CANADIAN CONSUMER PERCEPTION OF GENOME-EDITED FOOD PRODUCTS

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Abstract

New Breeding techniques (NBTs) have been developed in the last decade and allow for faster, more precise and less expensive genetic modification of new plant varieties with desired traits. Genome editing technology is potentially more socially acceptable than transgenics due to the possibility to add, delete, or alter specific parts of the DNA sequence without adding foreign genetic material. This thesis examines consumers' perceptions of food produced using genome editing techniques. To accomplish this, an online survey was administered across Canada, resulting in a sample of 503 participants. Econometric analysis was used to examine the relationship between consumers' perceptions of food produced using genome editing technology and consumer preferences. Additional analysis was conducted for the other two food technologies (transgenics and organic) and results were compared. Results suggest that surveyed Canadians have better perceptions of genome editing technology and four factors are relevant to predict consumers' levels of perception: trust in Canada's food safety system, their food technology neophobia score, knowledge of genetics, and self-rated knowledge of genome editing. Food technology neophobia scores and knowledge both impact willingness to consume genome-edited and transgenics food products but not organic food products.

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List of abbreviations

BWS	Best-worst scaling
CRISPR	Clustered regularly interspaced short palindromic repeats
DNA	Deoxyribonucleic acid
FNS	Food neophobia scale
FTNS	Food technology neophobia score
GM	Genetically modified
GMO	Genetically modified organisms
MNL	Multinomial logit model
NBT	New plant breeding techniques
OLM	Ordered logit model
TALEN	Transcription activator-like effector nucleases
WTC	Willingness to consume
WTP	Willingness to pay
ZFN	Zinc finger nuclei

Chapter 1

Introduction

1.1 Background

Genetically modified (GM) crops have been adopted at unprecedented rates since they were first planted in 1996 beginning with 1.7 million ha, and expanding to 114 million ha by 2007, 181 million ha by 2014, and 191.7 million hectares by 2018 (De Groote et al., 2016; Pino et al., 2015; Bett et al., 2010; ISAAA, 2018). Exponential growth was due in large part to the fact that GM crops offer many advantages besides the high potential for increasing food production. According to Cohen and Paarlberg (2004), recombinant deoxyribonucleic acid (DNA) techniques provide plant breeders with abilities to introduce traits into plants not possible through traditional plant breeding. The most important examples have been the transferring of the bacillus thuringiensis gene (Cohen, 2004) and several herbicide-tolerant traits such as dicamba, glufasinate, glyphosate, imazanomx isoxaflutole, mesotrione, oxynil and sulfonylurea (ISSAA, 2018), which reduces chemical use by up to 36% (Klümper and Qaim, 2014).

Despite the benefits to farmers, the use of GM products in food remains controversial (Bett et al., 2010). GM foods have sparked negative reactions among both individual consumers and organizations (e.g., non-governmental organizations, voluntary associations) (Pino et al., 2015). The main reasons are perceived environmental and human health impacts such as allergenicity, toxicity, carcinogenicity, and altered nutritional food quality (Azadi and Ho, 2010). Opponents have argued that science is unable to predict the long-term effects of consuming GM food products or the production impacts of biotechnology on the environment. Such allegations are often made without considering the consensus in the scientific community that currently available GM foods are safe for human consumption (Groote et al., 2016). According to Ishii and Araki (2016), the negative attitude toward genetically modified organisms (GMOs) is associated with insufficient information regarding GMOs, the lack of trust in developers and/or relevant regulations, poor risk-benefit communication, and consumers' ethical values.

The controversy surrounding GM food products has extended to new plant breeding techniques (NBTs) that have arisen as the next generation of gene technology (Tanaka, 2017). NBTs have given rise to new plant varieties with desired traits, that can be developed faster and more precisely compared to conventional breeding techniques (Madre and Agostino, 2017). Genome editing, a particular type of NBT, is expected to make genetic engineering/mediated crop breeding more socially acceptable (Ishii and Araki, 2016). According to the researchers, genome editing can be used to develop crop varieties without introducing transgenes, which have hampered the regulatory review and public acceptance of GM crops.

While many people have not accepted GMOs despite potential benefits such as the potential to promote food security (Helliwell et al., 2017), the same might not be true for plants arising from NBTs. In recent years studies have revealed that consumers' attitudes toward crops developed using NBTs have been somewhat more positive than their attitudes toward GM crops (e.g. Muringai et al., 2019; Tanaka, 2017). Genome editing is considered by the community of international scientists as key to future crop improvement, through enhanced agronomic performance (Lassoued et al., 2018). Notwithstanding, in Canada, there is a high level of uncertainty about the potential benefits and risks pertaining to the products of new breeding techniques. According to McFadden and Smyth (2019), Canadians believe in the benefits of crops produced using NBTs, however, they also consider risks such as the loss of biodiversity.

1.2 Problem statement and research objectives

The literature suggests that individual acceptance of GM crops is made under uncertainty, ignoring the multiple advantages that GM technology offers (McFadden and Lusk, 2015). According to Lucht (2015), NBTs do not give rise to some consumers' concerns as is the case with transgenic crops, given the possibility to modify genes without using foreign genetic material. Based on this criterion, an important part of the scientific community suggests that most transgenic-free NBT crops need to be treated differently from GM crops in terms of regulation and use.

While studies on consumer perceptions and public attitudes toward GM food and NBTs have been conducted in different countries using different methods, not much is known about Canadian consumers' perceptions about NBT-derived food products or whether perceptions differ for food produced using genetic modification. To fill this gap, this study uses survey data to explore the main drivers affecting Canadian consumer perceptions of genome-edited food and how that compares to perceptions of transgenic and organic food products. The thesis also examines the willingness to consume (WTC) genome-edited food products compared to GM and organic alternatives.

This study aims to answer the following research question: “What are the factors that affect consumers’ attitudes towards genome editing in Canada? The study is based on consumer perception and willingness to consume. The major objectives are:

- Estimate the consumer perception of genome editing technology in Canada
- Determinate the main drivers that affect consumer perception of genome editing technology in Canada.
- Determine the main drivers that affect the willingness to consume three genome-edited food products (apple, potato and milk).
- Examine the results by comparing the drivers that affect consumer perception and willingness to consume GM.

Many variables can influence attitudes toward food technology. Personal traits, risk concerns and benefit perceptions may drive food preferences, including preferences for technologies used to produce food (Hudson et al., 2015). Many studies have shown that consumers exhibit a high level of concern regarding novel food (Baker and Mazzocco, 2002), thus, lack of consumer acceptance could potentially restrict the commercialization and consumption of food products derived via NBTs. This research is important because it will help to generate knowledge of consumer preferences and acceptance of foods produced using NBTs and the drivers that explain such preferences. Understanding how attitudes affect the consumption of genome-edited food products could benefit stakeholders and regulation entities by enhancing their ability to design appropriate strategies to guarantee acceptance in the market.

1.3 Organization of the thesis

The reminder of the thesis is divided into five chapters. Chapter 2 is a literature review of consumer perceptions of GM food products and the most recent studies about perceptions of foods produced using NBTs and current regulatory rules. The chapter also includes a brief description of NBTs and details of genome editing. Chapter 3 explains the methods used in the study, including three different econometric models: multinomial logit model, ordered logit model, and probit model, each run with the survey data. Additionally, I describe the survey design used for data collection to examine consumer perceptions and WTC products of technologies. Chapter 4 presents descriptive statistics and data analysis. Chapter 5 discusses results followed by Chapter 6 with conclusions, study limitations and recommendations for further research.

Chapter 2

Literature Review

This chapter is a literature-based review of previous studies relating to consumer perception of GM and NBT technologies and the factors that influence consumer perception. It draws upon a thorough review of relevant social sciences literature in order to identify the methodology used in previous studies, key findings and relationships to our goal. The objective is to describe a series of factors that are included in the econometric models in Chapter 3. The chapter includes four sections. Section 2.1 provides an overview of new breeding techniques. section 2.2: covers the literature examining consumers' perception of biotech products. Section 2.3 defines the challenges for development of NBTs and finally, Section 2.4 provides an overview of the factors that influence consumer perceptions.

2.1 Overview of New Breeding Techniques

NBTs have advanced over the last decade allowing scientists to modify crops more efficiently (faster, cheaper, and more precisely) compared to conventional breeding techniques (mutagenesis, translocation breeding, and intergeneric crosses), which cannot generate targeted outcomes (Hartung and Schiemann, 2014; Lassoued et al., 2018). Conventional plant breeding generally relies on techniques with unpredictable outcomes, requiring long-term research to obtain desired characteristics to be used to develop new plant varieties. In the same way, transgenic techniques develop new plants using "foreign" genes, and often come from unrelated species (Madre and Agostino, 2017). Alternatively, NBTs rely on altering or deleting specific sites of a genome offering greater precision and resulting in shorter development times as compared to transgenic methods.

Genome editing is a form of NBTs. Though different in detail, genome editing allows the direct modification of plant genetic material (usually DNA) at specific locations in the genome (Kirkpatrick, 2017). According to Carroll (2017), genome editing is highly efficient because it makes a targeted DNA double-strand break (DSB) in the chromosomal sequence of interest by adding, deleting, or altering parts of the DNA sequence while it is repaired. This differs from the transgenic approach, which involves the introduction of foreign genetic material into unspecified locations within the plant genome (Zhang et al., 2017). Various genome-editing tools include:

Zinc Finger Nuclei (ZFNs) is one of the oldest gene editing techniques that introduces site-specific mutations into the plant genome (Lassoued et al., 2018). It was developed in the 1990s by Sangamo BioSciences (Arora and Narula, 2017). Genomic modification can either be restricted to one or few nucleotides (ZFN 1 and ZFN 2) or include the insertion or substitution of a gene (ZFN 3) (FSANZ, 2012; Lassoued et al., 2018). In the agriculture field, ZFNs have been successfully employed in tobacco, maize, soybean, etc. (Curtin et al., 2011; Ainley et al., 2013).

Transcription activator-like effector nucleases (TALENs) are fusions of the FokI cleavage domain and DNA-binding domains derived from TALEN proteins (Gaj et al., 2013). TALENs induce targeted DSBs that activate DNA damage response pathways and enable custom alterations. Over 50 genes have been targeted for mutations using this genome editing technique in plants, including: arabidopsis, barley, maize, potato, tobacco, rice, soybean, sugarcane, tomato, and wheat (Li et al., 2012; Malzahn et al., 2017; Lassoued et al., 2018).

The clustered regularly interspaced short palindromic repeats (CRISPR) or associated protein (CRISPR/Cas9) technique offers advantages over ZNFs and TALENs technologies such as: simplicity, accessibility, accuracy, versatility, and low cost (Rojas-Vasquez and Gatica-Arias, 2019; Smyth, 2019). Applications for the technology include enhanced yields and nutritional value, stress tolerance and herbicide resistance (Rojas-Vasquez and Gatica-Arias, 2019). Research done on CRISPR/Cas9-edited crops include acrylamide free potatoes, non-browning apples, low phytic acid in maize, sweet orange, mushrooms, wheat, rice, soybeans, and tomatoes (Arora and Narula, 2017; Lassoued et al., 2018).

2.2 Challenges for development of NBTs

Helliwell (2017) based his study on a focus group and nine semi-structured interviews of fourteen participants of European non-governmental organizations with an interest in genome-edited crops. Most of the participants disclaim genome editing technology potential to solve food insecurity, arguing that the problem is not one of food quantity but one of access and control. They also considerer that food security is used to justify genome editing, but that it has failed since crops are monocultures and are thereby unsustainable. Participants also considered that supporters of genome editing technology differentiate genome editing with "traditional" genetic modification by using nomenclature such as new plant breeding techniques. Notwithstanding, respondents found genome editing techniques to offer marginal solutions to improve food security by providing new options for insect and herbicide resistance.

Ishii and Araki (2017) analyzed the regulatory responses to genome-edited crops from four countries that currently develop GM food products: the U.S., Argentina, Sweden, and New Zealand. Argentina and the U.S. assume a positive attitude towards genome-edited product regulation. In the case of Argentina, the government established new regulations to encourage rapid development of transgene-free crops generated by NBTs. In the same way, Sweden deregulated transgene-free plants. Alternatively, New Zealand modified GM regulations to include crops bred using genome editing to fall under the same category as all other GM crops.

Lassoued et al. (2018) used a Delphi method to ask an international panel of 433 experts to identify the main biotechnologies for improving global food security. Results indicated that genome editing, led by CRISPR/Cas9 is key for future crop improvement and yields. Access to market was identified as the main limiting factor to the success of NBT implementation. Furthermore, Smyth and Lassoued (2019) explored the economic impacts of regulating NBTs specifically in Europe. The researchers argue that in the last 30 years, agriculture R&D investment had fallen dramatically reducing the competitiveness of European farmers in the production and trade of agricultural commodities. This was due to the dependence on older, less efficient breeding technologies.

2.3 Consumer perceptions of biotech products

2.3.1 Consumer perception of GM food products

Several studies such as those conducted by Lusk (2002), McFadden et al. (2015), Prati et al. (2012), and Vecchione et al. (2014), have assessed consumers' perceptions of GM foods and have been used to characterize consumer sentiment and to motivate more precautionary polices for GM foods (McFadden and Lusk, 2016). The results reveal a widespread concern about the use of GM technology, despite all the scientific evidence about the benefits of GM products. According to

McFadden and Lusk (2016), these apparent consumer doubts could lead to a climate that blocks research and lowers the potential return to investments in biotechnology applications.

McFadden and Lusk (2015) focused on the facts that influence public debate about newly developed GM foods such as the Arctic apple, fast-growing salmon, Golden Rice, and virus-resistant oranges, all of which offer direct benefits to consumers. The main purpose of their study was to determine whether the level of acceptance varied in response to the degree of processing and food type. A survey was conducted in 2014 across the U.S. revealing that the rejection of GM products largely applied to food products that are consumed fresh, whereas processed GM products are more widely accepted by the public.

In a second study, McFadden and Lusk (2015) used a nationwide online panel in the U.S. to assess public opinion. Results suggest that American respondents had low levels of knowledge and several misperceptions about GM food. A remarkable finding was American consumers' limited knowledge of science as evidenced through their support of nonsensical policies like "DNA labeling." The results show that a similar number of consumers prefer mandatory labeling of foods containing DNA as do those who prefer mandatory labeling of GM foods. The results suggest that consumers in the U.S. know less than what they think they know about GM food products. The study implies that consumers prefer that decisions about mandatory labels should be implemented through additional consultation with the scientific community.

McFadden and Lusk (2016) also studied how the U.S. population processes and responds to scientific information regarding global warming and genetically modified food. The study determined respondents processed information based on beliefs, thus manifesting cognitive biases that cause belief perseverance or biased information assimilation for controversial agricultural and environmental issues. These results suggest that the extent to which new information is adopted depends on the extent to which such information conforms to prior beliefs.

In 2014, Vecchione et al. carried out a study to examine the relationship between consumer knowledge, attitude toward GM foods, and the prevalence of GMO labeling in New Jersey supermarkets. The research was conducted using a cross-sectional study design. Researchers recruited 331 supermarket consumers who were Montclair State University students, faculty, and staff. The researchers found that attitudes towards GM foods do not always correlate with purchasing attitude. These results are consistent with Prati et al. (2012), while contradicting the Lusk et al. (2002) findings, that show a strong correlation between attitude and behaviour when it comes to purchasing intention. Focusing on the relation between knowledge and attitude, Vecchione et al. (2014) found a slight to moderate correlation, which is supported by Huffman et al. (2007) but contradicts Koivisto al. (2003) who found consumers with higher levels of knowledge regarding GM foods to have more positive attitudes towards these foods.

In 2008, Henson et al. evaluated consumer attitudes toward 21 food and non-food technologies in Canada including genetic modification. The study presented a repertory grid to 36 consumers. For food technologies, perceived risks and benefits were determinant drivers of consumers' acceptability. Pesticides in food production and genetic modification of meat animals are perceived to be high risk and low benefit, giving rise to higher skepticism regarding consumption.

Matin et al. (2013), used two online surveys to measure Canadian consumers' attitudes and willingness to pay (WTP) for juice produced by nanotechnology, and pork chops produced from pigs bred using genomic modification. Results highlight that most Canadians have limited knowledge about the use of genomic information, thus they do not identify benefits for these products, and they are not willing to pay a premium for food products using these technologies.

Agriculture and Agri-food Canada (2013) examined temporal changes in Canadian consumer support/opposition for biotechnology applications. The study used a logit regression model with information provided from public opinion surveys. Results indicate that Canadian consumers are polarized in their opinions. It is interesting to note that information received towards the end of the study was likely to be more positive and increased the probability of consumers becoming pro biotech. Results also showed an increasing confidence in the regulatory system of biotechnology applications in Canada.

Goddard et al. (2016) identified consumers' WTC different food products and the factors that explain preferences. The study recruited 100 individuals (staff and students) at the University of Alberta to measure food consumption habits, perceptions, attitudes, and preferences for food produced with different technologies including genetic modification. Results indicate that most respondents accept genetic modification. However, many were concerned particularly with its use in improving disease resilience, feed efficiency, and human and animal health.

A second study by Health Canada through the Strategic Council (2016), measured Canadians' opinions about GM foods and the possible issues related to the application of science and technology in food production and manufacturing. The study used two techniques: a qualitative method (two focus groups of eight people each) and a quantitative method (a 15-minute online survey, 2018 respondents). Qualitative results showed that Canada has a reasonably robust and thorough food safety system, with price being the most important factor in making food purchasing decisions. Survey respondents had limited scientific literacy: the majority had heard the term GM food, however most of them were unable to accurately explain the acronym (GMO) in full. Similar results were obtained from the quantitative data: for example, respondents also showed a considerable level of confidence in Canada's food safety system and price was also ranked as the top consideration when shopping. However, Canadians' understanding of genetic modification was minimal.

Goddard et al. (2018) collected data using two national online surveys (1800 people each) to identify food integrity concerns about GM and nanotechnology applications in food products in Canada. The results suggest that trust in food systems improves perceptions about food integrity of the two technologies. On the other hand, trust in advocacy organizations generate higher concerns levels. Health engagement had significant and positive impact on concern for food integrity, GM, and nanotechnology applications.

Charlebois et al. (2019), measure Canadian attitudes towards genetic engineering for plant-based foods and livestock using survey data collected from 1,049 respondents. Results show that 44% of respondents were confused about health effects related to genetically engineered food, and that 52% were uncertain about consuming products. Furthermore, less than half (40%) believed that testing was not enough to protect consumers. Animal-based GM products seemed to concern more than plant-based GM foods, and familiarity was identified as important driver to the adoption of biotechnologies for consumers. Finally, the study revealed that respondents had low scientific literacy.

Finally, several researchers have measured consumer perceptions of GM across different countries around the world finding a range of acceptability and knowledge (Aleksejeva 2014; Bett et al., 2010; Ceccoli and Hixon 2012; Curtis et al., 2004; Groote et al., 2016; Huang et al., 2005;

Jurkiewicz et al., 2014; Kikulwe et al., 2011; Wolf et al., 2012.; Pino et al., 2015; Tas et al., 2014; Tsourgiannis et al., 2010; Turker et al., 2013; Zhang et al., 2010)

2.3.2 Consumer perceptions of NBTs

Lucht (2015) examined consumer attitudes regarding NBTs, pointing out public rejection of traditional genetic engineering approaches. According to the author, researchers and seed companies should consider that this technology will encourage positive consumer perceptions: some NBTs do not involve genes transferred across species boundaries and the genomic changes by genome-edited tools often are indistinguishable from those present in plants developed by classical breeding. The research refers to sources that support this statement, such as a Eurobarometer survey (2010), in which respondents chose "genetically modified ingredients in food or drinks" as the fourth most worrying issue at that time. This perception has changed in the last years as, updated information from the Eurobarometer (2019) identified the same statement as the eighth most worrying issue, been recognized as a concern by only 27% of respondents.

Tanaka (2017) explored the psychological factors that affect the acceptance of products of NBTs in Japan based on a survey conducted in 2015 with 657 randomly selected respondents. The results showed that consumers' attitudes toward NBT-derived crops are somewhat more positive than their attitudes toward GM crops. This is because the meaning of NBTs was explained to participants. Alternatively, when the term "gene recombination" was used, respondents displayed negative attitudes toward NBT crops. The results showed that perceived risk, perceived benefit, trust, a sense of bioethics, anxiety, and anger play important roles in personal and public acceptance of products of NBTs.

Shew et al. (2018) conducted a multi-country assessment of willingness to pay and WTC using a hypothetical CRISPR rice (*Oriza sativa*) compared to a GM rice. Researchers used an online "artefactual field experiment" multi-country survey in the US, Canada, Belgium, France, and Australia. Results indicated the WTC both GM and CRISPR foods in the USA (56%), Canada (47%), Belgium (46%), France (30%), and Australia (51%). Participants were more willing to consume foods produced with CRISPR rather than GM. Familiarity with GM technology had a positive impact on the WTC in Australia (CRISPR and GM), Canada and the US (GM), and France

(CRISPR). The main drivers of WTC CRISPR and GM were perceptions of safety, environmental attitudes, technology familiarity, and previous experience.

Gatica-Arias et al. (2019), analyzed perceptions and attitudes toward the production and potential consumption of CRISPR/Cas9 crops in Costa Rica. They conducted a telephone survey among 1018 Costa Ricans between February 2018 and April 2018. Results show acceptance for genome editing with respect to nature conservation (85%), curing diseases in animals (83%), and crop improvement (81%). Approximately half the participants reported perceived low or no risk to the quality of life, health, and the environment while just over one third perceived medium or high risk.

Kato-Nitta et al. (2019) analyzed attitudes toward genome-edited crops compared to genetic modification and conventional breeding in Japan. Two web-based surveys were conducted with 3197 participants. Results demonstrated that scientific knowledge affects people's risk, benefit and value perceptions. Public tend to have more positive attitudes toward genome editing in comparison to genetic modification.

