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# Canadian perspectives on food security and plant breeding

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## Abstract

**Background:** The broadness of biotechnology serves to connect different types of modern plant breeding techniques with the potential to improve global food security. However, the topic goes beyond the specific example consumers' associate with the term—genetic modification. As a result, it is often unclear if consumers really know what they claim to understand and the efforts to clarify the science and reasoning behind the use of these practices is often obscured.

**Methods:** Two online surveys of 500 Canadians were conducted in 2017.

**Results:** Three-quarters of Canadians have high levels of trust in those who provide information about food, yet two-thirds believe that modern plant breeding technologies are unnatural.

**Conclusions:** Canadians lack basic knowledge about modern plant breeding practices and technologies and possess high levels of uncertainty regarding the potential for benefits or externalities to develop from the commercialization of new genome editing plant breeding technologies.

**Keywords:** Biotechnology, Consumer perceptions, Genetic modification, Gene editing, Modern plant breeding techniques, Risk

## Introduction

The safety of the food that is consumed has continually increased over time, due to combinations of improved plant breeding, regulations on chemical uses and testing for toxins (Smyth et al. 2015). Conversely, modern technologies and communication allow misinformation to be widely accessible, making it difficult for consumers to make heads or tails of the information they receive. As a result of false information, there is a lack of knowledge about food, its production and how it reaches store shelves (Sutherland et al. 2020). Why does this dichotomy exist? Part of the reason is that the food industry is a multi-billion-dollar industry and competition for space on grocery stores shelves and consumer grocery carts is fierce. This competition for consumers' food dollars leads

the food industry to aggressively brand food products and label to appeal to discerning consumers, especially consumers interested in, and willing to pay for, niche products. The result has been a plethora of food labels such as gluten-free, natural, hormone-free, or non-GMO. Using these as examples, responsibility then falls on public health authorities, and perhaps agricultural professionals where applicable, to ensure accuracy in consumer interpretation of the implications associated with each label (Hawley et al. 2012).

In spite of the dichotomy of information publicly available, food is being safely produced for Canadian consumers. In a survey commissioned by Health Canada (The Strategic Council 2016), 66% of Canadians were confident that the food system was strong and rigorous, protecting consumers from harmful or unsafe food products. Contrasting this is the 2019 report from the Canadian Centre for Food Integrity (CCFI) that identifies 24% of Canadians believed that Canada's food system is on the

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wrong track, with 42% unsure of whether the food system to be on the right or wrong track (CCFI 2019). The 2019 report identifies a significant increase in Canadians that are unsure about the direction of Canada's food system as the 2017 report found 14% believed the food system was on the wrong track, with 43% unsure (CCFI 2017). Between these two reports, there were 249 Class 1 food safety failures, where food products were recalled either nationally or provincially, that could help to explain the increase (CFIA 2021).

The question then becomes, what explains the contrast in Canadian attitudes about food safety and the food system? With two-thirds of Canadians supportive of the level of food safety in Canada, how is it that 66% are either unsure or believe Canada's food system is not headed in the right direction? This certainly appears to be a substantial contradiction in data. One possible explanation for this is that at a broad and general level, Canadians possess the knowledge and confidence to state that Canada has a safe food production system, but the more that research questions probe into the details and depths of this knowledge, confidences rapidly decline, hence 40% of Canadians being unsure if the food system is headed in the correct direction.

As part of the process of gaining insights into what consumers want when it comes to the provenance of the food products they are intending to purchase, it is helpful to quantify what they presently know. The objective of this article is to identify what knowledge and perspectives consumers have about food security and existing plant breeding technologies, as well as new technologies that are just beginning to be applied to plant breeding, such as gene editing.

## Background

As seen in consumer-related literature and research, biotechnology is rarely maintained in the broad term it is meant to represent and instead acts to polarize viewpoints on the subject (Bjoörnberg et al. 2015). Often, the surrounding debates focus on science versus credibility, in that the two can rarely be connected due to the corporate control over certain related aspects of the industry. Mistrust in the agriculture and/or food industry is only exacerbated by marketing campaigns led by non-government organizations (NGOs), who view genetically modified organisms (GMOs) negatively and spread that message (Bjoörnberg et al. 2015, Ryan et al. 2020; CAST 2020). Between 2012 and 2016, US\$850 million was spent by anti-biotechnology advocacy groups to campaign against GM crops (Genetic Literacy Project 2020). This partially contributes to the wide gap between scientist opinions and consumer opinions on the safety of both

genetically modified (GM) foods and pesticide use (Pew Research Center 2015).

