THE IMPACT OF THE NATIONAL BIOENGINEERED FOOD DISCLOSURE STANDARD AND ITS METHODS OF DISCLOSURE ON CONSUMER PREFERENCES FOR GENE EDITED AND GENETICALLY MODIFIED FOODS.

by

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ABSTRACT

Beginning January 1st, 2022, the National Bioengineered Food Disclosure Standard will require the labeling of food produced with, or containing, certain plant genetic improvement techniques - such as genetic modification. The standard introduces the new term “Bioengineered” on the approved label, which can be disclosed through methods such as a symbol, text, QR code, and mobile text message. Advances in gene editing technology are bringing gene edited foods into the food supply, yet it is unclear if they will be considered Bioengineered or if regulation would require a separate label for food that is gene edited. It is possible that there will be food that is both gene edited and genetically modified. This food may use the bioengineered label stacked with an additional label to signal the presence of gene editing. Disclosure methods and stacking of the Bioengineered label with other labels is the main focus of our study. We fielded an online choice experiment and survey to over 1,200 respondents to uncover the impact that the Bioengineered label and approved methods of disclosure have on consumer preference and how consumer preference changes when the Bioengineered label is stacked with labels indicating the presence of gene editing and genetic modification. Our results show that consumer choice, for both whole and processed foods, is influenced by disclosure method (i.e., symbol versus text). Additionally, we found that stacking the Bioengineered label on those that indicated the presence of gene editing or genetic

modification also impacts consumer preferences. The results from the survey showed low levels of association between the Bioengineered label and the plant genetic improvement techniques that it may be meant to disclose.

Chapter 1

INTRODUCTION

Approximately 75% of U.S consumers support for labeling genetically modified (GM) foods (Hallman et al, 2013). Public support and advocacy from special interest groups led to legislation being passed in 2018, when Congress signed the National Bioengineered Food Disclosure Standard, which requires mandatory labeling of bioengineered foods. The Agricultural Marketing Service (2021), an agency within the United States Department of Agriculture (USDA), regulation states that:

> "Bioengineered foods are food that contain genetic material that has been modified through in-vitro recombinant DNA techniques and for which the modification could not otherwise be obtained through conventional breeding or not found in nature."

GM crops have been widely adopted by U.S. producers; for example, in 2019 95% of the corn planted was genetically engineered, and approximately 80% of the corn acres planted in 2020 were of the stacked BT & HT variety (USDA ERS 2021). These traits are desirable to manufacturers because they improve cost savings, ease of production, improve yield, and reduce insect damage (Klümper and Qaim 2014; Acker et al. 2017; Smyth et al. 2015). Historically, the goal of most commercialized enhancements from GM are primarily for the benefit of the producer. Advances in gene editing and genetic modification are creating new varieties of plants which have consumer benefitting traits, such as improved nutritional profile, taste, aesthetics, and shelf life. For example, new advancements in gene editing have generated nonbrowning avocados, apples, and white button mushrooms, as well as vegetable oil with an increased nutritional profile (Agricultural Marketing Service 2021).

The implications of the NBFDS remain unclear and disputed. For example, it's not clear how gene edited foods will be classified under this legislation as there is uncertainty about what modifications can be found in nature, and if policy can evolve over time to keep pace with technological advances in gene editing (McFadden 2017). Additionally, the methods of disclosure are controversial and have heterogeneous effects (Organic Trade Association 2018; McFadden and Malone 2018). Low levels of genetic literacy among consumers could also be consequential to the impact of this policy, as perceptions and attitudes towards genetic technology are paramount to its future. Bovey and Alston 2018 suggest that the policy could be more burdensome to producers and consumers while being limited in its effectiveness due to disclosure options. Extent literature on these topics is further detailed in the Background section of this paper.

The methods of disclosure approved by the NBFDS include text, symbol, electronic or digital link, and/or text message. Previous research has compared the QR code and text disclose methods to labels that indicate the absence of GM and found the premium between a Non-GMO Verified label compared to a QR code to be smaller than the premium for the Non-GMO Verified label compared to text (McFadden and Malone 2018). Demographic characteristics such as age, gender, income, and education were found to be significant predictors to premiums of either disclosure method. Likewise, a survey of voters in 2016 found that 88% percent of the sample preferred a printed label visible to the naked eye over a barcode that could be scanned using a smartphone app (Just Label It 2021). It's likely that different methods of disclosing GM food products (Symbol, Text, QR code, text message) have heterogenous effects on consumers' willingness to pay.

The proposed label has received criticism for not accurately depicting bioengineered foods. Similar to the difference in premiums associated with non-GMO label compared to QR codes and text, some opponents of the NBFDS argue that consumers will be misled by the approved symbol that it doesn't convey the same meaning in comparison to text (Organic Trade Association 2018).

A meta-analysis of studies on the premiums associated with non-GMO foods found that, on average, consumers were willing to pay 23% higher to avoid genetically modified foods (Lusk et al. 2005). Research has shown that consumer preferences for genetically engineered foods improve by reducing the premium for non-GMO foods by 49% in response to direct benefits from the modification (Lusk et al. 20015). Additionally, the effect that information on the benefits of biotechnology has on WTP for food is dependent on if the source of information is Industry, Environmental, or Scientific groups (McFadden and Huffman 2017). Given that nearly all of the corn and soybean crops grown in the United States are genetically modified, producers will probably continue to grow the stacked trait variety of these crops. To improve the consumer response to genetic modification, manufacturers will likely seek to stack consumer benefiting traits along with BT and HT in the future.

The current level of adoption of GM technology in the food supply, and the potential that gene editing has to improve food traits and make it likely that future food products will be both gene edited and genetically modified. It's not yet clear how food with both GM and GE traits will be regulated under the NBFDS, and if stacked labels will be required for foods that are considered bioengineered and contain gene edited material. It is also unknown how consumer preferences will change for foods with stacked labels under the newly introduced labeling structure.

The objective of this study is to measure how consumer preferences differ across labels using the approved Bioengineered symbol and text disclosure methods, and how preferences change when labels are stacked. Discerning how consumer preferences change across disclosure methods and across labels under the new regulatory changes is important for food manufactures and science communicators such as the USDA and FDA. We researched these objectives by fielding an online survey though Qualtrics to over 1200 respondents. The survey measured demographic information, as well as a choice experiment, and additional questions to measure behavior, perception, and knowledge of plant genetic improvement techniques

Chapter 2

BACKGROUND

2.1 Adoption of Bioengineered Foods

Genetically modified foods were introduced to the food supply in the 1990s and have become increasingly more abundant. The most prevalent of GM foods and ingredients are derived from corn and corn oil, and approximately 80% of processed foods contain genetically modified foods (Food Safety News 2014). There has been widespread adoption of genetically modified crops in the United States. Over 90% of soybean, cotton, and corn planted in the US in 2020 had Herbicide Tolerant (HT) or Bacillus Thurgiensis (BT) traits, which are developed through genetic modification (USDA ERS 2021). Even with this widespread adoption within agriculture, consumers are generally unaware of the extent to which their food supply is made up of genetically modified foods. One national survey found that 48% of respondents said that they do not eat GM foods or do so not too much (Pew Research Center 2016).

Support and opposition of labeling is rooted in differences in consumer and producers perceived risk and benefits of technology (Messer et al. 2017). GM crops as an investment have increased the farm-level income significantly for the past 25 years. A meta-analysis estimating the relative investment gains from GM seeds compared to conventional seeds found that farmers in developing countries earned $4.41 more for each dollar invested. In developed countries the extra earnings on the investment relative to conventional seeds were $3.24 per dollar invested. Globally GM food technology has added $18.9 billion to farm gross incomes. This is equivalent to 5.8%

added value to the global production of soybeans, maize, canola, and cotton (Brookes and Barfoot 2020).

The increase in adoption of new plant breeding technologies within the last decade will also help contribute to the increased resiliency of food systems and reduce the impacts of agriculture on the climate. As gene edited technology becomes adopted worldwide, the benefits it will provide, such as reduce chemical pesticide use, improved resistance to pests and infections, resiliency to climate change driven stresses such as drought, heat flooding and soil salinity will be vital to combat a changing climate and growing population (Zaidi et al. 2019; Qaim 2020). Experts agree that gene edited crops offer better agronomic performance and product quality than genetically modified and conventional crops (Lassoued et al. 2019). Despite these many advantages to producers, food systems, and the natural environment, consumers continue to display resistance to and are uninformed about GM technologies.

2.2 Mandatory vs Voluntary Labeling

Scientific organizations have spoken out in opposition to mandatory labeling because of the behavioral consequences that could occur from the new labeling structure. The existing labeling structure allows for food manufactures to disclose the *absence* of genetically modified foods or ingredients. In contrast, the NBFDS approaches disclosure by mandating food manufactures disclose the *presence* of genetically modified foods or ingredients. Even though this might seem mundane, researchers have investigated the behavioral effects of such a change, and the results are disputed, making the possible impacts of this policy change difficult to predict.

Some research investigating this potential nudge effect suggests that disclosing the presence of GM food could act as a false alarm, signaling to consumers that GM foods are less safe than non-GM foods (American Association for the Advancement of Science, 2021). More recent studies have argued that there is little evidence to this support this claim that labels act as a signal to consumers (Costanigro and Lusk 2014). This same study also supports the claim that there are asymmetrical effects of “does not contain” and “contains” messaging. In contrast to the false alarm theory, a survey of Vermont residents in 2018 recorded a decrease in opposition and concern towards genetically engineered foods after the state instituted mandatory labeling; this suggests the opposite effect that mandatory labeling provides a sense of control to consumers and improves their perceptions of GM foods (Kolodinsky and Lusk 2018).

Evidence from studies measuring the welfare effects of mandatory labeling suggest that they will increase the cost to food processors in the form of segregating and monitoring bioengineered foods and increase household food expenditures by substituting for high-cost foods that are either organic or non-GMO, all the while not gaining any health benefit from consuming these higher priced alternatives (Alston and Sumner 2012; Lesser and Lynch 2014). For the time being, we may not know if this impact with improve the advancement of genetic technology and consumer welfare.

