Canadian Consumer Acceptance of Gene-Edited Versus Genetically Modified Potatoes: A Choice Experiment Approach

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Abstract

In 2016, the second-generation genetically modified (GM) potatoes were approved for production and sale in Canada. In this study, we analyze how consumer acceptance of GM potatoes are affected by various factors including the trait introduced (i.e., the product benefits) by using genetic technologies, the type of breeding technology used, and the developer of the potato with any technology. We conduct an online survey and use a stated choice experiment to collect data on consumer acceptance of GM and gene-edited potatoes in Canada. Random utility models are used to analyze the economic value consumers place on the attributes of the GM and gene-edited potatoes. Our results show that consumers are willing to pay more for a health attribute (reduced acrylamide produced when potatoes are fried) as compared to environmental benefits. Respondents in general need to face discounted prices to buy potatoes created by either gene editing or GM (both transgenic and cisgenic/intragenic) technologies. However, consumers are more accepting of the gene editing technology than GM technologies. Our results also show that government is the most preferred developer of the potatoes. Results from this study can help policymakers design better information policies to improve consumer acceptance of gene-edited and GM potatoes.

Keywords: Choice Experiment, Consumer Acceptance, Gene Editing, Genetically Modified, Potato

JEL classification: C25, D12, Q18

1. Introduction

Consumer acceptance plays a pivotal role in the success of genetically modified (GM)[1] foods in the market. The FLAVR SAVR tomato was the first GM food approved for commercialization. It was genetically modified to have a longer shelf life and was brought to the United States (US) market in 1994. Only a few years later, this GM tomato was pulled from the market due to public opposition (Bruening & Lyons, 2000). Since FLAVR SAVR reached the market, significant research has been conducted to study consumer perception, valuation, and attitudes (acceptance or rejection) toward GM food products (See Dannenberg, 2009; Frewer et al., 2013; Hess, Lagerkvist, Redekop, & Pakseresht, 2016; and Lusk, Jamal, Kurlander, Roucan, & Taulman, 2005 for reviews). Previous research finds that consumer acceptance of GM foods could be affected by individual characteristics and values, perceptions of risk and benefit associated with GM technologies, knowledge of the product and process, trust in developers and regulations, among other factors (Costa-Font, Gil, & Traill, 2008). However, consumers are heterogeneous and their attitudes toward GM foods can change as new breeding technologies introduced, new product traits designed, or new developers involved (Lusk, McFadden, & Wilson, 2018).

Gene editing technology, also known as genome editing technology, is a relatively new genetic technology with rapidly increasing agricultural applications. Gene editing technology differs from earlier GM technologies in that it can introduce desired traits in the targeted genome quickly and precisely, and without necessarily introducing transgenes from other species or organisms. These distinctions might reduce public opposition to foods developed by the gene editing technology, although this is an empirical question. Up to now, only a few studies have

[1] Genetic engineering and genetic modification are often used interchangeably with the latter better known by the public.

examined consumer acceptance of the gene editing technology (Araki & Ishii, 2015; Ishii & Araki, 2016; Shew, Nalley, Snell, Nayga, & Dixon, 2018), and there has been no study on Canadian consumer acceptance of the technology. The objective of this paper is to analyze Canadian consumer acceptance of a new potato produced, hypothetically, with a variety of different genetic technologies. We employ a choice experiment approach and use potatoes as the product of focus, given the recent approval of the second-generation GM potato for production in Canada in 2016. Specifically, we are interested in comparing consumer willingness to pay (WTP) for food that: (1) can be produced by the new gene editing technology versus other GM technologies (i.e., transgenic and cisgenic/intragenic), (2) can be bred by public research institutions or specialised agribusiness developers as opposed to Monsanto, a multinational agricultural biotechnology company, and (3) has direct consumer health benefits and environmental benefits versus only pest resistant or herbicide tolerant benefits (the most common traits currently used in commercialized GM crops globally (Brookes & Barfoot, 2018).

GM and Gene Editing Technologies

Agricultural scientists have applied multiple forms of genetic technologies to improve crop traits. The most well known genetic technology is the GM transgenic method, which introduces new genes from a sexually incompatible donor into a host plant. Concerns over the safety of transgenic procedures and their unknown long-term effects on the environment and human health contributed largely to public rejection of GM foods (Zilberman, Holland, & Trilnick, 2018). GM cisgenic/intragenic technology only introduces new genes from the same or sexually compatible donor into a host plant and thus should have been able to address some of the public concerns about the GM transgenic technology. Multiple studies indicate that consumer acceptance of the

GM cisgenic/intragenic technology is greater than that for the GM transgenic technology (Colson & Huffman, 2011; Delwaide et al., 2015; Edenbrandt, Gamborg, & Thorsen, 2018; Shew et al., 2016). It should be noted that the efficiency and specificity of the insertion of exogenous genes[2] in a plant genome are generally low under GM technologies (Ishii & Araki, 2016). It requires a long time to screen for the desired traits created by GM technologies – usually several years though much shorter than the conventional breeding method (Araki & Ishii, 2015).

Recently, much attention has been paid on the gene editing (also known as genome editing) technology, a relatively new form of genetic technology that can precisely and site-specifically add, modify or delete existing genes in a crop plant. The specific methods used for gene editing include clustered regularly interspaced short palindromic repeats (CRISPR)-associated systems (CRISPR-Cas), zinc-finger nucleases (ZFNs), and transcription activator-like effector nucleases (TALENs) (Huang, Weigel, Beachy, & Li, 2016). TALENs are an advanced version of ZFN with more precision and usability (WareJoncas et al., 2018). TALENs are more costly and require a longer time (than CRISPR-Cas) for creating new traits but are associated with low off-targeting risks. CRISPR-Cas is the most popular and versatile gene editing technology because it is simpler and less expensive to design and implement (Zaidi et al., 2019). However, CRISPR-Cas is associated with off-targeting risks, although some potential solutions have been proposed to mitigate the off-target risk (Chen, Wang, Zhang, Zhang, & Gao, 2019; Vakulskas & Behlke, 2019). Recent demonstrations of gene editing in plants include major crops such as barley, maize, rice, soybean, and wheat, and specialty crops such as mushrooms, sweet orange, cucumber, potato, and tomato (Eş et al., 2019; Zilberman et al., 2018). Urnov, Ronald, and Carroll (2018) provided a list

[2] In this paper, exogenous genes include both transgenes from other species or living organisms and cisgenes from the sextually compatible species.

of plant and mushroom species edited with CRISPR-Cas method. However, the only gene-edited food that has been commercialized (as of July 2019 in the North American market) is the TALEN-edited high oleic soybean oil with no trans fat and less saturated fat by the company Calyxt. Although USDA also gives free passes to several gene-edited plants (e.g., mushrooms and false flax), these products are not available on the market yet (Waltz 2018).

Compared with earlier GM technologies, gene editing can create desired traits in plants without necessarily introducing exogenous genes (Araki & Ishii, 2015). In addition, gene editing is more precise and predictable than earlier GM technologies thus the time and costs required for gene editing to identify and produce crops with desired traits has been dramatically reduced. When no exogenous gene is inserted, gene editing can – in principle – produce crops that are indistinguishable from those produced with the conventional breeding method. In contrast, when transgenes (from different species or organisms) are introduced, gene editing could be similar to GM transgenic technology. Although gene editing could be performed with the insertion of transgenes, the most common application of gene editing in generating desired traits in crops is a result of gene deletion or knockout (Chen et al., 2019). Therefore, these gene-edited foods can potentially be marketed as non-GM and transgene-free to mitigate the negatives associated with GM technologies, but this depends on how gene editing technology is regulated under different governance systems. For example, the Court of Justice of the European Union (EU) ruled in 2018 that crops created using gene editing technologies are subject to the same regulations as GMOs (Callaway 2018). On a different regulatory schema, USDA announced in 2018 that gene-edited plants do not need to go through the regulatory compliance process as traditional GM faced if no exogenous genes are introduced by the gene editing technology into the plant. The Canadian regulatory framework is similar to the US framework in that it is also product-based and not process-based, which means that gene editing technology will not trigger new regulation. The Canadian regulatory framework, however, is different from the US framework in that Canada regulates plants with novel traits (PNTs) rather than the introduction of exogenous genes. A pre-market safety assessment for products produced through gene editing if novel traits are introduced (Canadian Food Inspection Agency [CFIA], 2011). If the product does not express a novel trait, then such assessment is not required.