Despite no clear consensus between studies as to whether Canadians are uninformed or misinformed, the trends appear to be that Canadians feel as though the agriculture industry is not transparent. As a result, just under 80% of Canadians want mandatory GM labelling (The Strategic Counsel 2016). Many believe that scientific literature needs to be the secondary concern behind their own personal morals and values on the subject (Vecchione et al. 2015). This presents its own challenges, as the processing of scientific information varies, partially based on pre-existing beliefs and worsened by confirmation bias in certain cases (McFadden and Lusk 2015). According to a 2013 study, consumer acceptance of the information given to them is based on a 'cognitive mediating process', in which consumers utilize their own personal understanding of the background information and trust of those conveying the information to analyze the risks and benefits (Herath 2013). For example, although farmers may be more trusted as an overall source of agricultural information (CCFI 2017), food corporations are often regarded as having a higher responsibility in maintaining and communicating the health and environmental status of the food they provide (Morgan et al. 2018). As a result, perhaps rather obviously, it can be surmised that public trust in the food information they are provided relies heavily on a variety of sources, each with a different degree of accountability depending on what information is required. Similarly, demographics play a key role in the perception of technology use, in that millennials are more concerned about the effects of biotechnology on the economics (specifically price) of food more than other groups of people (CCFI 2019). Furthermore, it has been suggested that high schools could benefit the most from funding the integration of science curriculum into agriculture programs, and possibly vice versa (Myers and Washburn 2008), or commencing agricultural education programs, which has proven effective at increasing students' knowledge in urban schools (Jean-Philippe et al. 2017). Both these strategies to inform younger Canadians could increase the positive perception of the industry and biotechnology.

It is important to note that while overall opinions of biotechnology and modern plant breeding methods veer towards the negative, mainly due to an individualized understanding and perception toward the conveyance of raw, complex food science, yet when presented with benefits, consumers are more likely to favour and accept GM products (Vecchione et al. 2015). Although genetic modification is not the only existing aspect of biotechnology, little research has been done to compare opinions towards varying types; much of conducted

behavioural research in this area has focused on the term 'biotechnology', 'GM' or 'genetically engineered' with little divergence from those two broad headlines. Similarly, consumers feel the least confident that information about GM foods is accurately reported and shared, particularly in the long-term (McHughen 2013). When presented with questions pertaining to biotechnology, consumers were more confident in their knowledge of the subject before answering questions than after (McFadden and Lusk 2016). In the same study, 32% of participants could not pick out the GM crops from a list of crops given to them, but the majority still wanted mandatory GM labelling. However, 80% of the same participants wanted professionals to also adopt mandatory deoxyribonucleic acid (DNA) labelling (McFadden and Lusk 2016), suggesting that despite confidence in one's own understanding of the topic, true knowledge does not match. Similarly, consumer perception of GM varies with the type of food involved; while the majority would prefer if modern plant breeding techniques were not involved at all in food, consumers tend to prefer when GM foods are used as fresh ingredients, rather than in processed goods or used to produce meat products (Lusk et al. 2015).

## Methods

This article combines the results from two separate online surveys designed to determine consumer opinions and general knowledge on food safety and plant breeding. An extensive literature search was conducted for articles pertaining to consumer surveys, consumer preferences and consumer attitudes. Those articles that identified survey questions were then selected for further review and applicability to the research objectives of our current project. Additional literature was identified containing survey responses, that were published by public and private institutions. The surveys that were identified through this process, created a potential list of from literature sources that included Lusk et al. (2015), PEW Research Center (2015), Vecchione et al. (2015) and The Strategic Council (2016). The questions for our surveys were adapted from the questions contained in previous consumer surveys on consumer acceptance of biotechnology and innovation within the agricultural sector. Technical questions that related to specifics of plant breeding were developed by the authors and in consultation with plant breeders at the University of Saskatchewan's Department of Plant Science. Both surveys were beta-tested with small samples of 20–30 individuals, predominantly staff and students at the University of Saskatchewan. Following the beta-testing, the surveys were further revised for clarity. The surveys were submitted to the Ethics Office at the University of Saskatchewan. Each survey was reviewed, with subsequent minor edits and

revisions suggested. The revised versions were approved for public distribution.

The objective of the first survey was to accurately understand the level of knowledge possessed by the Canadian public about both plant breeding methods that have been used to develop new varieties for decades, such as chemical and radiation mutagenesis, and about new innovative breeding methods, like genetic modification. The objective of the second survey was to gain insights into Canadian perspectives on their confidence in Canada's food safety system and the security of Canada's food supply chains.

The desired 500 responses from adults were then distributed across Canada by Voxco, a Canadian owned and operated survey-building platform, in July (survey 1) and August 2017 (survey 2) and subsequently securely stored by Ekos, a Canadian research platform. Aside from the screener that participants needed to be at least 18 years of age, there were no demographic restrictions in recruitment.

Between the two distinct and separate participant pools, no responses were removed from the analysis, such that survey 1 (Insights into Food Security)  $N_1 = 509$ , and survey 2 (Direct Benefits of Biotechnology)  $N_2 = 502$ . All analyses were conducted by Statistical Package for the Social Sciences (SPSS) and values were considered significant if  $p \leq 0.05$ .

In comparison to 2016 census data (Table 1), sample demographics are relatively representative of the English-speaking Canadian population. The survey was not translated into French and the results therefore are not representative of the province of Quebec. The exceptions to this statement are average age and median household income. The slight discrepancy in age could be partially attributed to the difference in age requirements between the surveys and the census; census data was collected from the population 15 years old and older, whereas the surveys ensured participants were 18 years of age and older. While the difference in median income could be partially because of the same reason, but the majority of the divergence is likely due to the vetting process Voxco uses to find survey participants. Despite this risk, the congruent value to census data does not indicate that survey results are uncharacteristic of the English-speaking Canadian population based solely on this demographic criterion.