2.3 Genetic Literacy

Numerous studies have measured and compared consumer knowledge and perceptions of genetically modified foods to that of experts. A study by the Pew Research Foundation found that only 14% of Americans think that there is scientific consensus that GM foods are safe, while almost all researchers working on this topic think that GM foods are as safe as non-GMO foods (Pew Research Center 2016). This highlights how genetic literacy and knowledge of the current food supply have become a severe challenge to the future of genetic technologies, particularly given the importance education and knowledge have on acceptance of GM foods (McPhetres et al. 2019). Another study assessing familiarity with various plant breeding technologies found that genetic modification was the only plant genetic improvement technique in which over 50% of respondents reported having heard about to the point that they could explain it to a friend. Less than 10% reported feeling the same way for mutagenesis, cisgenisis/intragenisis, precision agriculture, and genetic marker-assisted breeding. Furthermore, 67% of respondents that reported either that they have not heard of or that they know very little about biotechnology (McFadden and Smyth 2019). These results compound with the low level of awareness consumers have regarding the extent to which GM foods are present in their food supply and what foods are and are not genetically modified (McFadden and Smyth 2019).

Transgenesis is a specific biotechnological technique that takes genes from a foreign species or a closed species and inserts them into the genes of another species; this technique is considered bioengineering under NBFDS. Common arguments for the moral opposition to genetically modified foods are that it is unnatural, and consumers want to preserve the natural qualities of their food. Evidence from a survey comparing whole and processed genetically modified foods found that consumer premiums to avoid GM foods were significantly different depending on the level of processing (He and Bernard 2011). For example, high fructose corn syrup is most likely derived from genetically modified corn, but the final product contains virtually no genetic material, as it is a highly processed food. Surprisingly, one study found that 80% of respondents were in favor of labeling food that contains DNA, and 32% of respondents thought that vegetables do not contain DNA (McFadden and Lusk 2016).

One would expect that consumers would find the premium for a highly processed product to be even smaller. Given the public's low understanding of DNA, it's unlikely that the level of processing will impact purchasing decisions.

Gene edited crops that are created by SND-1 and SND-2 techniques like CRISPR/CAS9 do not introduce any foreign DNA. Through the natural process of gene mutations and selective breeding, the same results could theoretically be obtained through conventional means, although not with the same precision of genetic marker assisted technologies. This may be an advantage for gene editing because it could possibly escape the moral concerns people associate with transgenesis. Evidence from choice experiments have shown that consumers are more accepting of enhancements though intragenic technology compared to transgenic technology (Colson et al. 2011). Although this may depend on individuals' understanding of genetics to be able to differentiate between these techniques.

Chapter 3

METHODS

3.1 Survey Design

The design had two distinct elements: general survey questions and a choice experiment (depicted in Figure 1 The survey began with questions to determine respondent eligibility to participate, which included ages 18 and older. This block of demographic questions came first so that we could fulfill the quota-based sampling for categories of age, gender, and income to match the US census. Furthermore, demographic characteristics such as, education, income and gender because are known to impact the premium associated with purchasing GM food. Respondents were asked questions to assess the association of bioengineering with other labels. Correspondingly, we then asked questions about association between the term Bioengineering and other plant genetic improvement techniques. These questions were asked to understand the perceived meaning of the Bioengineered label. Third, respondents were asked which statements from a list most and least aligns with their view on either gene editing or genetic modification to gauge if views on gene editing were similar to views on genetic modification. Next respondents answer a series of purchasing questions that make up the choice experiment. These questions are split into two blocks, a block that contains nine questions which respondents choose their most preferred avocado and a block for vegetable oil. After these, we asked a moderating question to validate their understanding of the choice experiment. Next, we asked questions to evaluate respondents' label seeking propensity. Finally, we asked an additional block of demographic questions before ending the survey

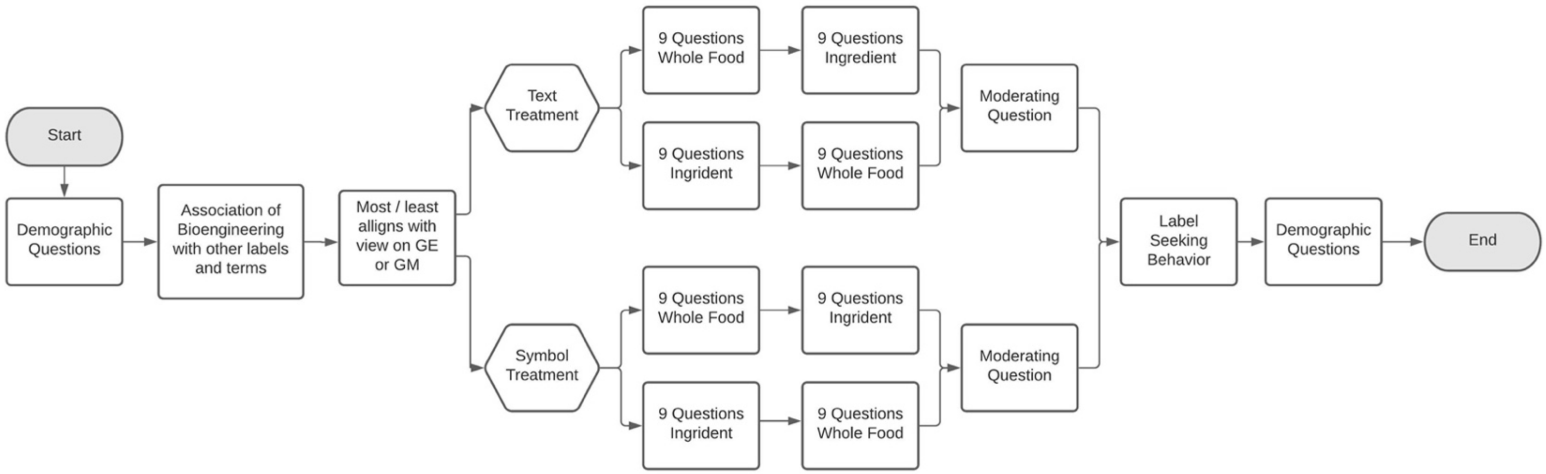

Figure 1: Survey Flow

We asked survey questions to assess respondents' association between the bioengineered label and other plant genetic improvement techniques. This is done in two ways, first we ask what the difference is between food with the bioengineered label and without a label, then we ask the difference between food with the bioengineered label and with a genetically modified label. Response options to these questions were there is a difference between the two labels, there is a difference, but I do not know what the difference is, and there is no difference between the two labels. Additionally, respondents were presented with a list of plant genetic improvement technique and asked which they consider bioengineering. The list included Gene editing, Genetic Modification, Mutagenesis, Hybridization, Genetic Marker Assisted, Conventional, and None of the above.

The following question asks what question most and least aligns with their view on either gene editing and genetic modification to understand how perceptions compare across these two technologies. Respondents were randomized into two groups. Half of the respondents were asked about their views on Gene Editing and Half were asked about their views on genetic modification. The response options which respondents choose from are displayed in Table 1. This question is inspired by Ruth and Rumble 2019, which asked which of the same statements align with respondents' views on GM food to a sample of Florida residents. Analysis of Variance and was used to analyze the responses for the Most / Least aligns questions to find if there was a difference between views on gene editing and genetic modification. Pairwise comparison was used to find if levels of trust in a message about GE and GM were equal for an institution.

Table 1: Most & Least Aligns Response Options

Gene Editing	Genetic Modification
GE food can cause cancer in humans	GM food can cause cancer in humans
GE food contributes to the prevalence of antibiotic resistant bacteria	GM food contributes to the prevalence of antibiotic resistant bacteria
Potential risks of GE food related to health have not been adequately investigated	Potential risks of GM food related to health have not been adequately investigated
GE foods might be riskier to consume than traditional food	GM foods might be riskier to consume than traditional food
GE foods are safe for human consumption	GM foods are safe for human consumption
GE food increases the food available for me to purchase	GM food increases the food available for me to purchase
GE food can provide me with improved nutrition compared to traditional food (e.g. increased vitamin C)	GM food can provide me with improved nutrition compared to traditional food (e.g. increased vitamin C)
GE food can be used to increase the safety of certain foods (e.g. remove toxins or allergens)	GM food can be used to increase the safety of certain foods (e.g. remove toxins or allergens)

The choice experiment utilized both within-subject and between-subject design. For the within-subject design, we examined nine responses for each of the two goods: an avocado and a 48-ounce bottle of vegetable oil. This allows us to test differences between whole and processed foods and compare the preferences for the nine labels within the same treatment and food type. This is an important distinction to make because previous research has identified the premium required to pay for GM whole food is larger than GM processed food (He and Bernard 2011). Within each choice set, respondents were asked to choose their most preferred alternative. The experiment is a labeled discrete choice experiment, each choice set included nine alternatives, containing every combination of the following: (i) Bioengineered Symbol, (ii) Genetically Modified, (iii) Gene edited, and one of three prices. The choice set also included an option without a label, and the option to not purchase any of the food products. The experimental design was balanced so that each combination was shown with each price level an equal number of times. Exact display and wording of all questions can be found in Appendix D: Choice Experiment Examples. Displayed below in Figure 2 is an example of a question for a respondent in the symbol treatment group for a question about avocado, and in Figure 3 an example of a question in the text treatment.

Figure 2: Choice Experiment Example Avocado Question in Symbol Treatment

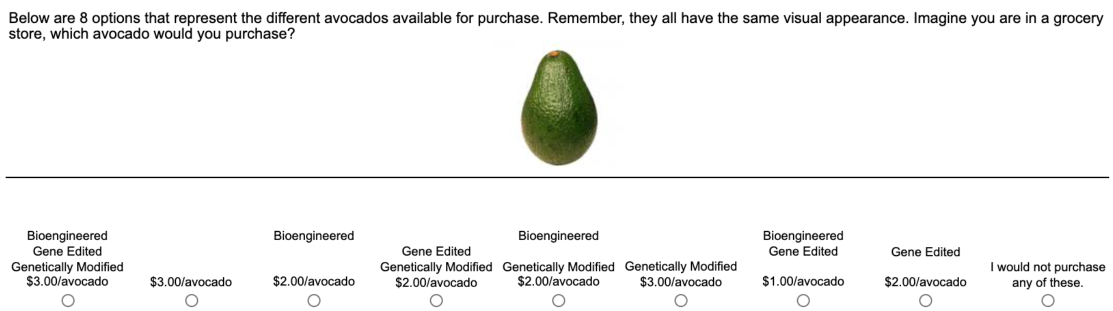

Figure 3: Choice Experiment Example Avocado Question in Text Treatment

The study also uses between-subject design because so that we can evaluate the effect that these of disclosure have on choice. Respondents were randomly assigned view the approved Bioengineered or Derived from Bioengineering symbols or the approved text disclosure “Bioengineered” or “Derived from Bioengineering.” This allows us to test for differences in the frequency that a label is chosen by disclosure method.

