer must dump half of his produce due to retailer grading. It was not reflected in our study that selling directly to retailers causes more food loss rate at farmgate, but the solutions they proposed could be supported by our study, such as second harvest, which can be regarded as diversifying the marketing channels and processing agricultural products to extend shelf-life.

In my personal view, the most feasible and inexpensive measure is to avoid growing crops with overlapping harvesting periods. Producers can choose to grow crops in which the harvest

period does not coincide, or one of the planted crops does not require intensive labour, or cultivars that stagger to avoid harvest overlapping as much as possible. The government should invest in seed breeders to cultivate such cultivars. In addition, cultivars that stagger from the peak harvest period of the crops could expand the period of availability of local produce and raise farmers' income. For producers, developing the local food system is a competition of producers against powerful food supply chain participators, such as retailers and distributors. In this point of view, local marketing channels should insist on maintaining the producer's market power and a fair share of the price consumers pay, especially for small-scale farms. Local marketing channels in this paper were defined as direct marketing to consumers, such as farmer's markets, farmer's shops, CSA baskets, etc. Therefore, in Canada's context, it seemed that local marketing and currently dominant commercial marketing are separate systems competing. Within the local food market, participants with sufficient capital became influential in the local food market, which made small-scale farmers feel disadvantageous (Allaby et al., 2021). More manners should be developed to sell through local marketing channels if possible.

We did not ask in the questionnaire how producers divide work between females and males and what role females take at the management level in each farm. Nevertheless, based on the current model, we can see that female participation indicates lower rates of food loss and thus a more sustainable application on the farm. More research needs to be done on the role of females in this field.

6.3 Future Study

We do not find evidence to support our hypothesis that farmers selling more through local marketing channels have a lower on-farm food loss rate than those selling through non-local marketing channels. We only investigated fruit and vegetable producers in Québec and Ontario.

First, all the data were reported by producers, so researchers can do large-scale on-field measurement to obtain precise data. In future studies, researchers can reach more farmers and extend to producers of fruit and vegetable producers of entire Canada and also other categories of agricultural products, such as nuts, meat, seafood etc. In our survey, the roles of contract farming and foreign workers are not significant; more studies should look into this part. We looked at the impact of marketing channels on on-farm food loss, but researchers can also investigate consumers' buying behaviour in different circumstances, because in our survey, farmers' comments suggested that customers were willing to buy "ugly produce" in direct marketing selling conditions, while in the literature, ugly fresh produce is not welcome at retailer stores. Our results show that the food loss rate at the primary production site does not vary quite a lot from one marketing channel to the other marketing channel. However, this does not suggest that the loss and waste rate of food selling through local marketing channels of the entire supply chain is higher than those selling through other marketing channels. Further, de Gorter et al. (2020) developed a model to study how the change in rates of food loss and waste in different stages of the supply chain impact the entire food supply chain and the overall food loss and waste. Our approach may be useful in understanding how the change of composition of marketing channels chosen by producers impacts the farmgate food loss and the entire food supply chain. In addition, our model showed that farms with female participation have lower food loss rates at farmgate. Researchers can investigate the influence of gender on farm management and operation.

Our cases showed that size partially impacted producers' choices of marketing channels and that larger farms tended to sell more through non-local marketing channels, of which directly selling to retailers is the most popular. Meanwhile, farmers smaller than ten acres have lower on-farm food loss rates. As mentioned above, farms that selling more directly to retailers had lower

food loss rates. This may suggest a dilemma for medium-scale farms. Unlike small-scale farms, they tended to sell more through non-local marketing channels than local marketing channels. As a result, medium-scale farms may have lost the advantages of small-scale farms, such as taking advantage of local consumers' willingness to purchase ugly produce from small local producers. On the other hand, unlike large-scale farms, many medium-scale farms may not have the capital to invest in storage and processing technologies that may reduce on-farm food loss. On-farm transformation reduced the on-farm food loss rate; this was confirmed in the study; at the same time, selling to processors could potentially reduce the on-farm food loss rate, as it has a negative coefficient although not statistically significant. Second-grade fruits and vegetables can be sold to processors, but it is a question if the medium-scale farm can generate enough quantity to sell to processors. Therefore, in-depth interviews or focus groups are recommended to understand farmers' experiences and concerns in selling to different buyers.

7. Conclusion

This paper studied the impact of distributional channels on the rate of on-farm food loss among fruit and vegetable producers in Québec and Ontario. It used primary data directly from fruit and vegetable producers to estimate the on-farm food loss rate of the two provinces. With fractional response models, the results show the direction and scale of each factor of the farm operation and farmers' choices regarding on-farm food loss. It turned out that based on our sample, direct selling to retailers has a lower on-farm food loss rate in comparison with selling through local marketing; overlapping harvesting time of crops induces a higher on-farm food loss rate; and processing by farmers could reduce the loss. Policymakers should consider the facts and the farmer's views to resolve food loss without compromising the farmers' welfare and income.