Although the gene editing technology already has many applications in agriculture, it is not clear how consumers perceive this new technology. Do they perceive gene editing technology as similar to the traditional GM transgenic technology? Alternatively, are they regarding the new gene editing technology as more similar to the GM cisgenic/intragenic technology or to conventional breeding methods? Will consumers value the precision and rapid breeding brought by gene editing? To answer these questions, it is important to compare consumer acceptance of gene editing technology with various GM technologies and with the conventional breeding method, for specific crops and with a variety of different traits. Given the unique Canadian regulatory framework regarding PNTs, it is also important to examine Canadian consumer attitude and acceptance of products produced by the new gene editing technology.

Studies on consumer acceptance of food products produced by gene editing technology have been lacking in the literature with a few exceptions. Araki and Ishii (2015) proposed a regulatory model to improve social acceptance of gene editing crops. Ishii and Araki (2016) explored the factors affecting consumer acceptance of food crops developed by gene editing. Bartkowski and Baum (2019) applied and extended Hirschman's exit–voice framework to evaluate the properness of the two options (“exit” through labelling and “voice” through public deliberation) to prevent opposition toward gene edited food. Both Ishii and Araki (2016) and

Bartkowski and Baum (2019) did not perform a quantitative analysis of consumer willingness to pay. Shew et al. (2018) compared consumer acceptance of CRISPR[3] rice versus GM transgenic rice and found that consumers are more willing to consume CRISPR rice than GM rice but the estimated WTP discounts for the two technologies are similar. However, Shew et al. (2018) did not compare CRISPR with GM cisgenic /intragenic technology. The comparison is critical because higher consumer acceptance of CRISPR technology could be attributed to the transgene-free aspect of gene editing which can also be realized via GM cisgenic/intragenic applications. Shew et al. (2018) used the multiple price list – a revealed preference method – to elicit consumer willingness to pay. In this paper, we use data from a stated preference choice experimental method to elicit consumer willingness to pay for potatoes produced with gene editing and GM technologies.

Product Traits and Benefits

Consumer acceptance of food developed by genetic technologies does not depend solely on whether transgenes are involved or the type of breeding technology used. There is evidence that consumer acceptance of GM foods can be improved if the GM food products are produced with traits that directly benefit consumers rather than just with agronomic traits such as pest resistance, herbicide tolerance, and increased yield (Costa-Font et al., 2008). Colson and Huffman (2011) find that consumers are willing to pay more for GM intragenic vegetables with enhanced nutrition (antioxidants and vitamin C) than for a conventional product. Moreover, Colson and Huffman (2011) indicate that consumers are more accepting of enhanced nutrition obtained through GM

[3] Shew et al. (2018) did not specify the exact CRISPR system (e.g., CRISPR-Cas system or other systems).

intragenic than through GM transgenic technology. Other studies also suggest similar results that consumer acceptance of GM foods can be improved when these GM foods offer health benefits such as improved nutritional quality (De Steur, Buysse, Feng, & Gellynck, 2013; González, Johnson, & Qaim, 2009), low acrylamide content (Harkness & Areal, 2018; McFadden & Huffman, 2017), better taste (Loureiro & Bugbee, 2005), mitigation of world food shortages (Moon & Balasubramanian, 2003), and environmental benefits (Frewer, Howard, & Shepherd, 1996).

In this paper, we will examine the relative importance of different traits or benefits on consumer acceptance of potatoes derived from gene editing, GM transgenic, and GM cisgenic/intragenic. The various benefits we examine include health benefits for consumers and environmental benefits such as reduced pesticide use and reduced food waste. Colson and Huffman (2011) already compared consumer WTP for enhanced nutritional value obtained through GM transgenic and GM intragenic applications. By comparing consumer WTP for gene editing versus GM technologies, this research adds to Colson and Huffman (2011) the value of consumer WTP for food products with health benefits obtained through gene editing. We also add to Loureiro and Bugbee (2005) and Lusk et al. (2004) to rank consumer WTP for different benefits associated with genetic technologies and identify the attribute with the highest level of consumer acceptance.

Trust in Developers

Trust in developers of GM products is another factor that is increasingly identified by researchers to affect consumer acceptance (Ishii & Araki, 2016; Lucht, 2015; Lusk et al., 2018; Siegrist, 1999; Siegrist, Connor, & Keller, 2012; Tanaka, 2004). A recent U.S. nationwide survey by Lusk et al. (2018) shows that consumers are more supportive of GM foods developed by public institutions (university and the government) than industry. Moreover, Lusk et al. (2018) find that consumer opposition is the highest for Monsanto among the various names of the companies mentioned in the survey (Dow, DuPont, and Bayer). Results from the Eurobarometer surveys show that EU consumers have low trust for government and the biotech industry and high trust for university scientists and consumer organizations (Lucht 2015). Moon and Balasubramanian (2003) also suggest that negative perceptions about the growing role of multinational corporations in farming contribute to consumer opposition to GM foods.

Despite the abovementioned evidence of consumer opposition to GM foods developed by multinational corporations, research on consumer WTP for different developers of genetic technologies has been missing in the literature. This study fills the gap by studying consumer acceptance and WTP for gene-edited and GM foods developed by different developers including a public institution (i.e., the government), a major multinational corporation (i.e., Monsanto), and a specialised agribusiness company (i.e., J.R. Simplot). The study of consumer acceptance of developers is particularly relevant to gene editing technologies because developers of currently commercialized GM crops are mainly multinational corporations (Bradford et al., 2018) whereas some of the leading inventors of gene editing technologies are academic institutions and specilised firms which include the Broad Institute (affiliated with MIT and Harvard), Caribou Biosciences, and the University of California (Das 2018). Consumer trust in the public institutions or more specialised developers might change their perceptions of the gene editing technology and consequently translate into acceptance of gene-edited foods.

GM Potatoes

The potato serves as an excellent example to study consumer acceptance of food produced by gene editing and GM technologies. Potatoes are the world's third most important food crop after rice and wheat in terms of human consumption (International Potato Center, 2019). Potatoes are the largest vegetable crop in Canada, accounting for $1.19 billion in farm cash receipts in 2017 and the crop was grown on 347,416 acres in Canada in 2017 (Agriculture and Agri-Food Canada [AAFC], 2018). Potatoes are one of the first few GM crops approved for commercialization globally. The first-generation GM potatoes (under the name NewLeaf) were released by Monsanto in 1995 to resist attack from Colorado potato beetle. Due to the introduction of the foreign *Bacillus thuringiensis* (or Bt) gene, that generation of GM potatoes is considered to be GM transgenic. They received great initial success in the US and Canada but were taken off the market after McDonald's and Frito-Lay, for example, stopped sourcing GM potatoes in response to consumers' concerns about GM food (Kilman, 2000). Similarly, another GM potato variety developed by BASF Plant Science (under the name Amflora), approved for industrial applications in the EU in 2010, was withdrawn from the EU market due to lack of acceptance from consumers and farmers (Kanter, 2012).

The second-generation GM potatoes, developed by J.R. Simplot (one of the largest potato processors in North America), were approved for sale in the US in 2015 and Canada in 2016. These GM potatoes have been engineered to produce less acrylamide (a potentially carcinogenic substance formed when starchy foods such as potatoes are cooked at high temperatures), to reduce blackspot bruising or browning, and to resist late blight disease (J.R. Simplot, 2017). This generation of GM potatoes, therefore, has both direct health benefits for consumers and environmental benefits for society. The traits of the second-generation GM potato are obtained through the GM cisgenic/intragenic method, without introducing transgenes. According to Simplot, about 1,000 acres were planted in the US in 2016 and 6000 acres in 2017 (Ridler, 2017)[4]. This generation of GM potatoes has not been grown in Canada as of 2017.

Gene editing technologies have been applied to create potatoes with similar traits, though innovators have not sought approval to commercialize gene-edited potatoes yet. TALEN and CRISPR/Cas technologies have been implemented in the potato to develop traits and benefits such as herbicide tolerance, improved cold storage capacities, reduced toxic compounds glycoalkaloids, among other traits (Andersson et al., 2017; Butler, Atkins, Voytas, & Douches, 2015; Butler, Baltes, Voytas, & Douches, 2016; Clasen et al., 2016; Nadakuduti, Starker, Voytas, Buell, & Douches, 2019; Sawai et al., 2014; Wang et al., 2015; Weeks, 2017). In 2018, J.R. Simplot announced that it had executed a joint intellectual property licensing agreement with Corteva Agriscience (agriculture division of DowDuPont) and the Broad Institute for CRISPR-Cas and related gene editing tools (J.R. Simplot, 2018). It is likely that J.R. Simplot will apply gene editing technologies to develop new potato varieties in the future. In addition, it is worth noting that Calyxt is already in the process of developing gene-edited (using TALEN method) potatoes that can safely be put in cold storage without accumulating sugars that catalyze into acrylamide when cooked at high temperatures.