The choice experiment incorporated four levels of randomization. Respondents were first randomly placed into either the symbol or the text treatment group. Next, the order of display for avocado or vegetable oil questions was randomized. After this, each of the nine questions in a block were displayed in a randomized order, and within each question, the display order of the choices was randomized.

After completing the choice experiment, respondents were asked questions to validate their understanding of the option from the choice experiment in which the food is has no label and only has its price displayed. Next, questions were asked to gauge consumer behavior in purchasing food. We asked about the frequency that respondents look for GM labels, the likelihood that they look on the back or front of food products for labels, and their likelihood to scan a quick response (QR) code. As there is disagreement regarding the use of QR codes as a method of disclosure because of disproportionate access to technology implying that it is discriminatory (Berning and Roe 2016). A main predictor for future use of QR code is the prior use of QR scanning. Previous research finds that those who said that they were very likely or somewhat likely to scan a QR code also indicated not doing so within the last twelve months (Tallapragada and Hallman 2018). This is valuable information for policy makers deciding what methods of disclosure provide sufficient information to the public.

We also asked a set of questions about the trustworthiness of a message about GE and GM from various institutions. Similar to previous research by Ruth and Rumble 2019, which examined heterogeneity in trustworthiness across institutions for messages about GM safety. We build on this literature by testing for differences in trust of a message about GE compared to GM. The final questions of the survey were a second set demographic characteristic.

3.2 Statistical Methods and Modeling

We use two statistical methods to analyze the choice experiment in order to measure how consumer preferences differ across labels using the approved Bioengineered symbol and text disclosure methods and how they differ when stacked with the Bioengineered label. The first hypothesis tested is for the equality in proportions of respondents that choose symbol or text labels across the avocado and vegetable oil blocks. We employed the Pearson's chi-squared test to see if any two distributions of choice were equal. For distribution's that are not equal we employ two-way multiple comparisons of proportions tests to test if labels across symbol and text treatments were chosen an equal number of times. We also employ the two-way multiple comparison test to find if un-stacked and stacked labels within symbol and text treatments were chosen an equal number of times.

The choice experiment is also analyzed using a modeling approach in which a Multinomial Logit Model is estimated for both avocado and vegetable oil blocks. The model estimates the likelihood of a label being chosen and variables of interaction with the symbol treatment estimate how the likelihood of being chosen changes when displayed with a symbol disclosure method.

The Multinomial Logit Models were used to examine how price, label, and disclosure treatment, affected the likelihood that a label was chosen.

Let the utility derived by respondent *i* from choice *k* is represented by

$$U_{ik} = V_{ik} + \varepsilon_{ik} \tag{1}$$

V_{ik} is the observable portion of the utility function and ε_{ik} is the random deviate that contains all unobservable determinants of utility. It is assumed that ε_{ik} is identically distributed and independent of irrelevant alternatives. If respondent *i* is faced with *k* choice options they would choose option k if $U_{ik} > U_{il}$ for all $k \neq l$. This is the option that gives them the highest level of utility. The probability of choosing option k is

$$Prob(option\ k\ is\ chosen) = \frac{e^{V_{ik}}}{\sum_{k=1}^{K} e^{V_{il}}} \qquad 2$$

Price, an independent variable in the model was equal to either \$1, \$2, \$3 for the model estimated from avocado questions, and \$2, \$4, and \$6 for the model estimated from vegetable oil questions. The labels in the choice experiment are variables that make up the deterministic portion of both models. These are: No Label, Bioengineered, Gene Edited, Genetically Modified, Bioengineered + Gene Edited, Bioengineered + Genetically Modified, Gene Edited + Genetically Modified, and Bioengineered + Gene Edited + Genetically Modified, with the exception of the "I would not purchase any of these," which was used as the reference.

The deterministic portion of the model was estimated as:

$$V_{ik} = \beta_1 + \beta_2 Price_k + \beta_3 NL_k + \beta_4 BIO_k + \beta_5 GE_k + \beta_6 GM_k + \beta_7 BIOGE_k + \beta_8 BIOGM_k + \beta_9 GEGM_k + \beta_{10} BIOGEGM_k + \beta_{11} Symbol_k + \beta_{12} PriceI_k + \beta_{13} NLI_k + \beta_{14} BIOI_k + \beta_{15} GEI_k + \beta_{16} GMI_k + \beta_{17} BIOGEI_k + \beta_{18} BIOGMI_k + \beta_{19} GEGMI_k + \beta_{20} BIOGEGMI_k. \qquad 3$$

The abbreviations for the variables in the model correspond to the options in the choice experiment. NL is for the No Label option; BIO corresponds to the option which just had the bioengineered label. GE and GM correspond to labels disclosing gene editing and genetically modified, respectively. $BIOGE$and $BIOGM$ correspond to labels that had both the bioengineered label and gene editing or genetically modified labels respectively. $GEGM$ corresponds to the option which disclosed both gene editing and genetically modified labels. $BIOGEGM$ corresponds to the option that had the bioengineered, Gene edited, and genetically modified label. The variable S$ymbol$ is a dummy variable for the symbol/text treatment and is equal to one for choices that are in the symbol treatment and zero for those in the text treatment. The Price and label variables are then interacted with the $Symbol$ variable to examine how the probability of being chosen changes when a label is displayed with a symbol as opposed to text. These variables are indicated by variable names $PriceI$, NLI, $BIOI, GEI, GMI, BIOGEI$, $BIOGMI, GEGMI$ and $BIOGEGMI$. β_1 is the constant which sets the intercept of the model.

Wald Tests are used to test for difference of expressions likelihoods between a label with and without the Bioengineered label, and labels with gene editing or genetic modification compared to a label with both gene editing and genetic medication using estimates from the MNL regression. The null hypothesis of the comparisons was that difference of the expressions are equal to zero; rejecting the null hypothesis of the expression would provide evidence that the stacking of a bioengineered symbol or stacking an additional genetic improvement technique significantly changes the likelihood of the label being chosen. There were ten Wald tests run in total, including five comparisons from the avocado model and five from the vegetable oil model. Each comparison's null and alterative hypothesis followed the structure below.

$$\text{Ho: } (\beta_5^{GE} + \beta_{15}^{GEI}) - (\beta_7^{BIO+GE} + \beta_{17}^{BIO+GEI}) = 0$$

$$\text{Ha: } (\beta_5^{GE} + \beta_{15}^{GEI}) - (\beta_7^{BIO+GE} + \beta_{17}^{BIO+GEI}) \neq 0$$

3.3 Respondents

This study was conducted online and fielded by Qualtrics to a diverse sample of 1,281 respondents who were prescreened to give a sample representative of the U.S census based on age, income, and sex. The survey was fielded between February 11th to February 17th, 2021. Descriptive statistics of the characteristics of respondents are shown in Table 2. Median age for the sample was 46, median household income was between \$50,000 to \$59,000, and 48.24% of the survey sample was male. This study was approved by the University of Delaware IRB and consent was obtained prior to a respondent completing the survey. An online survey was the best choice for this study for a few reasons. Online surveys allow a uniform and automated survey procedure, question diversity, and the collection of a large amount of data from a geographically diverse population in a short period of time (Evans and Mathur 2005). The survey took respondents about 12 minuets to complete. Conducting an in-person laboratory experiment during the Covid-19 pandemic could expose respondents to unnecessary risks, and potentially introduce bias to the sample.

Table 2: Summary Statistics for the Characteristics of Respondents

Variable	Levels	Median or Frequency
Gender (1-4)	1 - Male	48.24%
	2- Female	50.82%
	3 - Non-Binary	0.78%
	4 - Perfer not to say	0.16%
Age		46
Income (1-12)	1 - Less than $10,000	7.18%
	2 - $10,000 to $19,999	8.12%
	3 - $20,000 to $29,999	9.45%
	4 - $30,000 to $39,999	8.98%
	5 - $40,000 to $49,999	6.87%
	6 - $50,000 to $59,999	10.77%
	7 - $60,000 to $69,999	6.25%
	8 - $70,000 to $79,999	7.26%
	9 - $80,000 to $89,999	3.43%
	10 - $90,000 to $99,999	5.07%
	11 - $100,000 to $149,999	15.61%
	12 - $150,000 or more	11.01%
Education (1-6)	1 - Less than High School degree	2.19%
	2 - High School graduate (high school diploma or equivalent including GED)	27.24%
	3 - Some college but no degree	33.49%
	4 - Associate's degree in college (2-year)	27.26%
	5 - Bachelor's degree in college (4-year)	13.35%
	6 - Graduate or Professional degree (MS, PhD, JD, MD)	16.47%
Eployment Status (1-7)	1 - Employed full time	36.77%
	2 - Employed part time	9.13%
	3 - Stay at home parent/spouse	8.20%
	4 - Self employed	7.10%
	5 - Retired	25.68%
	6 - Full time student	5.93%
	7 - Currently seeking full time employment	7.18%
Urban Suburban Rural (1-3)	1 - Urban	29.59%
	2 - Suburban	46.45%
	3 - Rural	23.97%
Region (1-4)	1 - Northeast	20.37%
	2 - Midwest	21.62%
	3 - South	37.08%
	4 - West	20..92%
Race (1-8)	1 - Asian	3.98%
	2 - Black / African American	8.98%
	3 - Hispanic / Latino	4.61%
	4 - Native American	0.78%
	5 - Native Islander	0.16%
	6 - White / Caucasian	78.92%
	7 - Other	1.72%
	8 - Prefer not to answer	0.86%
Political Identity (1-5)	1 - Republican	26.39%
	2 - Democrat	39.50%
	3 - Independent	26.90%
	4 - Other	2.11%
	5 - No preference	5.07%