Yang and Hobbs (2020), analyzed information framing effects in consumer perception among genome editing (CRISPR-Cas9). The study compares the effectiveness of using logical-scientific versus narrative information to communicate with consumers about novel technologies in an online survey of 804 participants across Canada. Results showed that narratives help reduce negative perceptions regarding agricultural and food technologies.

Muringai et al. (2020), examined consumer acceptance of GM and genome-edited potatoes in Canada. Random utility models were used to analyze the value that consumers recognize from the attributes of the GM and genome-edited potatoes. Finding suggest that discounted prices are required to buy both GM and genome-edited potatoes technologies however consumers are willing to pay more for a health attribute (reduced acrylamide) as compared to environmental benefits. Other relevant finding suggest that individuals are more accepting of genome editing than GM technology and government is the most preferred developer of genome-edited potatoes.

Yang and Hobbs (2020), examined the influence of cultural values on food choice attitudes. They made use of a survey to analyze Canadians' cultural values about hierarchy-egalitarianism and individualism-communitarianism and their relationship with the perception about genome editing technology, genetic modification and edible coating. The study found that pre-existing cultural values are significant determinants of choice attitudes. Individuals pre-disposed towards a hierarchical worldview are more accepting of novel food technologies, in comparison to individuals with a communitarian worldview.

2.4 Factors that influence consumer perception

Cox and Evan (2008) developed a psychometric tool to identify neophobia levels in relation to technology based on the Food Neophobia Scale (FNS) developed by Pliner and Hobden in 1992. The food technology neophobia score (FTNS) has been recognized as a valid and accurate tool for assessing consumer fear of novel food technologies because of its specific focus on technology rather than food (Henriques et al., 2008; Evans et al., 2010; Matin et al., 2012; Goddard et al., 2018).

The FTNS aggregates responses to 13 agree/disagree statements on a seven-point scale (Lusk et al., 2014). According to Verneau et al. (2013), the scale statements evaluate items, which are divided into four components. The first component, "new food technologies are unnecessary" measures feelings, worries about risks of new food technologies, uncertainty, adverse health effects, and minimisation of associated benefits. The second component "perception risks," includes environmental, ideological, and risk perception for the evaluation of aversion to new food technologies. The third component evaluates health benefit perceptions, and the fourth is focused on the information available in the media. Finally, the set of statements has been validated in different languages: Italian (e.g. Cattaneo et al., 2018), Portuguese (e.g. Vidigal et al., 2014) and Spanish (e.g. Schnettler et al, 2013).

Evans et al. (2010) validated the score for several novel food technologies such as pasteurization, fortification, and bioactives. According to Cattaneo et al. (2018), the FTNS has been used to predict consumer attitudes to food that made use of novel technologies such as genetic modification, nanotechnology, and modified atmosphere packaging.

According to Lister et al. (2017), food values have been proposed as a method of identifying stable constructs of consumers preferences. Lusk and Briggerman (2009) found that individuals' food choices could be explained by their preference for more abstract food quality attributes, known as "food values," including: naturalness, taste, price, safety, convenience, nutrition, tradition, origin, fairness, appearance, and environmental impact. According to Bazzani et al. (2018), the set of food values can explain individuals' food choices across a variety of food products and does not depend on the specific context under investigation.

Lusk and Briggeman (2009) used a best-worst scaling (BWS) approach to identify the relative importance people place on each food value. Results revealed that safety, nutrition, taste, and price are the most important values for consumers in the United States. Similar results were found in Norway (Bazzani et al., 2018), and when food values were used to assess consumer preferences for livestock products (Lister et al., 2017). Other studies where food values (or a version of them) have been used to assess food preferences, WTC, or willingness to pay for all class of food products coming from different food technologies include: Van Loo et al., (2013); Costa et al., (2014); Papplardo et al., (2016); Verain et al., (2015); Lister et al., (2017); Fitzsimmons and Cicia, (2018); Janssen, (2018); Perez-Villarreal et al., (2019).

According to De Groote et al. (2016), the nature of GM crops has raised many concerns about ethics and safety, in particular, to human health and the environment. Woodside et al. (2005) found that in Australia, food manufacturers rejected the use of GM products because of consumer concerns about risks. Similarly, Knight et al. (2008), found that distributors in Europe did not trust that consumers would accept GM food products despite the perceived benefits. Trust (individual or institutional) has been used as a variable to measure consumers' acceptance and attitudes to food technologies in many analyses (e.g. Mohr and Golley, 2016; Goddard et al, 2018). Goddard et al. (2018) have assessed consumers' perceptions of acceptance to novel technologies including trust variables in the analysis. For example, Siegrist et al. (2007) identified that trust in the food industry affects people's willingness to buy food produced using nanotechnology. Similarly, Siegrist et al. (2008) showed that trust in the food industry was important in influencing acceptance of functional foods and food affected by nanotechnology. Bocker and Nocella (2006), examined the impact that institutional trust has on acceptance of genetically modified foods, concluding that trust in public authorities will have an impact on risk perception and acceptance of new food technologies. Roosen et al. (2015) examined the relationship between trust and willingness to pay for functional food attributes in Canada and Germany. The study found that higher levels of trust are correlated with low levels of risk perception, and an increase in the willingness to pay for nanotechnology food products.

There has been considerable research done that indicates personal traits, risk, and benefit perception drives food choice (De Groote et al., 2016; Hudson et al., 2015; Matin et al. 2012). Understanding the different factors that influence attitudes toward food technology is fundamental to estimating perceptions of and WTC foods produced using genome editing technology.

The literature covered in this chapter explores different approaches used to study consumers' behavior toward novel food products such as transgenic, biotechnology and genome editing. The most recently literature based on genome editing shows, by and large, a somewhat more positive attitude in comparison to GM. Since the main objectives of this study are based on the estimation of the consumer perception of genome editing and the identification of main drivers that affect this perception, as well as willingness to consume genome-edited food products, the hypothesized effects of each one of the factors that are tested in the analysis section of this study are listed in table 2.1. Chapter 3 develops the econometrics models that are used to test each one of these hypotheses.

Table 2. 1 Deduced hypotheses

H1	Confidence in the food safety system will positively influence consumer perception of genome editing and willingness to consume genome-edited food products.
H2	Knowledge of genetics will positively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.
H3	Self-rated understating in genome editing will positively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.
H4	Neophilico characteristics will positively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.
H5	Neophobic characteristics will negatively influence consumer perception of genome editing and willingness to consume genome-edited food products.
H6	Perceived benefits will positively influence willingness to consume genome-edited food products
H7	Perceived environment risks will negatively influence willingness to consume genome-edited food products
H8	Perceived health risks will negatively influence willingness to consume genome-edited food products
H9	Perceived ethical concerns will negatively influence willingness to consume genome-edited food products
H10	Perceived equity concerns will negatively influence willingness to consume genome-edited food products

Chapter 3

Methods

This chapter outlines the estimation methods used in the analysis of consumers' perceptions and willingness to consume genome-edited food products. The objective of this chapter is to describe the different econometric models used in the analysis to test the hypotheses derived in Chapter 2. The chapter is organized as followed: section 3.1 offers a brief description of survey design and the data collection process, followed by the description of the variables (section 3.2). Section 3.3 describes the ordered logit model used to analyze the consumer perception of genome editing technology, section 3.4 describes the multinomial logit model used in the analysis of willingness to consume genome-edited food products and finally section 3.5 describes the probit model used in the willingness to consume novel food products analysis.

3.1 Data collection

The survey instrument was developed based on literature assessing the public's perceptions and attitudes towards new food technologies such as genetic modification, modern plant breeding techniques, and nanotechnology, previously discussed in chapter 2. The survey was conducted in August 2018 across Canada by the University of Saskatchewan's Social Sciences Research Laboratories, which contacted a pool of respondents administrated by EKOS Research Associates. A total of 503 individuals participated in the survey and after removing incomplete information, 497 observations remained. The survey was only available in only English and results are representative of English-speakers in Canada. The University of Saskatchewan Behavioural Research Ethics Board (Beh-REB) approved the survey [BEH #76]. The survey instrument is available in Appendix A.

The survey explained the purpose of the research and sought information in three sections. The first part asked respondents to report where they find information about food products; the most important food attributes such as naturalness, price, and safety; respondents' confidence in Canada's food safety system; the degree of trust in organizations regarding food safety and food technology neophobia statements (based on Matin et al., 2013, Vidigal et al., 2015 and Goddard et al., 2018).

In order to identify basic knowledge of food production survey respondents completed a quiz of ten basic questions concerning genetics. The statements were from previous studies that identified the effect of knowledge on the acceptance of GM food products (Bett et al., 2010; Huang et al., 2005; McFadden and Lusk, 2016; Vecchione et al., 2014; Zhang et al., 2010). Respondents were given the options: “true,” “false,” or “don’t know.” Correct answers were given one mark and minus one for each incorrect one answer. Questions answered as “don’t know” received zero points. The variable “knowledge” is continuous between -10 (all questions answered incorrectly) and +10 (all questions answered correctly). Last, respondents rated their own knowledge about genetics and genome editing as “very poor,” “poor,” “fair,” “good,” and “very good.”

The second section of the survey defined genome editing and the differences with transgenics (GM). Participants were then questioned on their agreement with sixteen statements about genome editing to determine perceptions based on five criteria: benefits, environmental risks, health risks, ethics, and equity (based on Bett et al., 2010; De Groote et al., 2016; Kimenju et al., 2005). Participants were also questioned about their attitudes toward transgenics and genome editing and WTC GM, genome-edited and organic food products.

The last section gathered demographic data including gender, age, province of residence, number of children, education level, annual income, and whether respondents worked in a field related to agriculture. All qualitative data were coded and evaluated using descriptive statistics with Stata and Microsoft Excel and analyzed.

3.2 Description of the Variables

There are total of 66 explanatory variables included in the analysis section. Fifteen sources of information were included as binary variables, asking if the consumer uses them as a source to access information about food products. They are coded as 1 if yes, and 0 otherwise. Respondents were able to select all those that applied: radio, television, magazines, family/friends, printed newspapers, conferences, agronomist, Facebook, Twitter, Instagram, Snapchat, government institution websites, professional/scientific publication, food company websites, and food labels. Some sources were later grouped to give more explanatory power in the regressions. The variable social included: Facebook, Twitter, Snapchat and Instagram. Scientific sources included:

conferences, agronomists, professional/scientific publications. Information from companies included: food company websites and food labels.

Participants were asked to rank the three most important food values from the set of values proposed by Lusk and Briggerman (2009), resulting in eleven variables. They were coded as 1 if the food value in question was ranked among the top three chosen by the respondent, and 0 otherwise: naturalness, taste, price, safety, convenience, tradition, origin, fairness, appearance, environment impact, nutrition. Trust was also included due to its relevant explanatory power for perception of technologies and applications. The confidence level in Canada's food safety system was also captured in five variable levels: not at all confident, somewhat confident, moderately confident (base), confident and very confident.

Knowledge about genetics is a continuous variable between -10 (all questions answered incorrectly) and +10 (all questions answered correctly). Self-rated knowledge about genetics and genome editing is described in four variables: each level of self-rated knowledge: "very poor", "poor", "fair" (omitted), "good" and "very good".

Two dummy variables capture the effect of the FTNS. Participants had to indicate their level of agreement with each of 13 statements about new food technologies. A seven-point Likert scale ranging from strongly negative (1) to strongly positive (7) was used to measure the acceptance of foods produced by new technologies, identifying part of the population that has greater or lesser neophobia levels (Vidigal et al., 2015). Depending on their answers and the score obtained, participants were divided into three groups representing different levels of neophobia. The range corresponding to each group was defined from the average of the FTNS of the studied sample (47.28) plus and minus one standard deviation (10.75). Neophilicos have a low level of food technology neophobia, and a strong affinity for novel food technologies (13-36.54); neutral respondents have a medium level of food technology neophobia (>36.54, =< 58.04); and neophobic individuals are characterized by a dislike of new food technologies (>58.04). The variables neophilico and neophobic are coded as 1 and 0 otherwise.

Different levels of food technology neophobia have been studied for different populations. Such as the Finnish population (Tuorila et al., 2001), Lebanese and American students (Olabi et al., 2009), and Koreans (Choe and Cho, 2011).

A group of socio-demographic control variables are also included in the model all of which are categorical: gender, age, province of residence, parents, education level and household income.

Table 3. 1 Description of the explanatory variables – Ordered and probit models

Independent Variables	Code	Description
Classic sources (radio, TV, magazines, newspaper)	Classic_info	Dummy, 1 if radio, TV, magazines are sources used to access information about food products and 0 otherwise.
Family/friends	Family_info	Dummy, 1 if family / friends are a source used to access information about food products and 0 otherwise.
Scientific sources (conferences, agronomist, professional / scientific publication)	Scientific_info	Dummy, 1 if conferences, agronomist services or scientific publications are a source used to access information about food products and 0 otherwise.
Social media (Facebook, Twitter, Snapchat, Instagram)	Social_info	Dummy, 1 if social media is a source used to access information about food products and 0 otherwise.
Company (food company website, food label)	Company_info	Dummy, 1 if information provided from food companies are a source to access information about food products and 0 otherwise.
Government institution websites	GovWeb_info	Dummy, 1 if official websites are a source to access information about food products and 0 otherwise.
Naturalness ranked top three	Naturaltop3	Dummy, 1 if naturalness was ranked top 3 and 0 otherwise
Taste ranked top three	Tastetop3	Dummy, 1 if taste was ranked top 3 and 0 otherwise
Price ranked top three	Pricetop3	Dummy, 1 if price was ranked top 3 and 0 otherwise
Safety ranked top three	Safetop3	Dummy, 1 if safety was ranked top 3 and 0 otherwise
Convenience ranked top three	Conventop3	Dummy, 1 if convenience was ranked top 3 and 0 otherwise
Tradition ranked top three	Traditop3	Dummy, 1 if tradition was ranked top 3 and 0 otherwise
Origin ranked top three	Orgtop3	Dummy, 1 if origin was ranked top 3 and 0 otherwise
Fairness ranked top three	Fairtop3	Dummy, 1 if fairness was ranked top 3 and 0 otherwise
Appearance ranked top three	Appetop3	Dummy, 1 if appearance was ranked top 3 and 0 otherwise
Environment impact ranked top three	Enviromenttop3	Dummy, 1 if environment was ranked top 3 and 0 otherwise
Trust in Canada's food safety system (four variables)	TrustCan	Categorial variable (1=not at all confident, 2=somewhat confident, 4= confident, 5=very confident)
Knowledge	Know	Knowledge score
Self-rated understanding genetics	SelfGen	Categorial variable (1=very poor, 2=poor, 4= good, 5=very good)

Self-rated understanding genome editing	SelfGE	Categorial variable (1=very poor, 2=poor, 4= good, 5=very good)
Neophilico	Neophilico	Binary, 1 if individual is neophilico and 0 if neutral
Neophobic	Neophobic	Binary, 1 if individual is neophobic and 0 if neutral
Gender	Gender	Dummy (1 = male)
Age (seven variables levels)	Age	Categorical variable (2= 25-34; 3 =35-44; 4=45-54; 5= 55-64; 6= 65-75; 7= over 75; 8= prefer not to say)
Province (nine variables)	Prov	Categorical variable (1=AB; 2=BC; 3=MB; 4=NB; 5= NL; 7=NS; 10=PE; 11=QC; 12=SK; 14=prefer not to say)
Children (two variables)	Children	Categorical variable (1=have children; 2= prefer not to say)
Higher level of education (seven variables)	Education	Categorial variable (2=Graduated + bachelor's; 3= university below bachelor's; 4=college diploma; 5= apprenticeship; 7= no degree; 8= prefer not to say)
Household income (eight variables)	Income	Categorical variable (2= $30k-$50K; 3= $50K-$70K; 4=$70K-$90K; 5= $90K-$110K; 6= $110K – 4130K; 7= $130K-$150K; 8= more $150K; 9= prefer not to say)

Benefit awareness and perceived risks are listed in Table 3.2. The statements and methodology to calculate perception indices are based on previous studies focused on consumers' perceptions for GM food in Africa (Bett et al., 2010; Kimenju et al., 2005; De Groote et al., 2016). Original statements were adapted to obtain perception indices for genome editing technology. Statements such as: "genome editing technology has the potential to create foods with enhanced nutritional values" or "genome editing can lead to a loss of original plant varieties" were added in part two of the questionnaire. These indices were used exclusively in the second part of the analysis, being added as regressors with potential explanatory power of the WTC genome-edited food products.

During the survey, statements were shown in random order and later grouped into five categories: benefits, environment risks, human health risks, ethical concerns, and equity concerns. Responses were given scores for their level of agreement: strongly disagree (-1), disagree (-0.5), neither agree nor disagree (0), agree (0.5), strongly agree (1). The category index was calculated as the mean of scores in each category.

Table 3. 2 Explanatory variables - benefit and risk perception indices – Multinomial model

Independent Variables	Code	Description
Benefits awareness	ben_perx	Benefits awareness index
Perceived environment risks	env_perx	Perceived environmental risk index
Perceived health risks	health_perx	Perceived health risks index
Ethical concerns	ethic_index	Ethical concerns index
Equity concerns	equity_index	Equity concerns index

3.3 Consumer perceptions—Ordered logit model

The first part of the analysis identifies the drivers that impact consumer perceptions of genome editing and transgenics. Attitudes based on a five-point Likert scale were used as the controlled categorical variables in two separate regressions. The same regressors are used in both regressions in order to establish differences between the variables that impact perceptions of each food technology.

To estimate the variation in consumer perceptions I used an ordered logit, which is a type of multinomial response model. The model estimates the probability of the different possible outcomes of a categorically distributed dependent variable, given a set of independent variables. To use this model, the categories included in the dependent variable *(y)* must respond to an ordered pattern (Wooldridge, 2010). The model used to identify consumer perceptions of genome editing and transgenic technologies is derived from a latent variable model, where $X\beta$ includes all covariates and e is the error term.

$$y^* = x\beta + e \tag{1}$$

Unknown cut points (or threshold parameters) are introduced, and α, which defines each of the categories of the dependent variable:

$$y_i = \begin{cases} 1\ (strongly\ negative)\ \ if\ y_i^*\ \leq \propto_1 \\ 2\ (negative)\ if\ \alpha_1\ <\ y_i^*\ \leq\ \alpha_2 \\ 3\ (neutral)\ \ if\ \alpha_2\ <\ y_i^*\ \leq\ \alpha_3 \\ 4\ (positive)\ if\ \alpha_3\ <\ y_i^*\ \leq\ \alpha_4 \\ 5\ (strongly\ positive)\ if\ \ y_i^*\ >\ \alpha_4 \end{cases} \tag{2}$$

Then the probability for each respondent is calculated as:

$$P(y = strongly\ negative \mid x) = P(y^* \leq \alpha_1|x) = P(x\beta + e \leq \alpha_1|x) = \Lambda(\alpha_1 - x\beta) \quad (3)$$

$$P(y = negative \mid x) = P(\alpha_1 < y^* \leq \alpha_2|x) = \Lambda(\alpha_2 - x\beta) - \Lambda(\alpha_1 - x\beta) \quad (4)$$

$$P(y = neutral \mid x) = P(\alpha_2 < y^* \leq \alpha_3|x) = \Lambda(\alpha_3 - x\beta) - \Lambda(\alpha_2 - x\beta) \quad (5)$$

$$P(y = positive \mid x) = P(\alpha_3 < y^* \leq \alpha_4|x) = \Lambda(\alpha_4 - x\beta) - \Lambda(\alpha_5 - x\beta) \quad (6)$$

$$P(y = strongly\ positive \mid x) = P(y^* > \alpha_5|x) = 1 - \Lambda(\alpha_5 - x\beta) \quad (7)$$

where Λ is the logit distribution:

$$\Lambda = \frac{e^{\alpha_k - x\beta}}{1 - e^{\alpha_k - x\beta}} \quad (8)$$

and, $x\beta$ represents the sets of variables used in the regression:

$$\begin{aligned} = (\beta_0 + \sum_{k=1}^{K-1} \beta_k\ source\ info_k) + \sum_{l=1}^{L-1} \beta_l\ food\ value_l) \\ + \sum_{m=1}^{M-1} \beta_m\ Trust\ Can_m) + \beta_4\ knowledge_i \\ + \sum_{o=1}^{O-1} \beta_o\ understanding_o) + \sum_{p=1}^{P-1} \beta_p\ neophobia_p) \\ + \sum_{r=1}^{R-1} \beta_r\ gender_r) + \sum_{s=1}^{S-1} \beta_s\ age_s) + \sum_{t=1}^{T-1} \beta_t\ prov_t) \\ + \sum_{u=1}^{U-1} \beta_u\ education_u) + \sum_{v=1}^{V-1} \beta_v\ income_v) \end{aligned} \quad (9)$$

We get an estimate of α and β that maximizes the log-likelihood function using maximum likelihood estimation:

$$\ell_i(\boldsymbol{\beta}) = 1\,[y_i = strongly\ negative] \log[\,\Lambda\,(\alpha_1 - \boldsymbol{x}_i\,\boldsymbol{\beta})] + 1\,[y_i = negative] \log[\,\Lambda\,(\alpha_2 - \boldsymbol{x}_i\,\boldsymbol{\beta}) - \Lambda\,(\alpha_1 - \boldsymbol{x}_i\,\boldsymbol{\beta})] + 1\,[y_i = neutral] \log[\,\Lambda\,(\alpha_3 - \boldsymbol{x}_i\,\boldsymbol{\beta}) - \Lambda\,(\alpha_2 - \boldsymbol{x}_i\,\boldsymbol{\beta})] + 1\,[y_i = positive] \log[\,\Lambda\,(\alpha_4 - \boldsymbol{x}_i\,\boldsymbol{\beta}) - \Lambda\,(\alpha_3 - \boldsymbol{x}_i\,\boldsymbol{\beta})] + 1\,[y_i + strongly\ positive] \log[\,1 - \Lambda\,(\alpha_4 - \boldsymbol{x}_i\,\boldsymbol{\beta}) \quad (10)$$

3.4 Willingness to consume genome-edited food products - Multinomial logit model (MNL)

The analysis is focused on the identification of variables that impact the WTC three genome-edited food products: innate potatoes and artic apples (recently approved in Canada), and genome-edited milk (a hypothetical product). When consulted about their WTC, respondents chose yes, no, or don't know, which are used as categorical dependent variables. Genome editing benefit and risk indices (environmental, health, ethical, and equity) were added as regressors to the analysis to identify the components of perception that drive individuals' WTC genome-edited food products.