## Results and discussion

### Awareness of plant breeding

As a means of validating Canadians' basic information about Canada's food system, the first survey asked Canadians about various plant breeding technologies, finding that 69% are slightly, or not at all, familiar with plant

**Table 1** Sample demographics comparative with 2016 Canadian census results. Source: Statistics Canada (2017)

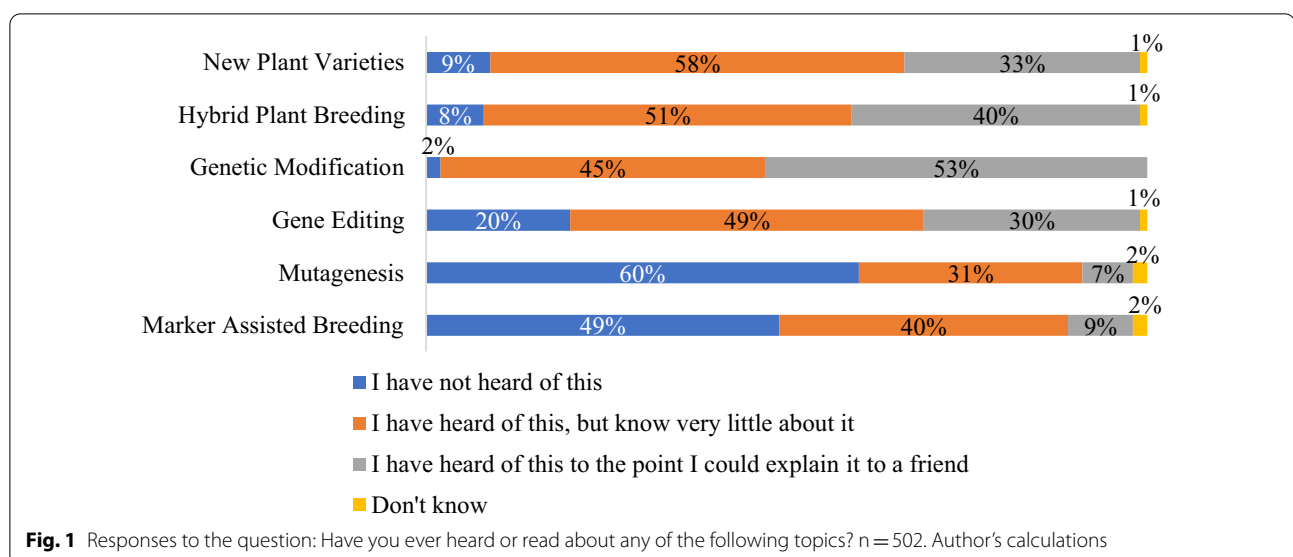
	Survey 1	Survey 2	2016 Census
Percentage Male/Female	50.7/49.0	53.2/46.8	49.1/50.9
Average age	49.0	50.3	41.0
Highest secondary education	Technical/college/university	Technical/college/university	Technical/ college/ university
Median household income	\$90,650	\$81,421	\$70,336
Percentage Married/common-law	66.1	66.5	57.6
Average number of children in household	0.6	0.6	0.6

breeding terms. Probing this topic further, the second survey asked about their specific knowledge on methods of plant breeding. Ninety-one percent of Canadians have either never heard of mutagenesis or possess very little awareness (Fig. 1). Mutagenesis plant breeding technologies originated in the 1930s and have over 80 years of global application to the development of new field crop and vegetable varieties. Mutagenic breeding exposes plant seeds to chemicals or radiation, which are then grown to determine what genetic changes have occurred (Friedberg et al. 2006). Mutagenesis, as a result, is commonly referred to as conventional plant breeding.

Similarly, hybrid breeding whose use dates back to the 1950s, is not well recognized, with 59% indicating they know little or nothing about it. The use of hybrid breeding in flower varieties, especially roses and fruit trees, dates back even further. Marker assisted breeding has been commonly used in recent decades, yet has very limited awareness. Gene editing, a technology developed in the past decade shows higher levels of awareness than older technologies. The most significant

takeaway message from Fig. 1 is that 67% of Canadians know very little about the basic term ‘new plant varieties’, which would include those plants labelled as biofortified, drought resistant, chemical tolerant, etc. The only breeding method to have over 50% awareness is genetic modification. These results align with those reported by the PEW Research Center (2015), where public awareness of some agricultural technologies is low.

The second survey identified that Canadians possess little to no awareness of how varieties of crops, fruits, and vegetables are developed, which could be contributing to their uncertainty about the direction Canada’s food system is headed, as identified by the CCFI. The CCFI (2019) identified that 91% of Canadians self-identified that they know little to nothing about modern agricultural practices. This also aligns with results reported by McFadden and Lusk (2016) regarding consumer awareness. In large part, this is because scientific publications about plant breeding are virtually inaccessible to the public as scientific journals charge fees to access articles, and/or are not written with them as the intended audience. As a result,