Several studies have specifically focused on consumer acceptance and valuation of GM potatoes. Thorne, Fox, Mullins, and Wallace (2017) analyze consumer acceptance of GM late blight resistant potatoes in Ireland. Their results suggest that consumers prefer conventional to GM potatoes but information about the potential economic and health benefits increased consumer acceptance of the GM potatoes. Both McFadden and Huffman (2017) and Lacy and Huffman

[4] Acreages for the years of 2018 and 2019 are not available at the time of publication.

(2016) find that consumers are willing to pay for enhanced food safety – low acrylamide – in potato products achieved using biotechnology. In another study, Pakseresht, McFadden and Lagerkvist (2017) find that consumers are more likely to reject GM products if other food chain actors have low support for it. These researches all used the experimental auction method to elicit consumer acceptance and WTP for GM potatoes. Experimental auction methods involved with real incentives are more expensive to implement and therefore generally have limited sample sizes. In this study, we will use the stated preference choice experiment approach. Stated preference choice experiment methods allow for large sample sizes and can account for heterogeneity in consumer acceptance and WTP for GM foods (Holmes, Adamowicz, & Carlsson, 2017).

2. Empirical Methods

A national Canadian online survey which includes a stated preference choice experiment is used to collect data on consumer acceptance of potatoes produced using different genetic technologies. Stated choice experiments present an attractive way of approaching the issue of foods produced using different technologies because the choices are presented in context and explicitly highlight the trade-offs that often have to be made in actual decisions. In this sense, results are likely to be more reliable than contingent valuation questions. In addition, stated choice experiments allow for the analysis of new product attributes and the combinations of levels of attributes that may not be found in the market (Edenbrandt, House, Gao, Olmstead, & Gray, 2018; James & Burton, 2003).

Frozen French-fried potatoes are used as the consumer product in the choice experiment because acrylamide occurs in potatoes when they are cooked at high temperatures. More importantly, more than 60% of potatoes grown in Canada are processed, mostly into frozen French-fries (AAFC, 2018). The current study focuses on a health attribute (reduction in acrylamide levels in fried potatoes), environmental attribute (reduction in the levels of waste generated due to bruising and browning, and reduction in the levels of on-farm pesticide applied), the breeding technology (conventional, GM cisgenic/intragenic, GM transgenic and gene editing) and breeders or developers (government, J.R. Simplot Company, Monsanto and no source identified). The attributes and attribute levels are presented in Table 1. Prices of the frozen French-fried potatoes range from $3.00 to $7.50 per kg and the actual price for a similar package of potatoes, at the time of the survey, was $3.00 per kg (Safeway, Flyer, Edmonton, 2018).

[Insert Table 1 here]

A fractional factorial experimental design was used for this study using the SAS software. There are a total of 48 choice sets in the design that are blocked into six versions. Therefore, each participant responds to 8 choice sets. For each choice set, there are four options (option 1, option 2, option 3 and "I would not purchase any of these products"). An example of the choice sets is in Table 2. Before responding to the choice experiment questions, respondents are provided with brief information about acrylamide, breeding technologies and breeding companies since some participants might not have enough information about the attributes. The information provided to participants before they answered the choice experiment questions is provided in the Appendix.

[Insert Table 2 here]

Random parameters logit (also known as mixed logit) models are used to analyze the effect of gene editing and GM technologies, product traits, developer of the technology, and other factors (e.g., demographic characteristics, knowledge on and attitudes towards GM foods) on the economic value consumers place on the product attributes. It is assumed that participants are rational, that is, they choose the alternative where they derive the highest level of utility. The indirect utility function for individual *n* for choice $i(U_{in})$ is represented as follows:

$$U_{in} = \gamma p + \boldsymbol{\beta z} + \boldsymbol{\theta z d} + \epsilon \qquad (1)$$

where p is price, $\boldsymbol{z}$ is a vector of attributes, $\boldsymbol{d}$ is a vector of individual specific variables, γ is the coefficient on price, $\boldsymbol{\beta}$ represents a vector of coefficients on the attributes, $\boldsymbol{\theta}$ is a vector of coefficients on the interaction terms of attributes and individual specific variables and ϵ is the error term.

Compared to the conditional logit, the random parameters logit model is more flexible which allow tastes to vary randomly across the sample and allows for unrestricted substitution patterns and correlation of unobserved factors across time (Train, 2009). Both the conditional and random parameters logit models are estimated with and without individual specific variables.

For the random parameters logit model, price is assumed to be fixed to for the various reasons mentioned in Train (2009) and other attributes are assumed to be normally distributed to avoid restricting the signs of their coefficients. The random parameters logit models are estimated using 50 Halton draws and WTP values are calculated using the Delta method. WTP for attribute *k* is calculated using the formula below:

$$WTP_k = -\frac{\beta_k + \boldsymbol{d'\theta_k}}{\gamma} \qquad (2)$$

3. Data

The online survey was administered by a major marketing research company that maintains a representative panel of more than 20,000 Canadian consumers. The survey was targeted at people who are aged 18 or older. The sample size is 3,014 respondents. The sample is generally representative of the national population in terms of household size, the gender of the respondent and the geographical location of the respondent (Table 3). The sample is composed of older respondents and more households with children aged less than 18 years as compared to the national population. Household income is higher for the sample as compared to the national population. In addition, there are more people with University and postgraduate degrees as compared to the national population.

[Insert Table 3 here]

The online survey consists of seven parts. The first part includes warm-up questions related to shopping and eating habits of participants, risk perceptions, trust in groups or institutions responsible for food and food safety information from various sources, natural product and general health interests and perceptions about fairness in the food industry. The second part consists of questions relating to general knowledge or familiarity with science and technology, biotechnology and GM. The third part consists of questions relating to knowledge of environmental problems and perceptions about the environment and the future. The fourth section consists of questions about food waste while the fifth part consists of the stated choice questions. The sixth section consists of questions about potatoes in general and specifically GM potatoes (including their risk and benefit perceptions). The last section consists of background questions including the socio-demographic status of the participants.

[Insert Table 4 here]

Table 4 presents the summary statistics of respondents' answers to some of the survey questions. The majority of the respondents state that the world is better off because of science and technology. On average, respondents state that they have moderate knowledge of environmental problems and below-average knowledge of technology and GM foods. The respondents perceive that most of the benefits of using new technologies in food production go to processors while not consumers and farmers. About 15% of the respondents stated that they had heard about the chemical compound acrylamide while 32% had heard of genetically modified potatoes (that have reduced bruising, black spots and acrylamide produced from frying). In terms of the consumption of potatoes and potato products, the majority of the people stated they consume these products one to three times per month (Figure 1).

[Insert Figure 1 here]

4. Results

In the questionnaire, a trap question was included before the stated preference experiment exercise which is as follows "Please select agree for this line. Thank you for reading carefully. 1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree". One hundred and forty-seven respondents failed the trap question. Respondents who failed the trap question are excluded from the analysis.

[Insert Table 5 here]

Conditional and random parameters logit model results are reported in Table 5. We mainly discuss results from the random parameter models (Model III and Model IV) since the coefficient estimates for the two types of models are very similar and the random parameter models have a better fit. All the coefficient estimates from the random parameter model with attributes included as the only explanatory variables (Model III) are significant at 1% level except J.R. Simplot. The attribute coefficients have the expected signs: on average respondents prefer frozen French fries with beneficial traits (reduced acrylamide level, reduced food waste, and reduced on-farm pesticide application in potatoes), produced by conventional breeding technology as opposed to GM and gene editing technologies, developed by the government over Monsanto.

We also estimate the random logit model (Model IV) with interactions between the alternative attributes and the individual specific variables of the respondents, which is suggested by Hensher and Greene (2003) and Holmes et al. (2017) to account for preference heterogeneity. The individual specific variables[5] we include in the random parameters logit model are the respondents' gender, age, knowledge of technology, perceived fairness in food production (consumer price fairness, farmer price fairness, and outcome fairness), worldview, eating frequency of frozen French fries and hash browns[6], general trust in people, and whether children (less than 18 years of age) present in the respondents' households. The significant standard deviations of parameter distributions for the random parameters logit models show that there is heterogeneity of parameter estimates around the mean. Individual specific variables significantly influence people's preferences for the attributes for frozen French fries. Older respondents are generally less likely to prefer the attributes as compared to younger respondents. Male respondents are generally more accepting of the GM and gene editing technologies. Perceived farmer price fairness and outcome fairness are negatively related to interest in frozen French fries developed by the GM and gene editing technologies. Outcome fairness is negatively related to interest in frozen French fries developed by Monsanto and J.R. Simplot. Worldview and eating frequency for frozen French fries are positively related to interest in all attributes.