Variable	Levels	Median or Frequency
Religious Identity (1-11)	1 - Protestant (Baptist, Lutheran, Methodist, Episcopalian, Anglican, Presbyterian, Pentecostal)	30.50%
	2 - Roman Catholic	20.22%
	3 - Greek or Russian Orthodox	1.17%
	4 - Jewish	5.31%
	5 - Mormon, LDS	0.94%
	6 - Muslim	2.11%
	7 - Hindu	0.62%
	8 - Agnostic	7.96%
	9 - Atheist	5.70%
	10 - Buddhist	0.86%
	11 - Other	25.06%
Disability Status (1-3)	1 - Yes, I have one or mode disabiliities or am disabled	22.40%
Is there a genetic componet to your disability? (1-4)	1- Yes	28.57%
	2- No	43.21%
	3 - I don't know	27.53%
	4 - Perefer not to answer	0.70%
	2 - No, I am not disabled	74.32%
	3 - Prefer not to answer	3.28%
Have you ever worked in Food or Agriculture? (1-2)	1 - Yes	17.41%
	2 - No	82.59%
Primary Shopper (1-2)	1 - Yes	82.44%
	2- No	17.56%
Purchased avocado in the last 12 months (1-2)	1 -Yes	62.45%
	2- No	37.55%
Purchased vegatble oil in the last 12 months (1-2)	1 - Yes	84.47%
	2 - No	15.53%
Interested in knowing if your food is GM (1-2)	1 - Yes	72.29%
	2- No	27.71%
Havey you ever scanned a QR code?	1 - Yes	27.17%
	2 - No	68.93%
	3 - I don't know	3.90%

Chapter 4

RESULTS

The respondents' choice was first analyzed using a Pearson's Chi-Squared test to find if the observed frequency distribution was equal between avocado and vegetable oil questions by treatment, and between symbol and text treatments by avocado and vegetable oil questions. The distributions tested were symbol avocado against text avocado ($X^2 = 62.234$, d.f = 8, p-value < 0.001), symbol vegetable oil against text vegetable oil ($X^2 = 81.652$, d.f = 8, p-value < 0.001), symbol avocado against symbol vegetable oil ($X^2 = 46.200$, d.f = 8, p-value < 0.001), and text avocado against text vegetable oil ($X^2 = 33.585$, d.f = 8, p-value < 0.001),. All null hypotheses for the equality of distributions were rejected. These results indicate that the observed frequency of label choice was different between the symbol and text treatment for both avocado and vegetable oil questions, and the frequency of label choice was different for avocado and vegetable oil within treatment groups.

Further analysis will measure if there are significant differences in the frequency that labels are chosen both within and between treatments. To test for the equality of these proportions we use pairwise comparisons tests. The results from the pairwise comparison tests will explain where the difference in proportions are due to the method of disclosure when making comparisons between treatment or explain difference in consumer preference for labels when making comparisons within treatments. The proportion of the sample who chose each label are shown in Figure 4 for the avocado and Figure 5 for the vegetable oil. The results from pairwise comparison of the difference of the proportion for each type of food is displayed in Table 3. *P*-values are corrected using the Bonferroni correction in order to preserve a constant family wise error rate.

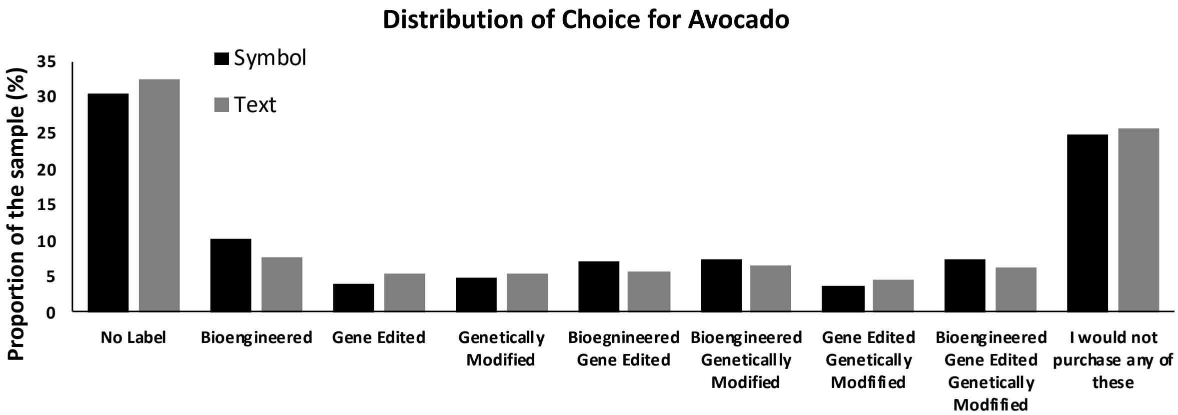

Figure 4: Distribution of Choice for Avocado

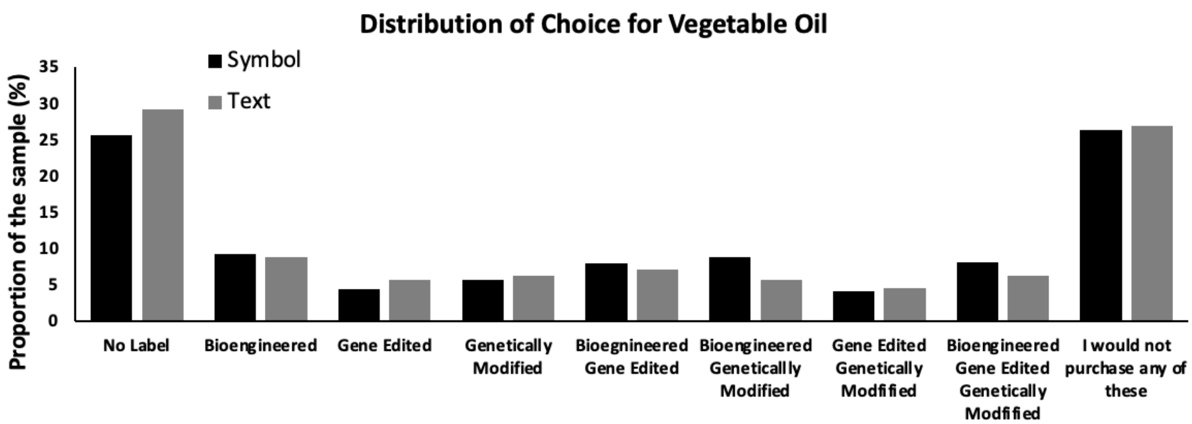

Figure 5: Distribution of Choice for Vegetable Oil

For the avocado questions, respondents choose the Bioengineered label more frequently in the symbol treatment than in the text treatment ($z = 4.78$, corrected *p*-value < 0.01). Despite this response to the symbol when asked about the avocado, the difference in the proportion that chose the Bioengineered label between the symbol and text treatments was not significant for the vegetable oil questions ($z = 1.00$, *corrected p*-value > 0.10).

For vegetable oil questions, a higher proportion of respondents in the text treatment group chose either the No Label option or the Gene Edited label option than did the respondents in the symbol treatment group (Vegetable Oil No Label $z = -4.19$, corrected *p*-value < 0.01, Vegetable Oil Gene Edited $z = -3.02$, corrected *p*-value < 0.05). Within the avocado question block, the comparison of proportion for those who chose gene edited between symbol and text treatments was higher for text treatment than the symbol treatment ($z = -3.56$, corrected *p*-value < 0.01).

In contrast, the proportion of respondents that chose the Bioengineered + Gene edited + Genetically Modified label was higher in the symbol treatment for both avocado and vegetable oil questions. (Avocado $z = 2.59$, corrected p-value < 0.10, Vegetable Oil $z = 3.92$, corrected *p*-value < 0.01).

Table 3: Two Sample Test of Proportions

	Avocado	Vegetable Oil
Choice	Difference in Proportion (Symbol - Text)	Difference in Proportion (Symbol - Text)
No Label	-0.020	-0.035***
	(0.009)	(0.008)
Bioengineered	0.025***	-0.005
	(0.005)	(0.005)
Gene Edited	-0.014***	-0.012**
	(0.004)	(0.004)
Genetically Modified	-0.006	-0.006
	(0.004)	(0.004)
Bioengineered + Gene Edited	0.015***	0.008
	(0.005)	(0.005)
Bioengineered + Genetically Modified	0.006	0.031***
	(0.005)	(0.005)
Gene Edited + Genetically Modified	-0.008	-0.005
	(0.004)	(0.004)
Bioengineered + Gene Edited + Genetically Modified	0.012*	0.019***

	(0.005)	(0.005)
I would not purchase any of these	-0.011	-0.005
	(-0.008)	(0.008)
No. of Observations		
Symbol	5,769	5,560
Text	5,760	5,969

*Note: *, **, and *** denote significance level at 0.10, 0.05, and 0.01, respectively. Standard errors are reported in parentheses.*

The proportion of respondents that chose the Bioengineered + Gene Edited option was higher in the symbol treatment than in the text treatment for the avocado questions ($z = 3.26$, corrected p-value < 0.01), but the difference for the vegetable oil questions was not significant ($z = 1.65$, corrected p-value > 0.10). Similarly, the difference in proportion of respondents that chose the Bioengineered + Genetically Modified option was higher in the symbol treatment than in the text treatment for the vegetable oil questions ($z = 6.47$, corrected p-value < 0.01); this difference in proportion was not statistically significantly different for the avocado questions, however ($z = 1.29$, corrected p-value > 0.10)

In both symbol and text treatments and for both avocado and vegetable oil questions, the Gene Edited + Genetically modified label was chosen the least frequently. The proportion of respondents that chose the Gene Edited + Genetically Modified label was not statistically significantly different for both the avocado questions and the vegetable oil questions ($z = -2.26$ corrected p-value > 0.10, $z = -1.21$, corrected p-value > 0.10).