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Appendices

Appendix A1. Categories of fruit and vegetables based on the period of storage

Long Storage Fruit and Vegetable (LFV)	Medium Storage Fruit and Vegetable (MFV)	Fragile Fruit and Vegetable (FFV)	Other
garlic	grape	peach	Ginseng
pumpkin	beet	herb	Grain
carrot	cucumber	leafy vegetable	Soya
onion	cabbage	edible flower	
squash	Chinese cabbage	raspberry	
potato	sweet corn	plum	
rutabaga	cauliflower	strawberry	
turnip	broccoli	bean	
apple	Brussel sprout		
pear	pea		
watermelon	celery		
	celeriac		
	zucchini		
	tomato		
	asparagus		
	blueberry		
	pepper		
	lettuce		

Appendix A2. **Associations to distribute the survey and the date of distribution**

Name of Association	Date	Newsletter	Email	Social Media	Note
Farm Fresh Association*	02/01/2022 07/05/2022	✓	✓		
Ontario Apple Grower's Association	12/21/2021	✓	✓		
Association des producteur maraîchers du Québec*	02/03/2022 05/30/2022	✓	✓		
Asparagus Farmers of Ontario	02/03/2022		✓		
Ontario Greenhouse Vegetable Growers	02/02/2022		✓		
Niagara Peninsula Fruit & Vegetable Growers' Association	02/01/2022		✓		To board members
Producteurs de pommes du Québec	02/23/2022	✓			
Fermier-ère de famille le réseau	02/18/2022	✓			
Producteur de légumes de transformation du Québec*	02/25/2022	✓		✓	
Association des producteurs de fraises et framboises du Québec *	07/23/2022		✓		
Les Producteurs en Serre du Québec*	07/23/2022		✓		
Ontario Berry Grower's Association*	07/23/2022		✓		

The associations with the asterisk symbol (*) show that the associations publish the contact information of their members which allowed direct distribution of our survey through email.

Appendix A3

	Number of observations	**Total Observations**
Top 10 Common Crops reported in the survey		72
Strawberries	30	
Raspberries	27	
Sweet Corns	21	
Blueberries	14	
Apples	13	
Tomatoes	12	
Pumpkins and Squashes	12	
Asparagus	11	
Onion	10	
Carrots	10	

Appendix A4 Harvested period of common fruit and vegetable in Québec and Ontario[6]

Fruit/Veg	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
apples							X	X	X	X	X	
apricots							X	X	X	X		
Asian pears								X	X	X	X	X
asparagus					X	X	X					
beans							X	X	X	X	X	
blackberries								X	X	X		
beets						X	X	X	X	X	X	
blueberries								X	X	X	X	
broccoli						X	X	X	X	X	X	
Brussels sprouts									X	X	X	X
cabbage						X	X	X	X	X	X	
cantaloupes							X	X	X	X	X	
carrots							X	X	X	X	X	
cauliflower						X	X	X	X	X	X	
celery							X	X	X	X		
carrots							X	X	X	X	X	X
cherries						X	X	X	X			
Christmas trees												X
crabapples									X	X	X	X
cucumbers							X	X	X	X	X	X
currants							X	X	X	X		
eggplant							X	X	X	X	X	
garlic							X	X	X	X	X	
gooseberries							X	X	X	X		
grapes								X	X	X	X	
greens						X	X	X	X	X	X	X
	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
herbs						X	X	X	X	X	X	X
lettuce (aka, greens)						X	X	X	X	X	X	X
leeks								X	X	X	X	X
muskmelon (cantaloupe)							X	X	X	X	X	X
nectarines								X	X	X		
onions							X	X	X	X	X	
parsnips								X	X	X	X	X
peaches							X	X	X			
pears								X	X	X	X	
peas						X	X					
peppers							X	X	X	X	X	
potatoes						X	X	X	X	X	X	
pumpkins									X	X	X	X
raspberries							X	X	X	X	X	X
rhubarb						X	X					
summer squash							X	X	X	X	X	
winter squash								X	X	X	X	X
saskatoons							X	X	X			
squash									X	X	X	X
strawberries (in the field)						X	X	X	X			
strawberries (greenhouse)		X	X	X	X	X	X	X				
sweet corn								X	X	X		
sweet potatoes										X	X	
tomatoes							X	X	X	X	X	X
watermelons									X	X		
zucchini							X	X	X	X	X	X
Fruit/Veg	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec

[6] Retrieved from: https://pickyourown.org/CNONharvestcalendar.htm

Appendix B1 Variable Description Table

Variable Name	Type	Description	Source
L	Numeric	percentage of farmer's total harvested produce through local marketing channels (e.g., farmer's market, farmer's shop, CSA, etc.)	Primary
R	Numeric	percentage of farmer's total harvested produce sold directly to retailers	Primary
P	Numeric	percentage of farmer's total harvested produce sold directly to processors	Primary
DI	Numeric	percentage of farmer's total harvested produce sold to distributors	Primary
O	Numeric	percentage of farmer's total harvested produce sold through other market channels	Primary
INMR	Numeric	percentage of farmer's total harvested produce sold in producer's region/county	Primary
INPRO	Numeric	percentage of farmer's total harvested produce sold in producer's province	Primary
INCAN	Numeric	percentage of farmer's total harvested produce sold in Canada	Primary
OUTCAN	Numeric	percentage of farmer's total harvested produce exported	
S	Binary	=1 if reported planted area is smaller than	Primary
GENDER	Binary	=1 if the participant is female	Primary
OVERLAP	Binary	=1 if the corps have coincided harvest period	Primary
PR	Binary	=1 if producers process their produce on their farms	Primary
FFV	Numeric	Percentage of reported planted area of fragile fruit and vegetables over total reported planted area	Primary
MFV	Numeric	Percentage of reported planted area of medium storage fruit and vegetables over total reported planted area	Primary
LFV	Numeric	Percentage of reported planted area of long storage fruit and vegetables over total reported planted area	Primary
OTHER	Numeric	Percentage of reported planted area of crops other than fruit and vegetables over total reported planted area	Primary