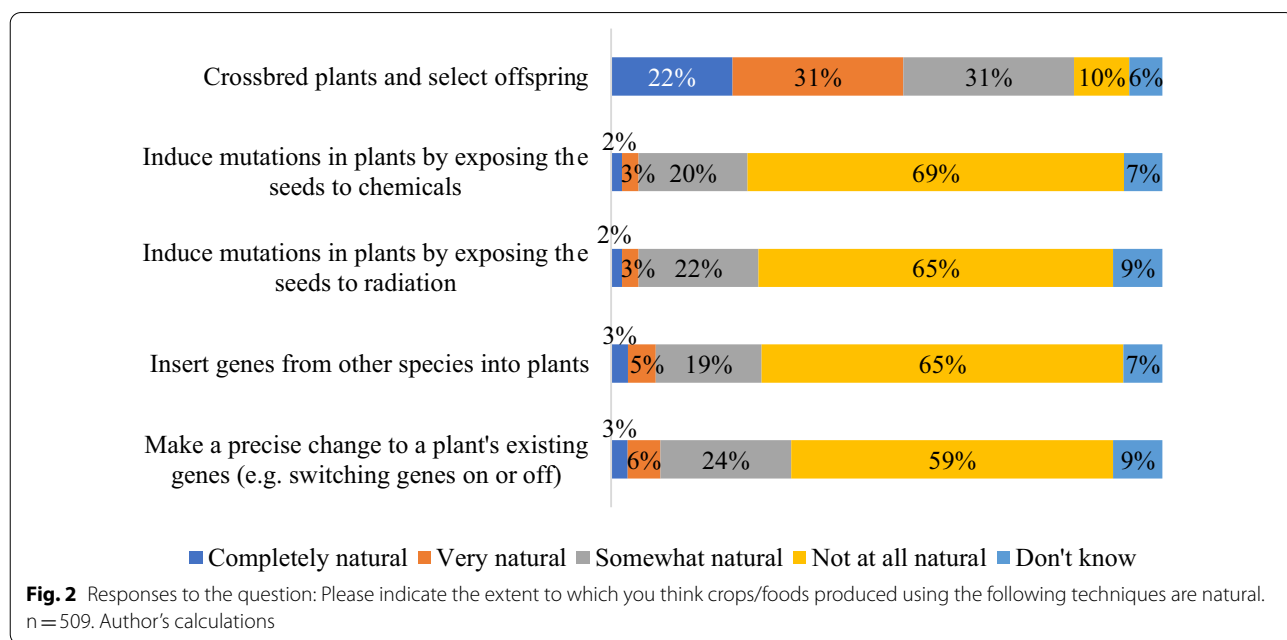
cereals and grains were the only crops to be found correlated with the level of education ( $p \leq 0.001$ ). The voice of the public sector and academic scientists are also virtually non-existent as there is a lack incentives to engage with the media or become science communicators (Ryan and Doerksen 2013). The result is a large void in the provision of trusted information for those individuals seeking it, that has to a large degree, been filled by those opposed to modern agriculture.

The first survey asked about different types of plant breeding technologies and how natural they are perceived, most participants generally perceive changes to the genetic composition of plants to not be natural at all (Fig. 2). Two-thirds of surveyed Canadians believe that the mutagenic technologies used to develop crop and vegetable varieties for decades are not at all natural. Probing this topic further, this survey found that one-third of surveyed Canadians believe that conventional plant breeding (chemical and radiation mutation breeding) does not alter a plants' genes, when in reality, it creates randomly uncontrolled changes, with approximately 20% of desirable mutations being lost due to complications in the plant's success rate (Oladosu et al. 2015). These findings support previous results that indicate consumers lack the knowledge and awareness about many aspects of their food production (PEW Research Center 2015; McFadden and Lusk 2016). Less than 10% of participants believe that mutagenesis, genetic modification and gene editing are natural means of breeding new crop and vegetable varieties. The combination of fully sequenced plant genomes and digital biology has created very

precise, controlled plant breeding technologies that create new varieties with a small number of genetic changes, of which the Canadian public has virtually no awareness. Respondent's low awareness and acceptance that mutations are an important means of creating new crop, fruit and vegetable varieties, suggests the public is uninformed about the natural rate of mutations from one generation of a plant species to the next. The natural rate of mutation in some species can be up to 20 genes per generation (Ulukapi and Gul Nasircilar 2018).

Genetic changes for crop and vegetable varieties is valuable for Canadian food production, especially as climate change impacts agriculture (Pew Research Center 2015); if the plants grown to produce our food do not change to adapt with the climate, less food will be produced. Identifying that Canadian consumers lack knowledge about the importance of genetic change for improved food production, suggests this lack of knowledge is a significant factor in the susceptibility that consumers have towards targeted misinformation campaigns. Activist groups that deliberately disseminate misinformation play on consumers emotions, suggesting that safe products are dangerous, ignoring the required risk assessment and approval processes that innovative crops and food are required to undergo prior to commercial production.

For all presented examples, younger participants perceived a more natural status in the methods than older participants, who also had a greater tendency to select 'don't know'. Statistical significance between age range and perceived naturalness is seen in crossbreeding ( $p \leq 0.050$ ), chemical mutations ( $p \leq 0.010$ ), gene



insertion from other species ( $p \leq 0.050$ ), and precise gene changes ( $p \leq 0.010$ ). Regardless of the truth in how 'natural' plant breeding techniques are, by fitting information distribution of agricultural processes to the preferences of older Canadians, opinions of used techniques may become more positive or, at the very least, may hold the potential for formed opinions to be based off a larger scope of understanding.