There was no difference in the proportion of respondents in either treatment that chose either the Genetically Modified label and the "I would not purchase any" option for both avocado and vegetable oil questions. (Avocado Genetically Modified $z = -1.37$, p-value > 0.10, Vegetable Oil Genetically Modified $z = -1.40$, p-value > 0.10, Avocado "I would not purchase any" $z = -1.38$, p-value > 0.10, Vegetable Oil "I would not purchase any" $z = -0.66$, p-value > 0.10)

The same method of analysis was used to distinguish differences in proportion for the data in Figure 6 for the Avocado block and Figure 7 for the vegetable oil block. The category bioengineered and non-bioengineered used the cumulative frequency of the original choices from the choice experiment. The bioengineered group contains the following options: Bioengineered, Bioengineered + Gene Edited, Bioengineered + Genetically Modified, and Bioengineered + Gene Edited + Genetically Modified. Conversely, the non-Bioengineered group contains available options without the Bioengineered label and is made up of these options: Gene Edited, Genetically Modified, and Gene Edited + Genetically Modified. The category of Gene Edited labels contains the following options: Gene Edited, Bioengineered + Gene Edited, Gene Edited + Genetically Modified, Bioengineered + Gene Edited + Genetically Modified. Correspondingly, the Genetically Modified group contains Genetically Modified, Bioengineered + Genetically Modified, Gene Edited + Genetically Modified, and Bioengineered + Gene Edited + Genetically Modified. The analysis of the two-way difference of proportions tests between symbol and text treatments for this data is in Table 4.

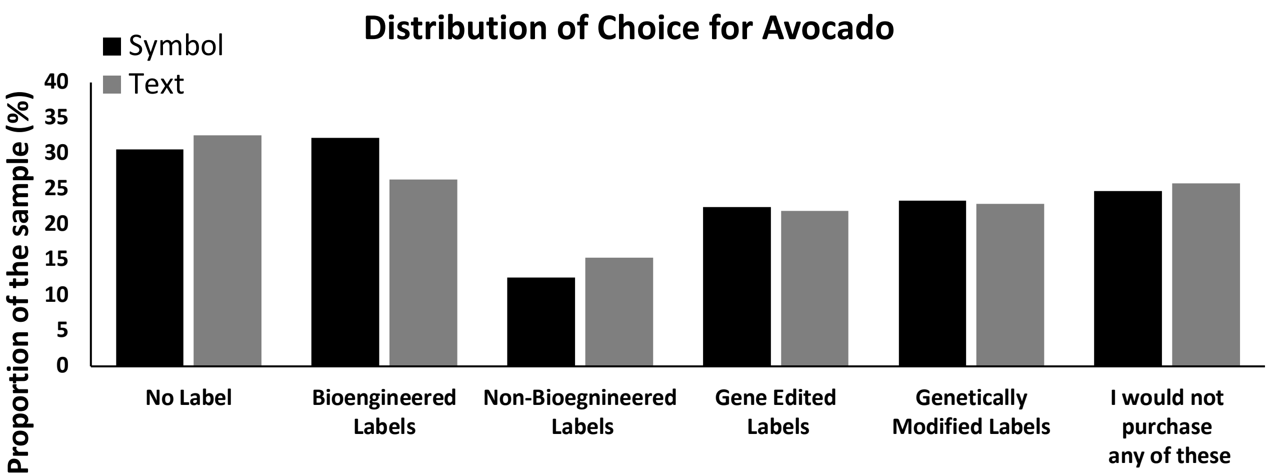

Figure 6: Distribution of Choice for Avocado, Grouped by Characteristics

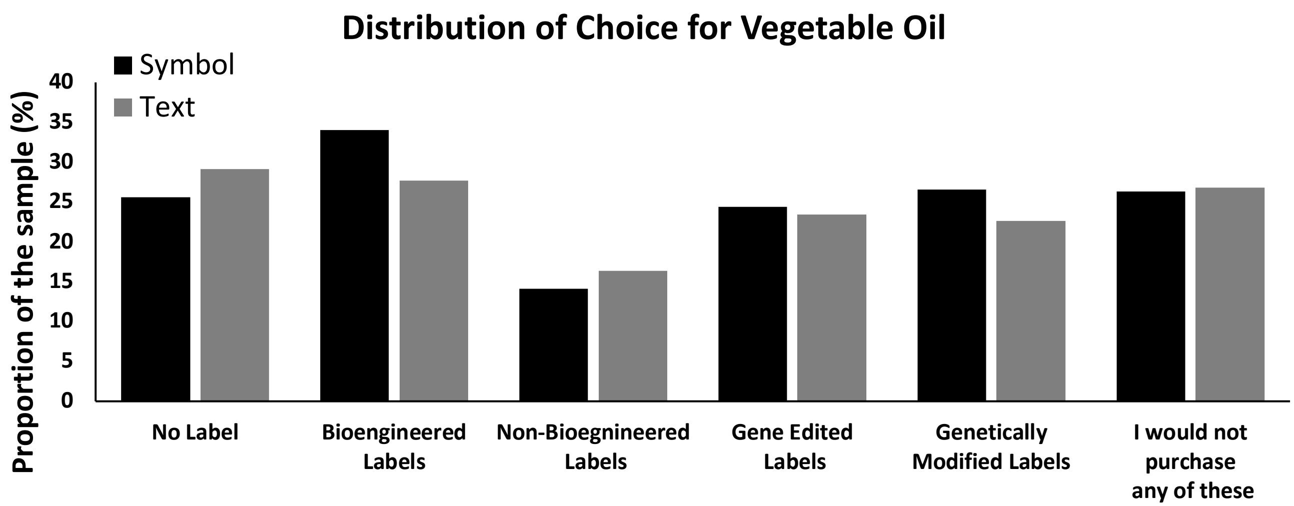

Figure 7: Distribution of Choice for Vegetable Oil, Grouped by Characteristics

When combined into these groups, we found that labels which contained the Bioengineered symbol were chosen more often than labels which contained the Bioengineered text for both avocado and vegetable oil questions. (Avocado z = 6.92, corrected *p*-value < .01, Vegetable Oil z = 7.37, corrected *p*-value < 0.01). This finding supports the argument that there is a difference between the Bioengineered symbol and text disclosure methods and that this difference is consistent for both foods types. The symbol and text proportions for the Non-Bioengineered labels and the No Label option are also statistically significantly different for vegetable oil foods, even though there was no visually apparent difference between these options in the symbol and text treatment groups. There were differences in the choice set presented to survey respondents, which could explain why there are differences across treatment groups for these labels. This difference is representative of market share moving away from the No Label and Non-Bioengineered labeled food products.

There was no difference between Symbol and Text treatment groups for gene edited labels in both avocado and vegetable oil blocks. On the other hand, the treatment effect for genetically modified labels did have a significant difference in the vegetable oil block but not the avocado block. The results in Table 2 break down the source of this difference within the Genetically Modified group to be primarily from questions with the Bioengineered Label. This comparison reveals the impact the symbol disclosure method will have on the processed genetically modified foods to be significant, while the impact on whole foods will be insignificant.

Table 4: Two-Sample Test of Proportions, Grouped by Characteristics

	Avocado	Vegetable Oil
Choice	Difference in Proportion (Symbol - Text)	Difference in Proportion (Symbol - Text)
No Label	-0.020	-0.035***
	(0.009)	(0.008)
Bioengineered	0.059***	0.063***
	(0.008)	(0.009)
Non-Bioengineered	-0.028***	-0.023***
	(0.006)	(0.007)
Gene Edited	0.004	0.010
	(0.008)	(0.008)
Genetically Modified	0.004	0.039***
	(0.008)	(0.008)
I would not purchase any of these	-0.011	-0.005
	(0.008)	(0.008)
No. of Observations		
Symbol	5769	5560
Text	5760	5969

*Note: *, **, and *** denote significance level at 0.10, 0.05, and 0.01, respectively. Standard errors are reported in parentheses.*

Table 5 compares the difference in proportion within treatments for stand-alone labels compared to their stacked counterpart. In the "Non-Bio" group is Gene Edited, Genetically modified, and Gene Editing + Genetically modified labels. In the

“Bio” group are these same labels but each is stacked with the bioengineered label. The proportion of respondents that choose the Bioengineered labels were higher than the Non-Bioengineered Labels by 9.5% for avocado questions and 10.7% for vegetable oil questions in the symbol treatment (z = 13.542 corrected *p*-value < 0.01, z = 14.216 corrected *p*-value < 0.01, respectively). For the text treatment, while still significant, the difference was only 3.4% for avocado questions and 2.6% for vegetable oil (z = 4.859 corrected *p*-value < 0.01, z = 3.671 corrected *p*-value < 0.01). Stacking the bioengineered label increased the proportion of respondents that choose the label, the increase is notably larger when the bioengineered label is displayed as a symbol than as text.

Table 5: Two-Sample Test of Proportions, (Bioengineered – Non-Bioengineered)

	Avocado	Vegetable Oil
Treatment	Difference in Proportion (Bio - Non-Bio)	Difference in Proportion (Bio - Non-Bio)
Symbol	0.095***	0.107***
	(0.007)	(0.007)
Text	0.034***	0.026***
	(0.007)	(0.007)
No. of Observations		
Symbol	5,769	5,560
Text	5,760	5,969

*Note: *, **, and *** denote significance level at 0.10, 0.05, and 0.01, respectively. Standard errors are reported in parentheses.*

Using the modeling approach to analyze the choice experiment finds similar results to the comparison of proportions across treatment groups. Table 6 contains the output of Multinomial Logit Models (MNL) for both the avocado and vegetable oil. The number of observations for each participant in both models is 81. Within each model there were 1,281 respondents each answering 9 questions that each had 9 alternatives. Robust standard errors are clustered by respondent and displayed in parentheses. The model measures the log likelihood of an option being chosen. The second half of the coefficients measure interaction with the symbol treatment. Significant coefficients in interaction terms are indicative of a difference between symbol and text treatments in influencing consumer preference for the labels. The model did not find significance in the interaction terms for labels without the Bioengineered label. The visual appearance of these labels (e.g., Gene Edited + Genetically Modified) were identical across the symbol and text treatments, so this is not surprising.