Appendix B2 Correlation among the explanatory variables The variable description is presented in Appendix B1

Matrix of correlations – distribution channels

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) L	1.000												
(2) R	-0.478	1.000											
(3) P	-0.287	-0.072	1.000										
(4) DI	-0.546	-0.218	-0.106	1.000									
(5) O	-0.247	-0.118	-0.007	-0.090	1.000								
(6) S	0.438	-0.386	0.023	-0.252	0.077	1.000							
(7) GENDER	-0.029	-0.129	-0.016	0.162	0.005	-0.044	1.000						
(8) OVERLAP	0.255	0.130	-0.237	-0.164	-0.294	-0.154	-0.236	1.000					
(9) PR	0.396	-0.285	-0.119	-0.187	0.021	-0.042	0.154	0.082	1.000				
(10) FFV	0.293	-0.056	-0.219	-0.226	0.047	0.246	-0.004	0.098	-0.124	1.000			
(11) MFV	0.044	-0.313	0.059	0.323	-0.233	0.021	-0.040	0.031	0.150	-0.457	1.000		
(12) LFV	-0.241	0.395	0.146	-0.160	0.042	-0.185	-0.058	-0.103	0.042	-0.500	-0.406	1.000	
(13) OTHER	-0.184	-0.061	0.036	0.129	0.275	-0.147	0.210	-0.042	-0.130	-0.133	-0.219	-0.167	1.000

Matrix of correlations – destinations of produce

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) INMR	1.000											
(2) INPRO	-0.874	1.000										
(3) INCAN	-0.561	0.289	1.000									
(4) OUTCAN	-0.448	-0.022	0.398	1.000								
(5) S	0.321	-0.216	-0.300	-0.231	1.000							
(6) GENDER	0.272	-0.142	-0.235	-0.287	-0.072	1.000						
(7) OVERLAP	0.192	-0.281	-0.019	0.114	-0.096	-0.103	1.000					
(8) PR	0.028	0.109	-0.173	-0.229	0.050	0.165	0.029	1.000				
(9) FFV	0.236	-0.236	-0.179	-0.027	0.155	0.108	0.023	-0.264	1.000			
(10) MFV	0.121	-0.071	-0.272	-0.046	0.062	-0.272	0.304	0.344	-0.326	1.000		
(11) LFV	-0.337	0.294	0.396	0.071	-0.159	0.083	-0.298	-0.018	-0.638	-0.469	1.000	
(12) OTHER	0.077	-0.070	-0.041	-0.030	-0.118	0.129	0.110	-0.058	-0.071	-0.131	-0.118	1.000

Survey:

English version:

Participant Consent Form:

Please read this document before continuing to the survey. Submitting your survey responses indicates that you consent to participate in this study.

This survey asks questions about your farm operation, distribution channels, and on-farm food loss. We are interested in your responses regardless of what crops you produce, or which channels you primarily distribute them through.

This survey has two parts. The first part should take you about 10 minutes to complete. If you are willing to answer a few more questions, you can continue to part 2 which will take about 5 minutes to finish. If you do not wish to complete part 2, you can proceed directly to the end of the survey.

Your responses will be completely anonymous. Your identity will in no way be connected to the information you provide here.

Your participation is completely voluntary, and you may skip any questions you do not wish to answer. If at any time you do not wish to continue, you may leave the survey at no penalty to yourself.

There are no anticipated risks to you by participating in this research. Participating in the study will have no direct benefit for you; however, we hope to learn more about how distribution channels impact the amount of on-farm food loss, and how local food systems affect the amount produce that goes unharvested.

Please save or print a copy of this page to keep for your own reference. If you have any questions about the survey, please do not hesitate to contact Xiaoyi Huang (xiaoyi.huang@mail.mcgill.ca) or Prof. Mary Doidge (mary.doidge@mcgill.ca)

If you have any ethical concerns or complaints about your participation in this study, and want to speak with someone not on the research team, please contact the Associate Director, Research Ethics at 514-398-6831 or lynda.mcneil@mcgill.ca citing REB file number 21-11-040.

If you agree to participate, please continue the survey.

Section 1: General Information on Agricultural Operation

1. How old are you? _____ years
2. What is your gender?

☐ Male ☐ Female ☐ Other/prefer not to say

3. How long have you worked in agriculture? _____ years
4. Where is your farm located?

☐ Bas-Saint-Laurent
☐ Saguenay-Lac-Saint-Jean
☐ Capitale-Nationale
☐ Mauricie
☐ Estrie
☐ Montréal
☐ Outaouais
☐ Abitibi-Témiscamingue
☐ Côte-Nord
☐ Nord-du-Québec
☐ Gaspésie-Îles-de-la-Madeleine
☐ Chaudière-Appalaches
☐ Laval
☐ Lanaudière
☐ Laurentides
☐ Montérégie
☐ Centre-du-Québec
☐ Southwestern Ontario
☐ Central Ontario
☐ Eastern Ontario
☐ Northeastern Ontario
☐ Northwestern Ontario

☐ Other (please specify): _____

5. Please list the main 5 horticultural crops you grow, and approximately how much land is allocated to each. If you cultivate more than 5 horticultural products, please list the top 5.

   a. Crop: _____ _____ acres

   b. Crop: _____ _____ acres

   c. Crop: _____ _____ acres

   d. Crop: _____ _____ acres

   e. Crop: _____ _____ acres

6. Do you produce your crops primarily in greenhouses?

7. ☐ Yes
8. ☐ No

9. Approximately how much of your total farm output do you estimate that you sell to each of the following marketing channels in **an average year**?