The first survey asked participants to agree or disagree with statements regarding potential consequences of modern plant breeding (Fig. 3). The majority (59%) believe that new breeding techniques will result in more affordably priced food. Over one-third of participants agree that modern plant breeding can lead to sustainable agricultural practices that are good for the environment, compared to 26% who disagree. This is contrasted with the finding that 42% believe that modern plant breeding will create more environmental problems. When asked if these technologies are a risk for their health, 33% disagreed, while 30% agree. One thing that stands out in the results of this question was the level of unwillingness to respond to the statements. Respondents that answered either 'don't know' or 'neither agree nor disagree' account for between 28 and 40%.

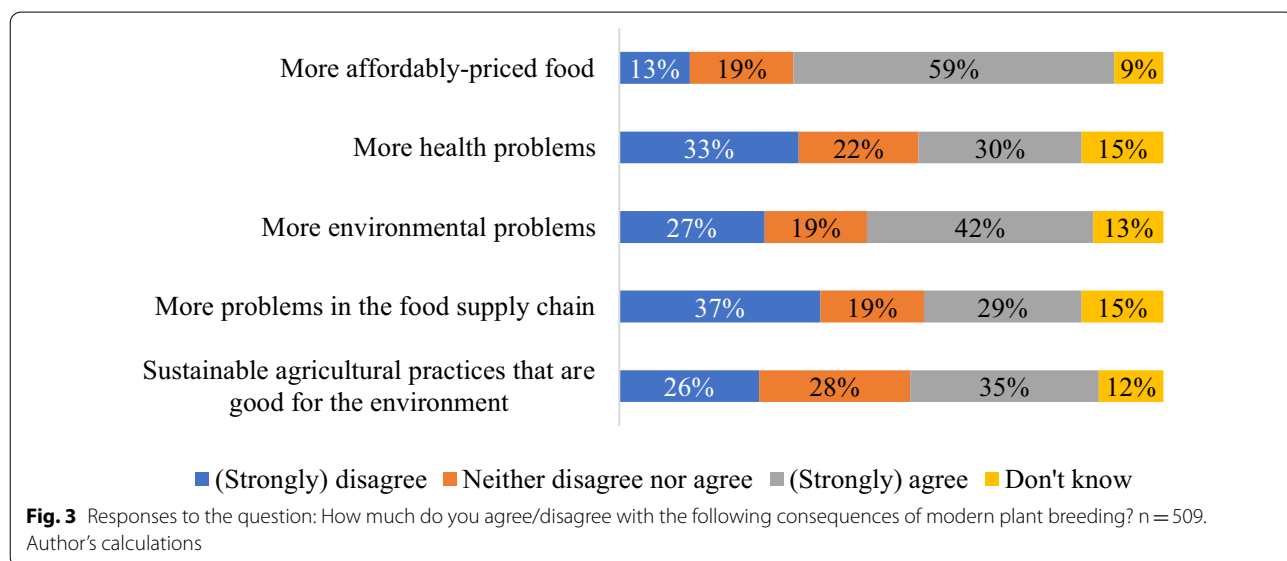
Two-thirds of Canadians in survey one express confidence in the food safety system, indicating the majority of total consumers are confident the food products they routinely purchase will not cause harm to them or their family. While participants expressed confidence in the safety of the food products they are purchasing, when asked about the technologies used to provide

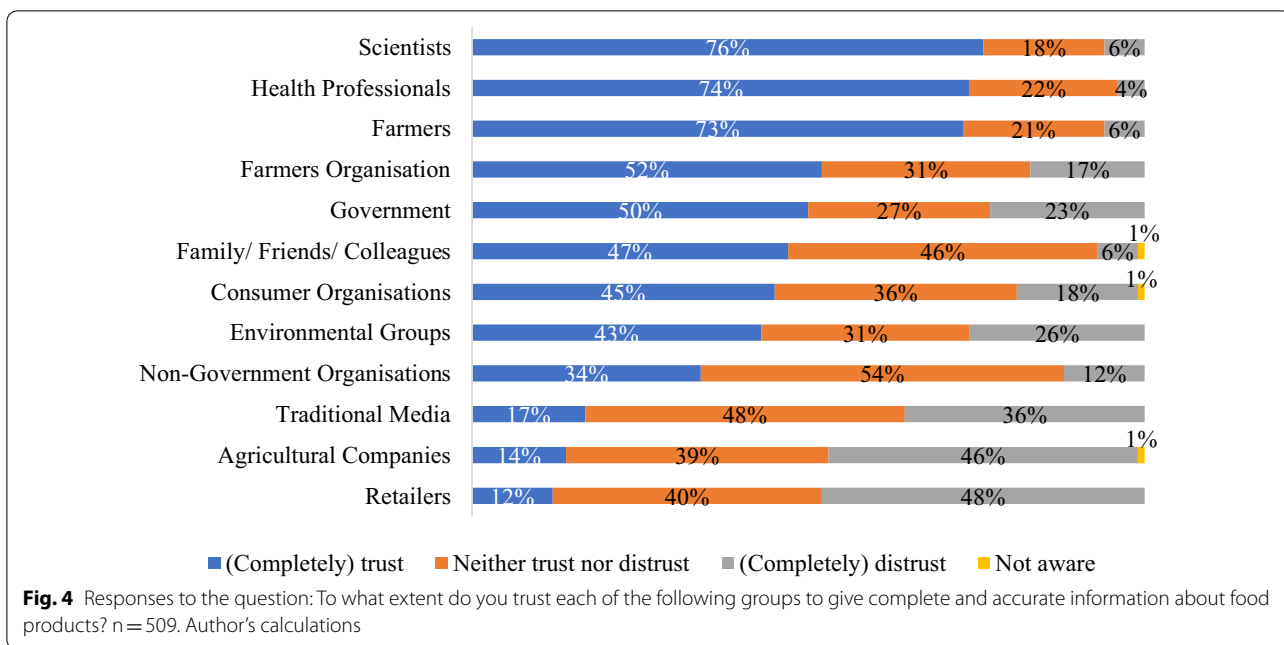
these food products, it is revealed that Canadians are less confident.