The interaction terms that were significant for avocado questions were the Bioengineered label, Bioengineered + Gene Edited label, and the Bioengineered + Gene Edited + Genetically Modified label. For the vegetable oil questions, the interaction terms that were significant were the Bioengineered + Genetically Modified label and the Bioengineered + Gene Edited + Genetically Modified label. These interaction terms were all positive, meaning they increased the log likelihood of the label being chosen. This finding supports the hypothesis that the symbol and text treatments are different and provides evidence to support the argument that the bioengineered symbol improves consumer preference compared to the bioengineered text label.

Table 6: Multinomial Logit Model fit to Choice Experiment data

Explanatory Variables	Avocado	Vegetable Oil
Price	-0.545***	-0.312***
	(-0.043)	(-0.022)
No Label	1.384***	1.311***
	(-0.139)	(-0.135)
Bioengineered	-0.428**	-0.222
	(-0.140)	(-0.135)
Gene Edited	-0.814***	-0.685***
	(-0.141)	(-0.135)
Genetically Modified	-0.800***	-0.560***
	(-0.144)	(-0.138)
Bioengineered + Gene Edited	-0.734***	-0.450***
	(-0.137)	(-0.133)
Bioengineered + Genetically Modified	-0.574***	-0.650***
	(-0.138)	(-0.139)
Gene Edited + Genetically Modified	-0.985***	-0.904***
	(-0.137)	(-0.137)
Bioengineered + Gene Edited + Genetically Modified	-0.644***	-0.604***
	(-0.145)	(-0.14)
= 1 if Symbol Treatment, = 0 if Text Treatment	-0.059	-0.028
	(-0.109)	(-0.105)
Price Interaction	-0.102	-0.050
	(-0.061)	(-0.031)
No Label Interaction	0.153	0.018
	(-0.198)	(-0.19)
Bioengineered Interaction	0.551**	0.312
	(-0.198)	(-0.192)
Gene Edited Interaction	-0.092	-0.083
	(-0.199)	(-0.195)
Genetically Modified Interaction	0.111	0.070
	(-0.208)	(-0.197)

Bioengineered + Gene Edited Interaction	0.480*	0.363
	(-0.196)	(-0.19)
Bioengineered + Genetically Modified Interaction	0.325	0.630**
	(-0.199)	(-0.194)
Gene Edited + Genetically Modified Interaction	0.013	0.069
	(-0.198)	(-0.194)
Bioengineered + Gene Edited + Genetically Modified Interaction	0.423*	0.535**
	(-0.202)	(-0.197)
Constant	-1.057***	-1.004***
	(-0.076)	(-0.074)
Observations	81	81
Log Pseudolikelihood	-31405.755	-31813.503
Pseudo R-Squared	0.1323	0.1211

*Note: *, **, and *** denote significance level at 0.05, 0.01, and 0.001, respectively. Robust standard errors are reported in parentheses.*

Using the estimated values in the MNL models, Wald tests were conducted to test for the difference of expressions comparing a label and its interaction to its equivalent label stacked with the bioengineered label and the interaction.

Table 7: Comparison of Label Effects using Multinomial Logit Model Coefficient Estimates

Wald Test Null Hypothesis Expression	Avocado	Vegetable Oil
$(\beta_5^{GE} + \beta_{15}^{GEI}) - (\beta_7^{BIO + GE} + \beta_{17}^{BIO + GEI})$	-0.652***	-0.681***
$(\beta_6^{GM} + \beta_{16}^{GMI}) - (\beta_8^{BIO + GM} + \beta_{18}^{BIO + GMI})$	-0.440**	-0.470***
$(\beta_9^{GE + GM} + \beta_{19}^{GE + GMI}) - (\beta_{10}^{BIO + GE + GM} + \beta_{20}^{BIO + GE + GMI})$	-0.751***	-0.766***
$(\beta_5^{GE} + \beta_{15}^{GEI}) - (\beta_9^{GE + GM} + \beta_{19}^{GE + GMI})$	0.066	0.450
$(\beta_6^{GM} + \beta_{16}^{GMI}) - (\beta_9^{GE + GM} + \beta_{19}^{GE + GMI})$	0.283**	0.345***

*Note: *, **, and *** denote significance level at 0.05, 0.01, and 0.001 of the X^2 test statistic, respectively. Degrees of freedom = 1*

The null hypotheses from the six comparisons of the stacked bioengineered labels were rejected. Results of the Wald tests are found in Table 7. This finding suggests that stacking the Bioengineered symbol on Gene Edited, Genetically Modified or Gene Edited and Genetically Modified food labels improve the likelihood of the food being selected. This result is surprising considering that adding the Bioengineered symbol to a label that already discloses the presence of a Genetically Modified food would seem redundant, as it provides no additional information and does not indicate a change to the food at all. When the bioengineered label is stacked with the Gene Edited label, it also improves consumer preference. In this case, the Bioengineered symbol is disclosing the presence of an additional plant genetic improvement technique used in production, yet this still improved consumer preference.

The four Wald tests comparing the stacking of the Gene Edited label and Genetically Modified label found mixed results. For both the avocado and vegetable oil the null hypothesis was not rejected for differences in Gene Edited compared to Gene Edited + Genetically Modified. In reverse, for both avocado and vegetable oil the null hypothesis was rejected for differences in Genetically Modified compared to Gene Edited + Genetically modified. This result implies that stacking a Gene Edited disclosure on a product that is Genetically Modified increases consumer preference but stacking Genetically Modified disclosure on a label that already discloses the presence of Gene Editing has no change on consumer preference. Given the current abundance of genetically modified food in the food supply, it is likely that manufactures would be stacking Gene Edited traits on what is currently produced. These results indicate that disclosing the Gene Edited trait would improve consumer preference for the food product. This result is in agreement with Lusk et al 2015, which finds providing consumer-based benefits in Gene Edited traits to already Genetically Modified food increase consumer willingness to pay for the food, but our results find a similar improvement in consumer preference without providing information to consumers on the benefit being added with the additional Gene Edited label.

The No Label option was the most frequently chosen by respondents in both symbol and text treatments for avocado and vegetable oil questions; the only exception was the symbol treatment for vegetable oil questions, where “I would not purchase any of these” was most frequently chosen. To validate the respondents’ understanding of the No Label option, questions asked after the choice experiment investigated what respondents understood this option to mean. For the avocado questions, 65.89% of respondents understood this option as it was intended: that the option was neither gene edited nor genetically modified. For the vegetable oil questions, this same proportion was 63%. As the NBFDS becomes law, there may be a greater need for labels such as the Non-GMO verified label, as the public may be unequipped with information to identify foods that do not contain Genetically Modified and Gene Edited material from the Bioengineered label alone. This question was asked separately for the Text and Symbol treatment groups, and no difference was found in a chi-squared test for the questions about avocados (X^2 = 6.69, d.f = 3, *p*-value = 0.082) and for those about vegetable oil ($X^2 = 2.32$, d.f = 3, *p*-value = 0.508).

When asked whether or not there is a difference between a food product with the Bioengineered symbol and without, 15.46% of respondents answered “No, there is not difference” (n = 1,281). The response when asked about the difference between a food product with the Bioengineered symbol and a Genetically Modified label, 30.13% answered "No, there is not difference" (n = 1,281), but 56.67% reported that "There is a difference, but I am not sure what the difference is." Approximately 30% of the sample reported that there is not a difference between food products with these two labels, which does not constitute a high level of understanding given that the NBFDS may only require GM foods to be labeled as Bioengineered.

The results from the knowledge test provide another measure of respondents understanding the Bioengineered label. When asked which plant genetic improvement techniques from a list provided are considered bioengineering, 25.45% of respondents' answers did not include either Genetic Modification or Gene Editing. 7.42% answered that only Gene Editing and Genetic Modification were considered Bioengineering. 10.23% consider Gene Editing to be Bioengineering, but also consider the other plant genetic improvement techniques such as mutagenesis, hybridization, genetic marker assisted, and conventional as Bioengineering. A greater proportion, 23.58%, consider Genetic Modification to be Bioengineering, but also consider the other plant genetic techniques to be as well.

The results of the knowledge test and the comparison of the Bioengineered label to the Genetically Modified label suggest that there is a low level of association between Bioengineering and Genetic Modification. Given that the Bioengineered label is meant to at least disclose the presence of Genetically Modified material, our results indicate that it will only do so for between a 23.58% to 30.13% of the public. If it is also meant to disclose the presence of Gene Edited material, this proportion of the public understanding the label may be even lower.

The term “Bioengineering” is new to consumers, so there is a lot of room for improvement for consumers to better understand Bioengineering and its association to Gene Editing and Genetic Modification. Institutions like the USDA, and EPA, FDA, CDC, WHO, and Departments of Health are often a source of science communication in the food and agriculture and the health and medical fields. We asked respondents to measure their trust in a message about the safety of GM and GE from these institutions on a scale of 1-5. (1 – Not Trustworthy at all, 5 – Extremely Trustworthy). Respondents reported a message about GE safety to be more trustworthy than a message about GM safety ($z = 1.963$, p-value < 0.05). When disjoined by institutions respondents reported a higher level of trust in a message about GE than GM from the EPA, FDA, and CDC ($z = 2.201$ p-value < 0.05, $z = 1.92$ p-value < 0.10, $z = 2.301$ p-value < 0.05, respectively) but no difference for messages from the USDA, WHO, and DOH ($z = 1.349$ p-value > 0.10, $z = 1.420$ p-value > 0.10, $z = 1.145$ p-value > 0.10, respectively).

Although the perceived safety of gene editing and genetic modification is of importance to the current and future use of these technologies, it is but one element that makes up the public’s full perception of them. To measure respondent’s perception of these technologies, we asked respondents to choose from a list of views those which most and least aligns with their view of either Gene Editing or Genetic Modification shown in Table 1. For both Gene Editing and Genetic Modification treatment groups respondents identified the statement “The potential risks of GE (GM) food related to health have not been adequately investigated” as most aligning with their views (18.63% n = 120, 16.01% n = 102, respectively). Similarly, for both GE and GM foods respondents identified the statement “GE (GM) food can cause cancer in humans” as least aligning with their views (26.40% n = 170, 22, 14% n = 141, respectively). The results from an ANOVA test between GE and GM for both most and least aligns found no significant difference between groups ($F = 1.433$ d.f = 1 *p*-value > 0.10, $F = 6.527$ d.f = 1 *p*-value > 0.10, respectively).