Outlet	**% of your output sold to each outlet**
Directly to consumers (i.e., farmer's market, farm shop, pick-your-own, community supported agriculture, etc.)	%
Directly to retailers (i.e., grocery stores, supermarkets)	%
Directly to processors	%
Sold to distributors	%
Other (please specify)	%
	100%

10. Is your farm certified organic?

☐ Yes

☐ No, and I have no plans to become organic

☐ No, but I plan to transition to organic production in the next few years (or I am currently transitioning my operation)

11. What post-harvest activities are undertaken on your farm? *Please check all that apply*

☐ Sorting

☐ Packaging

☐ Shipping

☐ Processing

☐ Other, please specify: _____

12. How many employees do you hire in an average season?

a. Total number of employees during the average **non-harvest season**: _____

b. Total number of employees during the average **harvest season**: _____

13. Do you employ foreign temporary workers?

☐ Yes → *if yes, how many do you employ in a typical year?* _____

☐ No

14. Are all or some of your products produced under contract for a buyer (i.e., the buyers provide inputs and technical advice to you, and purchase your produce after harvest)?

☐ Yes → *if yes, please answer questions 12*

☐ No → *if no, please skip to question 13*

15. This past growing season, roughly what proportion of your total output was produced under these types of contracts? _____%

16. In an average year, what percentage of your **total harvested produce** intended for each outlet do you estimate is rejected due to grade requirements (size, colour, shape, etc.)?

Outlet	**% of your produce rejected by each outlet**
Directly to consumers (i.e., farmer's market, farm shop, pick-on-your-own, community supported agriculture, etc.)	%
Directly to retailers	%
Directly to processors	%

Sold to distributors	%
Other (please specify):	%

17. What happens to your rejected harvested produce? Please check all that apply. If possible, please estimate what percentage of the **unsold** produce is dealt in each way.

☐ Sold to another outlet (e.g., sold to a processor, another retailer, etc.): _____%

☐ Donated to a charitable organization (e.g., food banks, gleaning): _____%

☐ Given to friends, relatives, employees: _____%

☐ Used for animal feed: _____%

☐ Discarded/composted: _____%

☐ Other, please specify _____%

18. In an average year, roughly what percentage of the total edible produce on your farm is left **unharvested** and/or discarded, and/or ploughed under? _____%

19. Do you think that on-farm food loss is a problem for fruit and vegetable producers in {your province}?
☐ Yes
☐ No
☐ Unsure

20. Are you concerned about on-farm food loss on your operation?
☐ Yes
☐ No
☐ Unsure

21. Did your main distribution channel(s) change as a result of the COVID-19 pandemic?

☐ Yes → *If yes, please answer questions 19 and 20*

☐ No → *If no, please proceed to question 21*

22. In what way did your main sales channels change? Please check all that apply.

o Sold **more** directly to consumers ☐ Sold **less** directly to consumers

☐ Sold **more** directly to retailers ☐ Sold **less** directly to retailers

☐ Sold **more** directly to processors ☐ Sold **less** directly to processors

☐ Sold **more** to distributors ☐ Sold **less** to distributors

☐ Other (please specify) _____

23. Do you think this change of marketing channel will be permanent?

☐ Yes ☐ No

Thank you for completing the survey!

We are hoping to gather more information about fruit and vegetable production in {your province} and would be grateful if you have the time to answer a few more questions.

24. Are you willing to continue with the survey?

☐ Yes ☐ No → *if no, skip to the end of the survey*

Section 2: Further Details

1. Does your growers' association negotiate with buyers on your behalf (or the behalf of other growers)?
   ☐ Yes → If yes, *please answer question 2.*
   ☐ No → If no, *skip to question 3.*

2. How satisfied are you with the contracts that the association has been able to negotiate?
   ☐ Extremely satisfied
   ☐ Satisfied
   ☐ Neither satisfied nor dissatisfied
   ☐ Dissatisfied
   ☐ Extremely dissatisfied

3. When you negotiate sales on your own, do you feel that you are able to negotiate fair sales contracts with your buyers?

   ☐ Yes → *If yes, skip to question 5*
   ☐ No → *If no, please answer question 4*

☐ I don't negotiate sales contracts on my own

4. What do you think is unfair about the way your sales contracts are negotiated?
   _____
   _____
   _____
   _____

5. Are the prices you receive for your produce determined by the cosmetic appearance of your produce?
   ☐ Yes
   ☐ No

6. How often are you offered a lower than anticipated price, post-harvest, due to the appearance of your produce?
   ☐ Never → *Skip to question 8*
   ☐ Rarely
   ☐ Sometimes
   ☐ Often
   ☐ Very often

7. When you are offered a lower price, do you accept that price rather than search for another buyer in the hopes of receiving a higher price?