**Public trust in food information**

If the public does not trust the food they eat, this can be viewed as a failure in the system, whether it is the actual safety of the food or a failure to publicly communicate the safety of the system. The first survey asked participants about their level of trust in a series of food information providers, finding scientists, health professionals and farmers at 76%, 74% and 73%, respectively, rank the highest as either completely trusted or trusted sources (Fig. 4). These findings are representative of the CCFI (2017) that indicate the public places a high level of trust in farmers. Of these highly trusted groups, farmers were the only ones with a significant correlation with education ( $p \leq 0.050$ ), such that those with a higher level of education are more receptive to agricultural information from farmers. Additional interesting observations are that traditional media sources are not well trusted, with 36% saying they completely distrust, compared to 17% who do trust. Environmental organizations have a surprising level of distrust, with 26% saying they completely distrust compared to 43% who do trust. Friends, family, colleagues and consumer organizations are trusted by nearly half of the respondents as responsible sources of food information. Governments are additionally recognized by exactly half of the respondents as a trusted source of information.

As has been confirmed in other studies (CCFI 2019), trust in the industry is exceptionally low, with trust levels in agricultural companies of 14% and retailers at 12%. Distrust in these sources is far higher, revealing that

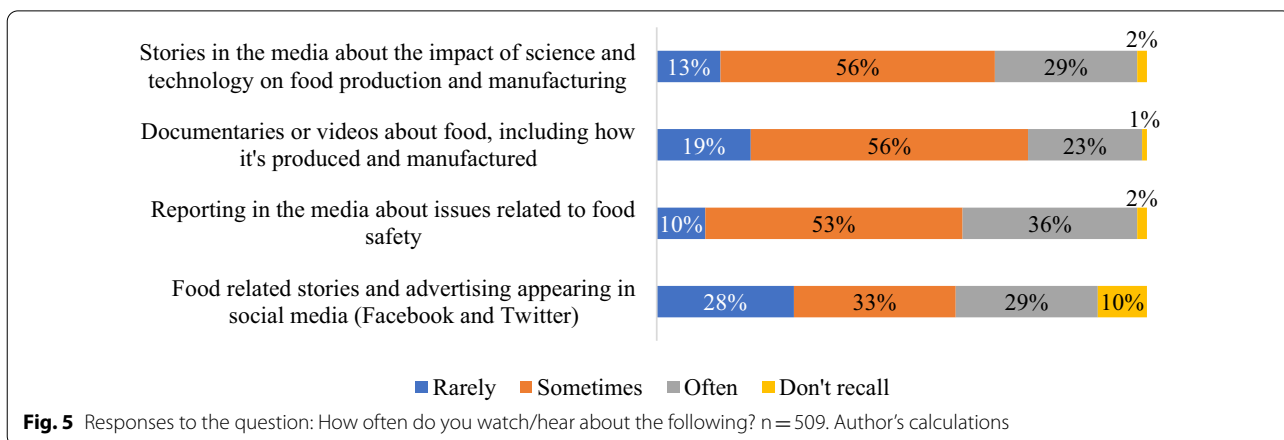




consumers are as skeptical of food processing firms as they are of agricultural chemical companies. The level of distrust in retail firms is surprising, given the vast sum that these firms have spent on marketing themselves to the Canadian public in the past several years. This result is also of interest as consumers interact with retail stores on a weekly basis, which raises the question of why consumers have a high level of distrust in something that is such a routine part of their food purchase habits.

One aspect of food safety that was investigated in the first survey was whether the public pays attention to news stories that relate to food, food safety or the science and technology of food products. Survey respondents indicated that media stories relating to food safety issues are most often paid attention to, with 89% saying

they often or sometimes pay attention to such stories (Fig. 5). Clearly, Canadians take food safety very seriously, with nine out of ten expressing that this information is to some degree, important to them. Media stories about science and technology regarding food production are also news items that are listened to or watched, with 85% indicating they sometimes or often listen or watch. Those indicating they watch documentaries or videos about food are also a common part of what Canadians tune into, with 79% indicating they listen to or watch these. Observed here is a correlation with the level of education, wherein as education increases, so, too, does attention paid to documentaries ( $p < 0.050$ ). Over the past 10–15 years, numerous documentaries have been produced that were critical of the