[5] The definition and summary statistics of these individual specific variables are shown in table 4 and figure 1.
[6] In the stated choice experiment, we use frozen French fries as the product of focus, which did not include frozen hash browns.

Willingness to pay for the attributes for the frozen French fries

Results on mean WTP for the different attributes are summarized in Table 6. Rather than calculate the WTP for the average respondent as most studies do, we calculate the WTP for each individual using the formula in Equation (2) and report the mean WTP. The k-density plots of individual WTP for the attributes are summarized in figures 2 to 4. For the same reason mentioned above, we mainly discuss results from Model IV (random parameters logit with individual specific variables included).

[Insert Table 6 here]

[Insert Figures 2-4 here]

Compared to the conventional frozen French-fried potatoes, on average respondents are willing to pay $1.06 more for potatoes with reduced acrylamide. WTP values for acrylamide reduction in frozen French fries are also higher than all other attributes and results are consistent across all regression models. Respondents are also willing to pay positive premiums for pesticide reduction ($0.97). Although the average premiums for pesticide reduction are lower than those for acrylamide reduction, they are higher than all other attributes which are also not surprising given that respondents might have some health-related concerns regarding the use of pesticides in potato production in addition to environmental concerns.

Respondents have negative willingness to pay for frozen French fries produced using genetic technologies (GM cisgenic/intragenic, GM transgenic and gene editing) as compared to conventional potato production practices and the results are consistent across the regression models. Respondents want to be compensated more for GM transgenic as compared to GM cisgenic/intragenic and gene editing maybe because GM transgenic introduces new genes from a sexually incompatible donor into a host potato plant. WTP discount for products produced by gene editing technology is less than the discounts required for products produced by the GM technologies (both transgenic and cisgenic/intragenic).

Respondents are willing to pay positive premiums for the frozen French fries from potatoes developed by the government as compared to potatoes that have no source identified as the developer of the potatoes. Respondents need to be compensated for frozen French fries from potatoes developed by Monsanto as compared to all other developers maybe because of the negative publicity from some advocacy groups.

In Figure 5, comparisons are made between willingness to pay for the sample with women with children and the sample excluding women with children. There are significant differences between the two groups (at ≤ 5% level of significance) except for acrylamide reduction. The presence of children (less than 18 years of age) in a household may make a female consumer less willing to pay for GM and gene editing technologies.

[Insert Figure 5 here]

5. Discussion and Conclusions

In this paper, we analyze consumer acceptance of a particular food, in this case the second-generation GM potatoes which have been approved for production but are currently not being significantly planted yet. Although the approved potatoes are produced by GM cisgenic/intragenic technology, our focus is on whether the actual technology used would have any impact on acceptance – for example if the potatoes were created by gene editing technology versus GM transgenic or GM cisgenic/intragenic technologies. We find that survey respondents would in general need to face discounted prices to buy potatoes created by either gene editing or GM (both transgenic and cisgenic/intragenic) technologies as compared to conventional breeding methods. Consumer WTP for GM transgenic is the most discounted among the three genetic technologies we examined. This result is in line with current public opposition to GM transgenic methods (Ishii & Araki, 2016). Similar to previous research, we find that GM cisgenic/intragenic technology is preferred over GM transgenic technology. More importantly, our results provide evidence that the WTP discount for products produced with the gene editing technology is less than the discount for the GM cisgenic/intragenic technology. In other words, consumers are more accepting of gene editing technology than GM cisgenic/intragenic technology.

Better consumer acceptance of gene editing technology and GM cisgenic/intragenic technology could be attributed to consumer perception that they are more "natural" than GM transgenic (Lusk, Roosen and Bieberstein 2014) though researchers (and the public) have not agreed on the definition of naturalness. Gene editing can be realized via the non-homologous end-joining (NHEJ) pathway where no exogenous gene is introduced or via the homology-directed repair (HDR) pathway where exogenous genes are added to plant cells, something that may not be clear to the respondents in our survey. Based on the findings from this paper, we conjecture that NHEJ might be more acceptable by consumers because no exogenous gene – even cisgene – is introduced. Depending on whether gene editing is operated on a single chromosome or different chromosomes or assisted with donor DNA, gene editing can lead to different outcomes such as gene deletion, gene inversion, gene translocations, or gene insertion (Samanta, Dey and Gayen 2016). Some of the outcomes might be perceived by consumers as more natural (or more close to conventional breeding) than others. In addition, the pathways and outcomes of gene editing technology are also affected by the specific tool (ZFN, TALEN, or CRISPR) utilized (WareJoncas et al., 2018). Future research should explore the impacts of different tools, pathways, and outcomes on consumer acceptance of gene editing technology, and whether or not information about the technology at this level could influence purchase intentions or revealed purchase behaviour. Findings can help direct the focus of future gene editing technology innovation and development, to enhance acceptance in the marketplace.

Our results are consistent with previous studies that consumers are more accepting of GM foods with direct health benefits or environmental benefits (Colson and Huffman 2011; Delwaide et al., 2015; Lusk, Roosen, & Bieberstein, 2014). Results from our choice experiment show that consumer WTP for the low-acrylamide attribute has the highest value followed by the pesticide reduction attribute and lastly the food waste reduction attribute. Our results provide more evidence that breeders or developers should design GM products/foods (including gene-edited foods) that have direct health benefits to the consumers to improve consumer acceptance. However, our research has more implications than that. Previous research mainly revealed consumer acceptance and WTP for GM foods with enhanced nutritional benefits while there are no risks associated with the foods produced by the conventional method. Few explored consumer acceptance of GM foods when the conventional food is associated with risks to human health with the technology helping to mitigate or eliminate the risks, which is the case for the potatoes of focus in this study. In such cases, consumers have to decide on their trade-offs between health benefits provided by GM and gene-edited foods and risks if genetic technology is not used. In this sense, our results are also relevant for GM and gene-edited food products with similar beneficial attributes such as the gene-edited soybean oil with no trans-unsaturated fat. Due to the perceived risks associated with conventional products, consumer acceptance of GM and gene-edited foods that can counter health risks might be higher than those with just enhanced nutritional benefits, based on our results.

While we agree that consumer attitudes and acceptance of GM and gene-editing technologies are affected by the current regulation frameworks, their acceptance can also be influenced by regulations around conventional products. California Proposition 65 lists acrylamide as a chemical that can cause cancer or reproductive toxicity and requires a warning label if contained in a product. A new EU regulation that recently came into force sets the amount of acrylamide allowed in various food products including potato products. If similar regulations are approved by Canadian regulatory authorities in the future, consumer acceptance of GM or gene-edited potatoes with reduced acrylamide might be further improved. Should the perceived benefits outweigh the perceived risks of GM and gene editing technologies, a voluntary label might be adopted by the agricultural biotechnology companies to capture the benefits brought by these technologies.

In addition, we find that government is the most preferred developer of the potatoes. Respondents actually have a positive WTP for products developed by the government and negative WTP for products developed by Monsanto. The mean WTP for J.R. Simplot as the developer is not significantly different from zero. Our results suggest that consumers have strong negative feelings towards Monsanto (which may spill over to Bayer now that they have acquired Monsanto). This is probably because most commercialized GM crops are from large multinational corporations like Monsanto. Having public institutions and more specialised agribusiness companies like J.R. Simplot as the developer might improve consumer acceptance of GM and gene-edited foods. However, the cost of regulatory compliance may be too high for public institutions and specialised agribusiness companies to market GM and gene-edited foods. As mentioned above, Canada regulates PNTs while not the technology used. This Canadian aspect of regulation might create challenges for public institutions and specialised agribusiness companies when marketing gene-edited food products in Canada. Because some products created by gene editing may be considered novel in Canada while not regulated in the US and other jurisdictions. For example, a gene-edited herbicide-tolerant Canola should be subject to regulation in Canada while not in the US.

Gene editing technology is creating new opportunities that traditional GM technologies cannot achieve and opens up the possibility of attributes that could improve consumer acceptance of gene-edited foods. These include better efficiency and specificity of the technology, exogenous gene free products, the involvement of public institution and specialised agribusiness developers, and new beneficial traits for supply chain players, among other aspects. This paper provides some initial evidence on aspects that might affect consumer acceptance and willingness to pay for gene editing technology versus traditional GM technologies. However, gene editing technologies are rapidly advancing which may lead to changes in consumer acceptance. For example, if improvements in gene editing technology can address the off-target risk, consumer perception of the risk associated with genetic technology might change which will further translate into less opposition. Future research should continue exploring how consumer acceptance of food products derived from gene editing technologies evolve when there are changes in the dynamics of technology advancement, players of the technology along the supply chain, information from anti-GM and pro-GM groups, and regulatory process.