   ☐ Yes, I usually accept the lower price
   ☐ No, I usually search for another buyer

8. For your contracting farming, do contract farming buyers buy the produce that does not reach their quality standards?

   ☐ Yes

   ☐ No → *If No, skip to question 10*

   ☐ Sometimes

   ☐ Not sure

9. Are you allowed to sell this produce to another outlet?
   ☐ Yes
   ☐ No
   ☐ Some buyers allow this
   ☐ Not sure

10. If your yield is better than expected, will the contract buyers buy more than specified in the original contract?

    ☐ Yes
    ☐ No
    ☐ Sometimes
    ☐ Unsure

11. Do you think that your rate of on-farm food loss would be different if you sold your produce through another channel? (e.g., if you sell primarily to grocery stores and large distributors, you changed your distribution to local markets)

    ☐ Yes
    ☐ No
    ☐ Unsure

12. Do you think that financial incentives such as tax credits for food donation are effective in reducing on-farm food loss?
    ☐ Yes
    ☐ No
    ☐ Unsure

13. Have you ever used one of these financial programs?
    ☐ Yes
    ☐ No

14. Do you know where most of your fresh (i.e., unprocessed) produce is sold to consumers?

    ☐ Yes → *please answer question 15*

    ☐ No → *skip to question 16*

15. Approximately how much (by volume) of your fresh produce is sold to consumers in each of these locations?

Within my municipality or region	%
Within the province	%
Within Canada	%
Outside of Canada	%

16. The term "local food" is often used without a clear definition. Which markets would you consider as a local market? *Please check all that apply.*

☐ Within my municipality

☐ Within my county or region

☐ Within my province

☐ Within Canada

☐ Within 50 km of my farm

☐ Within 100 km of my farm

☐ Within 500 km of my farm

☐ Other, please specify: _____

If they employ foreign workers:

17. Has the COVID-19 pandemic affected your ability to harvest your produce in a timely manner?
    ☐ Yes
    ☐ No

18. Did the amount of unharvested produce on your farm increase due to the pandemic?
    ☐ Yes
    ☐ No
    ☐ Unsure

Drawing

1. Do you wish to participate into the drawing?

☐ Yes

☐ No

2. Please answer the skill testing question: (1+8) × 3 = _____
3. Please leave an email address where we can reach you. You will be contacted only if you are selected. Your information will be confidential, and your survey response will not be linked to your operation. _____

End of survey (seen by all participants)

Thank you for your participation.

If you have any questions about the survey, please do not hesitate to contact Xiaoyi Huang (xiaoyi.huang@mail.mcgill.ca) or Prof. Mary Doidge (mary.doidge@mcgill.ca)

Have a nice day!

French version

Merci de lire le présent document avant d'aller au sondage. En soumettant vos réponses, vous acceptez participer à l'étude.

Le sondage contient des questions sur l'exploitation de votre ferme, vos canaux de distribution et vos pertes alimentaires à la ferme. Vos réponses nous intéressent, peu importe les produits que vous cultivez et les canaux de distribution que vous privilégiez.

Il y a deux parties au sondage. La première vous prendra environ 10 minutes, et si vous acceptez de remplir la deuxième, il faudra compter 10 minutes supplémentaires. Si vous ne voulez pas répondre aux questions de la deuxième partie, vous pouvez aller directement à la fin du sondage.

Les réponses seront recueillies à l'aide de la plateforme LimeSurvey. Elles seront totalement anonymes, de sorte que votre identité ne sera en aucun cas liée aux renseignements que vous fournissez. Par contre, le sondage étant anonyme, il sera impossible de supprimer vos réponses une fois soumises.

Votre participation est complètement volontaire, et vous pouvez sauter les questions auxquelles vous ne voulez pas répondre.

Aucun risque prévu n'est associé à votre participation à l'étude. De même, le fait d'y participer n'aura aucun avantage direct pour vous. Cela dit, nous espérons en apprendre plus sur la façon dont les canaux de distribution influent sur la quantité de pertes alimentaires à la ferme, et sur la façon dont les systèmes alimentaires locaux influent sur la quantité de fruits et de légumes non récoltés.

Nous vous invitons à enregistrer et à imprimer cette page pour vous y référer. Si vous avez des questions au sujet du sondage, n'hésitez pas à communiquer avec Xiaoyi Huang (xiaoyi.huang@mail.mcgill.ca) ou la P^{re} Mary Doidge (mary.doidge@mcgill.ca).

Si vous avez un commentaire ou une plainte à formuler concernant le caractère éthique de votre participation à l'étude, et que vous voulez parler à quelqu'un qui ne fait pas partie de l'équipe de recherche, communiquez avec la directrice adjointe, éthique de la recherche au 514 398-6831 ou à lynda.mcneil@mcgill.ca, en indiquant le numéro de dossier du CER 21-11-040.

Si vous acceptez de participer, continuez le sondage.

1. Quel âge avez-vous? _____ ans
2. Quel est votre genre?

   ☐ Homme ☐ Femme ☐ Autre/préfère ne pas répondre
3. Depuis combien de temps travaillez-vous dans le secteur agricole? _____ ans
4. Où est située votre ferme?