A tradeoff with doing labeled choice experiments is that we are presenting the label clearly to respondents, while in reality some people may not seek out information about what plant genetic improvement techniques were used when buying foods. 31.46% (n = 403) of respondents reported either often or always looking for GM labels when buying food. A higher percent, 38.41% (n = 492) of respondents reported either never or rarely looking for GM labels when buying food. Additionally, our presentation of the labels was displayed differently than a typical food item. The NBFDS allows for food manufactures to display information disclosing the presence of Bioengineered food either adjacent to the manufacturer information panel, typically found on the back of food packaging, or on the principal display panel, which is the front of the packaging most often seen by customers. Using ANOVA, the results found no difference in the stated likelihood of looking at the front in comparison to the back of a package for GM information.

Aside from symbol and text methods of disclosure, manufactures can opt to use a quick response code (QR code) or a mobile text message to provide consumers with additional information. Research has shown that people are unlikely to scan the QR code because of lack of access to a smart phone, lack of access to the internet, or unwillingness to scan for more information. When asked the likelihood of scanning a QR code while shopping for food the highest proportion of respondents indicated that they were very unlikely to do so (31.91% n = 396). This proportion is higher than the proportion of respondents that reported being either somewhat likely or very likely to scan (29.59% n = 379).

Chapter 5

CONCLUSION

Mandatory compliance with The National Bioengineered Food Disclosure Standard will take effect on January 1st, 2022, ushering in a new architecture for the disclosure of Gene Edited and Genetically Modified foods. Genetically Modified food is already abundant in the food supply, and Gene Edited food is likely to increase in abundance, as it can potentially provide consumer and producer-based benefits. It is certain that Genetically Modified food labels will require disclosure under the guidelines of the NBFDS. The regulatory requirements for Gene Edited foods, however, remain uncertain. Future food products could potentially have one or more labels indicating the use of plant genetic improvement techniques. Furthermore, consumers are aversive to Genetically Modified foods, possibility reflective of low genetic literacy and understanding of science among the public. This study gives insight into how consumer preferences for food changes based on plant genetic improvement technique and method of disclosure using the approved Bioengineered label in a choice experiment.

We found significant differences the impact of text and symbol methods of disclosure in six of eight multiple comparisons of proportions tests on foods with the Bioengineered label. All six significant tests found a higher proportion of respondents choosing a label if the Bioengineered label was disclosed using the approved symbol. When analyzed though a multinomial logit model, five of eight coefficients measuring the impact of a symbol verses a text disclosure for food with the Bioengineered symbol were statistically significant. All five of the statistically significant coefficients were positive, indicating that the symbol method of disclosure improved consumer preference for those labels in the choice experiment.

There are differences between consumer behavior in our choice experiment and consumer behavior when shopping for food. The choice experiment in this study clearly and always displayed label information, however in our sample only 13% reported always looking for GM labels when purchasing food at a store. Requiring consumers to scan a QR code creates a barrier to accessing information and can result in as low as 1.2% of respondents accessing information (Li and Messer 2019). This implies that food manufactures will likely avoid more transparent methods of disclosing GE or GM foods by using a QR code. If choosing between a text or symbol method of disclosure food manufactures would most likely choose the symbol, as evidence from this study shows consumers are more likely to purchase food with the symbol opposed to text.

We also explored the impact of stacking the Bioengineered label with a label that indicates the presence of gene editing, genetic modification, or both. An increased proportion of respondents chose these stacked labels over the unstacked labels in both the symbol and text treatment groups, and this increase was even greater when the Bioengineered label was displayed as symbol, as opposed to text. The results of the Wald tests post-estimation of the multinomial logit models confirmed the result that Bioengineered label improves consumer preferences. In addition, the Wald tests found that consumers prefer the stacked Gene Edited + Genetically Modified more than just Genetically Modified alone, but they do not prefer the Gene Edited + Genetically Modified label over Gene Edited alone. Similar to previous research we found that consumers prefer food without either gene edited or genetic modified labels, but also prefer gene edited labels than genetically modified labels (Muringai et al. 2020; Shew et al. 2018).

The knowledge test of which plant genetic improvement techniques are Bioengineering and a question about association between the Bioengineered label and Genetically Modified label revealed a low level of understanding the new term “Bioengineered”. If the NBFDS is also going to regulate gene edited foods, the association between the proposed label and the technology could be even lower. This begs to question: who will disseminate scientific information to the public on the potential risks and benefits of these plant genetic technologies? Our results found that people trust institutions such as the EPA, FDA, and CDC more about gene editing information than about genetic modification, but not much could be said about relative levels of trust among institutions.

Levels of association between the term bioengineered with Gene Editing and Genetic modification remain low. It’s possible the preference for food labeled as Bioengineered, identified in this paper is consequential of the low level of association. If gene edited and genetically modified foods are both labeled as “bioengineered”, then the larger premium consumers require for transgenic genetically modified food is going to affect the price for gene edited food if consumers are aware that bioengineered food is genetically modified. Knowledge and association between the bioengineered label and the technology it discloses should continue be carefully studied. As gene editing expands into new food, medical, and human health applications, the public’s understand, and perception could be consequential to how consumers make purchasing decisions in food markets.

There are many facets of the NBFDS that will reshape the choices consumers make when purchasing food. The shift from voluntary to mandatory disclosure could increase costs to producers and thus increase price, as well as potentially signal that the regulated food is unsafe (Golan et al 2001; Costanigro & Lusk 2014). The policy allows text and symbol methods of disclosure which McFadden and Malone 2018 identified have heterogenous effects on consumer preference. Our study further confirms there's have heterogenous effects on consumer preference using the approved symbols and text disclosure methods. Whether or not the policy will require the labeling of GE food as bioengineered has additional implications for products with GE and GM traits as we have identified that this labeling decision effects consumer choices.

Additional research is needed on this topic to fully discern the impact that the National Bioengineered Food Disclosure Standard has on consumer behavior and the food industry more broadly.