I used a multinomial logit model to identify the variables that influence the WTC genome-edited food products. In this case respondents' probable responses (yes, no, don't know) do not follow a specific order, like in the ordered logit model. The multinomial logit model focuses on the possible answers regarding the WTC genome-edited products, which become the dependent variable categories.

According to Wooldridge (2010), in the multinomial model the probabilities are calculated to determine what ratio 'm' alternative will be chosen among M alternatives that are part of the dependent variable. The probability of an m response among M alternatives in the dependent variable is:

$$P(Y = m \mid X) \tag{11}$$

Where X is the specific regressor to explain every alternative in the dependent variable. The multinomial logit model has response probabilities:

$$P(Y_i = m \mid X_i) = \frac{e^{X_i \beta_m}}{1 + \sum_{J=1}^{M} e^{X_i \beta_j}}, \quad m = 1, \dots M \tag{12}$$

Where:

M is all the WTC categories*: yes, no, don't know,*

m is any of the three categories of WTC: *yes, no, don't know,*

j is the value of the number of possible categories in M, and

$X_i\beta_m$ includes all the observations for "i" individuals with outcome m:

$$\beta_{0,m} + \beta_{1,m}\, source\ info_i + \beta_{2,m}\, food\ atribute_i + \beta_{3,m}\, conf.Canada\ safety_i + \beta_{4,m}\, knowledge_i + \beta_{5,m}\, understanding_i + \beta_{6,m}\, neophobia_i + \beta_{7,m}\, gender_i + \beta_{8,m}\, ben\_perx_i + \beta_{9,m}\, env\_perx_i + \beta_{10,m}\, health\ perx_i + \beta_{11,m}\, ethics\_index_i + \beta_{12,m}\, equity\_index_i + \beta_{13,m}\, gender_i + \beta_{14,m}\, age_i + \beta_{15,m}\, prov_i + \beta_{16,m}\, education_i + \beta_{17,m}\, income_i \quad (13)$$

Estimation of the multinomial logit model is carried out by maximum likelihood. The sample log-like hood function is:

$$\ell_i(\boldsymbol{\beta}) = \sum_{j=0}^{J} 1\,[y_i = j] \log[p_j\,(\boldsymbol{x}_i, \boldsymbol{\beta})] \quad (14)$$

Equation 14 makes it possible to measure the response probability per observation. Then the complete log-likelihood function including all the observations in the population (n) is:

$$L(\beta) = \sum_{i=1}^{N} \ell_i(\beta) \quad (15)$$

Equation 15 is used to get estimates of β, which maximizes the log-likelihood function.

3.5 Willingness to consume genome-edited, GM, and organic food products – Probit model

This analysis measures and compares the variables that impact the WTC food products presented in the survey. This includes three genome-edited foods (potatoes, apples, and milk), three GM foods (salmon, papaya and sweet corn) that are in the Canadian market already. Because the WTC the food products includes "don't know," these values were dropped from the regression to enable me to run a probit model for each of the food products.

I used a probit model that estimate the probability that an individual would consume a particular food product. The mathematical expression for the binary response model is:

$$consume = \begin{cases} 1\ if\ \ y* > \ 0 \\ 0\ if\ y* \leq \ 0 \end{cases} \quad (16)$$

$$y* = x\beta + e \quad (17)$$

$$P(consume\ =\ 1|\ X)\ =\ P\ (y* >\ 0|\ X\ ) \tag{18}$$

where *consume* takes the value of 1 or 0 (consume or not). The latent variable estimates the probability of the binary response. Individuals consume when $y*$ is greater than zero, and the opposite when y^* is less than or equal to zero. Since $y*$ is not observed, it is assumed to have an expected value of $x\beta$, which includes all the predictor variables, and an error term (e).

The generalized logit equation is derived from the steps above:

$$P(Consume_i\ =\ 1|\ X)\ =\ \Phi\ (X\beta\ ) \tag{19}$$

Replacing the variables used in the probit regressions, the actual probit model is:

$$P(\ Consume_i\ =\ 1|\ X)\ =\ \Phi\ (\beta_0 + \sum_{k=1}^{K-1} \beta_k\ source\ info_k)\ +\ \sum_{l=1}^{L-1} \beta_l\ food\ atribute_l)\ + \sum_{m=1}^{M-1} \beta_m\ conf.Canada\ safety_m)\ + \beta_4\ knowledge_i +\ \sum_{o=1}^{O-1} \beta_o\ understanding_o)\ + \sum_{p=1}^{P-1} \beta_p\ neophobia_p)\ + \sum_{r=1}^{R-1} \beta_r\ gender_r)\ + \sum_{s=1}^{S-1} \beta_s\ age_s)\ + \sum_{t=1}^{T-1} \beta_t\ prov_t)\ + \sum_{u=1}^{U-1} \beta_u\ education_u)\ + \sum_{v=1}^{V-1} \beta_v\ income_v) \tag{20}$$

The generalized equation of density of consumption for one observation is:

$$f(consume_i|\ X)\ =\ [\Phi(x_i\beta\ )^{consume_i} +\ [1 - \Phi(x_i\beta)]^{(1-\ consume_i)} \tag{21}$$

Then the sample log-like hood function is:

$$\ell_i(\beta) = consume_i\ ln[\Phi\ (x_i\beta)] + (1 - consume_i)\ \ln[1 - \Phi(x_i\beta)] \tag{22}$$

We get an estimate of β that maximizes the log-likelihood function using maximum likelihood estimation.

$$L(\beta) =\ \sum_{i=1}^{N} \ell_i(\beta) \tag{23}$$

The estimates of β are the marginal effects of each one of the regressors included in the model, on the likelihood of consuming genome-edited food products.

This chapter described the methods and the respective variables (driver to influence consumers' perception and willingness to consume) used to test the set of hypotheses generated in chapter 2. In the next chapter (4) the data collected from the survey is used to provide descriptive statistics analysis while econometric analysis of the described variables (section 3.2) takes place in chapter 5.

Chapter 4

Descriptive Analysis

This chapter presents the descriptive statistics analysis of the data set. The chapter is organized as follows: Section 4.1 provides a brief comparison with the socio-demographic characteristics of the study sample with Canadian population. Section 4.2 provides the descriptive analysis of the survey data. This section also compares, and contrasts results with previous literature. Finally, key findings of the chapter are summarized.

4.1 Socio-demographic characteristics

Table 4.1 summarizes respondents' socio-demographic characteristics including frequency of responses, and percentage of the survey population as compared to the Canadian population to establish representativeness. Overall, the sample closely reflects the national population with respect to age, however, there are slight differences (within 3%) across age categories (Table 4.1). The gender ratio is also representative of the Canadian population with 231 males (46%) and 267 females (53%). About 1% preferred not to say or selected "other."

Sample data slightly overrepresents higher-income individuals and underrepresents the lowest income categories, particularly \$50,000 - \$70,000, which accounted for 19% of the population in Canada but only represents 9% of survey respondents. About 17% of respondents chose not to select an income category. The sample is skewed toward higher educated individuals with about 52% having a university education (33%) or graduate studies (20%).

The sample, overall, closely represents the English-speaking national population. Since the survey was conducted exclusively in English, Quebec is underrepresented with only one respondent. There was no representation from the Northwest Territories, Nunavut, or Yukon. Finally, fewer than 4% of the participants claimed to work in an agri-food related field.

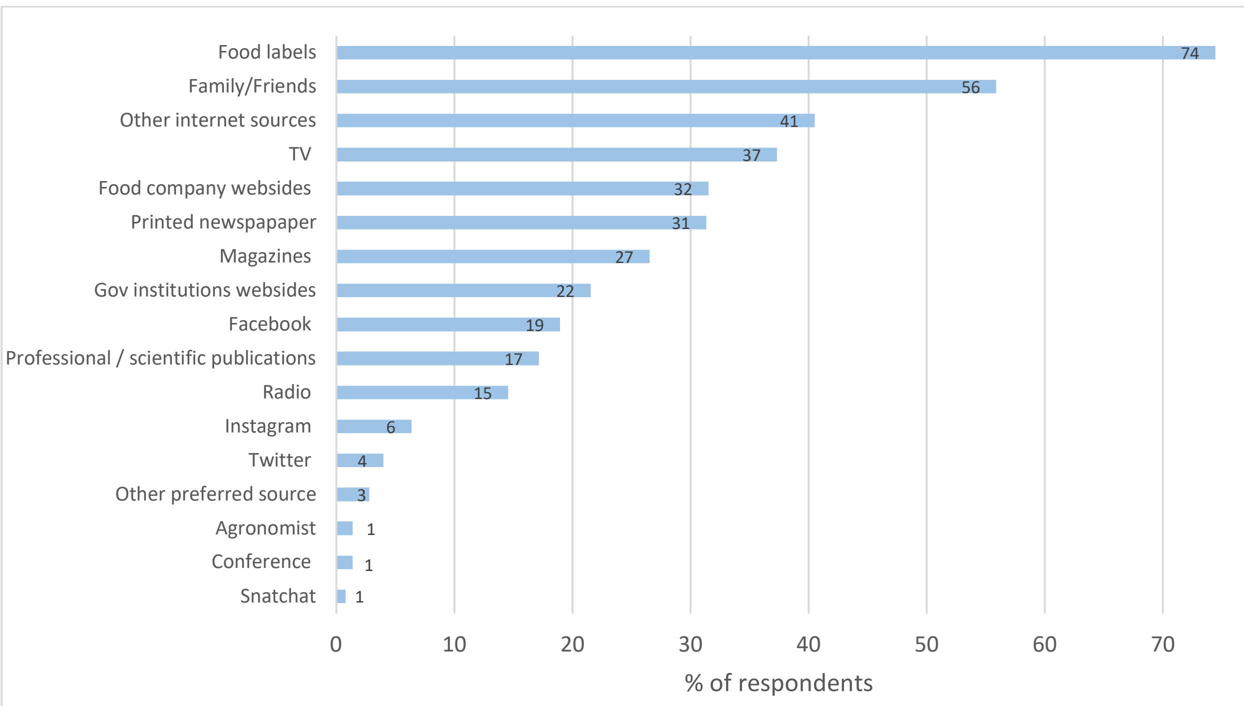
Table 4. 1 Socio-economic characteristics (n = 497)

	Survey sample (%)	Canadian population (%)
Age range		
Under 25	4.99	8.22
25-34	18.36	16.91
35-44	16.37	16.65
45-54	20.76	18.46
55-64	19.76	18
over 65	19.16	21.75
Gender		
Male	46.1	49.11
Female	53.3	50.89
Annual household income (before taxes)		
<$30,000	6.19	9.82
$30001 - $50000	14.17	17.84
$50001 - $70000	9.38	19.29
$70001 - $90000	12.18	16.76
$90001 - $150000	28.14	26.28
>$150000	13.37	10
Education		
Graduate + bachelor's degree	52.20	28.5
University bellow bachelors	8.38	3.1
College diploma	20.76	22.4
Apprenticeship or other trades certificate	4.99	10.8
High school diploma	10.38	23.7
No certificate diploma or degree	1.40	11.5
Province or territory		
Alberta	14.40	15.07
British Columbia	16.80	17.22
Manitoba	4.80	4.74
New Brunswick	3.20	2.77
Newfoundland and Labrador	2.00	1.93
Nova Scotia	4.00	3.42
Ontario	51.40	49.83
Prince Edward Island	0.60	0.53
Saskatchewan	2.40	4.07

4.2 Descriptive data

Information sources regarding food products was presented in random order to avoid bias. The respondents had to choose their preferred source of information about food products. The three most frequently selected sources were food labels (75%), family/friends (56%) and other internet sources (41%). The three least selected sources were Snapchat (1%), conferences (1%), and agronomists (1%). About 24% chose social media as one source of information, with Facebook the most popular at 19% (Figure 4.1).

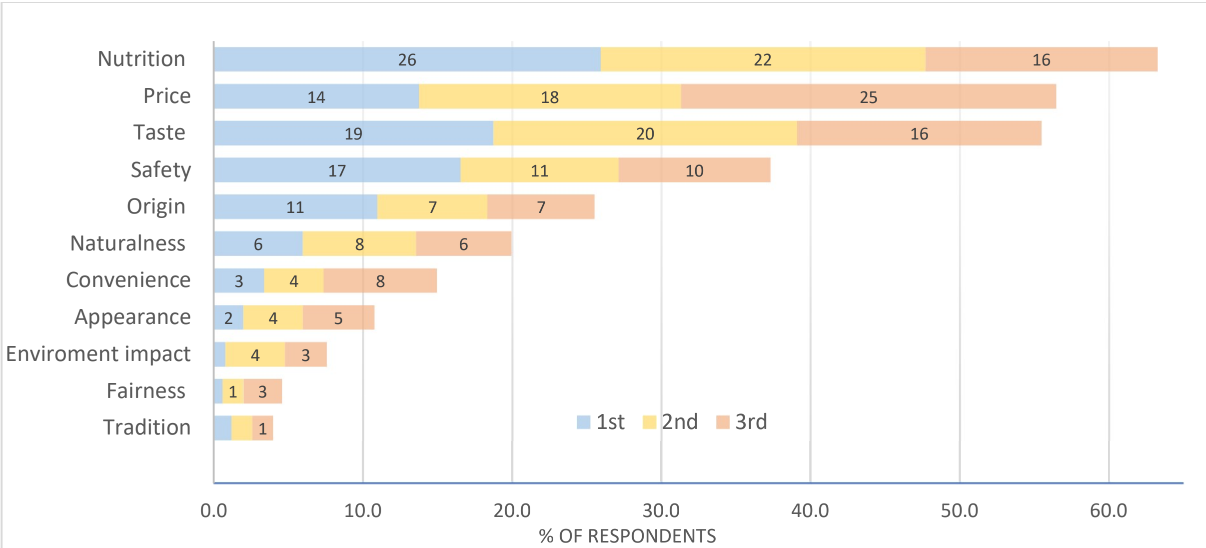
Figure 4.1: Preferred sources of information about food products (%).



Consumers chose all sources they use for food products information. Total does not add up to 100% as the question is a multiple response task

Respondents were presented randomly with food values (Figure 4.2), and indicated that nutrition (63%), price (56%), and taste (57%) are the three most important. Only 5% of respondents considered tradition or fairness as their top choice. Results closely reflect those reported by Lusk and Briggerman (2009), where the top four choices were safety, nutrition, taste, and price. Similar results were found by Bazzani et al. (2018) for Norwegian consumers. Finally, Lister et al. (2017) found the top choices to be safety and freshness for animal food products in the U.S.

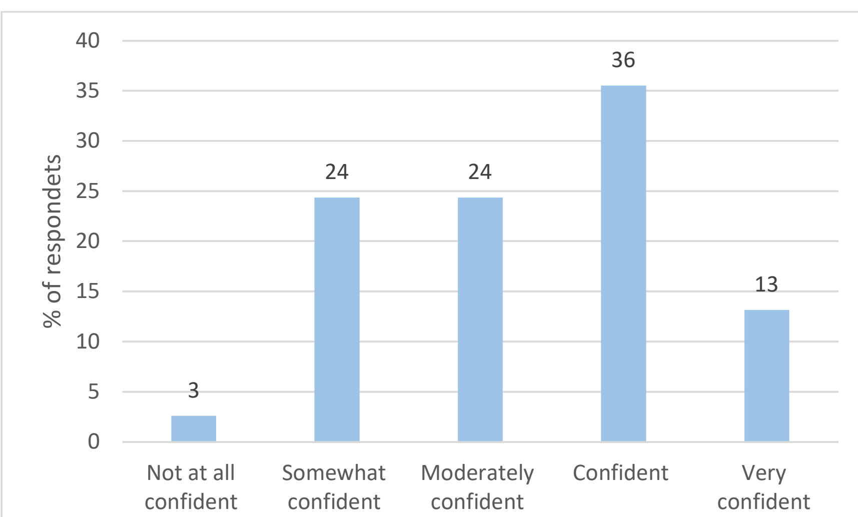
Figure 4.2: Top three food values



Consumers were presented with a random list and asked to select the top three choices in terms of value of food choices.

Participants were also asked about their level of confidence in Canada's food safety system (Figure 4.3). About half of the participants (49%) were confident or very confident in Canada's food safety system. Those moderately confident and somewhat confident were the same (24%) with only 2.6% not at all confident. The levels of confidence are lower than those identified by Health Canada (2013) where 66% of Canadians express confidence in Canada's food safety.

Figure 4.3: Level of confidence in Canada's food safety system.

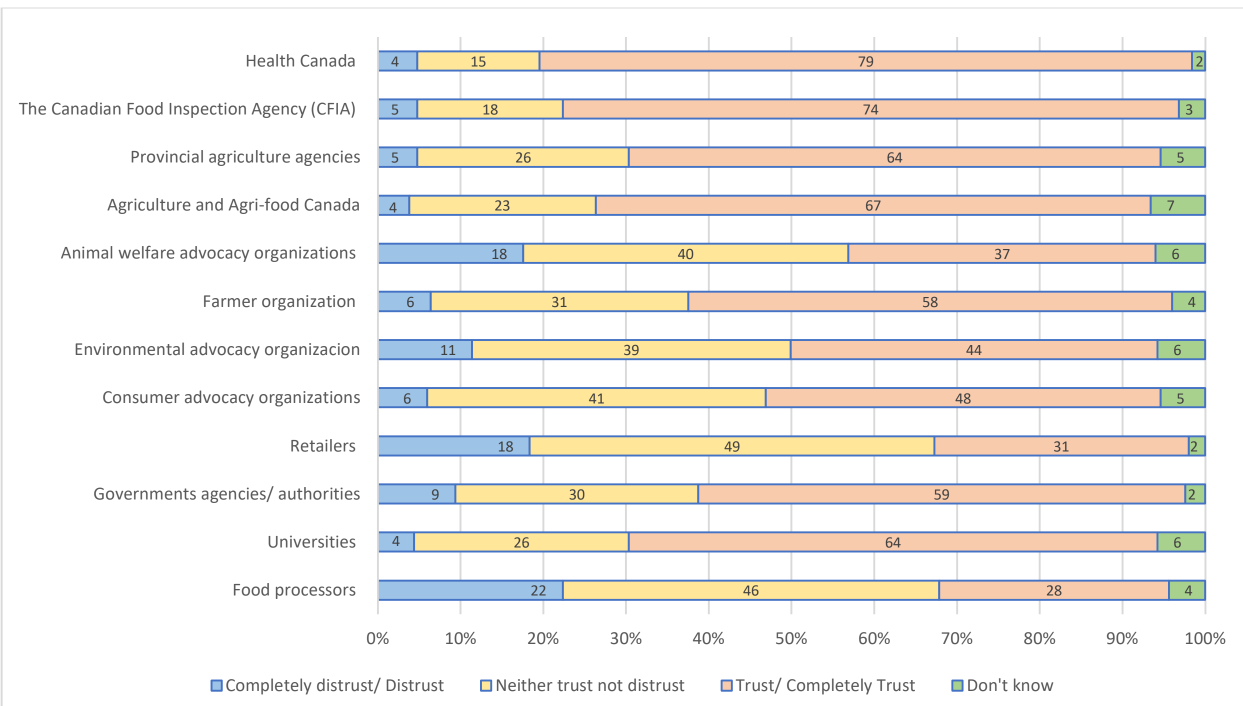


Consumers expressed their level of confidence in Canada's food safety system

When asked about the level of trust in food information providers, the three highest ranked as either “completely trust” or “trust” were Health Canada (79%), the Canadian Food Inspection Agency (75%) and Agriculture and Agri-food Canada (67%). The three least trusted organizations are food processors (22%), retailers (18%), and animal welfare advocacy organizations (18%) (Results are consistent with the percentages reported by Goddard et al. (2018): research organizations/universities in Canada are highly trusted, while industry and advocacy groups garner very low levels of trust.

Figure 4.4.4). Results are consistent with the percentages reported by Goddard et al. (2018): research organizations/universities in Canada are highly trusted, while industry and advocacy groups garner very low levels of trust.

Figure 4.4: Degree of trust in organizations regarding information about food safety in Canada.

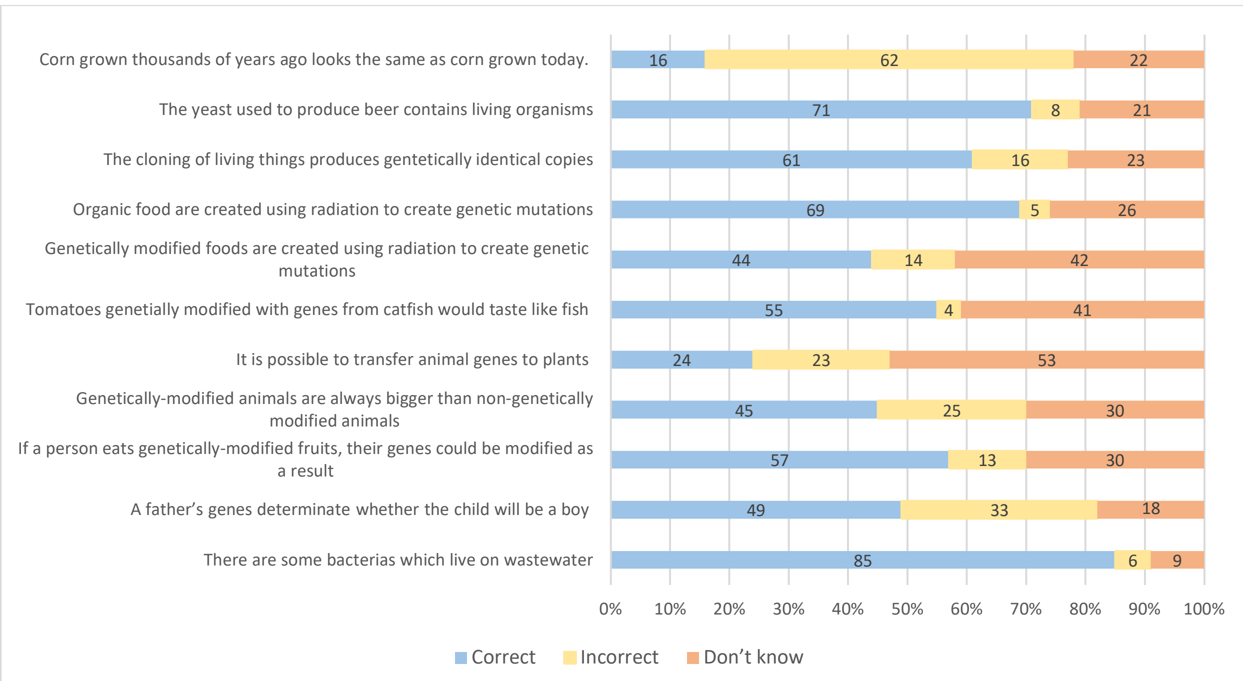


Participants expressed their trust in organizations. Choices were randomized to prevent bias

Results of subject knowledge based on the 10-question quiz are expressed in Figure 4.5. Findings indicate that on average participants chose the correct answer half of the time. One question was answered incorrectly for most of the participants: corn grown thousands of years ago looks the same as corn grown today (62% incorrect). There were three questions for which people were largely uncertain: the transfer of animal genes to plants (53% don't know), the use of radiation to create genetic mutations (42% don't know), and the possibility that catfish genes would alter the flavour of a tomato (41% don't know).