☐ Bas-Saint-Laurent	☐ Chaudière-Appalaches
☐ Saguenay-Lac-Saint-Jean	☐ Laval
☐ Capitale-Nationale	☐ Lanaudière
☐ Mauricie	☐ Laurentides
☐ Estrie	☐ Montérégie
☐ Montréal	☐ Centre-du-Québec
☐ Outaouais	☐ Southwestern Ontario
☐ Abitibi-Témiscamingue	☐ Central Ontario
☐ Côte-Nord	☐ Eastern Ontario
☐ Nord-du-Québec	☐ Northeastern Ontario
☐ Gaspésie-Îles-de-la-Madeleine	☐ Northwestern Ontario

☐ Other (please specify): _____

5. Énumérez vos cinq principales cultures horticoles, en indiquant la superficie approximative occupée par chacune. Si vous cultivez plus de cinq produits horticoles, inscrivez vos cinq principaux.

   a. Culture: _____ _____ acres

   b. Culture: _____ _____ acres

   c. Culture: _____ _____ acres

   d. Culture: _____ _____ acre

   e. Culture: _____ _____ acres

6. Cultivez-vous vos produits principalement en serre?

   ☐ Oui
   ☐ Non

7. Selon vos estimations, quelle proportion de la production de votre ferme est vendue par les canaux suivants dans **une année moyenne**?

Canal	**% de la production vendue par ce canal**
Directement aux consommateurs (marché de producteurs, magasin de ferme, autocueillette, agriculture soutenue par la communauté, etc.)	%
Directement à des détaillants (épiceries, supermarchés)	%
Directement à des transformateurs	%
Vendu à des distributeurs	%
Autre (précisez)	%
	100 %

8. Votre ferme est-elle certifiée biologique?

☐ Je n'ai aucune intention de passer à la culture biologique.

☐ Je prévois passer à la culture biologique dans les prochaines années (ou je suis en train de faire la transition).

9. Quelles activités après la récolte sont effectuées sur votre ferme? *Cochez toutes les réponses qui s'appliquent.*

☐ Tri

o Emballage

☐ Expédition

☐ Transformation

☐ Autre (précisez) : _____

10. Combien de personnes employez-vous durant une saison moyenne?

a. Nombre total d'employés durant une **saison sans récolte** moyenne : _____

b. Nombre total d'employés durant une **saison de récolte** moyenne : _____

11. Employez-vous des travailleurs étrangers temporaires?

☐ Oui
☐ Non

12. Vos produits sont-ils cultivés, en tout ou en partie, aux termes d'un contrat avec un acheteur (qui vous donne des commentaires et des conseils techniques, puis achète vos fruits et légumes après la récolte)?

☐ Oui
☐ Non

13. Lors de la dernière période de végétation, environ quel pourcentage de votre production totale faisait l'objet de tels contrats? _____%

14. Lors d'une année moyenne, quel pourcentage de la **quantité totale de fruits et de légumes récoltés** et destinés à chacun des canaux de distribution est rejeté en raison des exigences relatives aux catégories (taille, couleur, forme, etc.)?

Canal	**% des fruits et légumes rejetés pour ce canal**
Directement aux consommateurs (marché de producteurs, magasin de ferme, autocueillette, agriculture soutenue par la communauté, etc.)	%
Directement à des détaillants (épiceries, supermarchés)	%
Directement à des transformateurs	%
Vendu à des distributeurs	%
Autre (précisez)	%

15. Que faites-vous des fruits et légumes rejetés? Cochez toutes les réponses qui s'appliquent. Si possible, indiquez environ quel pourcentage des fruits et légumes **non vendus** est traité de chaque façon.

☐ Vente par un autre canal (p. ex. à un transformateur, un autre détaillant) : _____%

☐ Don à un organisme de bienfaisance (p. ex. banques alimentaires, glanage) : _____%

☐ Don à des amis, des membres de la famille ou des employés : _____%

☐ Utilisation comme nourriture pour animaux : _____%

☐ Mise au rebut/compostage : _____%

☐ Autre (précisez) : _____% _____

16. Dans une année moyenne, quel pourcentage des aliments comestibles produits sur votre ferme n'est **pas récolté**, ou encore est jeté ou enterré? _____%

17. Pensez-vous que les pertes alimentaires à la ferme représentent un problème pour les producteurs de fruits et de légumes [du, de l' OU de la] {votre province}?

☐ Oui
☐ Non
☐ Je ne sais pas

18. Êtes-vous préoccupé par les pertes alimentaires à votre ferme?

☐ Oui
☐ Non
☐ Je ne sais pas

19. Vos principaux canaux de distribution ont-ils changé en raison de la pandémie de COVID-19?

☐ Oui
☐ Non

20. De quelle façon vos principaux canaux de vente ont-ils changé? Cochez toutes les réponses qui s'appliquent.

☐ J'ai vendu **plus** de produits directement aux consommateurs.
☐ J'ai vendu **plus** de produits directement à des détaillants.
☐ J'ai vendu **plus** de produits directement à des transformateurs.
☐ J'ai vendu **plus** de produits à des distributeurs.

☐ J'ai vendu **moins** de produits directement aux consommateurs.
☐ J'ai vendu **moins** de produits directement à des détaillants.
☐ J'ai vendu **moins** de produits directement à des transformateurs.
☐ J'ai vendu **moins** de produits à des distributeurs.

o Autre (précisez) : _____

21. Pensez-vous que ce changement sera permanent?

Merci d'avoir répondu au sondage!

Nous aimerions recueillir plus d'information sur la production de fruits et de légumes [en, au OU à l'] {votre province}, et vous serions reconnaissants de répondre à quelques questions supplémentaires, si vous avez le temps.

22. Acceptez-vous de continuer le sondage?

☐ Oui
☐ Non

Section 2 : Information supplémentaire

1. Votre association de producteurs agricoles négocie-t-elle en votre nom (ou celui d'autres producteurs) avec les acheteurs?