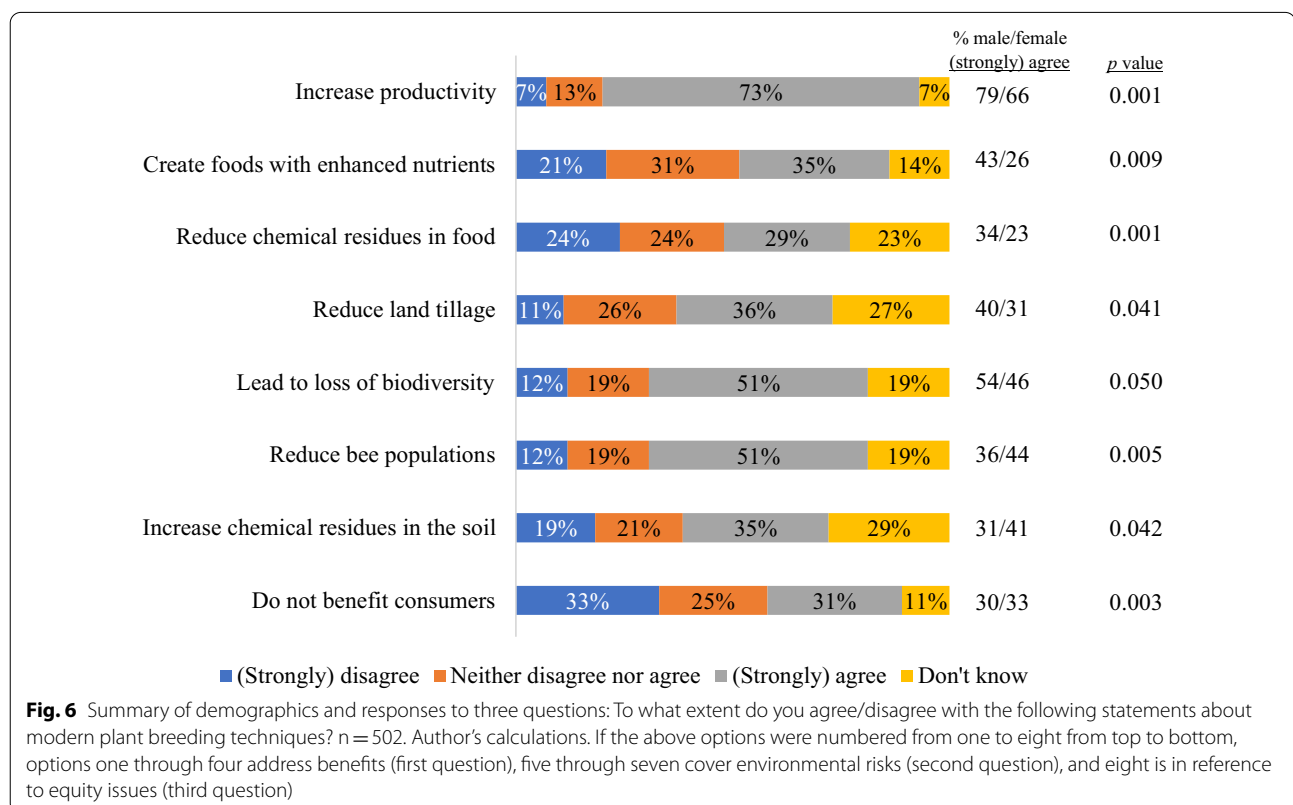
food industry, however, in the past several years, documentaries presenting a more scientific perspective are being shown (CAST 2020). Stories and advertising in social media outlets are the least likely to have a serious impact on participants, with the highest percentage of participants unable to recall (10%) and 28% rarely paying attention. A correlation with education is also seen with this media source ( $p \leq 0.001$ ).

Overall, surveyed Canadians express trust in the food system, especially when the information is provided by those viewed as experts, such as scientists, health professionals and farmers. Additionally, respondents identify that they have considerable interest in, and pay attention to, stories relating to food or the science and technologies regarding food production. Upon further analysis, the responses to frequency of attention paid to food-related news are influenced by the age of the respondent, with older participants more concerned with the science and technology aspect of media reporting ( $p \leq 0.050$ ) and younger participants valuing the ease of social media as a platform ( $p \leq 0.010$ ). This data could serve as a starting point to correcting the lack of information between the agriculture industry and the public, by taking advantage of the media sources consumers' value for food-related reporting

and tailoring that information to those demographics who perceive in it the most value.

#### Uncertainties about food production

While surveyed Canadians show high levels of confidence in food safety, they are seeking additional information about a multitude of effects from food production. Canadian participants in the second survey indicate they are interested in how their food is produced but express high levels of uncertainty about many potential positive and negative impacts of their food production (Fig. 6). These results reflect those of Vecchione et al. (2015), in that when presented with benefits of new technologies, some will receive strong public support. Respondents indicate confidence that new breeding techniques would result in an increase in productivity, with 73% either agreeing or strongly agreeing with this statement. Contrasting this is that 51% of the respondents believe that new breeding techniques would lead to a loss of biodiversity, compared to only 28% that disagree. This reflects results in Fig. 3, where respondents identified increased adverse environmental impacts as a potential outcome of modern plant breeding techniques. Reductions in chemical residues in food were viewed as a potential benefit by 29%, yet 24% disagree or strongly disagree with the statement. One-third of respondents disagreed that consumers do not





benefit, which was equal to those who agree with the statement. It should be noted that, in the case of all the listed outcomes, consumers were asked how much they agree with the statements, and the exact wording of the statement observed in Fig. 6. As a result, there is a possibility for directional bias for those that appear more positive with the question structure presented.