The sample obtained an average knowledge score of 4.2 out of 10. This result was expected taking into consideration the high percentage of "don't know" answers that received zero points in the grading system. Limited scientific knowledge of consumers is very well documented in previous studies in the U.S. and Canada (Goddard et al., 2018; McFadden and Lusk, 2016).

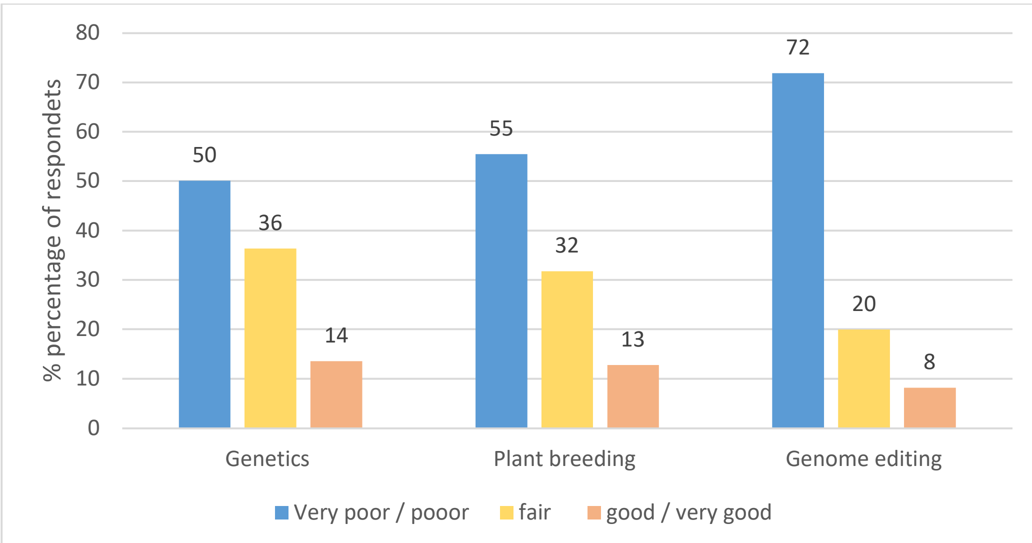
Figure 4.5: Consumers' knowledge about genetics



Results of knowledge questions quiz, percentage (%) of correct, incorrect and don't know answers

Regarding previous knowledge about food technologies, more than half of the respondents self-rated as very poor or poor for genetics (50%), plant breeding (56%) and genome editing (72%). Only 8% of participants self-rated as having a good or very good understanding of genome editing (Figure 4.6). Results reported by Health Canada (2013) are more positive: only 37% reported their understanding as very poor or poor for genetics, GM (32%) and food biotechnology (42%) These results were expected given the size differences between samples. Little knowledge of genome editing technology has also been identified in Costa Rica—where 96% had heard or read nothing about genome editing (Gatica-Arias et al., 2019), and Japan where 68% have never heard of genome editing (Uchiyama et al., 2017).

Figure 4.6: Understanding of food technology (self-rating).

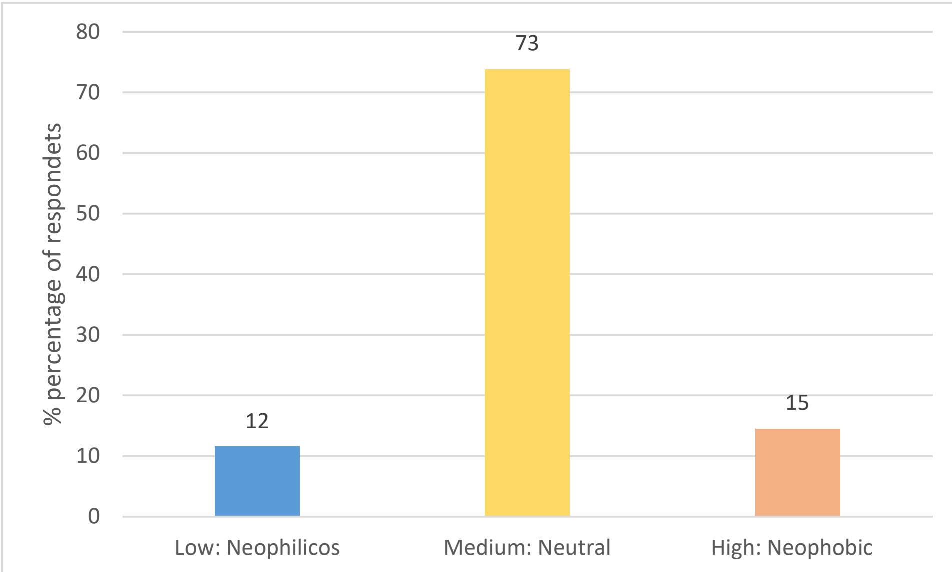


Self-rated understanding of genetics, plant breeding and genome editing technologies of consumers in Canada

Results of the FTNS were defined from the sample average (47.28) plus and minus one standard deviation (10.75). Neophiliacs have a low level of food technology neophobia and strong affinities for novel food technologies (13.00 – 36.54); neutral respondents have a medium level of food technology neophobia (36.55 – 58.04); and neophobics have a high level of food technology neophobia and a dislike of new food technologies (> 58.04).

Most participants fell into the neutral category at 74%, followed by neophobics at 15%, with only 12% registering as neophilicos (Figure 4.7). Results suggest slight differences from previous studies in Canada. Matin et al. (2012), found on average, that Canadians are more food technology neophobic (mean 58.45 ± 6.2) as compared with this sample (mean 47.28 ± 10.75). On the other hand, similar levels of food technology neophobia were identified in Italians (mean 44.2± 13.7) (Cattaneo et al., 2019) and Brazilians (mean 47.0 ± 12.0) (Vidigal et al., 2015).

Figure 4.7: Food technology neophobia score (FTNS)



Percentage of individuals for each category of FTNS in Canada

Benefits awareness and perceived risks from genome editing were calculated by asking participants their level of agreement with 16 statements about genome editing technology. Responses were given scores (calculated by giving the answers a score from -1 to +1) for their level of agreement and grouped into five categories: benefits, environment risks, human health risks, ethical concerns, and equity concerns. The category index was calculated as the mean of scores in each category. The results are available in Table 4.2

The majority of participants provided positive responses for perceived benefits (agree and strongly agree) with a score of 0.28, which is the highest index across the five evaluated criteria. It is also important to note that less than 7% of respondents chose negative responses (disagree and strongly disagree). Results showed a considerable level of concern with environmental risks, specifically, potential loss of original plant varieties (50%). However, responses to the other two statements indicated lower levels of concern. The general perceived environmental risks index is 0.14.

The health risk index is 0.03. More than half of the respondents agree that the use of GM is tampering with nature, and that food is not natural (46%). However, scores for “neither agree nor disagree” are slightly higher resulting in the ethical index being 0.01.

Table 4. 2 Benefits and risk perception indices toward genome editing technology

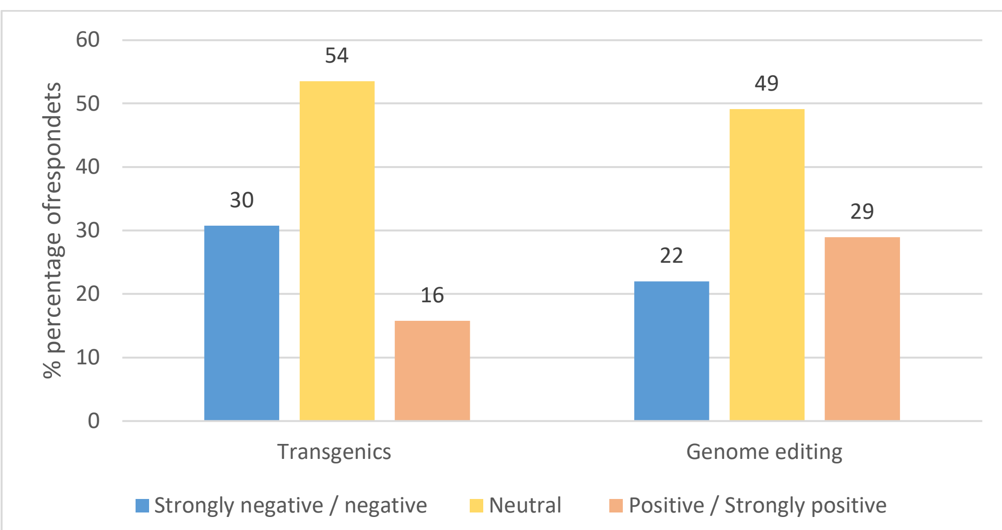
		Statement	Agree/ strongly agree	Neither agree nor disagree/ don't know	Disagree/ strongly disagree	Perception score
Perceived benefits	1	Genome editing technology has the potential to create foods with enhanced nutritional value	**56.28**	37.13	6.59	0.3
	2	Genome editing has the potential to reduce pesticide residue on food	**49.1**	45.71	5.19	0.26
	3	Genome editing has the potential to reduce pesticide residue in the environment	45.31	49.7	4.99	0.25
	4	Genome editing technology can result in pest-resistant crops	**53.29**	42.52	4.19	0.31
		Benefits perception index				***0.28***
Perceived environmental risks	5	Genome-edited crops are negative for the environment	17.17	57.28	25.55	-0.03
	6	Insect-resistant crops developed using genome editing could cause death of untargeted insects	38.32	54.29	7.39	0.2
	7	Genome editing can lead to a loss of original plant varieties	**49.7**	37.32	12.98	0.24
		Environmental perception index				***0.14***
Perceived health risks	8	Consuming genome-edited food products can damage human health	19.56	55.49	24.95	-0.02
	9	Consuming genome-edited foods products can lead to more allergies	20.96	62.08	16.96	0.04
	10	Consuming genome-edited foods might lead to an increase in antibiotic-resistant diseases	26.15	58.48	15.37	0.06
		Health risk perception index				***0.03***
Ethical concerns	11	Genome editing is tampering with nature	**55.69**	27.75	16.56	0.24
	12	Genome editing technology makers are imitating God	21.76	40.12	38.13	-0.13
	13	Genome-edited food is not natural	**46.11**	36.92	16.97	0.19
		Ethical perception index				***0.10***
Equity concerns	14	Genome-edited products only benefit multinational producers	23.75	48.31	27.94	0
	15	Genome-edited products don't benefit smaller farms	24.75	49.9	25.35	0.02
	16	Genome-edited products are being forced on developing countries by developed countries	17.96	65.87	16.17	0.02
		Equity concerns perception index				***0.01***

About a quarter of participants believe that genome-edited products only benefit multinational companies and do not benefit smaller farmers. A smaller percentage of respondents (18%) considered that genome-edited products are being forced on developing countries by developed countries. The overall equity index was 0.01.

Overall results are in line with McFadden and Smyth (2019) who reported that the majority of Canadians believe that modern plant breeding will increase production as well as lead to a loss of biodiversity. Studies in other countries revealed similar results for novel technologies. Bett et al. (2010) identify perceived benefits from GM food products in Africa, yet respondents also had concerns regarding environmental impacts (De Groote et al., 2016), likewise Costa Rican consumers agreed that CRISPR foods would increase crop production (Gatica-Arias et al., 2019).

Prior to reporting attitudes toward transgenics and genome editing participants were provided with a statement, highlighting the main differences between the two. Results revealed that the majority of respondents expressed a neutral attitude towards both (Figure 4.8): transgenics (54%) and genome editing (50%). With respect to a positive attitude results show a greater positive attitude (positive and strongly positive) for genome editing (29%) in comparison to transgenics (16%). The reverse was true for negative and strongly negative attitudes.

Figure 4. 8: Attitudes toward transgenics (GM) and genome editing



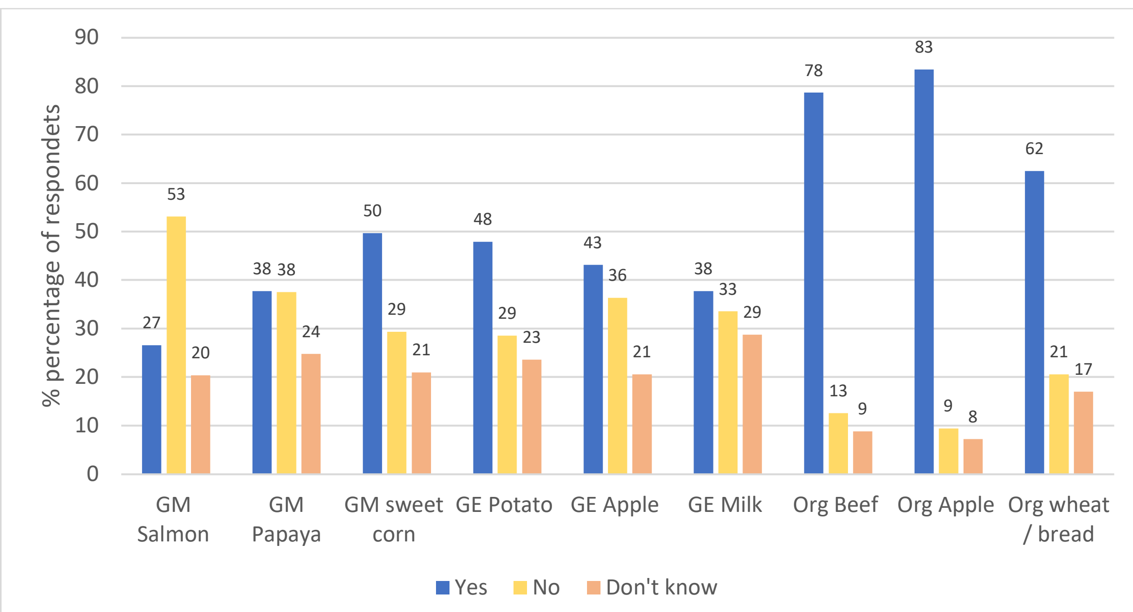
Consumers expressed their attitude (perception) toward transgenic and genome editing technologies in Canada

Participants were consulted about their WTC food products that make use of food technologies to obtain a specific characteristic (Figure 4.9). For this part of the analysis, participants were not identified via a screening question (consulted if they were already regular consumers of such food products). The absence of this question implies that we may not be able to distinguish between WTC a product made with a specific technology from the product category itself.

Between 20% and 25% of respondents do not know whether they would be willing to consume GM products. Only 26% of respondents would be willing consume GM salmon, whereas 38% would be willing to consume GM papaya and 50% GM sweet corn. These results are consistent with Charlebois et al. (2019) and Cuite and Morin (2016) who indicated that animal-based GM products appear to concern Canadians more than plant-based GM foods.

Concerning genome-edited food products, 48% of respondents were willing to consume the genome-edited potato. In the case of the genome-edited apple and genome-edited milk, the WTC decreased to 43% and 37%. Only 20% of respondents did not know whether they would consume genome-edited apples or potatoes, and about 30% in the case of genome-edited milk. Most respondents would consume organic products ranging from 62% to 83%.

Figure 4. 9: Willingness to consume food products



Consumers expressed their wiliness to consume GM, genome-edited and organic food products.

Results from this chapter show that Canadians trust key elements of Canada’s food safety system including: Health Canada, the Canadian Food Inspection agency, and Agriculture and Agri-Food Canada. Consumers showed low scientific literacy, and perceived knowledge of food technologies is found by McFadden and Smyth (2019). It is possible that low levels of knowledge about genome editing could be the result of insufficient scientific communication with consumers though the media (Gatica-Arias et al., 2019) or the relative novelty of the technology emerged within the last decade. Findings from this study also show that most surveyed Canadians believe there are benefits to genome editing technology, particularly for enhanced nutrition, and reduction of pesticide residues in food and in the environment. The most remarkable reported risk was the potential loss of original plant varieties, similar to McFadden and Smyth’s findings (2019).

Drivers of consumer attitudes and WTC are examined in the next chapter through three econometric models. The descriptive analysis presented in this chapter helps to identify the dependent and independent variables used in the models.

Chapter 5

Results and Discussion

This chapter presents the results from the empirical analysis. Main drivers are identified for consumers' perception of genome editing technology and for the willingness to consume genome-edited food products. These results are compared/contrasted with the main drivers of GM technology. Hypothesis testing is detailed in each sub-section of the chapter. The chapter is organized as followed: section 5.1 covers the analysis of the consumer perception of genome editing and transgenic technologies, making used of an ordered logit model. Section 5.2 covers the analysis of willingness to consume genome-edited apples, potatoes and milk using a multinomial logit model. In section 5.3 the willingness to consume genome-edited food products and GM food products is analyzed using a probit model. Discussion and conclusion of the chapter are provided in section 5.4.

5.1 Consumer perceptions of genome editing and transgenic technology – Ordered Logit Model

The dependent variables of the ordered logit model (OLM) regressions measure the attitudes toward genome editing and transgenics based on a five-point Likert scale ranging from strongly negative (1) to strongly positive (5). Fifteen sources of information were included in the survey as binary variables (Table 5.1).

The model (Equation 3) used 66 variables, of which eight were statistically significant for genome editing perceptions and nine for transgenics. The total number of observations (497) is at least seven times the number of regressors used in the model, thus no problems with degrees of freedom issues were identified. McFadden's Pseudo R2 was calculated to provide a parameter to register goodness of fit for the model. In the case of the ordered logit model, the R2 of genome editing and transgenic consumer perceptions is equal to 0.16 and 0.18, which means that the models explain only 16% and 18% of the variance in the dependent variables. It is important to keep in mind that the Pseudo R2 is different from the R2 in OLS regressions; the interpretation should only be referential. The estimated coefficients of perception of genome editing and transgenics from the ordered logit regression are expressed in Table 5.1. The table shows only the coefficients that are statistically significant. The complete regression parameters are available in Appendix 2.

No source of information was statistically significant for genome editing perception, however social media was significant in the GM perception regression, meaning that individuals who have social media as one of their main sources of information regarding food products tend to have a positive perception of transgenics. These results are unexpected, since information from social media is usually based on poorly-executed studies with no scientific approach (Ryan and Vicini, 2016), and because attitudes toward GM on Twitter are highly negative (Munro et al., 2015).

Table 5.1 Parameters estimated for Ordered Logit Model

Variables	Genome editing	Transgenics
Convenience ranked top 3	--	0.789** (0.327)
Tradition ranked top 3	--	1.003* (0.573)
Neophilico	0.956*** (0.293)	1.189*** (0.288)
Neophobic	-1.05*** (0.337)	-0.911** (0.362)
Social media	--	0.499** (0.239)
Trust in Canada's food safety system: Not at all confident	-1.985** (0.808)	--
Confident	0.473* (0.244)	0.511* (0.267)
Very confident	0.760** (0.333)	0.647* (0.333)
Self-rated understanding genome editing: Very poor	-1.05*** (0.351)	-0.95 ** (0.368)
Poor	--	-0.676** (0.311)
Very good	2.244** (0.978)	--
Knowledge	0.158*** (0.043)	0.093** (0.041)
Gender	0.676*** (0.212)	0.378* (0.217)

***, **, *statistical significance at 1%, 5%, and 10% levels. Standard error in parentheses.
The table reports only significant parameter estimates of each regression. Full model estimation results are available in Appendix 2

Two categorical variables relating to the level of confidence in Canada's food safety system (not at all confident and very confident) are statistically significant 5% level in the genome editing perception regression. These two categorical variables tell us that, if all other variables in the model are held constant, consumers that are not at all confident in the Canadian food safety system tend to have a negative perception of genome editing technology. On the other hand, respondents that felt very confident tend to have a positive perception of genome editing, ceteris paribus. The categories "confident" and "very confident" have a small impact on the perception of transgenics technology. Trust in the Canadian food system was expected to impact both technologies with expected signs. Results are supported by Goddard et al. (2018) who identified a positive impact from trust in government institutions related to perceptions of GM food products in Canada.

Coefficients for both variables relating to food technology neophobia are statistically significant and consistent in both regressions. Since "neutral" is the base category, the interpretations are relative to "neutral." Coefficients tell us that, based on all other variables being equal, neophilico consumers tend to have positive perceptions of genome editing and transgenics relative to neutral consumers, while neophobic consumers are more inclined to have a negative perception in comparison to neutral consumers. The direction of the signs for both variables was expected. Furthermore, the literature supports these results: Matin et al. (2012), found that Canadian neophobia is significant in explaining the opposition to novel technology use (nanotechnology).