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Table 1. Attributes and attribute levels

French Fried Potatoes, Frozen: Attribute	Levels
Health attributes:	
Level of acrylamide formed during cooking (% change from current)	-62, 0
Environmental attribute:	
Level of waste produced due to bruising or browning (% change from current)	-15, 0
Level of on-farm pesticide application (% change from current)	-45, 0
Breeding technology for the potatoes	Conventional, GM transgenic, GM cisgenic/intragenic, and gene editing
Breeder of the potatoes	Government, Monsanto, J.R. Simplot Company, No source identified
Prices (per kg)	\$3.00, \$4.50, \$6.00 and \$7.50

Table 2. Example of a choice set

Question: Please assume you have walked into a supermarket and you wish to purchase a 1kg bag of frozen French fried potatoes. The price for frozen French fried potatoes in Canada is $3.00 per 1kg. Please consider each of the eight scenarios below and indicate your choice for each scenario. Please select Option 1, Option 2, Option 3 or 'I would not purchase any of these product' for each scenario. Please make your decision as if these were the only French fried potatoes in the supermarket.

French Fried Potatoes, Frozen: Attributes	**Option 1**	**Option 2**	**Option 3**	**Neither**
Price ($/1 kg)	$7.50	$6.00	$3.00	I would not purchase any of these products
Level of acrylamide formed during frying the potatoes (% change from current)	No reduction	Reduced by 62%	Reduced by 62%	
Level of waste produced due to bruising or browning of the potatoes (% change from current)	No reduction	Reduced by 15%	No reduction	
Level of on-farm pesticide application to the potatoes (% change from current)	No reduction	Reduced by 45%	Reduced by 45%	
Breeding technology for the potatoes	GM cisgenic/intragenic	GM transgenic	Gene editing	
Breeder of the potatoes	Government	Monsanto	J.R. Simplot Company	
I would choose . . .	○	○	○	○

Table 3. Demographic characteristics of respondents		
	Survey data	**Census**[1]
	Mean (SD)	
Age (years)	46.8 (14.6)	41.0
Household size	2.41 (1.13)	2.40
Income ($1,000)	81.0 (34.3)	76.2[2]
	Frequency (%)	
Male	49.9	49.1
Children	43.5	39.6
Education[3]		
Elementary school	0.4	11.5
Secondary (high) school	15.4	23.7
Technical/business school/community college	28.4	33.2
University	37.8	24.8
Postgraduate studies (Masters or PhD)	18.1	6.8
Respondent or relatives who own or work on a farm	10.9	-
Live in the countryside/rural	13.1	18.7
Newfoundland and Labrador	1.66	1.48
Prince Edward Island	0.36	0.41
Nova Scotia	3.15	2.63
New Brunswick	1.99	2.13
Quebec	24.42	23.2
Ontario	38.59	38.3
Manitoba	3.52	3.64
Saskatchewan	2.46	3.12
Alberta	10.72	11.6
British Columbia	13.14	13.2
Yukon, Northwest Territories, Nunavut	0.00	0.32
N	3,014	

[1] Statistics Canada (2017a, 2017b, 2017c, and 2018); [2] net household income; [3] for people aged 25 to 64;

Table 4. Summary statistics for some questions in the survey		
	Mean (SD)	Frequency (% yes)
Worldview: All things considered, would you say that the world is better off, or worse off, because of science and technology? (1=worse off; 10=better off)	7.17 (2.04)	
Knowledge of technology: In general, to what extent do you feel knowledgeable about scientific and technological developments? (1=little knowledge; 10=know a lot)	4.87 (2.38)	
Knowledge of GM foods: How knowledgeable would you say you are about the facts and issues concerning genetic modification in food production? (1=little knowledge; 10=know a lot)	4.64 (2.34)	
Knowledge of environmental problems: To what extent do you feel knowledgeable about environmental problems? (1=little knowledge; 10=know a lot)	5.82 (2.19)	
Consumer price fairness: Perceived fairness of food prices paid by consumers	2.50 (0.93)	
Farmer price fairness: Perceived fairness of food prices paid to farmers	2.64 (0.84)	
Outcome fairness (1=strong disagree; 5=strongly agree)		
The benefits will all go to food processors, not regular farmers.	3.36 (0.89)	
It is fair spending my tax dollars on developing these new technologies.	3.14 (0.92)	
All the benefits of new technologies will go to consumers.	2.50 (0.86)	
Consumers will experience an unfair amount of risk from the use of new technologies.	2.98 (0.85)	
Trust: Generally speaking, would you say that most people can be trusted?		56.5
Before completing this survey had you ever heard of the chemical compound acrylamide?		14.9
Before completing this survey had you ever heard of genetically modified potatoes (that have reduced bruising, black spots and acrylamide produced from frying)?		32.2

Table 5. Estimated parameters for the Conditional Logit and Random Parameters Logit models

	Conditional Logit				Random Parameters Logit			
	Model I		Model II		Model III		Model IV	
	β	SE	β	SE	β	SE	β	SE
Would not buy	-0.930***	(0.042)	-1.039***	(0.043)	-1.695***	(0.053)	-1.749***	(0.053)
Price (*fixed parameter*)	-0.359***	(0.006)	-0.369***	(0.006)	-0.501***	(0.009)	-0.500***	(0.009)
Random Parameters								
Acrylamide	0.522***	(0.020)	-0.511***	(0.155)	0.535***	(0.041)	-0.977**	(0.302)
Waste	0.245***	(0.020)	0.142	(0.152)	0.136***	(0.037)	0.035	(0.262)
Pesticide	0.471***	(0.020)	0.038	(0.151)	0.537***	(0.038)	-0.187	(0.284)
GM Cisgenic	-0.802***	(0.027)	-0.366	(0.209)	-1.093***	(0.039)	-0.345	(0.262)
GM Transgenic	-0.860***	(0.028)	-0.911***	(0.207)	-1.158***	(0.039)	-1.040***	(0.257)
Gene Editing	-0.717***	(0.028)	-0.921***	(0.215)	-0.987***	(0.040)	-1.177***	(0.280)
Government	0.270***	(0.027)	0.126	(0.199)	0.360***	(0.041)	0.219	(0.291)
J.R. Simplot	-0.010	(0.029)	0.139	(0.205)	0.022	(0.038)	0.122	(0.262)
Monsanto	-0.313***	(0.030)	0.075	(0.226)	-0.408***	(0.046)	0.204	(0.303)
Interactions with Demographic Variables								
Acrylamide*Age			-0.001	(0.001)			-0.003	(0.003)
Acrylamide*Male			-0.105*	(0.042)			-0.110	(0.082)
Acrylamide*Children			0.005	(0.041)			0.022	(0.079)
Acrylamide*Consumer Price Fairness			0.008	(0.042)			0.046	(0.082)
Acrylamide*Farmer Price Fairness			-0.032	(0.044)			-0.118	(0.085)
Acrylamide*Outcome Fairness			0.114**	(0.043)			0.093	(0.083)
Acrylamide*Trust			-0.001	(0.001)			-0.002	(0.002)
Acrylamide*Knowledge of Technology			-0.001	(0.009)			0.005	(0.017)
Acrylamide*World View			0.103***	(0.011)			0.152***	(0.021)
Acrylamide*Fries Eating Frequency			0.106***	(0.022)			0.204***	(0.043)

Table 5. Continued

	Conditional Logit				Random Parameters Logit			
	Model I		Model II		Model III		Model IV	
	β	SE	β	SE	β	SE	β	SE
Waste*Age			-0.009***	(0.001)			-0.013***	(0.002)
Waste*Male			0.093*	(0.042)			0.131	(0.072)
Waste*Children			-0.007	(0.040)			-0.052	(0.068)
Waste*Consumer Price Fairness			-0.006	(0.041)			-0.052	(0.071)
Waste*Farmer Price Fairness			0.063	(0.043)			0.108	(0.073)
Waste*Outcome Fairness			-0.036	(0.042)			-0.063	(0.072)
Waste*Trust			-0.000	(0.001)			-0.002	(0.002)
Waste*Knowledge of Technology			0.004	(0.009)			0.003	(0.015)
Waste*World View			0.023*	(0.011)			0.036*	(0.018)
Waste*Fries Eating Frequency			0.090***	(0.021)			0.148***	(0.038)
Pesticide*Age			-0.004**	(0.001)			-0.009***	(0.003)
Pesticide*Male			0.016	(0.041)			0.134	(0.078)
Pesticide*Children			-0.055	(0.040)			-0.155*	(0.074)
Pesticide*Consumer Price Fairness			-0.036	(0.041)			-0.022	(0.077)
Pesticide*Farmer Price Fairness			0.064	(0.043)			0.126	(0.080)
Pesticide*Outcome Fairness			0.037	(0.042)			0.080	(0.078)
Pesticide*Trust			-0.001	(0.001)			-0.002	(0.002)
Pesticide*Knowledge of Technology			-0.020*	(0.009)			-0.036*	(0.016)
Pesticide*World View			0.059***	(0.011)			0.090***	(0.019)
Pesticide*Fries Eating Frequency			0.086***	(0.021)			0.142***	(0.040)
GM Cisgenic*Age			-0.011***	(0.002)			-0.014***	(0.002)
GM Cisgenic*Male			0.234***	(0.057)			0.348***	(0.072)
GM Cisgenic*Children			-0.039	(0.055)			-0.064	(0.069)
GM Cisgenic*Consumer Price Fairness			-0.108	(0.057)			-0.083	(0.071)