2. Dans quelle mesure êtes-vous satisfait des contrats que l'association a réussi à négocier?
   ☐ Extrêmement satisfait
   ☐ Satisfait
   ☐ Ni satisfait ni insatisfait
   ☐ Insatisfait
   ☐ Extrêmement insatisfait

3. Lorsque vous négociez vous-même, pensez-vous que vous arrivez à conclure des contrats de vente justes avec vos acheteurs?

☐ Je ne négocie pas de contrats de vente moi-même.

4. Qu'y a-t-il d'injuste, selon vous, dans la façon dont vos contrats de vente sont négociés?

5. Le prix que vous obtenez pour vos fruits et légumes est-il déterminé en fonction de leur apparence?

6. À quelle fréquence vous propose-t-on un prix plus bas que prévu, après la récolte, en raison de l'apparence de vos fruits et légumes?
   ☐ Jamais
   ☐ Rarement
   ☐ Parfois
   ☐ Souvent
   ☐ Très souvent

7. Lorsqu'on vous propose un prix plus bas, l'acceptez-vous au lieu de chercher un autre acheteur qui vous fera une meilleure offre?

   ☐ Oui, j'accepte généralement le prix plus bas.
   ☐ Non, je cherche généralement un autre acheteur.

8. En ce qui concerne l'agriculture contractuelle, les acheteurs qui concluent ces contrats achètent-ils les fruits et légumes qui ne répondent pas à leurs normes de qualité?

   ☐ Oui
   ☐ Non
   ☐ Parfois
   ☐ Je ne sais pas

9. Êtes-vous autorisé à vendre ces produits d'une autre façon?

   ☐ Oui
   ☐ Non
   ☐ Certains acheteurs l'autorisent
   ☐ Je ne sais pas.

10. Si votre rendement est meilleur que prévu, les acheteurs achètent-ils plus que ce qui était prévu dans le contrat original?

    ☐ Oui
    ☐ Non
    ☐ Parfois
    ☐ Je ne sais pas

11. À votre avis, votre taux de pertes alimentaires à la ferme serait-il différent si vous vendiez votre production par un autre canal (p. ex. vous faites affaire surtout avec des épiceries et de grands distributeurs, et vous changez pour des marchés locaux)?

    ☐ Oui
    ☐ Non
    ☐ Je ne sais pas

12. Pensez-vous que les incitatifs financiers comme les crédits d'impôt pour les dons alimentaires contribuent efficacement à réduire les pertes à la ferme?

    ☐ Oui
    ☐ Non
    ☐ Je ne sais pas

13. Vous êtes-vous déjà prévalu de l'un de ces programmes?

    ☐ Oui

o Non

14. Savez-vous où la plupart de vos fruits et légumes frais (c.-à-d. non transformés) sont vendus aux consommateurs?

☐ Oui
☐ Non

15. Environ quelle quantité (volume) de vos fruits et légumes frais est vendue aux consommateurs dans chacun des lieux suivants?

À l'intérieur de ma municipalité ou de ma région	%
À l'intérieur de la province	%
À l'intérieur du Canada	%
À l'extérieur du Canada	%

16. Le terme « alimentation locale » est souvent employé sans définition claire. Quels marchés considérez-vous comme des marchés locaux? *Cochez toutes les réponses qui s'appliquent.*

☐ À l'intérieur de ma municipalité

☐ À l'intérieur de mon comté ou de ma région

☐ À l'intérieur de ma province

☐ À l'intérieur du Canada

☐ À 50 km ou moins de ma ferme

☐ À 100 km ou moins de ma ferme

☐ À 500 km ou moins de ma ferme

☐ Autre (précisez) : _____

17. La pandémie de COVID-19 vous a-t-elle empêché de récolter vos fruits et légumes dans un délai raisonnable?

☐ Oui
☐ Non

18. La quantité de fruits et légumes non récoltés à votre ferme a-t-elle augmenté à cause de la pandémie?

☐ Oui
☐ Non
☐ Je ne sais pas

Tirage

1. Souhaitez-vous participer au tirage au sort?
   ☐ Oui
   ☐ Non
2. Veuillez répondre à la question d'habileté: (1+8)×3=_____
3. Veuillez laisser une adresse électronique où nous pourrons vous joindre. Vous ne serez contacté que si vous êtes sélectionné. Vos informations seront confidentielles et votre réponse au sondage ne sera pas liée à vous ou à votre ferme: _____

Recruitment Letter:

Email recruitment (First round)

English version:

Hello producers!

I am a graduate student in Agricultural Economics at McGill University. I am writing to ask for your participation in a survey about on-farm food loss, different sales channels, and your perceptions of local food markets. Your participation is important for us to understand how different distribution channels and standards affect rates of fruit and vegetable loss. If you choose to participate, your responses will be completely anonymous.

If you are willing to participate, please click the link below.

If you have any questions about this survey, please email me (Xiaoyi.huang@mail.mcgill.ca) or Prof. Mary Doidge (mary.doidge@mcgill.ca).

Many thanks,

Xiaoyi Huang

French version:

Bonjour, chers producteurs!

J'étudie au doctorat en agroéconomie à l'Université McGill, et je vous écris pour vous inviter à répondre à un sondage sur les pertes alimentaires à la ferme, les différents canaux de vente et les avis sur les marchés de producteurs locaux. Votre participation est importante, car elle nous aidera à comprendre les effets des différents canaux et normes de distribution sur les taux de perte de fruits et de légumes. Si vous acceptez de remplir le sondage, sachez que vos réponses seront totalement anonymes.