Knowledge about basic genetics has a large positive impact on the perception of genome editing as well as transgenics. This means that high levels of knowledge are associated with an increase in the log odds of having a positive perception of genome editing. In other words, the positive sign is interpreted as an inclination for there to be a positive perception of genome editing and transgenics as the knowledge score increases. A strong correlation among knowledge and genome editing perception was expected given previous studies (Chen et al., 2013; McFadden and Lusk, 2016; Vecchione et al., 2014).

Two variables relating to self-rated understanding of genome editing (very poor and very good) were statistically significant and had expected sign. Results shows that consumers who have a very poor self-rated understanding of genome editing tend to have negative perceptions of genome editing. On the other hand, consumers who consider themselves to have a very good understanding of genome editing technology are more inclined to have a positive perception of genome editing.

This variable was also included in the transgenics perception regression, and "very poor" and "poor" were statistically significant. Given the negative sign of the coefficients, the results show that individuals with poor self-rated understanding of genome editing also tend to have a negative perception of transgenics technology. Results were expected and are supported in the literature (Goddard et al., 2018).

Gender is statistically significant at 1% with a positive sign for genome editing perception, however the significance is weak for transgenics. Results tell us that males tend to have a positive perception of genome editing technology relative to females. This is similar to other research where male consumers were found to have less concern for novel food technologies (Bellows et al., 2010; Goddard et al., 2018). Likewise, gender was the only socio-economic parameter that affected consumer perception of genome editing technology.

5.1.1 Marginal effects – consumer perceptions of genome editing technology

The marginal effects of the statistically significant variables are summarized and interpreted, in order to discuss the magnitudes of the effects. Results in table 5.2 show that the marginal effect of the level of confidence in Canada's food safety system is significant for the three categories of the dependent variable. Consumers who are not at all confident in Canada's food safety system are 15% more likely to have a negative perception of genome editing technology. Consumers who are not at all confident in Canada's food safety system are about 15% less likely to have a positive perception of genome editing and are 3% less likely to have a strong positive perception.

For FTNS, the neutral category was identified as the base meaning that results for the other two categories will be relative to this one. Both categories: neophiliacs (strong affinity to novelty) and neophobic (low affinity to novelty) are statistically significant. Neophiles are about 3% less likely to have a strongly negative perception of genome editing technology and are about 10% less likely to have a negative perception of genome editing technology relative to the neutral category. Respondents that fall in this category are about 11% more likely to have a positive perception and 4% more likely to have a strongly positive perception.

Table 5.2 Marginal effects – consumer perceptions of genome editing

Variables	Strongly negative	Negative	Neutral	Positive	Strongly positive
TrustCan (Not at all confident)	0.150	0.150 ***	-0.176	-0.149 ***	-0.032 ***
	(0.101)	(0.101)	(0.108)	(0.039)	(0.009)
TrustCan (Very confident)	-0.031 **	-0.032 **	-0.024	0.090 **	0.032 **
	(0.009)	(0.009)	(0.020)	(0.041)	(0.016)
Neophilico	-0.029 ***	-0.097 ***	-0.021	0.108 ***	0.039 ***
	(0.011)	(0.031)	(0.011)	(0.032)	(0.014)
Neophobic	0.032 ***	0.107 ***	0.023	-0.119 ***	-0.042 ***
	(0.012)	(0.034)	(0.014)	(0.039)	(0.015)
Know	-0.005 ***	-0.016 ***	-0.003	0.018 ***	0.006 ***
	(0.002)	(0.005)	(0.002)	(0.005)	(0.002)
Selfgenome editing (Very poor)	0.032 **	0.110 ***	0.023	-0.127 ***	-0.037 **
	(0.013)	(0.036)	(0.019)	(0.043)	(0.015)
Selfgenome editing (Very good)	-0.022 ***	-0.103 ***	-0.280 **	0.165 ***	0.240
	(0.008)	(0.029)	(0.114)	(0.040)	(0.155)
Gender	-0.021 ***	-0.068 ***	-0.015 *	0.076 ***	0.027 ***
	(0.008)	(0.021)	(0.008)	(0.024)	(0.009)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively. Standard error in parentheses.

For the neophobic consumer, the results are consistent with expectations. Neophobic consumers are about 3% more likely to have a strong negative perception and are about 11% more likely to have a negative perception of genome editing relative to neutral consumers. Neophobic consumers were also about 12% less likely to have a positive perception and 4% less likely to have a strong positive perception of genome editing relative to the neutral category. It was expected that FTNS was a relevant predictor of the attitudes of consumers toward genome-editing technology. Categories have a strong impact in the perception of genome editing technology, with ranges that are higher only for trust in Canadian food safety system.

Knowledge is highly correlated with consumer perceptions of genome editing. On average, for each one unit increase in the knowledge index, there is a reduction of 2% in the likelihood of having a negative perception of genome editing. Marginal effects also show that on average, a one unit increase in the knowledge index enhances the likelihood of choosing the positive perception option by 2%. This too, was expected, and supported by the literature (Chen et al., 2013; McFadden and Lusk, 2016; Vecchione et al., 2014). However, the measured impact is not as strong as it is for other variables with percentages lower than 2%.

Marginal effects of two categories of self-rated understanding for genome editing are statistically significant: very poor and very good. Consumers who consider themselves to have a very poor understanding of genome editing are 11% more likely than people with a fair understanding to have a negative perception about genome editing and about 13% less likely to have a positive perception about genome editing relative to fair understanding. Having a very good self-rated understanding about genome editing has the expected result: a very good understanding is about 10% less likely than fair understanding to have a negative perception about genome editing and, 16% more likely to have a positive perception relative to the fair understanding. Expected results are supported by Goddard et al., 2018.

Food values have been identified as an important predictor of consumers' attitudes; however, no effect was identified from any of the eleven food values included in the statistical analysis. Likewise, gender is the only significant demographic variable. Marginal effects obtained for this category show that men are about 2% less likely to have a strong negative perception and about 7% less likely to have a negative perception relative to women. Variables such as income, level of education and province had no effect on genome editing perceptions.

5.1.2. Marginal effects – consumer perceptions of transgenic technology

Both categories, neophilicos and neophobic, are statistically significant (Table 5.3). Neophiles are less likely to have a strongly negative or negative perception of GM technology. They are about 9% more likely to have a positive perception and 3% more likely to have a strongly positive perception. Neophobic consumers are about 5% more likely to have a strongly negative perception and are about 10% more likely to have a negative perception of GM technology relative to neutral consumers. Neophobic consumers are also less likely to have a positive perception and a strongly positive perception of GM relative to the neutral category (7% and 2%). Due to all the controversy derived from the GM technology debate, it was expected that neophile individuals would be more likely to have a positive perception and the opposite for the neophobic. The calculated impact is stronger on the middle levels of the predicted variable categories (9% and 10% more likely) than in the extremes (3% and 5% more likely).

Knowledge is highly correlated to consumer perceptions of GM, however it does not register a strong impact. On average for a one unit increase in the knowledge index, there is a 1% reduction in the likelihood of having a negative perception. Marginal effects also show that, on average, a one unit increase in the knowledge index generates a positive 1% difference in the likelihood of choosing the positive perception option. The results contradict previous studies (Bredahl, 1999; Chen et al., 2013) that described the effect of knowledge as fundamental or significant for the formation of consumer attitudes among GM food products.

Table 5. 3 Marginal effects – consumer perceptions for transgenic technology

Variables	Strongly negative	Negative	Neutral	Positive	Strongly positive
Neophilico	-0.071***	-0.126***	0.074***	0.093***	0.030**
	(0.020)	(0.031)	(0.023)	(0.022)	(0.011)
Neophobic	0.054**	0.097**	-0.057**	-0.072**	-0.023**
	(0.022)	(0.039)	(0.024)	(0.029)	(0.010)
Conventop3	-0.047**	-0.084**	0.049**	0.062**	0.020**
	(0.021)	(0.035)	(0.022)	(0.025)	(0.010)
Media	-0.030**	-0.053**	0.031*	0.039**	0.012*
	(0.015)	(0.025)	(0.016)	(0.019)	(0.006)
Know	-0.006**	-0.010**	0.006**	0.007**	0.007**
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
SelfGen (Very good)	-0.059***	-0.165**	-0.107	0.215**	0.116
	(0.015)	(0.050)	(0.135)	(0.103)	(0.092)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively. Standard error in parentheses.

Self-rated understanding about genetics is statistically significant and has numbers that are consistent with what is expected: very good understanding is about 6% less likely to have a negative perception about transgenics and 22% more likely to have a positive perception relative to the fair category. The effects of self-rated scientific knowledge on attitude toward GM technology were previously discussed by Goddard et al. (2018), who concluded that self-rated knowledge of science and technology reduces concerns about GM technology.

Marginal effects of two categories of self-rated understanding of genome editing are statistically significant as well: very poor and poor. Consumers who consider themselves to have a very poor understanding of genome editing are about 10% more likely than people with a fair understanding to have a negative perception of genome editing and about 8% less likely to have a positive perception of genome editing relative to fair understanding.

Consumers that rank convenience in their top three food values are about 8% less likely to have a negative perception of transgenics and they also are about 6% more likely to have a positive perception relative to people who ranked nutrition in their top three food values.

Consumers that include social networks as one of their main sources of information about food products are about 5% less likely to have a negative and 4% more likely to have a positive perception about transgenics. Social media impact was an unexpected positive driver. Previous research demonstrates a clear anti-GM sentiment expressed through Twitter (Munro et al., 2015) with the involvement of disinformation campaigns (Ryan and Vicini, 2016).

5.2 Willingness to consume genome-edited food products – Multinomial logit model

The dependent variables relate to three categories defining whether a respondent would consume food produced using genome-editing technology: yes, no, and don't know (Table 5.4). The dependent variables of the multinomial logit model (equation 12) measure the WTC of three genome-edited food products: innate potatoes and artic apples (recently approved in Canada), and genome-edited milk (a hypothetical product). The benefits obtained by using genome-editing technology are different for each product. Innate potatoes resist blackspot bruising and contain lower levels of asparagine; artic apples do not brown; and genome-edited milk is produced by dairy cows that do not need horns removed. Since the benefits vary by product, it is expected that individuals' WTC would vary resulting in different results across the set of models.

The model used the same variables as in the OLM regressions, except for the addition of the five genome editing perception indices (71 in total). The effects of the five index scores are captured by five continuous variables: benefits awareness, perceived environment risks, perceived health risks, ethical concerns, and equity concerns. Respondents were not consulted if they were regular consumers of the food products (i.e. apples, potatoes, milk). The absence of this question implies that we cannot separate the WTC product made with genome editing technology from the product category.

Due to the high number of observations used, no degrees of freedom issues were identified. McFadden's Pseudo R^2 was also calculated to register goodness of fit. The Pseudo R^2 for each of the WTC models were 0.39 for the genome-edited potato; 0.34 for the genome-edited apples; and 0.27 for genome-edited milk. Results can be interpreted to explain 39%, 34% and 27% of the variance for the response variables. The estimated statistically significant coefficients are expressed in Table 5.5, and the complete regression parameters are available in Appendix 3.

Table 5. 4 Description of the dependent variables

Predictor variables	Code	Response categories
Would you consume the following food products?	1	Yes
Genome-edited potato (resist blackspot bruising, and	2	No
contains lower levels of asparagine)	3	Don't know
Would you consume the following food products?	1	Yes
Genome -edited apple (non-browning)	2	No
	3	Don't know
Would you consume the following food products?	1	Yes
Genome-edited milk (eliminates the need to remove	2	No
horns from dairy cows)	3	Don't know

Coefficients in table 5.5, show that WTC genome-edited potatoes has thirteen variables that are statistically significant. Neophilico is significant and negative for consumers and non-consumers, meaning that neophilicos are less likely to consume genome-edited potatoes compared to those who responded with don't know. In other words, neophilicos are more likely to respond don't know about the WTC genome-edited potatoes. The results are unexpected since neophilico individuals tend to have a positive attitude to novel technology food products. It is important to consider that high levels of food technology neophobia do not impact the WTC genome-edited potatoes. Origin and environmental impact are strongly statistically significant. People who ranked origin in their top three food values are more likely to respond, "don't know" about eating genome-edited potatoes, while on the other hand, people who ranked environmental impact in their top three are less likely to consume genome-edited potatoes relative to the don't know position. This finding could be related to the environmental risk associated with production of genome-edited food products in general. In regard to sources of information, the results show that people who included government institution websites as a source of information would consume genome-edited potatoes, and users of such information provided by food companies are more likely to respond, "don't know" (Table 5.5).

The relationship between positive WTC genome-edited potatoes and trust in the information is interesting. Individuals who perceive benefits from genome editing technology provided a positive answer as expected, while people who identify health problems from genome editing technology are more likely to have a negative response. According to Rodriguez-Entrena (2016) public-perceived risk plays a critical factor in determining acceptance of novel food technology. The other perception indices do not have significant impacts on the model. Three demographic characteristics were also statistically significant and resulted in a lower likelihood of consumption: gender (male), province (British Columbia), and having children (parents).

Table 5. 5 Parameters estimated from Multinomial Logit Model

	Genome-edited Potato		Genome-edited Apple		Genome-edited Milk	
Variables	Yes	No	Yes	No	Yes	No
TrustCan	0.083	0.437	0.396	0.985**	0.876**	0.863**
(Not at all Confident)	(0.419)	(0.472)	(0.437)	(0.453)	(0.389)	(0.387)
Neophilico	-1.379***	-2.059***	-0.820*	-0.505	-0.765*	-0.306
	(0.467)	(0.740)	(0.480)	(0.551)	(0.434)	(0.488)
Neophobic	-0.499	-0.011	0.758	1.408**	-1.423**	0.116
	(0.620)	(0.577)	(0.727)	(0.688)	(0.694)	(0.474)
Origentop3	-1.086**	-0.927*	-0.956*	-0.561	-0.249	-0.350
	(0.479)	(0.525)	(0.503)	(0.521)	(0.446)	(0.424)
Enviromenttop3	1.047	2.171***	1.180	2.645***	0.573	1.020*
	(0.743)	(0.758)	(0.834)	(0.807)	(0.666)	(0.596)
Friend/Fam	-0.027	-0.084	0.287	0.200	0.687**	0.200
	(0.320)	(0.372)	(0.334)	(0.351)	(0.305)	(0.295)
GovWeb	0.867**	0.677	0.583	0.353	0.268	-0.072
	(0.428)	(0.483)	(0.429)	(0.452)	(0.371)	(0.372)
Company	-0.340	-1.325**	-0.300	-0.749*	0.224	0.115
	(0.432)	(0.488)	(0.433)	(0.449)	(0.369)	(0.369)
Self genome editing	-0.531	-0.567	-0.215	-0.030	-1.657***	-0.918
(very poor)	(0.595)	(0.669)	(0.605)	(0.610)	(0.567)	(0.536)
Ben_perx	2.774***	-1.022	2.512***	0.957	1.715***	-0.077
	(0.653)	(0.808)	(0.668)	(0.702)	(0.563)	(0.576)
Health_perx	0.360	1.880**	-1.091	0.234	-0.508	0.601
	(0.786)	(0.931)	(0.852)	(0.909)	(0.702)	(0.739)
Ethic_index	-0.957*	1.082	-0.297	0.298	-0.058	1.114**
	(0.558)	(0.675)	(0.579)	(0.639)	(0.506)	(0.533)
Gender	0.138	-1.300***	-0.316	-1.46***	-0.310	-0.652**
	(0.337	(0.405)	(0.351)	(0.378)	(0.317)	(0.315)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively. Standard error in parentheses.
The table reports only significant parameter estimates. Full model estimation results are available in Appendix 3

The WTC genome-edited apples is impacted by both food technology neophobia categories. Nevertheless only "neophobic" is strongly significant. Results in Table 5.5 show that neophobics are not willing to consume genome-edited apples. On the other hand, neophilicos will tend to respond "don't know" for WTC genome-edited apple. Environmental impact is the only food value that strongly affects the WTC genome-edited apples. People who ranked it in their top three food values are less likely to consume apples relative to having a neutral position, and as happens with genome-edited potatoes, this is probably due to the identification of environmental risk associated with the production of genome-edited food products in general, consistent with Bett et al. (2011) and De Groote et al. (2016).

Benefit perception is the only index that has a strong impact on the WTC genome-edited apples. The results have the expected sign, since people who perceive benefits from genome editing technology tend to be willing to consume genome-edited apples relative to taking a neutral position. The impact from benefit perception indices among novel food consumption were also identified by Bett et al. (2011) and De Groote et al. (2016). However, regression results also show an impact from participants who do not trust at all Canada's safety system; they are more likely to provide a negative answer about the WTC apples relative to a neutral answer. Demographic results are similar to those for genome-edited potatoes: male respondents tend to have a neutral position relative to a negative response; and British Columbia residents tend to respond negatively relative to neutral.

Willingness to consume genome-edited milk, is strongly impacted by seven variables. Respondents with high level of trust in Canada's safety system are more likely to respond "yes" or "no" relative to "don't know." While trust in the Canadian food safety system was shown to relate to a positive perception of genome editing technology, the results indicate that such consumers would consider any one of the options but "don't know." The neophobic also is statistically significant. People in this category tend to reject the consumption of genome-edited milk relative to neutral. Low neophobia does not have a strong impact on WTC genome-edited milk, however neophilicos, unexpectedly, are more likely to respond, "don't know" rather than "yes."

Regarding the source of information, individuals who chose family and friends tend to provide a positive answer relative to a neutral one, while individuals with low self-rated understanding of genome editing are less likely to consume genome-edited milk relative to those who don't know.

Perceiving benefits from genome editing technology is associated with WTC relative to the neutral position, while perceiving ethics risks from genome editing does the opposite. The other risk indices do not have a statistically significant impact. As in the other two regressions, gender provide positively affect the WTC. Compared to respondents in Ontario, participants in Nova Scotia tend to be willing to consume the genome-edited milk.

5.2.1 Marginal effects – willingness to consume genome-edited food products

Consistent with the previous results, marginal effects show the change in the probability of the WTC genome-edited products. Detailed interpretation of each one of the significant variables is described in this section.

5.2.1.1 Genome-edited potato

According to the results in Table 5.6, neophilico individuals are 14% less likely to not consume genome-edited potatoes relative to neutral, and they are also about 22% more likely to respond "don't know," which is interpreted as an ambiguous attitude about the WTC of genome-edited potatoes by neophilico individuals. Marginal effects for the food value "origin" are statistically significant for the undecided category, meaning that individuals who ranked origin as a top food value are about 14% more likely to be undecided about WTC. In the case of environmental impact, people will be 18% more likely to pick a negative answer and will also be about 20% less likely be undecided. This result puts the latter food value (environmental impact) as one of the strongest drivers for WTC genome-edited potatoes, just behind benefit perception indices.

People who consult government institution websites are about 11% less likely to be undecided, while individuals who consult the information provided by food companies are about 12% less likely to have a negative response for the WTC genome-edited potatoes. Gender is also significant: males are about 15% less likely to provide a negative response to consuming genome-edited potatoes.

The benefits perception index has a positive and significant impact on the WTC genome-edited potatoes: for each unit increase in the benefit perception index the likelihood of providing a positive answer increases by about 44%, while the likelihood of providing a negative answer decreases by about 27%. Likewise, a one unit increase in the health risks perception index increases the likelihood of providing a negative answer by 18%. The benefit perception index is the strongest driver of WTC genome-edited potatoes followed by environmental impact food value and health risk perception indices.

Table 5.6 Marginal effects – willingness to consume genome-edited potatoes

Variables	Yes	No	Don't Know
Neophilico	-0.074	-0.144**	0.218***
	(0.065)	(0.075)	(0.058)
Orgtop3	-0.098*	-0.038	0.136**
	(0.058)	(0.049)	(0.056)
Impacttop3	0.022	0.175**	-0.196**
	(0.085)	(0.066)	(0.086)
GovWeb	0.081	0.024	-0.105**
	(0.050)	(0.044)	(0.051)
Company	0.028	-0.124***	0.095
	(0.050)	(0.043)	(0.052)
ben_perx	0.441***	-0.268***	-0.174
	(0.074)	(0.073)	(0.076)
health_perx	-0.057	0.182**	-0.125
	(0.095)	(0.087)	(0.095)
Gender	0.093**	-0.148***	0.055
	(0.040)	(0.037)	(0.040)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively.
Standard error in parentheses.

5.2.1.2. Genome-edited apples

The marginal effect of the WTC genome-edited apples has five statistically significant variables (Table 5.7). The trust in Canada's food safety system is relevant in two of its categories and provided expected results: people who are not at all confident are about 44% less likely to provide a positive answer and 47% more likely to provide a negative answer about consuming genome-edited apples. This result supports the first part of the analysis, in which trust is correlated to positive perceptions of genome editing technology and vice versa. Other levels of trust are not statistically significant. Similarly, neophobic people are 13% more likely to provide a negative answer to consuming genome-edited apples. This latter result is also expected since neophobic individuals usually do not consume food products from novel technologies. Differing from genome-edited potatoes, WTC genome-edited apples is mainly driven by trust in the institutions in charge of regulation and control of genome-edited food products.

Individuals that ranked environmental impact as a top food value are about 27% more likely to pick a negative answer and 22% less likely be undecided. The benefits perception index strongly affects WTC apples. For each unit increase in the index the likelihood of providing a positive answer increases by about 31%, while the likelihood of responding “don’t know” decreases by about 22%. Results are similar to the those for genome-edited potatoes with respect to the environmental food value and benefit perception indices. Finally, males are about 18% less likely to provide a negative response and 10% more likely to respond “don’t know” regarding WTC.

Table 5. 7 Marginal effects – willingness to consume genome-edited apples

Variables	Yes	No	Don’t Know
TrustCan (not at all confident)	-0.443***	0.465***	-0.021
	(0.041)	(0.136)	(0.136)
Neophobic	-0.005	0.131**	-0.125
	(0.080)	(0.065)	(0.079)
Impacttop3	-0.047	0.266***	-0.219**
	(0.093)	(0.078)	(0.089)
Ben_perx	0.305***	-0.084	-0.220***
	(0.076)	(0.075)	(0.071)
Gender	0.078*	-0.177***	0.099**
	(0.043)	(0.040)	(0.037)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively.
Standard error in parentheses.