The main benefit that consumers believe they are receiving from innovative breeding technologies is lower food prices. An analysis of the share of benefits that consumers receive from GM crops, reveals that 20% of the total benefits are received by consumers (Smyth et al. 2015). Other plant breeding benefits include new crops with higher nutritional content, such as increased proteins in crops like potato, rice and wheat or better fatty acids in canola, cotton and corn (Newell-McGloughlin 2014). Additional food nutritional research is focused on improving essential amino acids, carbohydrates, micro-nutrients, vitamins and mineral availability.

Other statements about potential benefits or potential adverse effects exhibit higher levels of uncertainty as a striking observation in Fig. 6 is the significant percentage of respondents that did not express an opinion on potential positive or negative impacts. Combining those that selected 'neither disagree nor agree' with 'don't know' resulted in the majority of responses in some options, such as whether tillage will be reduced (53%) or impacts on bee populations (49%).

Of the examples of possible effects listed above, male participants had a greater tendency to agree with the presented benefits and disagree with risks than women (the exception to this above seen in regards to the potential biodiversity loss). While part of this significance could be attributed to the phrasing of the questions (i.e. participants could be reacting positively to a question that forces them to consider a positive outcome), providing consumers with information regarding food production that is better fitted to the preferences of women in regards to causative effects of the technology used, may serve to alter attitudes toward biotechnology as a whole.

## Conclusion

The results from both surveys provide a glimpse into public knowledge and perceptions of innovative agriculture, particularly as a tool for food security. Both surveys aligned with previous survey results, in that the public has a limited knowledge and awareness of standard agricultural practices. Gaining public insight into the acceptability of these practices is one of many ways to improve upon how the agriculture industry communicates the progression of food science. As seen in the results, however, opinions are vastly different not only in how agriculture is perceived, but also in the trust of information

sources. By comprehending the complexities of the spectrum of opinion, it is possible to determine how informed majority opinion is, which impacts the transparency of knowledge-sharing between the agriculture industry and the public. While determining the most sought out information desired by consumers is a challenge, discerning the best strategy to convey valuable information is its own separate challenge. The importance of this is highlighted by the CCFI's identification that 91% of Canadians know little about modern farming, but 60% of Canadians want to know more about agriculture and food production (CCFI 2019).

For decades, governments have had to balance the delicate line between regulating innovations, products, and industries, as well as publicly supporting Canadian products and technologies. Often, governments have chosen to be conservative in their support of a specific product or technology, except to offer support for the approval process, the public funding that may have been provided, or to promote the society-wide benefits. Government communications about the safety of food technology and products is important as the results of the first survey indicate that half of Canadians trust information provided by governments, but more importantly, scientists are ranked as the most trusted source, which will include public scientists. This delicate balance was successfully observed in most instances, until recently. Social media is impacting society's perception of science, innovation, food production and food safety, to the point that a serious rethink is required about the role of state advocacy.

Canada has a world leading science-based regulatory system that delivers consistent risk assessment decisions in a timely manner. This is crucial for innovation investments (Smyth et al. 2014). While it is essential that the regulatory independence of Health Canada and the Canadian Food Inspection Agency regulators be maintained, thereby continuing to provide the trust that Canadians have in our food safety system, however, the lack of a consistent, factual voice about the safety of Canadian food products is noticeably absent. While science communication by the agricultural industry, including firms, universities, farm organizations and farmers, has improved, these efforts are frequently disconnected and too fractionated. These communications are often directed at specific or focused issues within the various segments of the agricultural industry and there is a lack of national voice that speaks to the overall safety of the risk assessment process, what risks are assessed, and how monitoring is an ongoing part of the regulatory process. The absence of a trusted government agricultural science voice has allowed the void to be filled by communications from various organizations that are critical of modern agricultural technologies and practices.

Limitations to these results may be that French-speaking Canadians were not included as the survey was not translated into French, therefore is unrepresentative of the opinions of Quebec inhabitants. A further limitation to both surveys that were implemented is that respondents were not provided with definitions for some of the technical terms in each survey. Terms such as mutagenesis, genetic modification and others related to plant breeding were not provided, forcing respondents to use their own, limited knowledge to respond. Given evidence of the limited knowledge found in our surveys and by the CCFI, respondents' perceptions as to the terms would be expected to differ from the technical definition.

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None.

#### Authors' contributions

All authors contributed equally to the paper. All authors read and approved the final manuscript.

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#### Availability of data and materials

The survey data is on file with the authors.

#### Declarations

#### Ethics approval and consent to participate

The surveys were approved by the Behavioural Research Ethic Board at the University of Saskatchewan. Approval #: 17-290. A copy of approval is on hand with Dr. Smyth. Participants were required to consent to participate in the survey.

#### Consent for publication

All authors have consented to this submission.

#### Competing interests

The authors declare no competing interests.

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