Table 5. Continued

	Conditional Logit				Random Parameters Logit			
	Model I		Model II		Model III		Model IV	
	β	SE	β	SE	β	SE	β	SE
GM Cisgenic*Farmer Price Fairness			-0.205***	(0.059)			-0.283***	(0.074)
GM Cisgenic*Outcome Fairness			-0.290***	(0.058)			-0.402***	(0.073)
GM Cisgenic*Trust			-0.001	(0.001)			-0.000	(0.002)
GM Cisgenic*Knowledge of Technology			0.028*	(0.012)			0.028	(0.015)
GM Cisgenic*World View			0.055***	(0.015)			0.065***	(0.019)
GM Cisgenic*Fries Eating Frequency			0.084**	(0.029)			0.084*	(0.037)
GM Transgenic*Age			-0.009***	(0.002)			-0.011***	(0.002)
GM Transgenic*Male			0.227***	(0.056)			0.309***	(0.070)
GM Transgenic*Children			-0.119*	(0.054)			-0.159*	(0.067)
GM Transgenic*Consumer Price Fairness			-0.095	(0.056)			-0.117	(0.070)
GM Transgenic*Farmer Price Fairness			-0.135*	(0.058)			-0.182*	(0.073)
GM Transgenic*Outcome Fairness			-0.279***	(0.057)			-0.394***	(0.071)
GM Transgenic*Trust			0.001	(0.001)			0.001	(0.002)
GM Transgenic*Knowledge of Technology			0.021	(0.012)			0.033*	(0.015)
GM Transgenic*World View			0.073***	(0.015)			0.076***	(0.018)
GM Transgenic*Fries Eating Frequency			0.155***	(0.029)			0.180***	(0.036)
Gene Editing*Age			-0.005**	(0.002)			-0.008**	(0.003)
Gene Editing*Male			0.179**	(0.059)			0.259***	(0.077)
Gene Editing*Children			0.008	(0.056)			0.012	(0.073)
Gene Editing*Consumer Price Fairness			-0.028	(0.058)			0.023	(0.076)
Gene Editing*Farmer Price Fairness			-0.077	(0.060)			-0.156*	(0.079)
Gene Editing*Outcome Fairness			-0.290***	(0.059)			-0.374***	(0.077)
Gene Editing*Trust			0.0	(0.001)			0.002	(0.002)
Gene Editing*Knowledge of Technology			0.022	(0.012)			0.039*	(0.016)

Table 5. Continued

	Conditional Logit				Random Parameters Logit			
	Model I		Model II		Model III		Model IV	
	β	SE	β	SE	β	SE	β	SE
Gene Editing*World View			0.075***	(0.015)			0.084***	(0.020)
Gene Editing*Fries Eating Frequency			0.079**	(0.030)			0.093*	(0.040)
Government*Age			-0.009***	(0.002)			-0.011***	(0.003)
Government*Male			0.211***	(0.054)			0.223**	(0.079)
Government*Children			0.018	(0.052)			0.076	(0.076)
Government*Consumer Price Fairness			-0.082	(0.054)			-0.167*	(0.079)
Government*Farmer Price Fairness			0.037	(0.056)			0.074	(0.082)
Government*Outcome Fairness			-0.050	(0.054)			-0.037	(0.080)
Government*Trust			-0.002	(0.001)			-0.002	(0.002)
Government*Knowledge of Technology			-0.010	(0.011)			-0.021	(0.017)
Government*World View			0.045**	(0.014)			0.065**	(0.020)
Government*Fries Eating Frequency			0.111***	(0.028)			0.119**	(0.041)
J.R. Simplot*Age			-0.009***	(0.002)			-0.010***	(0.002)
J.R. Simplot*Male			0.200***	(0.056)			0.177*	(0.071)
J.R. Simplot*Children			-0.055	(0.054)			-0.062	(0.068)
J.R. Simplot*Consumer Price Fairness			-0.033	(0.055)			-0.040	(0.071)
J.R. Simplot*Farmer Price Fairness			0.025	(0.058)			0.024	(0.074)
J.R. Simplot*Outcome Fairness			-0.187***	(0.057)			-0.165*	(0.072)
J.R. Simplot*Trust			-0.003	(0.001)			-0.004*	(0.002)
J.R. Simplot*Knowledge of Technology			-0.006	(0.012)			-0.012	(0.015)
J.R. Simplot*World View			0.002	(0.014)			0.004	(0.018)
J.R. Simplot*Fries Eating Frequency			0.175***	(0.029)			0.194***	(0.037)
Monsanto*Age			-0.008***	(0.002)			-0.010***	(0.003)
Monsanto*Male			0.124*	(0.062)			0.126	(0.083)

Table 5. Continued								
	Conditional Logit				Random Parameters Logit			
	Model I		Model II		Model III		Model IV	
	β	SE	β	SE	β	SE	β	SE
Monsanto*Children			0.010	(0.059)			0.013	(0.079)
Monsanto*Consumer Price Fairness			-0.014	(0.061)			-0.019	(0.081)
Monsanto*Farmer Price Fairness			-0.066	(0.063)			-0.123	(0.085)
Monsanto*Outcome Fairness			-0.229***	(0.063)			-0.276***	(0.083)
Monsanto*Trust			-0.001	(0.001)			-0.001	(0.002)
Monsanto*Knowledge of Technology			0.005	(0.013)			0.006	(0.018)
Monsanto*World View			0.004	(0.016)			0.006	(0.021)
Monsanto*Fries Eating Frequency			0.095**	(0.031)			0.106*	(0.043)
Standard Deviations of Parameter Distributions								
Acrylamide					1.740***	(0.045)	1.600***	(0.045)
Waste					1.314***	(0.042)	1.218***	(0.042)
Pesticide					1.537***	(0.044)	1.519***	(0.046)
GM Cisgenic					0.585***	(0.074)	0.317**	(0.103)
GM Transgenic					0.450***	(0.073)	0.047	(0.156)
Gene Editing					0.393**	(0.126)	0.450***	(0.100)
Government					1.106***	(0.052)	1.106***	(0.054)
J.R. Simplot					0.402***	(0.086)	0.544***	(0.068)
Monsanto					0.817***	(0.067)	0.792***	(0.066)
Log likelihood	-28,496.8		-27,202.2		-24,524.1		-23,854.9	
Number of observations	24,112		24,088		24,112		24,088	
Number of choice sets	8		8		8		8	
Sample Size	3,014		3,011		3,014		3,011	

Notes: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

Table 6. Mean willingness to pay for frozen French-fried potatoes (base price: $3.00/kg)

	Conditional Logit		Random Parameters Logit	
	Model I	Model II	Model III	Model IV
Individual Specific Variables	No	Yes	No	Yes
Product Trait (base=no benefit)				
Acrylamide reduction	1.45***	1.42***	1.07***	1.06***
	(0.060)	(0.183)	(0.083)	(0.261)
Waste reduction	0.68***	0.62***	0.27***	0.22
	(0.057)	(0.178)	(0.073)	(0.226)
Pesticide reduction	1.31***	1.27***	1.07***	0.97***
	(0.060)	(0.178)	(0.077)	(0.244)
Breeding Technology (base=conventional)				
GM transgenic	-2.39***	-2.52***	-2.31***	-2.41***
	(0.088)	(0.247)	(0.085)	(0.227)
GM cisgenic/intragenic	-2.23***	-2.32***	-2.18***	-2.23***
	(0.083)	(0.249)	(0.082)	(0.231)
Gene editing	-2.00***	-2.05***	-1.97***	-2.10***
	(0.084)	(0.254)	(0.083)	(0.246)
Developer (base=no source identified)				
Government	0.75***	0.71***	0.72***	0.65***
	(0.077)	(0.233)	(0.083)	(0.252)
J.R. Simplot Company	-0.03	-0.09	-0.04	-0.06
	(0.080)	(0.242)	(0.075)	(0.229)
Monsanto	-0.87***	-0.91***	-0.81***	-0.86***
	(0.086)	(0.265)	(0.094)	(0.265)
Number of respondents	3,014	3,011	3,014	3,011