5.2.1.3. Genome-edited milk

Results in table 5.8 show the marginal effects for the statistically significant variables for the WTC genome-edited milk. Individuals who are confident in Canada’s food safety system are about 14% less likely to be undecided relative to a moderate trust in the domestic safety system. Similar unexpected results were found for the genome-edited apples. Neophobic consumers are about 23% less likely to consume genome-edited milk. It is a strong and expected result, meaning that attitudes for food technology also manifest in the WTC food products from same technologies. People who mention “friends or family” as one of their main sources of information about food products are about 9% more likely to provide a positive answer about WTC genome-edited milk. Sources of information without scientific support are expected to have a negative impact on the WTC genome-edited food products, thus making this finding unexpected. Individuals who self-rated their understanding of genome editing technology as very poor are 18% less likely to provide a positive answer and about 20% more likely to be undecided about the WTC genome-edited milk, both relative to "fair" knowledge.

Table 5. 8 Marginal effects – willingness to consume genome-edited milk

Variables	Yes	No	Don't Know
TrustCan (Confident)	0.075	0.069	-0.144**
	(0.053)	(0.052)	(0.056)
Neophobic	-0.227**	0.122*	0.106
	(0.094)	(0.067)	(0.081)
Friends	0.091**	-0.019	-0.072*
	(0.041)	(0.041)	(0.041)
SelGen (Very poor)	-0.180**	-0.022	0.202**
	(0.072)	(0.074)	(0.069)
Ben_perx	0.270***	-0.137*	-0.132*
	(0.073)	(0.078)	(0.078)
Ethic_index	-0.090	0.178**	-0.088
	(0.068)	(0.072)	(0.072)
Gender	0.001	-0.079*	0.079*
	(0.043)	(0.042)	(0.044)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively.
Standard error in parentheses.

The benefit index also has a significant impact, which is consistent with the other two multinomial models. Individuals are 27% more likely to consume genome-edited milk for each unit increase in the benefit index, while individuals are 18% more likely to provide a negative answer for each unit increase in the ethics risk index. It is important to consider that milk is the only genome-edited food product affected by this variable. The negative effect was expected given a study of Canadians found more concern about genetic-engineered animal-based products when compared to plant-based (Charlebois, 2018). Finally, males are 8% less likely to provide a negative response relative to women.

5.3 Willingness to consume genome-edited and GM food products – Probit model

A multinomial logit model (equation 12) was used to determine the WTC genome-edited potatoes, apples, and milk. In this section probit regressions (equation19) and marginal effects are used to establish differences and similarities with the variables affecting transgenics. Results from the MLM and probit model are expected to be impacted by similar variables, however it is important to remember that perception indices of genome editing are not included (benefit, environment risk, health risks, equity risks and ethics ricks) and several values were dropped to keep only two categories of dependent variables (yes/no), due to the characteristics of the probit model, therefore the number of observations in each regression is different (GM Salmon= 382; GM papaya= 348; GM sweet corn= 377; genome-edited potato= 364; genome-edited apple= 368; genome-edited milk= 346). The same limitations from the MLM about the inability to separate the technology effect from the product category effect, must be considered in the interpretation of the probit models' coefficients.

Table 5.9 Description of the dependent variables (Probit models)

Predictor variables	Code	Response categories
Would you consume the following food product?	0	No
Genetically modified salmon (grows faster)	1	Yes
Would you consume the following food product?	0	No
Genetically modified papaya (virus resistant)	1	Yes
Would you consume the following food product?	0	No
Genetically modified sweet corn (insect resistant)	1	Yes
Would you consume the following food product?	0	No
Genome-edited potato (resist blackspot bruising, and contains lower levels of asparagine)	1	Yes
Would you consume the following food product?	0	No
Genome-edited apple (non-browning)	1	Yes
Would you consume the following food product?	0	No
Genome-edited milk (eliminates the need to remove horns from dairy cows)	1	Yes

The dependent variables of the model measure the WTC food products including potatoes, apples, and milk (genome-edited products), salmon, papaya, and sweet corn (GM products). The dependent variables (Y) are detailed in Table 5.9. The estimated coefficients of WTC genome-edited and GM food products from the probit regression are available in Appendix 4. The following section provides a high-level overview of which variables were significant in each model.

5.3.1 GM products

GM salmon: In the probit model neophilico, origin, knowledge, self-rated understanding, and gender were statistically significant. In the case of neophilico, individuals who fall into this category tend to be willing to consume GM salmon relative to people who are neutral on the FTNS. Consumers who ranked origin in their top three food values will tend not to consume GM salmon. Knowledge has a positive impact on the WTC the food product as evidenced by higher consumption probability. Individuals who considered themselves to have very good knowledge of genetics would consume GM salmon. Finally, men are more likely to consume GM salmon relative to women.

GM papaya: Willingness to consume GM papaya is strongly impacted by confidence in Canada's food safety systems. Consumers that trust Canadian food safety system will tend to have a positive WTC GM papaya. Neophobics will tend to reject the consumption of GM papaya. Knowledge has a positive effect, as expected, and gender with men more likely to consume than women.

GM sweet corn: Three categories of the trust in the Canadian food safety system impact the WTC of this food product. Consumers who feel very confident, confident, and even somewhat confident will tend to be willing to consume GM sweet corn. Neophilicos impact WTC positively, while neophobic impacts negatively. Individuals who ranked naturalness and environmental impact are less likely to consume GM corn. Scientific sources of information tend to have a negative impact, while the use of government institution websites, and food company information increases the probability. Knowledge has a positive effect on WTC, as does being male.

5.3.2 Genome editing products

Genome-edited potatoes: Both categories of the FTNS were statistically significant and have expected signs. Neophilicos tend to be willing to consume genome-edited potatoes, while neophobics tend to reject it. Individuals who ranked taste and convenience in their top three food values tend to answer yes to WTC. Those who value environmental impacts tend to reject the consumption while users of classic media sources (tv, radio and newspaper), those with knowledge, and men are more likely to respond positively.

Genome-edited apples: Neophobic impacts the WTC genome-edited apples with an expected sign. Individuals in this category will tend to not consume the product. Environmental impact as food value will have a negative impact on WTC. Consumers tend to consume genome-edited apples as their knowledge score of genetics increases. Men will tend to consume more genome-edited apples relative to women.

Genome-edited milk: Neophobic consumers will tend to reject the consumption of genome-edited milk. Top 3 ranked food values taste, and convenience positively impact of the WTC genome-edited milk, while environmental impact has a negative impact as in the case of the other food products. Knowledge has a positive impact, as does male gender.

5.3.3 Marginal effects on willingness to consume genome-edited and GM food products

As showed in table 5.10, trust in Canada's food safety system has the largest impact on the WTC GM sweet corn. Individuals who chose the categories somewhat confident, confident and very confident will be more likely to consume GM sweet corn. Likewise, individuals who are very confident will be about 18% more likely to be able to consume GM papaya. The variable impacts only one genome-edited product: milk. Positive impact in the WTC novel food (particularly GM and nanotech) products have been previously identified by Goddard et al. (2018). Impact from trust in Canada Food safety system on genome-edited milk is also identified in the previous section of this analysis, where individuals were less likely to respond "don't know" about genome-edited milk WTC.

Categorical variables of the neophobia scale impact on all the GM and genome-edited food products. Actually, in all the six food products but one (GM salmon) FTNS categories have the highest impact. Neophilicos are about 19% more likely to consume GM salmon and are about 18% more likely to consume genome-edited potatoes, relative to the neutral category (table 5.10). Alternatively, neophobics are less likely to consume GM papaya, GM sweet corn, genome-edited potatoes, genome-edited apples and genome-edited milk with very high percentages (51%, 33%, 24%, 26% and 41% respectively). The expected direction of the impact of FTNS confirms the finding of Matin et al. (2012) that reveled that the food technology neophobia score is a significant negative indicator of Canadians' novel food.

Table 5. 10 Marginal effects on willingness to consume genome-edited, GM and organic food products

	GM Salmon	GM papaya	GM sweet corn	Genome-edited potato	Genome-edited apple	Genome-edited milk	Organic beef	Organic apples	Organic wheat/bread
TrustCan									
Confident	--	--	0.106** (0.050)	--	--	--	--	--	--
Very confident	--	0.175** (0.083)	0.167** (0.064)	--	--	0.176** (0.078)	--	--	--
Neophilico	0.191*** (0.065)	--	--	0.177** (0.083)	--	--	--	--	--
Neophobic	--	- 0.514*** (0.087)	-0.334*** (0.052)	-0.241*** (0.064)	-0.262*** (0.072)	-0.411*** (0.093)	--	--	--
Top3 Food Value									
Naturaltop3	--	--	-0.141** (0.056)	--	--	--	--	--	--
Tastetop3	--	--	--	0.157** (0.063)	--	0.134** (0.066)	--	--	--
Pricetop3	--	--	--	--	--	--	--	-0.083*** (0.036)	-0.150** (0.057)
Safetop3	--	--	--	--	--	--	-0.097** (0.045)	-0.109*** (0.038)	--
Conventop3	--	--	--	0.151** (0.067)	--	--	-0.107** (0.051)	-0.086** (0.041)	--
Orgtop3	-0.16*** (0.063)	--	--	--	--	--	--	--	--
Environment top3	--	--	-0.207*** (0.075)	-0.189** (0.083)	-0.250*** (0.084)	-0.185*** (0.090)	-0.16*** (0.056)	-0.146*** (0.044)	-0.189** (0.079)
Source of information									
Classic_info	--	--	--	0.090** (0.044)	--	--	--	0.101*** (0.027)	0.152*** (0.043)
Family_info	--	--	--	--	--	--	--	--	-0.096** (0.042)
Scientific_info	--	--	-0.137*** (0.049)	--	--	--	--	-0.064** (0.030)	-0.102** (0.051)
GovWeb_info	--	--	0.098** (0.049)	--	--	--	--	--	--
Company_info	--	--	0.114** (0.049)	--	--	--	--	--	--
know	0.029*** (0.009)	0.024** (0.009)	0.046*** (0.007)	0.025*** (0.008)	0.034*** (0.009)	0.045*** (0.010)	--	0.010** (0.004)	--
Self rated understanding genome editing									
Very poor	--	--	--	--	--	--	0.086** (0.041)	0.109*** (0.033)	--
Poor	--	--	--	--	--	--	0.079** (0.037)	0.078** (0.033)	--
Very good	0.336** (0.152)	--	--	--	--	--	--	--	--
Gender	0.133** (0.045)	0.125** (0.047)	0.220*** (0.041)	0.192*** (0.041)	0.184*** (0.046)	0.105** (0.049)	--	--	0.106** (0.043)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively. Standard error in parentheses.

Environmental impact has a negative impact on the WTC: GM sweet corn and all the three genome-edited food products. There is a decrease in the likelihood of consuming these products for respondents that ranked environmental impact in their top three food values, Convenience (ease with which food is cooked and/or consumed) had a positive impact in the WTC genome-edited potatoes. The WTC GM sweet corn is impacted negatively by naturalness. Environmental food value impact is consistent with the previous finding in this study. In the multinomial regression, the food value 'environment' impacted WTC genome-edited apples and genome-edited potatoes, both negatively. Environmental concerns about WTC novel food products are consistent with Matin et al. (2012) for the Canadian population.

Scientific information sources have a strong negative impact on the WTC GM sweet corn, while government websites and company information have a positive impact on the WTC GM sweet corn. The use of classic media sources (tv, radio and newspaper), will positively impact the WTC genome-edited potatoes. The use of government websites and company information have a positive impact on the WTC GM sweet corn. The WTC GM salmon and GM papaya was not impacted by sources of information.

Consistent with what is expected, knowledge positively affects WTC for all the GM and genome-edited products, although the magnitude is not strong. Individuals who consider themselves to have a very good understanding of genetics will be about 3% more likely to consume GM salmon. Males are also more likely to consume all the genome-edited and GM food products tested in the survey.

As a reference, marginal effects of the WTC three organic food products (beef, apple and wheat/bread) are included in Table 5.10. Willingness to consume organic product is not driven by trust in the Canadian food safety system or where people register on the FTNS. However, the organic products are affected by at least one food value or a source of information. Knowledge has a positive impact on organic apple WTC, however consumers who self-rated as "very poor" and "poor" regarding genetic knowledge tend to be more willing to consume organic beef and apples.

5.4 Discussion and hypotheses testing

Hypotheses to be tested in this study were listed in chapter 2. Based on the parameters obtained in the regression analysis and the previous sections of this chapter, results of the hypotheses testing are presented in table 5.11.

Table 5. 11 Results of the hypotheses testing

Hypotheses		Results			
		Genome editing technology	**Willingness to consume potato**	**Willingness to consume apple**	**Willingness to consume milk**
H1	Confidence in the food safety system will positively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.	Supported	Not supported	Supported	Supported
H2	Knowledge of genetics will positively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.	Supported	Supported	Supported	Supported
H3	Self-rated understating in genome editing will positively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.	Supported	Not supported	Not supported	Not supported
H4	Neophilico characteristics will positively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.	Supported	Supported	Not supported	Supported
H5	Neophobic characteristics will negatively influence consumer perceptions of genome editing and willingness to consume genome-edited food products.	Supported	Supported	Supported	Supported
H6	Perceived benefits will positively influence willingness to consume genome-edited food products	NA	Supported	Supported	Supported
H7	Perceived environment risks will negatively influence willingness to consume genome-edited food products	NA	Not supported	Not supported	Not supported
H8	Perceived health risks will negatively influence willingness to consume genome-edited food products	NA	Supported	Not supported	Not supported
H9	Perceived ethical concerns will negatively influence willingness to consume genome-edited food products	NA	Not supported	Not supported	Supported
H10	Perceived equity concerns will negatively influence willingness to consume genome-edited food products	NA	Not supported	Not supported	Not supported

Some spurious correlations were identified by the results such as the relationship between WTC genome-edited food products and two food values (origin and convenience), sources of information (friends, company information) and gender. Attitudes toward genome editing technology are influenced by trust in the Canadian food safety system (H1). Regulatory institutions such as Heath Canada, CFIA, provincial agriculture agencies, and Agriculture and Agri-Food Canada are trusted by 70% of surveyed Canadians. High levels of trust were also identified by Health Canada in 2016, where focus groups participants pointed out that the Canadian food system was more advanced and more rigorous as evidenced by fewer incidences of illness stemming from food safety problems such as recalls. Consumer perceptions of genome editing technology is affected by the categories that consumers feel not at all confident and very confident about the domestic food safety system. Consumers with a strong positive attitude about the Canadian food safety system tend to have a positive perception about genome editing, whereas the opposite happens for individuals with strong negative attitudes about the domestic food safety system (H1). Trust in the different agencies within the food system (government, industry and researchers) might reduce integrity concerns (Goddard et al., 2018; Marques et al., 2015), and thus affect attitudes regarding genome editing. Self-rated understanding of genome editing (H3) and food technology neophobia scores (H4 -H5) also had a significant and expected impact on the attitude toward genome-editing technology. As identified by Goddard et al. (2018), higher self-rate knowledge of science and technology reduces concerns about GM foods for Canadian consumers. While it is true that knowledge impacts consumer perceptions of genome editing, this effect was weak (H2).

When compared with drivers that impact consumer attitudes toward GM technology, some differences occurred. Self-understanding of genetics and the degree to which people were neophobic were the main drivers for consumer perceptions. However, unlike for genome editing technology, GM technology was affected by the source of information. Consumers that selected social media were more likely to have positive perceptions. This was unexpected, considering that information shared through social media is not generally scientifically based or referenced (Ryan and Vicini, 2016).

The same variables were not be used in both the multinomial and ordered logit models, however the main drivers in both models are similar. Neophobia food categories impacted the WTC of all the genome-edited food products (with expected signs) in the same way as consumer attitudes toward technology. The effect is repeated in the probit model analysis, where the FTNS scores impacted GM WTC similarly to genome-edited foods (H5). This finding supports results showing that consumers with high degrees of food technology neophobia are more reluctant to consume GM and other novel food products (Chen et al., 2017; Hosseini et al., 2012; Matin et al., 2012; Vidigal et al., 2015).

Prate et al. (2012), found a strong relationship between perceived benefits and intention to consume GM foods. The benefit perception index has a significant impact in all the multinomial models and is the strongest driver across all the multinomial regressions (H6). Perception indices also revealed that WTC genome-edited food products was impacted by at least two risk perception factors: the health risk perception index (H8), and in the case of genome-edited milk, the ethics risk perception index (H9). The latter could be explained by ethics related to animal welfare. Previous studies suggest that genetic modification of animals is considered morally unacceptable for some consumers (Marques et al., 2015). These findings not only suggest that perceived risks and benefits are identified as critical factors in determining WTC genome-edited food products among Canadians, but that misconceptions about GM also affect consumers' acceptance of genome-edited products.

Knowledge also affected attitude toward genome-editing technology and WTC genome-edited food products, albeit weakly (H2). Similarly, an effect of knowledge was registered in the probit models for both genome editing and GM food WTC, the results of which contradict Bredahl, (1999) and Chen et al. (2013) that described the effect of knowledge as fundamental for consumer attitudes among novel food products. Finally, similarly as found by Charlebois et al. (2019), most of the demographic characteristics were not identified as significant drivers except gender (male).

Chapter 6

Summary and Conclusions

This sixth and final chapter discusses the key findings based on the research objectives from chapter 1 and discuss policy and research implications. Section 6.1 presents a summary of major research findings, identifying the main drivers that impact consumer perception of genome editing technology and willingness to consume genome-edited food products. Section 6.2 discusses the policy implications of the findings detailed in section 6.1. Lastly, section 6.3 discusses the limitations pertaining to the research methodology and provides suggestions for future research arising from this study.

6.1 Summary of major research findings

The main objective of this research was to determine the drivers that affect consumer perceptions of genome-editing technology. Results indicate that surveyed Canadian consumers have a more positive attitude toward genome editing technology compared to GM technology. Positive responses were about 15% higher for foods produced using genome editing technology than for GM technology. An ordered logit model shows that the main drivers that strongly attitudes toward genome editing technology were trust in the Canadian food safety system and self-rated understanding of genome editing. Another important variable that drives attitudes is being neophobic toward new technologies. When compared with GM technology, positive attitudes are correlated with awareness or previous knowledge as per self-rated understanding of genetics, while negative attitudes are driven by the tendency to be neophilico. Together, these results suggest both technologies are driven by variables focused on the availability of scientific and reliable information for consumers and concerns about food technology.

Findings from the consumer survey also revealed that most Canadians believe there are benefits to genome editing technology, particularly with respect to nutrition, and reduction of pesticide residues in food and in the environment. In the multinomial logit model, the benefit perception index was the main driver for positive responses to the WTC genome-edited food products. Negative responses to the WTC genome-edited food products are driven by health risk index for genome-edited potatoes, trust in Canada's food safety system for genome-edited apples, and the ethics risk index in the case of genome-edited milk. This part of the study confirmed the importance of perceived benefits and risks for consumer acceptance of novel food products.

In the probit model comparison analysis, the FTNS becomes important. For neophobics, the main driver of the WTC for five out of the six food products analyzed (GM versions of papaya and corn; genome-edited versions of potatoes, apples, and milk). The main driver for GM salmon is self-rated knowledge of genetics. Other relevant drivers for genome-edited apples and milk WTC are the environmental impact, as well as gender (male) for the genome-edited potatoes.

6.2 Implications

The findings of this thesis may assist stakeholders and policy makers, consumers, and regulatory entities in understanding the drivers for the attitudes of genome editing technology applied to food production in the local context. The results of this study have several important policy implications for future practice.

The research finds that surveyed Canadians have low levels of scientific knowledge, a low level of self-rated knowledge of genome editing technology, which limits the consumption intention for genome-edited food products. There is, therefore, a definite need for better scientific disclosure to educate consumers about genome editing technology. According to Lutch (2015), educated consumers with objective information will tend to weigh risks and benefits in a rational way. However, it is important to consider that a strategic campaign based exclusively on the information deficit model could lead consumers to a confirmation bias. A more appropriate approach would consider ideological beliefs, and consider the public’s ethical, political, religious and culture views. Since the FTNS was identified as an important driver of respondents’ willingness to consumer genome-edited food products, consumer characteristics should be considered in the design of communication strategies. Canadians consumers were strongly affected by two factors: risks and health characteristics (Chen et al., 2013). Therefore, to offset food technology neophobia, education campaigns must inform consumers about genome-edited food products in terms of health risks and consumption.

Consumers also identified benefits from genome-editing technology. The perceived benefits play a significant role in the WTC genome-edited food product; therefore, information campaigns should be focused on strengthening consumers' already positive perceptions about nutritional contributions and pest-resistant characteristics. According to Gatica-Arias et al. (2019), low levels of knowledge about genome editing occur because information generated in scientific studies has not been communicated effectively to consumers. On the other hand, the WTC of genome-edited food products could be negatively affected by perceptions about environmental effects, particularly the loss of original plant varieties. Concerns related to unnaturalness, untrustworthiness, uncertainty, unhealthiness, and risks are frequently associated with GM production (Chen et al., 2017) and consumers tend to consider genome editing as similar to transgenics (Kato-Nitta et al., 2019), therefore, it is also important to highlight the differences with GM technology to avoid and prevent misconceptions of emerging novel food technologies.

Considering the important impact that Canada's food safety system has on consumer perceptions of genome-editing technology, institutions play a fundamental role as information providers to consumers. According to Lucht (2015), consumers have limited knowledge and depend on entities they consider trustworthy to make informed decisions. Therefore, Health Canada, the Canadian Food Inspection Agency, and Agriculture and Agri-food Canada are likely the most appropriate information dissemination channels for consumer studies and regulation standards status. The use of modern media sources to disseminate scientific knowledge is of crucial importance for effectively communicating biotechnology findings to the public (Wunderlich and Gatto, 2015), therefore the inclusion of interactive media should be considered for the introduction of genome-edited food products into the Canadian market.