Pour participer, cliquez sur le lien ci-dessous.

Si vous avez des questions au sujet du sondage, veuillez m'écrire (xiaoyi.huang@mail.mcgill.ca) ou écrire à la P^{re} Mary Doidge (mary.doidge@mcgill.ca).

Merci beaucoup,

Xiaoyi Huang

Email Recruitment (Second Round)

English version:

Hello {FIRSTNAME},

I am a graduate student in Agricultural Economics at McGill University. I am conducting a survey of fruit and vegetable producers in Québec and Ontario. The survey asks about on-farm food loss, different sales channels, and your perceptions of local food markets. Your participation is important for us to understand how different distribution channels and standards affect rates of fruit and vegetable loss.

We understand that this is a busy time of year for you, but we would be grateful if you considered participating in the survey. If you participate, you will have the chance to win one of 10 $50 gift cards to the gas station of your choosing! We anticipate approximately 100 people will enter, so your odds of winning will be roughly 1 in 10.

All information that we collect will be completely confidential.
If you have any questions about this survey, please email me (Xiaoyi.huang@mail.mcgill.ca) or Prof. Mary Doidge (mary.doidge@mcgill.ca).

Many thanks,
Xiaoyi Huang

Click here to do the survey:
{SURVEYURL}

If you do not want to participate in this survey and don't want to receive any more invitations, please click the following link:
{OPTOUTURL}

French version:

Bonjour {FIRSTNAME},

J'étudie à la maîtrise en agroéconomie à l'Université McGill. Je mène une enquête auprès des producteurs de fruits et légumes du Québec et de l'Ontario. L'enquête porte sur les pertes alimentaires à la ferme, les différents canaux de vente et les avis sur les marchés de producteurs locaux. Votre participation est importante, car elle nous aidera à comprendre les effets des différents canaux et normes de distribution sur les taux de perte de fruits et de légumes.

Nous comprenons que cette période de l'année est très occupée, mais nous apprécierions que vous preniez quelques minutes pour participer. Si vous répondez, vous pourriez gagner l'une des 10 cartes-cadeaux de 50 $ à la station-service de votre choix! Nous prévoyons qu'environ 100 personnes participeront, donc vos chances de gagner seront d'environ 1 sur 10.
Vos réponses seront totalement confidentielles.

Si vous avez des questions au sujet du sondage, veuillez m'écrire (xiaoyi.huang@mail.mcgill.ca) ou écrire à la P^{re} Mary Doidge (mary.doidge@mcgill.ca).

Merci beaucoup,
Xiaoyi Huang

Cliquez ici pour participer:

{SURVEYURL}

Si vous ne souhaitez pas participer et ne souhaitez plus recevoir d'invitations, cliquez sur le lien ci-dessous:

{OPTOUTURL}

Email Recall (Second round only)

English version:

Dear {FIRSTNAME},

Recently we invited you to participate in a survey.
We note that you have not yet completed the survey, and wish to remind you that the survey is still available should you wish to take part.
If you participate, you will have the chance to win one of 10 $50 gift cards to the gas station of your choosing! We anticipate approximately 100 people will enter, so your odds of winning will be roughly 1 in 10.

We know that this is a busy time of year for fruit and vegetable producers, and your input is greatly appreciated.

To participate, please click on the link below. Your responses will be confidential and not linked to your identifying information in any way.

Sincerely,

Xiaoyi Huang

Click here to do the survey:
{SURVEYURL}

If you do not want to participate in this survey and don't want to receive any more invitations please click the following link:
{OPTOUTURL}

French version :

Bonjour {FIRSTNAME},

Nous vous avons récemment invité à participer à une enquête sur votre ferme et vos canaux de distribution. Si vous n'avez pas encore répondu au sondage, il est toujours ouvert si vous souhaitez y participer.

Si vous répondez, vous pourriez gagner l'une des 10 cartes-cadeaux de 50 $ à la station-service de votre choix! Nous prévoyons qu'environ 100 personnes participeront, donc vos chances de gagner seront d'environ 1 sur 10.
Nous comprenons que cette période de l'année est très occupée, et votre contribution est grandement appréciée.
Pour participer, veuillez cliquer sur le lien ci-dessous. Vos réponses seront confidentielles et ne seront en aucun cas liées à vos informations d'identification.

Merci encore,
Xiaoyi Huang

Cliquez ici pour participer :

{SURVEYURL}

Si vous ne souhaitez pas participer et ne souhaitez plus recevoir d’invitations, cliquez sur le lien ci-dessous :

{OPTOUTURL}

Newsletter Announcement (First round)

English version:

Researchers at McGill University are looking for survey participants! The survey will help us understand how different sales channels and standards affect rates of fruit and vegetable loss. If you participate, your responses will be completely anonymous.

For more information, go to, or email Xiaoyi Huang (xiaoyi.huang@mail.mcgill.ca) or Prof. Mary Doidge (mary.doidge@mcgill.ca)

French version :

Des chercheurs de l'Université McGill recherchent des participants à un sondage ! Leurs réponses nous aideront à comprendre les effets de différents canaux et normes de vente sur les taux de perte de fruits et de légumes. Si vous participez, sachez que vos réponses seront totalement anonymes.

Pour en savoir plus, communiquez avec Xiaoyi Huang (xiaoyi.huang@mail.mcgill.ca) ou la Pre Mary Doidge (mary.doidge@mcgill.ca).