Note: Standard errors in parentheses; ***, ** and * implies significance at 1%, 5% and 10% level

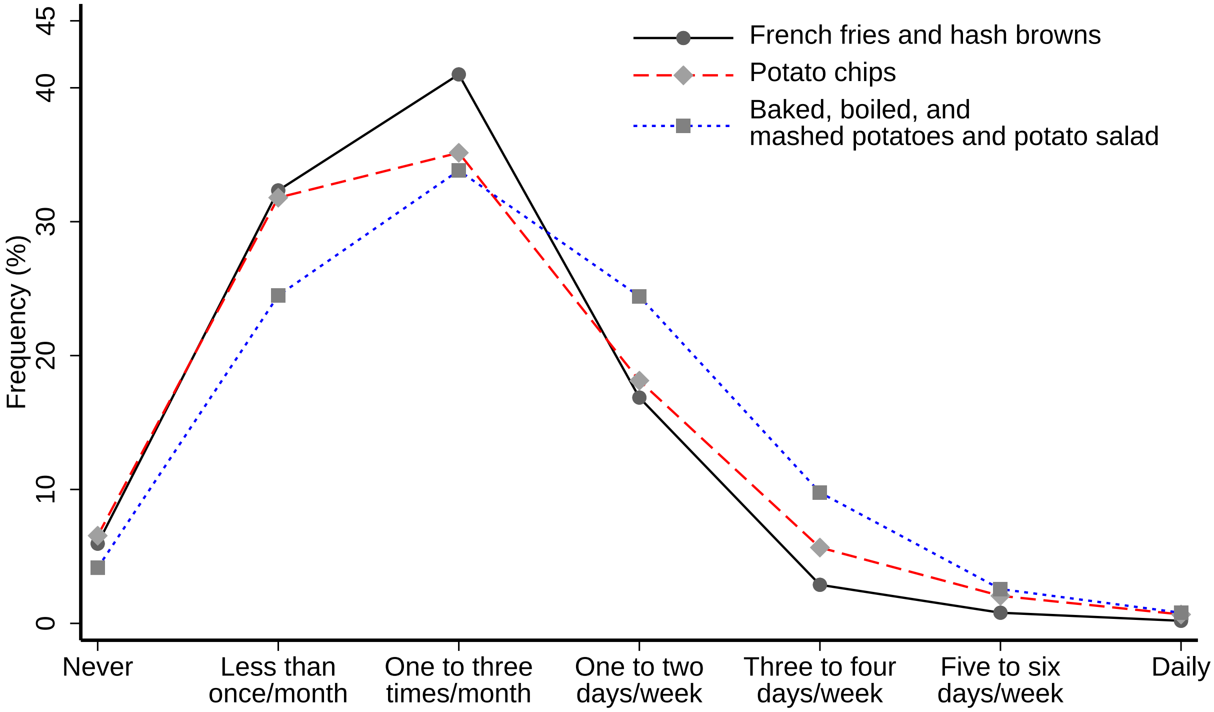

Figure 1. Eating frequency of potatoes and potato products

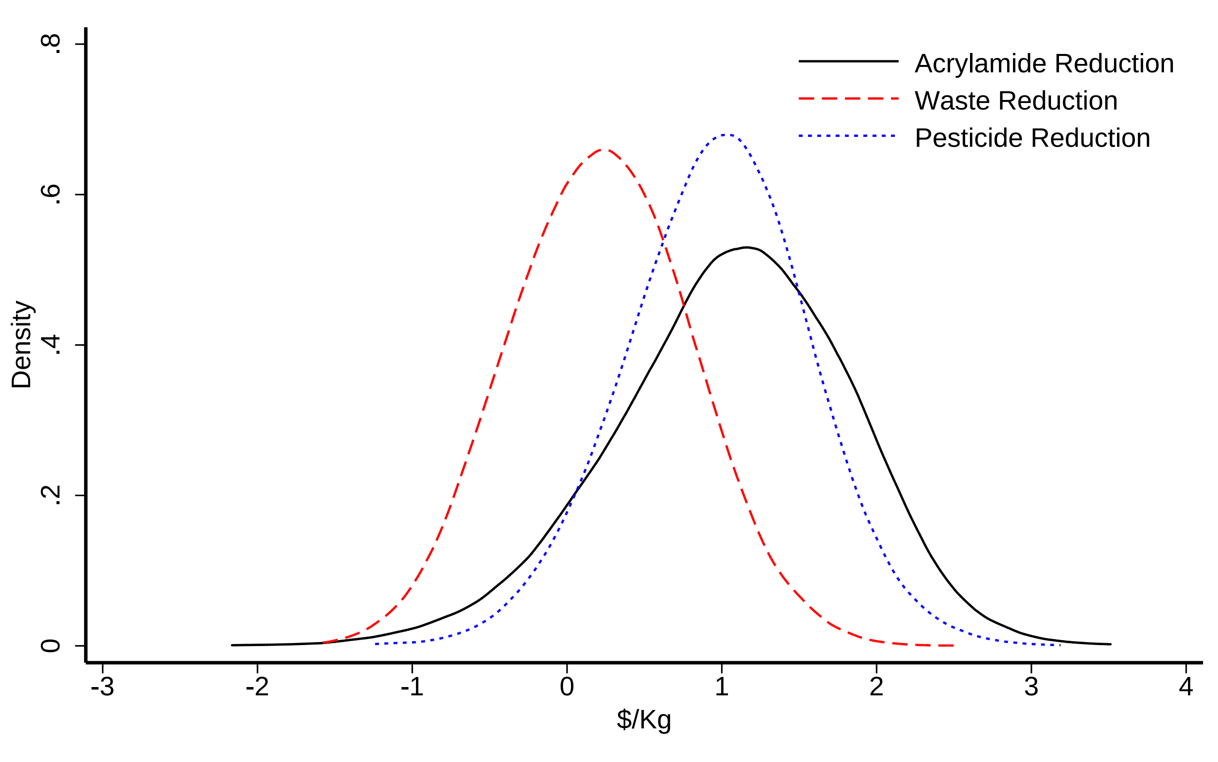

Figure 2. Distribution of individual WTP for product traits

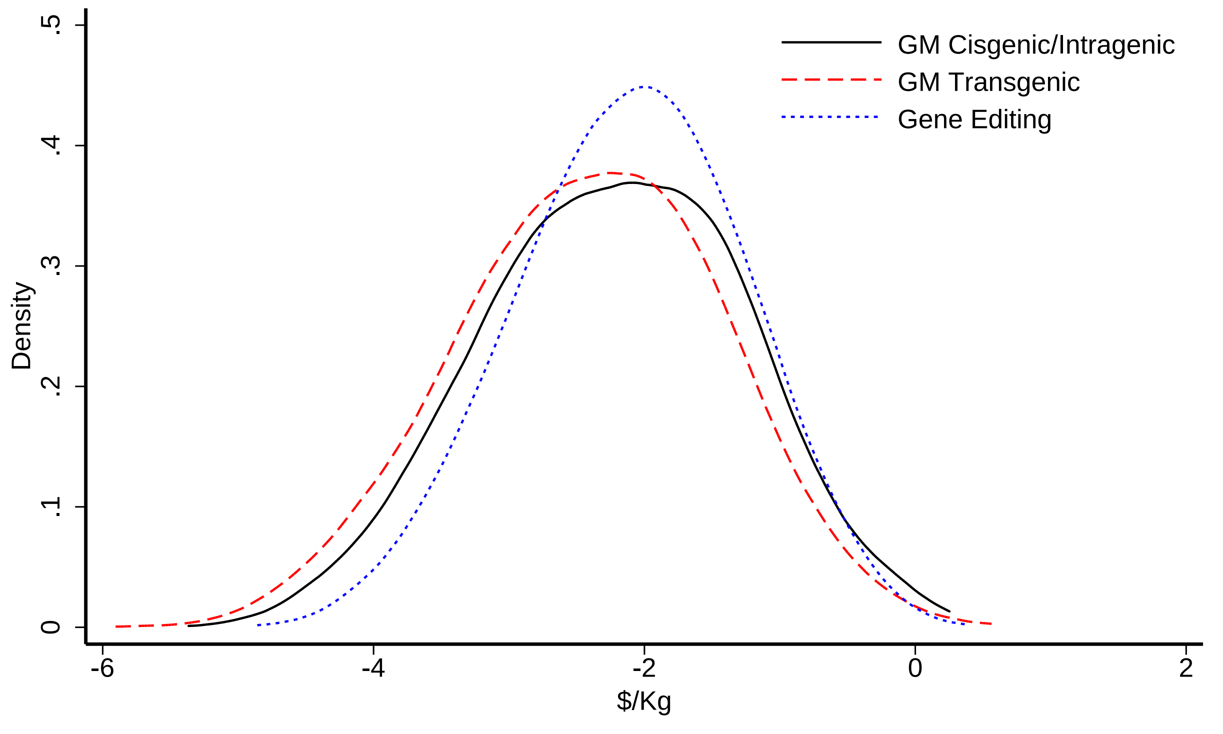

Figure 3. Distribution of individual WTP for breeding technologies

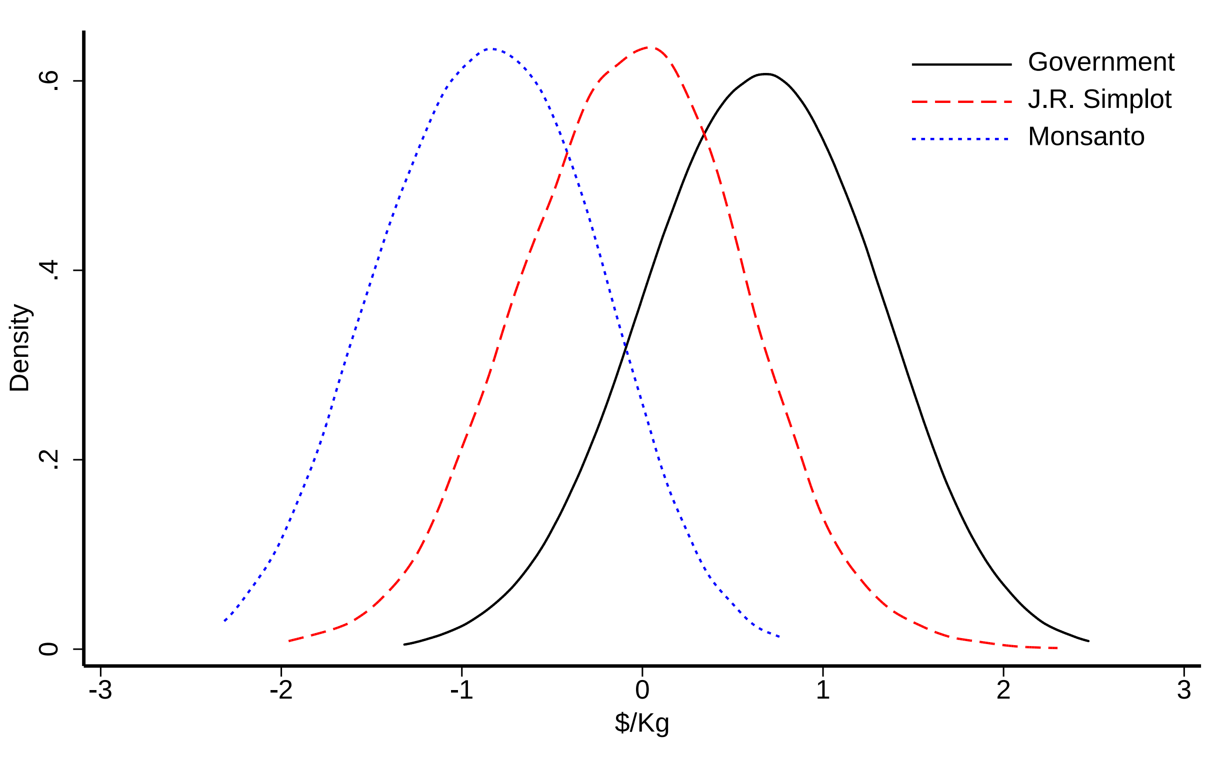

Figure 4. Distribution of individual WTP for developers

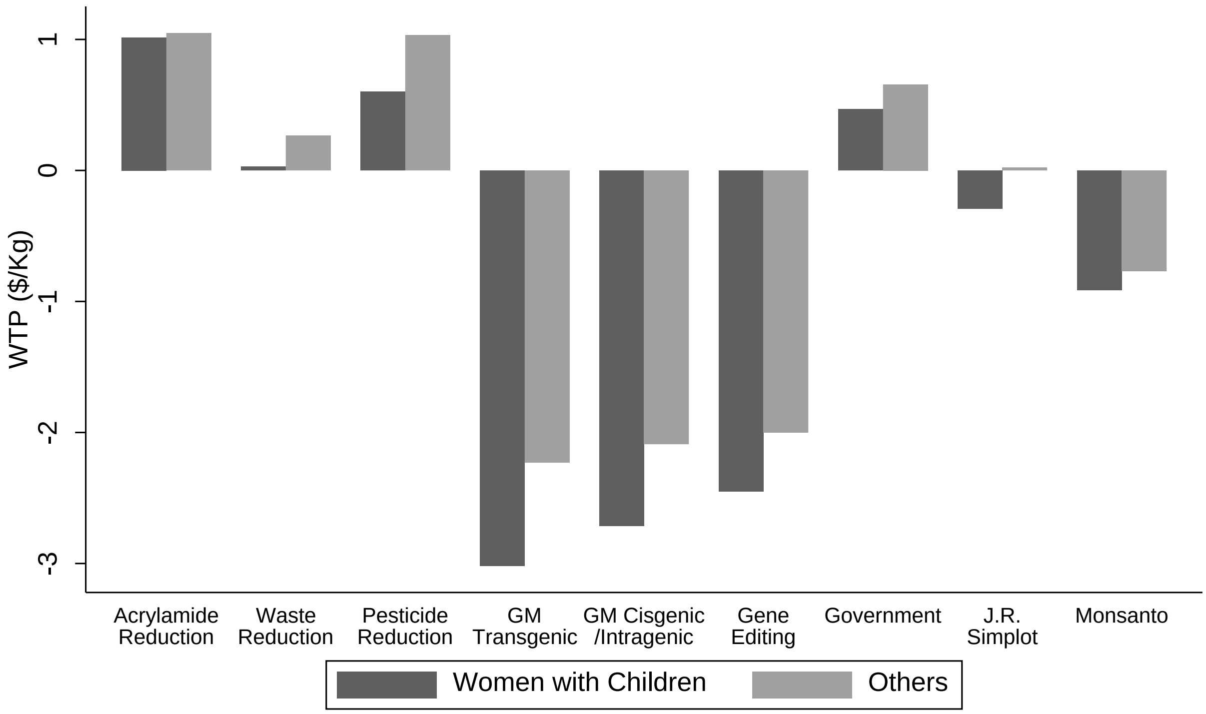

Figure 5. Comparison of WTP: women with children (N=666) versus other respondents (N=2,345)

Appendix: Information provided to participants before the choice experiment questions

In this research, we are looking at the breeding of potatoes with different attributes including level of acrylamide formed, food waste generated, and on-farm pesticide applied.

- Acrylamide has been discovered in foods containing certain natural sugars when cooked at high temperatures (above roughly 250 °F), such as French fries, hash browns and potato chips. It is a toxin and possible carcinogen in humans
- Potatoes with black spot bruising/browning are often a cause of food waste
- Potatoes are susceptible to late blight which is a disease that caused the potato famine in Ireland and that increased the use of pesticides

In this research, **breeding technology** refers to the type of breeding practice used to produce the crops. The four technologies considered in this research include:

- **GM cisgenic/intragenic** technology which introduces new genes from the same or sexually compatible donor into a host plant
- **GM transgenic** technology which introduces new genes from a sexually incompatible donor into a host plant
- **Gene editing** technology which is more advanced and can precisely and site-specifically add, modify or delete existing genes in a crop plant, and
- **Conventional technologies** which refer to standard crop breeding practices in Canada

In this research, it is assumed that the potatoes consumed in Canada are bred either by the government or by companies including the J.R. Simplot Company and Monsanto.

- **J.R. Simplot Company** is a global food and agribusiness company that pioneers innovations in plant nutrition and processing
- **Monsanto** is a global agriculture company that develops products and tools to assist farmers to grow crops more efficiently

Please assume you have walked into a supermarket and you wish to purchase a 1kg bag of frozen French fried potatoes. The price for frozen French fried potatoes in Canada is $3.00 per 1kg. Please consider each of the eight scenarios below and indicate your choice for each scenario. Please select Option 1, Option 2, Option 3 or 'I would not purchase any of these product' for each scenario. Please make your decision as if these were the only French fried potatoes in the supermarket.