6.3 Limitations and future research

Results should be considered in the context of the following limitations. First, the survey was conducted in English only, limiting results and interpretation to the English-speaking provinces in Canada. One observation from Quebec was collected although but dropped due to under-representation. Quebec is the second biggest province in Canada with 23% of the population, meaning that its exclusion restricts the ability to make inferences.

Second, the analysis of the WTC genome-edited and transgenic food products did not allow specification of technology (genome editing or transgenic) for the product category. The introduction of a set of questions asking if the participant is a regular consumer of the food products would allow the separation of non-consumers from the sample, prior to econometric analysis.

Third, results of the study are focused on genome-edited food products that have been approved in Canada such as artic apple developed by Okanagan Specialty Fruit and the innate potato, developed by Simplot (Smyth, 2017). Genome-edited milk is a hypothetical product. Consumers likely have different attitudes depending on the food product category (plant, animal), it is important for future studies to examine the drivers for different types of food to determine appropriate marketing strategies.

Despite these limitations, this study is a very good start to estimate consumer perceptions of genome editing technology regarding foods currently available in Canadian food markets. Since many Canadians do recognize advantages of genome editing, it is imperative to identify how willing consumers are to purchase such products. Willingness to buy and willingness to pay studies of genome-edited food products should be explored including neophilic/neophobic characteristics to determinate the impact of people's beliefs in the buying decision process, proving valuable information to influence successful introduction of new food products with added value from genome editing technology.

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APPENDIX A1

Questionnaire

Consent Form:

We would like to invite you to participate in a study regarding plant-breeding techniques. Your answers will help document attitudes toward modern agriculture in Canada and provide insights to policy makers.

The survey takes approximately 15 minutes to complete and includes questions about food, the environment, and health, in addition to basic demographic questions. Your participation in this study is appreciated and completely voluntary. All responses to this questionnaire are anonymous, the results will be aggregated, and the researchers will not be able to identify you.

If you have any questions concerning this study, you may contact the principal investigator:
Dr. Stuart Smyth, Assistant Professor
Department of Agricultural and Resource Economics, University of Saskatchewan
51 Campus Drive, Saskatoon, SK, S7N 5A8, Canada.
Ph.: (306) 966 2929. Email: stuart.smyth@usask.ca

This survey has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. If you have any questions about your rights during the course of this research, please contact the University of Saskatchewan Behavioral Research Office at: ethics.office@usask.ca; (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

This survey is hosted by Voxco, a Canadian-owned and managed company; data are securely stored in Canada. Electronic data will be stored on secure University of Saskatchewan servers indefinitely.

Completion of the survey implies your consent to participate in this research. Survey results will be used in a report, and in scholarly publications. Only aggregated data will be reported. You should feel free to decline to answer any question. You may withdraw from this survey at any time before data analysis. However, data withdrawal is no longer possible once the data have been pooled for analysis. By selecting next and completing this questionnaire, your free and informed consent is implied and indicates that you understand the above conditions to participate in this study.

S1
Are you partly or totally responsible for doing the grocery shopping in your household?

	Yes – partly or totally responsible
	No – not responsible (screen out)

Part One

Question 1
Please select your preferred source to access information about food products (select all that apply):
[Randomize row order]

- □ Radio
- □ Television
- □ Magazines
- □ Family/Friends
- □ Printed newspaper
- □ Conference
- □ Agronomist
- □ Facebook
- □ Twitter
- □ Instagram
- □ Snapchat
- □ Government institution websites
- □ Other Internet sources
- □ Professional/scientific publications
- □ Food company websites
- □ Food labels
- □ Other preferred source (please indicate)

Question 2
Which of the following food attributes are most important to you?
Please rank your top three choices by clicking and dragging them into the box below Place the attribute most important to you at the top of the list, followed by the second and third most important attributes.
[Randomize row order]

Naturalness (extent to which food is produced without modern technologies)
Taste (extent to which consumption of food is appealing to the senses)
Price (the price that is paid for the food)
Safety (extent to which consumption of food will not cause illness)
Convenience (ease with which food is cooked and/or consumed)
Nutrition (amount and type of fat, protein, vitamins, etc.)
Tradition (preserving traditional consumption patterns)
Origin (where the food was grown or produced)
Fairness (the extent to which all parties involved in the production of food equally benefits)
Appearance (extent to which food looks appealing)
Environmental impact (effect of food production on the environment)

Question 3
Overall, how confident are you in Canada's food safety system?
- ◻ Not at all confident
- ◻ Somewhat confident
- ◻ Moderately confident
- ◻ Confident
- ◻ Very confident

Question 4
Please indicate your degree of trust in the following organizations regarding information about food safety in Canada. ***[Randomize row order]***

	Completely distrust	Distrust	Neither trust not distrust	Trust	Completely trust	Don't know
Food processors	◻	◻	◻	◻	◻	◻
Universities	◻	◻	◻	◻	◻	◻
Governments agencies/authorities	◻	◻	◻	◻	◻	◻
Retailers	◻	◻	◻	◻	◻	◻
Consumer advocacy organizations	◻	◻	◻	◻	◻	◻
Environmental advocacy organizations	◻	◻	◻	◻	◻	◻
Farmer organizations	◻	◻	◻	◻	◻	◻
Animal welfare advocacy organizations	◻	◻	◻	◻	◻	◻
Agriculture and Agri-food Canada	◻	◻	◻	◻	◻	◻
Provincial agriculture agencies	◻	◻	◻	◻	◻	◻
The Canadian Food Inspection Agency (CFIA)	◻	◻	◻	◻	◻	◻
Health Canada	◻	◻	◻	◻	◻	◻

Question 5
Please indicate whether you believe the following statements are true or false.

	True	False	Don't Know
There are bacteria that live in drinking water.	◻	◻	◻
A father's genes determinate whether a child will be a boy.	◻	◻	◻
If a person eats genetically modified fruits, their genes could be modified as a result.	◻	◻	◻
Genetically modified animals are always bigger than non-genetically modified animals.	◻	◻	◻
It is possible to transfer animal genes to plants.	◻	◻	◻
Tomatoes genetically modified with genes from catfish would taste like fish.	◻	◻	◻
Genetically modified foods are created using radiation to create genetic mutations.	◻	◻	◻
Organic food are created using radiation to create genetic mutations.	◻	◻	◻
The cloning of living things produces genetically identical copies.	◻	◻	◻
The yeast used to produce beer contains living organisms.	◻	◻	◻
Corn grown thousands of years ago looks the same as corn grown today.	◻	◻	◻

Question 6
How would you rate your understanding for each of the following aspects of food technology?
[Randomize row order]

	Very poor	**Poor**	**Fair**	**Good**	**Very good**
Genetics	☐	☐	☐	☐	☐
Plant breeding	☐	☐	☐	☐	☐
Genome editing	☐	☐	☐	☐	☐

Question 7
Please indicate your level of agreement with each of the following statements about new food technologies on a scale from 1 to 7 (where 1 is strongly disagree and 7 is strongly agree)
[Randomize row order]

	Strongly disagree 1	**Disagree 2**	**Disagree somewhat 3**	**Neither agree or disagree 4**	**Agree somewhat 5**	**Agree 6**	**Strongly agree 7**
New food technologies are something I am uncertain about.	☐	☐	☐	☐	☐	☐	☐
New foods are less healthy than traditional foods.	☐	☐	☐	☐	☐	☐	☐
The benefits of new food technologies are often grossly overstated.	☐	☐	☐	☐	☐	☐	☐
There are plenty of tasty foods around, so we do not need to use new food technologies to produce more.	☐	☐	☐	☐	☐	☐	☐
New food technologies decrease the natural quality of food.	☐	☐	☐	☐	☐	☐	☐
New food technologies are unlikely to have long-term negative health effects.	☐	☐	☐	☐	☐	☐	☐
New food technologies give people more control over their food choices.	☐	☐	☐	☐	☐	☐	☐
New products using new food technologies can help people have a balanced diet.	☐	☐	☐	☐	☐	☐	☐
New food technologies have long-term negative environmental effects.	☐	☐	☐	☐	☐	☐	☐
It can be risky to switch to new food technologies too quickly.	☐	☐	☐	☐	☐	☐	☐
Society should not depend heavily on technologies to solve its food problems.	☐	☐	☐	☐	☐	☐	☐
There is no sense trying out high-tech food products because the ones I eat are already good enough.	☐	☐	☐	☐	☐	☐	☐
The media usually provides a balanced and unbiased view of new food technologies.	☐	☐	☐	☐	☐	☐	☐

PART Two

Information Session genome editing

GENOME EDITING is a plant breeding technique that precisely modifies a plant's genetics one gene at the time. The plant's genetic material can be altered to enhance or remove certain traits.

This process is different from GENETIC MODIFICATION (transgenics) because it does not add genetic material from different species.

Question 8

Please indicate your level of agreement with the following statements about genome editing on a scale from 1 to 5 (where 1 means strongly disagree and 5 means strongly agree). ***[Randomize row order]***

	Strongly disagree 1	**Disagree 2**	**Neither agree or disagree 3**	**Agree 4**	**Strongly agree 5**	**Don't know**
Genome editing technology has the potential to create foods with enhanced nutritional values.	☐	☐	☐	☐	☐	☐
Genome editing has the potential to reduce pesticide residue on food.	☐	☐	☐	☐	☐	☐
Genome editing has the potential to reduce pesticide runoff in the environment.	☐	☐	☐	☐	☐	☐
Genome-editing technology can result in pest-resistant crops.	☐	☐	☐	☐	☐	☐
Genome-edited crops are negative for the environment.	☐	☐	☐	☐	☐	☐
Insect-resistant crops developed using genome editing could cause death of untargeted insects.	☐	☐	☐	☐	☐	☐
Genome editing can lead to a loss of original plant varieties.	☐	☐	☐	☐	☐	☐
Consuming genome-edited food products can damage human health.	☐	☐	☐	☐	☐	☐
Consuming genome-edited food products can lead to more allergies.	☐	☐	☐	☐	☐	☐
Consuming genome-edited foods might lead to an increase in antibiotic-resistant diseases.	☐	☐	☐	☐	☐	☐
Genome editing is tampering with nature.	☐	☐	☐	☐	☐	☐
Genome editing technology is like imitating God.	☐	☐	☐	☐	☐	☐
Genome-edited food is not natural.	☐	☐	☐	☐	☐	☐
Genome-edited products only benefit multinational companies.	☐	☐	☐	☐	☐	☐
Genome-edited products don't benefit smaller farms.	☐	☐	☐	☐	☐	☐
Genome-edited products are being forced on developing countries.	☐	☐	☐	☐	☐	☐

Question 9

Please indicate your attitude toward the following technologies.

[Randomize row order]

	Strongly negative	**Negative**	**Neutral**	**Positive**	**Strongly positive**
Transgenics	☐	☐	☐	☐	☐
Genome editing	☐	☐	☐	☐	☐

Question-10

Would you consume the following food products? -*[Randomize row order]*

	Yes	**No**	**Don't know**
Genetically modified salmon (grows faster)	☐	☐	☐
Genetically modified papaya (virus resistant)	☐	☐	☐
Sweet corn (insect resistant)	☐	☐	☐
Genome-edited potato (resists blackspot bruising, and contains lower levels of asparagine)	☐	☐	☐
Genome-edited apple (non-browning)	☐	☐	☐
Genome-edited milk (eliminates the need to remove horns from dairy cows)	☐	☐	☐
Organic beef (no antibiotics)	☐	☐	☐
Organic apple (no chemical sprays)	☐	☐	☐
Organic wheat/bread (herbicide tolerant)	☐	☐	☐

PART Three - demographics

D1
Which gender do you prefer to identify with?

- ◻ Male
- ◻ Female
- ◻ Other
- ◻ Prefer not to say

D2
Please choose your age range

- ◻ Under 25
- ◻ 25-34
- ◻ 35-44
- ◻ 45-54
- ◻ 55-64
- ◻ 65-75
- ◻ Over 75
- ◻ Prefer not to say

D3
In which province or territory do you live?

- ◻ Alberta
- ◻ British Columbia
- ◻ Manitoba
- ◻ New Brunswick
- ◻ Newfoundland and Labrador
- ◻ Northwest Territories
- ◻ Nova Scotia
- ◻ Nunavut
- ◻ Ontario
- ◻ Prince Edward Island
- ◻ Quebec
- ◻ Saskatchewan
- ◻ Yukon
- ◻ Prefer not to say

D4
How many children younger than 18 years old live in your house?

D5
What is the highest level of education you have completed?

- ◻ Graduate degree
- ◻ Bachelor's degree
- ◻ University below bachelor's
- ◻ College diploma
- ◻ Apprenticeship or other trades certificate
- ◻ High school diploma
- ◻ No certificate diploma or degree
- ◻ Prefer not to say

D6
Do you work in an agri-food related field (eg. farming, fisheries, forestry, grocery store, food industry manufacturing, retail, etc.?)

- ◻ Yes
- ◻ No
- ◻ Prefer not to say

D7
For comparison purposes only, which one of the following best describes your annual household income before taxes?

- ◻ Under $29,999
- ◻ $30,000-$49,999
- ◻ $50,000-$69,999
- ◻ $70,000-$89,999
- ◻ $90,000-$109,999
- ◻ $110,000-$129,999
- ◻ $130,000-$150,000
- ◻ More than $150,000
- ◻ Prefer not to say

APPENDIX A2 **Coefficients for ordered logit model: consumer perception of genome editing and GM technologies**

Variables	**Genome editing**	**Transgenics**
Observations	497	497
Pseudo R2	0.18	0.16
Food Value ranked top 3		
Naturalness	-0.155 (0.364)	-0.259 (0.349)
Taste	0.443 (0.309)	0.159 (0.310)
Price	-0.055 (0.287)	0.079 (0.303)
Safety	0.161 (0.282)	0.334 (0.296)
Convenience	--	0.789** (0.327)
Tradition	0.090 (0.612)	1.003* (0.573)
Origin	0.075 (0.300)	-0.135 (0.315)
Fairness	0.408 (0.545)	0.388 (0.541)
Appearance	0.320 (0.320)	0.546 (0.338)
Environment impact	-0.647* (0.383)	0.797* (0.408)
Self rated understanding Genetics:		
Very poor	0.079 (0.373)	-0.146 (0.353)
Poor	-0.157 (0.238)	-0.183 (0.244)
Good	-0.187 (0.495)	-0.181 (0.458)
Very good	0.184 (1.038)	2.075** (0.993)
FTNS		
Neophilico	0.956*** (0.293)	1.189*** (0.288)
Neophobic	-1.05*** (0.337)	-0.911** (0.362)
Source of information		
Classic_info	0.0709 (0.233)	-0.322 (0.231)
Family_info	0.248 (0.205)	0.348* (0.207)
Government institution websites	0.466* (0.239)	0.265 (0.281)
Social media	0.090 (0.250)	0.499** (0.239)
Professional / scientific	-0.102 (0.283)	-0.083 (0.299)
Food companies	0.076 (0.275)	-0.037 (0.256)
Trust in Canada's food safety system:		
Not at all confident	-1.985** (0.808)	-1.198 (0.933)
Somewhat confident	0.161 (0.276)	-0.059 (0.279)

Confident	0.473*	0.511*
	(0.244)	(0.267)
Very confident	0.760**	0.647*
	(0.333)	(0.333)
Self rated understanding GE:	-1.05***	-0.95 **
Very poor	(0.351)	(0.368)
Poor	-0.448	-0.676**
	(0.274)	(0.311)
Good	0.338	-0.048
	(0.778)	(0.699)
Very good	2.244**	0.890
	(0.978)	(0.926)
Knowledge	0.158***	0.093**
	(0.043)	(0.041)
Gender	0.676***	0.378*
	(0.212)	(0.217)
Age		
25-34 years old	-0.171	-0.086
	(0.579)	(0.550)
35-44 years old	-0.286	0.369
	(0.640)	(0.569)
45-54 years old	-0.044	0.198
	(0.583)	(0.545)
55-64 years old	-0.148	0.127
	(0.552)	(0.521)
65-75 years old	0.098	0.695
	(0.558)	(0.523)
Over 75 years old	0.147	0.437
	(0.737)	(0.838)
Education		
Graduate degree	0.013	-0.638
	(0.456)	(0.432)
Bachelor's degree	-0.139	-0.632
	(0.433)	(0.385)
University bellow bachelor's	-0.618	-1.006**
	(0.473)	(0.433)
College diploma	-0.655	-0.645
	(0.440)	(0.399)
Apprenticeship	-0.279	-0.591
	(0.549)	(0.478)
No certificate	0.693	-0.580
	(0.750)	(0.591)
Province	-0.040	-0.490
Alberta	(0.317)	(0.354)
BC	-0.129	-0.154
	(0.270)	(0.267)
Manitoba	0.364	0.577
	(0.387)	(0.377)
New Brunswick	-0.029	-0.826
	(0.457)	(0.478)
New foundland	1.520**	0.930
	(0.754)	(0.669)
Northwest territories	0.029	-0.194
	(0.365)	(0.413)
Prince Edward	0.824	2.039
	(0.681)	(0.870)
Saskatchewan	0.405	0.415
	(0.817)	(0.648)
Income		
$30K - $49K	0.025	0.587
	(0.482)	(0.513)

$50K - $69K	0.337	0.757
	(0.516)	(0.584)
$70K- $89K	0.064	0.027
	(0.480)	(0.504)
$90K - $109K	-0.183	0.154
	(0.524)	(0.535)
$110K -$129K	-0.316	0.366
	(0.521)	(0.562)
$130K - $150	-0.172	-0.494
	(0.649)	(0.684)
+ $150K	0.042	0.536
	(0.500)	(0.549)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively. Standard error in parentheses.

APPENDIX A3 **Coefficients for multinomial logit model : willingness to consume genome-edited potato, apple, milk.**

	Genome-edited potato		**Genome-edited apple**		**Genome-edited milk**	
Observations	497		497		497	
Pseudo R2	0.39		0.34		0.27	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Trust in Canada's food safety system						
No at all	-0.316	0.741	-13.957	1.892	-0.244	1.209
	(1.400)	(1.027)	(13.472)	(1.256)	(1.435)	(0.882)
Somewhat	-0.236	0.022	-0.276	-0.138	-0.254	0.336
	(0.426)	(0.482)	(0.429)	(0.450)	(0.405)	(0.390)
Confident	0.083	0.437	0.396	**0.985****	**0.876****	**0.863****
	(0.419)	(0.472)	(0.437)	(0.453)	(0.389)	(0.387)
	0.450	0.161	0.600	0.566	**0.846***	0.171
Very confident	(0.561)	(0.675)	(0.561)	(0.608)	(0.496)	(0.534)
FTNS						
neophilico	**-1.379*****	**-2.059*****	**-0.820***	-0.505	**-0.765***	-0.306
	(0.467)	(0.740)	(0.480)	(0.551)	(0.434)	(0.488)
neophobic	-0.499	-0.011	0.758	**1.408****	**-1.423****	0.116
	(0.620)	(0.577)	(0.727)	(0.688)	(0.694)	(0.474)
Food Value ranked top 3						
Naturalness	-0.816	0.006	0.122	0.405	0.590	0.275
	(0.507)	(0.546)	(0.523)	(0.533)	(0.476)	(0.452)
Taste	0.231	**-0.882***	0.079	-0.386	0.489	-0.273
	(0.454)	(0.521)	(0.471)	(0.478)	(0.430)	(0.423)
Price	0.493	0.192	0.385	0.299	0.298	0.080
	(0.448)	(0.506)	(0.464)	(0.483)	(0.406)	(0.406)
Safety	-0.230	-0.343	-0.127	0.185	0.223	0.152
	(0.459)	(0.529)	(0.469)	(0.490)	(0.433)	(0.429)
Convenience	-0.106	**-1.124***	0.288	0.349	**0.774***	0.124
	(0.487)	(0.629)	(0.525)	(0.553)	(0.465)	(0.497)
Tradition	1.176	-0.061	-0.500	-0.304	0.727	-0.304
	(0.919)	(0.945)	(0.946)	(0.832)	(0.766)	(0.730)
Origin	**-1.086****	**-0.927***	**-0.956***	-0.561	-0.249	-0.350
	(0.479)	(0.525)	(0.503)	(0.521)	(0.446)	(0.424)
Fairness	0.708	1.168	0.870	0.357	1.251	0.127
	(0.892)	(0.941)	(0.828)	(0.911)	(0.767)	(0.802)
Appearance	**1.235***	0.963	0.308	0.072	0.357	-0.053
	(0.631)	(0.700)	(0.574)	(0.619)	(0.528)	(0.520)
Environment	1.047	**2.171*****	1.180	**2.645*****	0.573	**1.020***
	(0.743)	(0.758)	(0.834)	(0.807)	(0.666)	(0.596)
Nutrition	0.000	0.000	0.000	0.000	0.000	0.000
	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
Source of information						
classic	0.177	-0.443	-0.351	-0.386	-0.009	**-0.586***
	(0.340)	(0.396)	(0.352)	(0.368)	(0.314)	(0.321)
Friends/fam	-0.027	-0.084	0.287	0.200	**0.687****	0.200
	(0.320)	(0.372)	(0.334)	(0.351)	(0.305)	(0.295)
scientific	0.324	-0.546	-0.089	0.067	0.304	0.091
	(0.461)	(0.538)	(0.480)	(0.491)	(0.414	(0.416)
media	0.178	-0.376	**0.765***	-0.073	0.424	0.081
	(0.387)	(0.437)	(0.407)	(0.431)	(0.352	(0.353)
GovWeb	**0.867****	0.677	0.583	0.353	0.268	-0.072
	(0.428)	(0.483)	(0.429)	(0.452)	(0.371	(0.372)
Company	-0.340	**-1.325****	-0.300	**-0.749***	0.224	0.115
	(0.432)	(0.488)	(0.433)	(0.449)	(0.369	(0.369)
know	-0.096	-0.095	0.019	-0.040	0.016	-0.067
	(0.069)	(0.077)	(0.071)	(0.074)	(0.063	(0.061)

Self rated understanding Genetics						
Very poor	-0.543	-0.262	-0.372	-0.386	0.746	-0.127
	(0.571)	(0.650)	(0.602)	(0.609)	(0.562	(0.533)
Poor	0.040	-0.344	-0.175	-0.175	**0.696***	0.102
	(0.391)	(0.447)	(0.416)	(0.431)	(0.382	(0.358)
Good	0.659	0.449	0.341	0.151	-0.252	-0.293
	(0.705)	(0.904)	(0.741)	(0.799)	(0.609	(0.652)
Very good	-0.447	0.104	-0.664	-0.988	0.046	0.252
	(1.391)	(1.907)	(1.403)	(1.619)	(1.259	(1.486)
Self rated understanding GE						
Very poor	-0.531	-0.567	-0.215	-0.030	**-1.657*****	-0.918
	(0.595)	(0.669)	(0.605)	(0.610)	(0.567	(0.536)
Poor	-0.465	-0.473	0.517	-0.238	**-0.790***	-0.638
	(0.491)	(0.579)	(0.504)	(0.530)	(0.448	(0.452)
Good	0.385	-0.748	1.570	1.283	0.411	-0.296
	(0.948)	(1.224)	(1.153)	(1.207)	(0.825	(0.869)
Very good	0.810	-2.701	0.139	-2.665	0.389	-1.633
	(1.555)	(2.367)	(1.428)	(1.830)	(1.267	(1.666)
Ben_perx	**2.774*****	-1.022	**2.512*****	0.957	**1.715*****	-0.077
	(0.653)	(0.808)	(0.668)	(0.702)	(0.563	(0.576)
Env_perx	-0.052	**1.492***	-1.050	-0.275	-0.015	0.710
	(0.754)	(0.853)	(0.802)	(0.818)	(0.705	(0.696)
Health_perx	0.360	**1.880****	-1.091	0.234	-0.508	0.601
	(0.786)	(0.931)	(0.852)	(0.909)	(0.702	(0.739)
Ethic_index	**-0.957***	1.082	-0.297	0.298	-0.058	**1.114****
	(0.558)	(0.675)	(0.579)	(0.639)	(0.506	(0.533)
Equity_index	**-1.338***	-0.366	0.067	1.107	-0.744	-0.427
	(0.694)	(0.784)	(0.741)	(0.750)	(0.628	(0.632)
Gender	0.138	**-1.300*****	-0.316	**-1.467*****	-0.310	**-0.652****
	(0.337)	(0.405)	(0.351)	(0.378)	(0.317)	(0.315)
Age						
25-34	-0.759	0.838	-1.219	-0.010	-0.495	1.314
	(0.801)	(1.091)	(0.882)	(0.903)	(0.728)	(0.905)
35-44	**-1.593***	0.875	-1.304	-0.994	-0.192	1.173
	(0.843)	(1.106)	(0.894)	(0.927)	(0.751)	(0.932)
45-54	-0.882	0.519	-0.858	-1.121	0.269	1.406
	(0.802)	(1.096)	(0.872)	(0.914)	(0.743)	(0.931)
55-64	0.423	0.381	-0.351	-0.773	-0.181	1.248
	(0.805)	(1.091)	(0.872)	(0.916)	(0.739)	(0.917)
65-75	-0.508	0.559	-1.399	-1.535	-0.010	**1.658***
	(0.816)	(1.111)	(0.888)	(0.937)	(0.774)	(0.952)
Over 75	1.397	2.027	1.137	0.132	0.775	**2.092***
	(1.375)	(1.707)	(1.493)	(1.615)	(1.059)	(1.247)
Province						
Alberta	-0.406	**0.953***	0.397	0.735	0.202	0.305
	(0.473)	(0.526)	(0.493)	(0.508)	(0.426)	(0.430)
BC	0.052	**1.057****	0.522	**1.110****	-0.012	**0.924****
	(0.448)	(0.496)	(0.481)	(0.498)	(0.420)	(0.405)
Manitoba	-1.033	-0.987	0.036	0.014	-0.461	0.326
	(0.665)	(0.810)	(0.676)	(0.732)	(0.696)	(0.647)
New	-0.405	0.808	-0.398	-0.533	0.216	0.342
Brunswick	(0.797)	(0.960)	(0.808)	(0.939)	(0.762)	(0.815)
Newfoundland	15.535	-14.352	0.794	-31.580	-0.263	-0.669
	(1.867)	(1.061)	(1.222)	(1.021)	(0.916)	(1.199)
Northwest	0.787	1.501	1.875	1.573	**2.190****	**1.616***
Territories	(0.918)	(1.078)	(1.168)	(1.239)	(0.973)	(0.929)
Prince Edward	16.038	16.121	15.968	17.524	-14.499	1.743
	(3.137)	(3.137)	(34.124)	(34.124)	(17.047)	(1.567)
Saskatchewan	-1.253	-0.552	-0.947	-1.084	-0.481	0.423
	(0.956)	(1.278)	(0.902)	(1.270)	(0.851)	(0.957)
Education						
Graduate	-0.412	0.492	-0.254	0.172	-0.866	-0.095

degree	(0.608)	(0.662)	(0.629)	(0.651)	(0.587)	(0.575)
Bachelor’s	-0.385	-0.257	0.108	-0.254	-0.477	-0.496
degree	(0.546)	(0.621)	(0.570)	(0.609)	(0.539)	(0.538)
University	0.551	0.915	0.670	0.773	**-1.478****	**-1.158***
below bachel	(0.724)	(0.800)	(0.755)	(0.785)	(0.694)	(0.653)
College	-0.056	0.013	-0.151	-0.307	-0.730	-0.612
diploma	(0.537)	(0.619)	(0.555)	(0.593)	(0.540)	(0.533)
Apprenticeship	0.130	0.255	1.250	0.840	0.880	0.620
	(0.775)	(0.945)	(0.868)	(0.959)	(0.795)	(0.836)
No certificate	**-3.417****	1.031	15.613	17.873	15.548	15.257
	(1.718)	(1.325)	(74.676)	(24.676)	(15.624)	(15.624)
Income						
Under $29K	**-1.315***	-1.215	-1.140	**-2.454*****	0.007	-0.706
	(0.682)	(0.886)	(0.708)	(0.857)	(0.687)	(0.701)
$30K - $49K	-0.206	1.107	1.343	**1.814***	0.816	0.634
	(0.696)	(0.741)	(0.929)	(0.958)	(0.644)	(0.644)
$50K - $69K	-0.146	0.707	-0.424	0.559	0.282	0.206
	(0.600)	(0.676)	(0.636)	(0.651)	(0.566)	(0.573)
$90K - $109K	0.432	0.510	-0.446	-0.303	0.077	-0.069
	(0.590)	(0.709)	(0.601)	(0.650)	(0.542)	(0.567)
$110K -$129K	-0.441	0.389	-0.223	0.794	-0.671	0.812
	(0.642)	(0.741)	(0.731)	(0.756)	(0.643)	(0.602)
$130K - $150	0.653	**1.751****	0.270	1.086	0.317	0.653
	(0.744)	(0.866)	(0.733)	(0.785)	(0.660)	(0.665)
+ $150K	0.222	-0.479	-0.602	-0.901	0.435	-0.373
	(0.578)	(0.699)	(0.591)	(0.662)	(0.554)	(0.577)
_cons	1.671	1.623	1.114	1.778	-0.820	-0.642
	(1.291)	(1.559)	(1.367)	(1.401)	(1.224)	(1.328)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively. Standard error in parentheses.

APPENDIX A4 **Coefficients for multinomial logit model : willingness to consume genome-edited potato, apple, milk.**

	GM Salmon	GM papaya	GM sweet corn	Genome edited potato	Genome edited apple	Genome edited milk	Organic beef	Organic apple	Organic wheat
Observations	382.000	348.000	377.000	364.000	368.000	346.000	437.000	435.000	407.000
Pseudo R2	0.283	0.274	0.438	0.349	0.263	0.303	0.164	0.290	0.172
Trust in Canada's food safety system									
Not at all	0.000	0.000	-0.417	-0.655	0.000	-0.966	0.007	0.105	-0.184
	(0.000)	0.000	(0.637)	(0.718)	(0.000)	(0.788)	(0.576)	(0.566)	(0.473)
Somewhat	-0.314	0.066	**0.687****	0.001	0.146	-0.009	0.014	0.390	-0.009
	(0.235)	(0.233)	(0.252)	(0.235)	(0.221)	(0.245)	(0.225)	(0.304)	(0.223)
Confident	0.156	0.281	0.480*	-0.016	-0.190	0.290	0.321	0.099	0.291
	(0.205)	(0.209)	(0.228)	(0.219)	(0.203)	(0.229)	(0.213)	(0.264)	(0.214)
Very confident	0.187	**0.609****	**0.780****	0.320	0.166	0.650**	-0.064	0.388	0.375
	(0.272)	(0.296)	(0.301)	(0.294)	(0.274)	(0.298)	(0.288)	(0.319)	(0.266)
FTNS									
neophilico	**0.74*****	0.298	0.645	**0.731****	0.206	-0.010	0.246	-0.187	0.069
	(0.259)	(0.265)	(0.377)	(0.346)	(0.266)	(0.281)	(0.263)	(0.296)	(0.272)
neophobic	-0.440	**-1.812*****	**-1.60*****	**-0.99*****	**-0.92*****	**-1.51*****	-0.084	-0.256	-0.432
	(0.285)	(0.332)	(0.280)	(0.276)	(0.261)	(0.369)	(0.264)	(0.300)	(0.251)
Food Value ranked top 3									
naturaltop3	-0.079	-0.199	**-0.675****	-0.302	-0.206	0.109	-0.203	0.283	-0.336
	(0.270)	(0.288)	(0.273)	(0.272)	(0.261)	(0.288)	(0.249)	(0.346)	(0.250)
tastetop3	0.206	0.424	0.436	0.648**	0.365	**0.493****	-0.124	0.080	0.021
	(0.232)	(0.246)	(0.285)	(0.268)	(0.230)	(0.248)	(0.252)	(0.284)	(0.227)
pricetop3	0.340	0.122	-0.043	0.078	-0.027	0.094	-0.415	**-0.623****	**-0.56*****
	(0.221)	(0.233)	(0.242)	(0.247)	(0.226)	(0.235)	(0.242)	(0.275)	(0.220)
safetop3	0.012	-0.282	-0.309	0.209	-0.045	0.086	**-0.509****	**-0.813****	-0.262
	(0.234)	(0.237)	(0.286)	(0.282)	(0.237)	(0.265)	(0.238)	(0.290)	(0.223)
conventop3	0.417	-0.278	0.304	**0.624****	0.198	0.445	**-0.562****	**-0.644****	-0.371
	(0.247	(0.252)	(0.273)	(0.275)	(0.255)	(0.256)	(0.274)	(0.315)	(0.250)
traditop3	-0.111	0.165	-0.375	0.296	-0.482	0.374	-0.527	-0.381	-0.304
	(0.511)	(0.430)	(0.480)	(0.434)	(0.430)	(0.501)	(0.497)	(0.507)	(0.495)
orgtop3	**-0.628****	-0.032	0.000	-0.072	-0.323	0.016	-0.413	0.122	-0.125
	(0.247)	(0.232)	(0.252)	(0.247)	(0.231)	(0.241)	(0.256)	(0.266)	(0.235)
fairtop3	-0.165	0.257	-0.747	-0.037	0.193	0.716	-0.657	-0.484	0.018
	(0.410)	(0.449)	(0.434)	(0.396)	(0.382)	(0.380)	(0.360)	(0.386)	(0.362)
appetop3	0.211	0.226	0.181	0.113	0.112	0.259	-0.082	-0.468	-0.096
	(0.288)	(0.300)	(0.307)	(0.277)	(0.287)	(0.319)	(0.286)	(0.312)	(0.272)
impacttop3	-0.227	-0.564	**-0.990****	**-0.779****	**-0.877*****	**-0.680****	**-0.835*****	**-1.091****	**-0.73****
	(0.350)	(0.336)	(0.367)	(0.347)	(0.300)	(0.333)	(0.304)	(0.335)	(0.308)
Source of information									
classic	-0.072	0.037	0.067	**0.373****	0.147	0.262	0.289	**0.754*****	**0.58*****
	(0.170)	(0.181)	(0.200)	(0.183)	(0.172)	(0.191)	(0.182)	(0.211)	(0.171)
Friend/fam	0.113	0.202	0.140	-0.032	-0.054	0.234	0.134	0.091	**-0.370****
	(0.167)	(0.174)	(0.188)	(0.181)	(0.162)	(0.188)	(0.161)	(0.202)	(0.164)
scientific	-0.203	-0.214	**-0.654*****	-0.043	-0.315	0.011	-0.421	**-0.480****	**-0.39****
	(0.212)	(0.230)	(0.244)	(0.240)	(0.217)	(0.231)	(0.210)	(0.233)	(0.198)
media	-0.065	0.310	0.243	0.189	0.346	0.334	-0.069	0.151	-0.019
	(0.197)	(0.203)	(0.199)	(0.205)	(0.196)	(0.206)	(0.204)	(0.240)	(0.196)
GovWeb	0.266	0.411	**0.467****	0.252	0.318	0.341	0.089	0.212	0.294
	(0.200)	(0.212)	(0.238)	(0.225)	(0.195)	(0.219)	(0.205)	(0.219)	(0.192)
Company	-0.012	0.295	**0.545****	0.340	0.242	-0.063	-0.178	0.274	0.048
	(0.214)	(0.213)	(0.237)	(0.219)	(0.216)	(0.236)	(0.199)	(0.220)	(0.204)
know	**0.11*****	**0.085*****	**0.220*****	**0.105*****	**0.118*****	**0.165*****	0.047	**0.077*****	0.058
	(0.036)	(0.032)	(0.037)	(0.032)	(0.031)	(0.038)	(0.032)	(0.031)	(0.030)
Self-rated understanding genetics									
Very poor	0.276	-0.282	0.130	-0.111	-0.310	0.176	**0.455***	**0.895*****	0.405
	(0.264)	(0.260)	(0.263)	(0.258)	(0.240)	(0.252)	(0.239)	(0.323)	(0.233)
Poor	0.135	-0.020	0.347	0.118	-0.131	0.115	**0.408****	**0.551****	0.225
	(0.195)	(0.193)	(0.219)	(0.212)	(0.189)	(0.202)	(0.193)	(0.255)	(0.181)
Good	0.264	0.280	-0.263	0.333	0.095	0.112	0.132	0.093	0.263
	(0.267)	(0.288)	(0.299)	(0.296)	(0.270)	(0.309)	(0.281)	(0.301)	(0.263)

Very good	1.215**	0.935	0.718	1.130	0.962	0.999	0.000	0.000	0.167
	(0.574)	(0.632)	(0.739)	(0.742)	(0.609)	(0.556)	(empty)	(empty)	(0.466)
Gender	**0.51***	**0.441***	**1.053***	**0.793***	**0.644***	**0.388**	0.058	-0.094	**0.406**
	(0.175)	(0.169)	(0.211)	(0.182)	(0.167)	(0.184)	(0.175)	(0.192)	(0.168)
Age									
25-34	-0.738	-0.814	-0.786	-0.764	-0.546	-0.901	-0.296	0.389	-0.327
	(0.377)	(0.432)	(0.480)	(0.464)	(0.403)	(0.482)	(0.415)	(0.493)	(0.436)
35-44	-0.774*	-0.596	-0.850*	-0.981*	0.036	-0.414	0.004	0.158	-0.608
	(0.393)	(0.439)	(0.446)	(0.465)	(0.415)	(0.482)	(0.418)	(0.531)	(0.450)
45-54	-0.321	-0.271	-0.403	-0.514	0.317	-0.343	-0.108	0.395	-0.485
	(0.366)	(0.428)	(0.454)	(0.451)	(0.405)	(0.476)	(0.434)	(0.527)	(0.456)
55-64	-0.231	-0.341	-0.031	-0.113	0.386	-0.463	-0.002	0.322	-0.577
	(0.363)	(0.420)	(0.439)	(0.454)	(0.396)	(0.490)	(0.420)	(0.503)	(0.461)
65-75	-0.293	-0.425	-0.096	-0.328	0.267	-0.505	0.018	0.610	-0.905
	(0.387)	(0.424)	(0.450)	(0.479)	(0.415)	(0.485)	(0.425)	(0.543)	(0.463)
Over 75	0.309	-0.003	0.278	-0.130	0.734	-0.382	-0.282	0.665	-0.330
	(0.486)	(0.570)	(0.683)	(0.646)	(0.551)	(0.653)	(0.630)	(0.781)	(0.653)
Province									
Alberta	0.052	0.032	-0.432	-0.652**	-0.080	-0.116	-0.384	-0.80**	-0.093
	(0.215)	(0.244)	(0.286)	(0.252	(0.232)	(0.229)	(0.231)	(0.254)	(0.224)
BC	0.010	-0.313	-0.438*	-0.388	-0.108	-0.502**	-0.110	-0.433	-0.144
	(0.229)	(0.224)	(0.250)	(0.230	(0.211)	(0.229)	(0.217)	(0.254)	(0.196)
Manitoba	0.517	0.274	0.297	0.250	0.334	-0.095	0.006	-0.043	0.146
	(0.339)	(0.340)	(0.366)	(0.397	(0.338)	(0.355)	(0.350)	(0.353)	(0.347)
New Brunswick	-0.563	0.170	-0.414	-0.467	0.119	0.306	0.242	0.383	0.285
	(0.440)	(0.414)	(0.476)	(0.475)	(0.452)	(0.476)	(0.590)	(0.585)	(0.478)
Newfoundland	0.662	0.000	0.000	0.000	0.000	0.589	-0.662	0.000	0.389
	(0.500)	(empty)	(empty)	(empty)	(empty)	(0.599)	(0.608)	(empty)	(0.616)
Northwest Territories	0.772**	-0.511	-1.255***	-0.304	0.141	0.315	0.044	0.107	-0.018
	(0.327)	(0.360)	(0.388)	(0.364)	(0.335)	(0.337)	(0.386)	(0.596)	(0.342)
Prince Edward	1.399	0.520	0.000	-0.034	-0.543	0.000	0.000	0.000	0.000
	(0.865)	(0.539)	(empty)	(0.911)	(0.737)	(empty)	(empty)	(empty)	(empty)
Saskatchewan	-0.491	0.463	-0.505	-0.291	0.310	-0.203	-1.140	-0.727	-0.094
	(0.566)	(0.494)	(0.459)	(0.538)	(0.541)	(0.550)	(0.586)	(0.617)	(0.693)
Education									
Graduate degree	0.318	-0.110	-0.698*	-0.274	-0.293	-0.103	0.165	0.129	0.127
	(0.322)	(0.327)	(0.334)	(0.328)	(0.308)	(0.310)	(0.308)	(0.325)	(0.284)
Bachelor's degree	0.339	0.289	0.004	-0.086	0.053	0.213	0.027	0.134	0.142
	(0.299)	(0.308)	(0.301)	(0.292)	(0.288)	(0.298)	(0.294)	(0.291)	(0.262)
University	0.299	0.225	-0.462	-0.269	-0.194	-0.288	0.000	0.585	0.080
	(0.358)	(0.347)	(0.371)	(0.387)	(0.349)	(0.360)	(0.374)	(0.403)	(0.348)
College/diploma	0.309	-0.048	-0.381	-0.072	0.024	0.048	0.166	0.358	0.125
	(0.318)	(0.310)	(0.312)	(0.304)	(0.298)	(0.300)	(0.328)	(0.339)	(0.271)
Apprenticeship	-0.071	0.520	0.105	-0.067	0.140	0.428	-0.090	-0.095	-0.312
	(0.410)	(0.470)	(0.466)	(0.518)	(0.414)	(0.455)	(0.452)	(0.435)	(0.405)
No certificate	0.026	0.000	-1.719	-1.742*	-0.836	0.248	-0.067	-0.313	-1.217
	(0.697)	(empty)	(0.678)	(0.686)	(0.654)	(0.663)	(0.534)	(0.524)	(0.726)
Income									
Under $29K	-0.373	-0.886	-0.406	0.141	0.469	0.527	-0.899**	-0.362	-0.105
	(0.402)	(0.432)	(0.434)	(0.433)	(0.449)	(0.416)	(0.366)	(0.438)	(0.374)
$30K - $49K	0.579*	-0.552	-0.285	-0.311	-0.027	0.449	0.478	-0.592	0.335
	(0.335)	(0.342)	(0.401)	(0.367)	(0.310)	(0.357)	(0.389)	(0.406)	(0.326)
$50K - $69K	0.254	-0.715**	-0.304	-0.354	-0.449	-0.081	0.056	0.673	0.115
	(0.299)	(0.324)	(0.337)	(0.334)	(0.307)	(0.304)	(0.344)	(0.529)	(0.289)
$90K - $109K	0.296	-0.364	-0.029	0.004	0.011	0.148	-0.414	-0.983***	0.221
	(0.313)	(0.325)	(0.371)	(0.344)	(0.298)	(0.306)	(0.331)	(0.351)	(0.303)
$110K -$129K	0.387	-0.629	-0.597	-0.282	-0.545	-0.833*	-0.713*	-0.673	0.080
	(0.318)	(0.357)	(0.377)	(0.337)	(0.327)	(0.331)	(0.358)	(0.431)	(0.316)
$130K - $150	0.272	-0.527	-1.221***	-0.448	-0.538	-0.263	-0.375	-1.244**	-0.364
	(0.353)	(0.379)	(0.405)	(0.407)	(0.371)	(0.378)	(0.362)	(0.430)	(0.352)
+ $150K	0.318	-0.110	0.151	0.360	0.211	0.486	-0.348	-1.008**	-0.030
	(0.331)	(0.321)	(0.358)	(0.353)	(0.321)	(0.311)	(0.344)	(0.380)	(0.303)
_cons	-1.662	-0.448	-0.544	-0.363	-0.580	-1.040	1.917	1.255	0.997
	(0.629)	(0.680)	(0.718)	(0.726)	(0.653)	(0.757)	(0.679)	(0.840)	(0.682)

***, **, * statistical significance at 1%, 5%, and 10% levels respectively. Standard error in parentheses.