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Appendix A

MOST & LEAST ALIGNS WITH VIEWS ON GE & GM

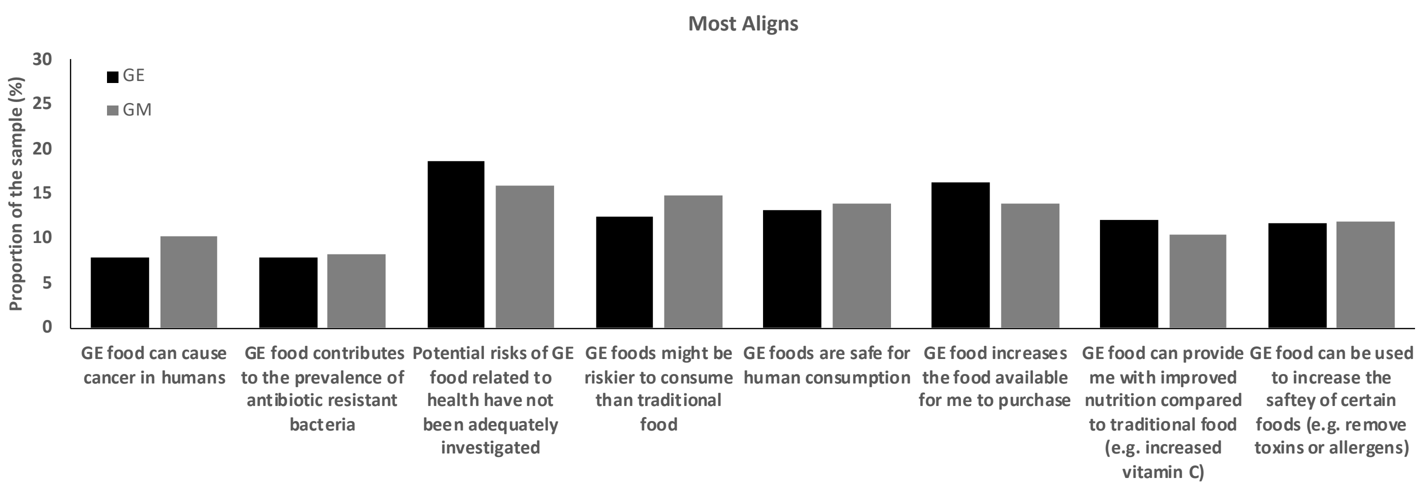

Figure 8: Most Aligns with Views on GE & GM

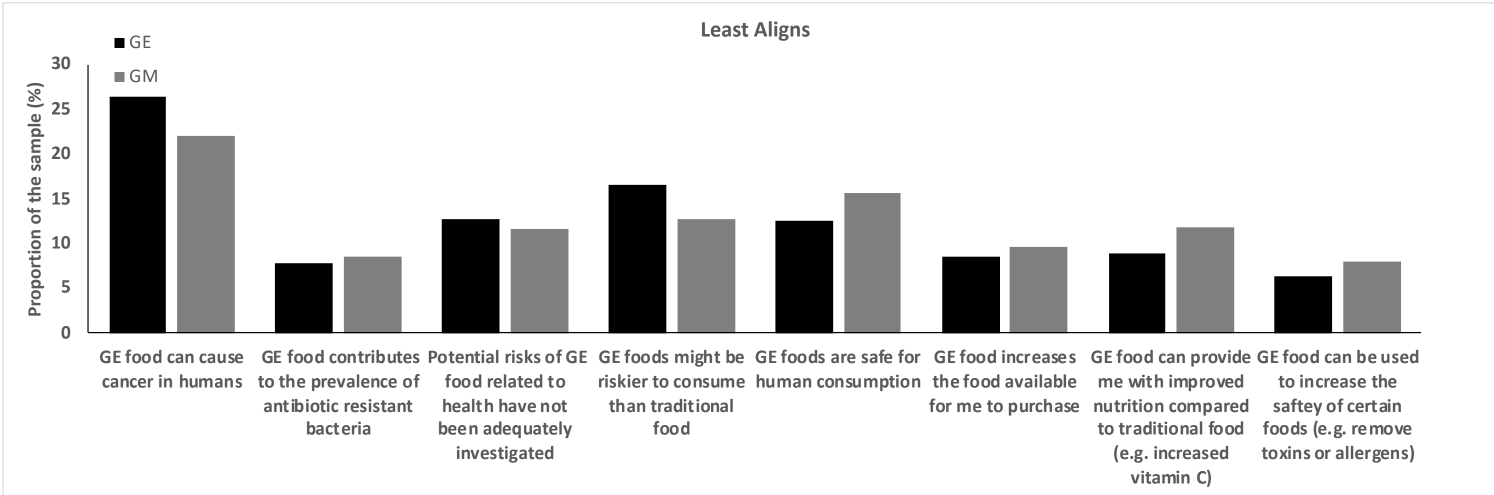

Figure 9: Least Aligns with Views on GE & GM

Appendix B

TRUST IN INSTITUIONS

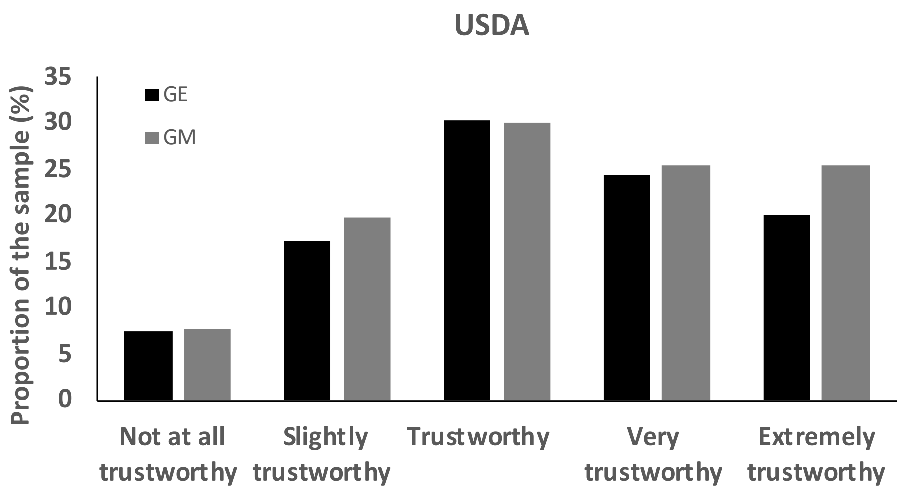

Figure 10: Trustworthiness of a Message about GE & GM by the USDA

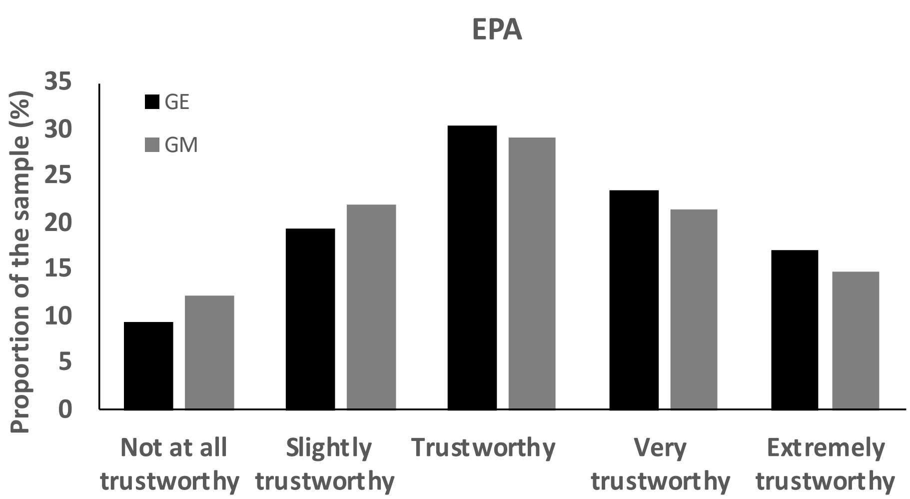

Figure 11: Trustworthiness of a Message about GE & GM by the EPA

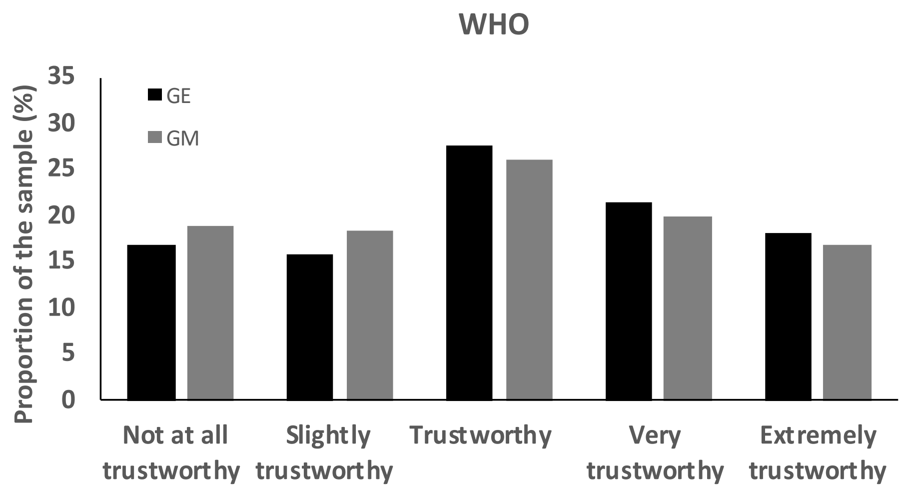

Figure 12: Trustworthiness of a Message about GE & GM by the WHO

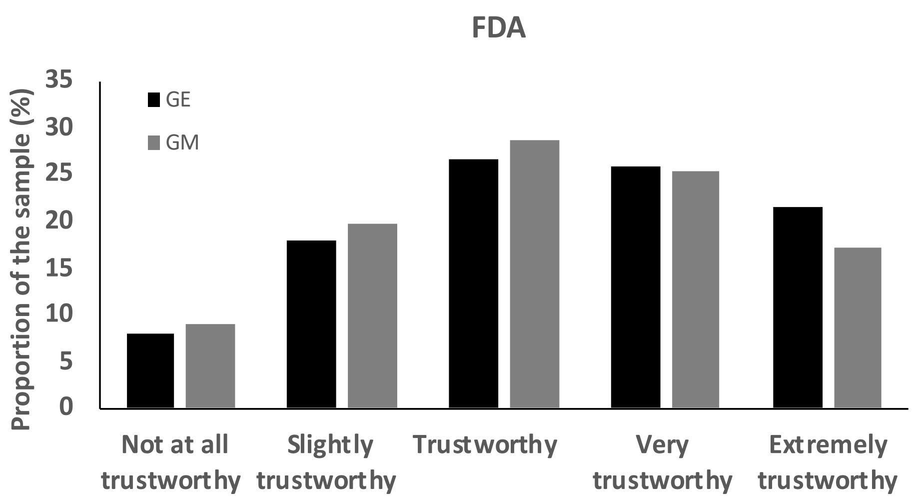

Figure 13: Trustworthiness of a Message about GE & GM by the FDA

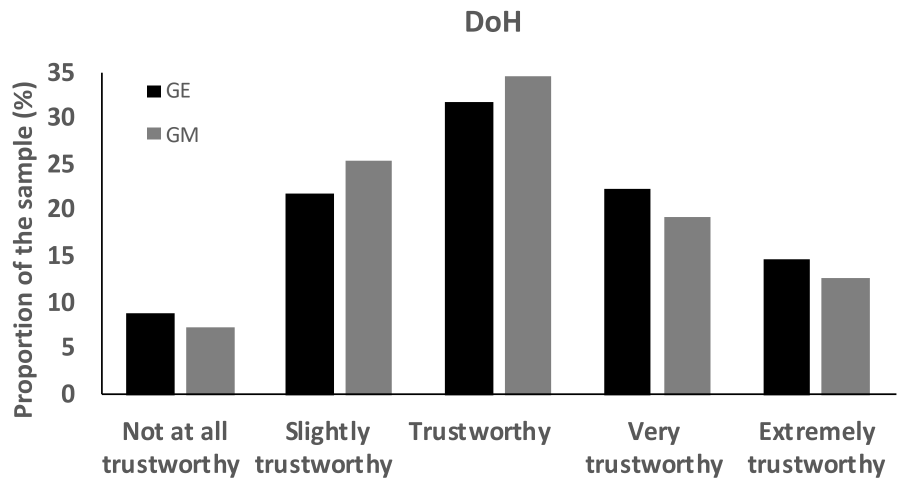

Figure 14: Trustworthiness of a Message about GE & GM by the DoH

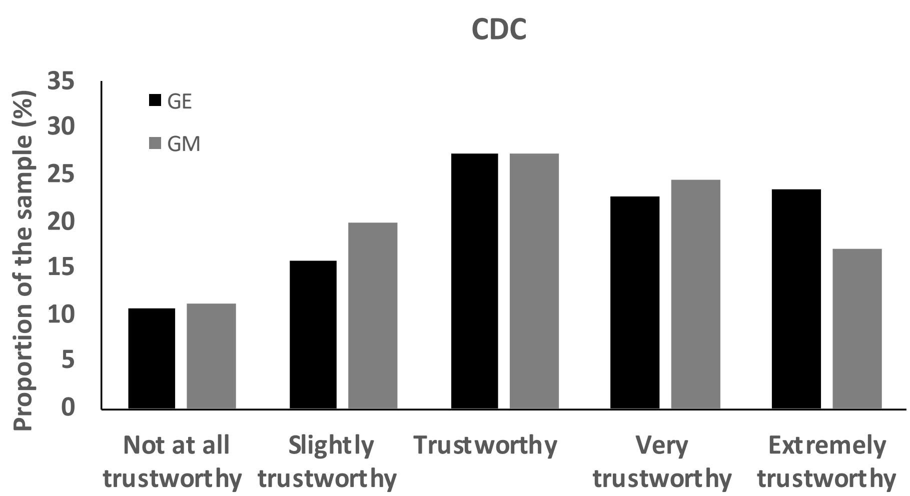

Figure 15: Trustworthiness of a Message about GE & GM by the CDC

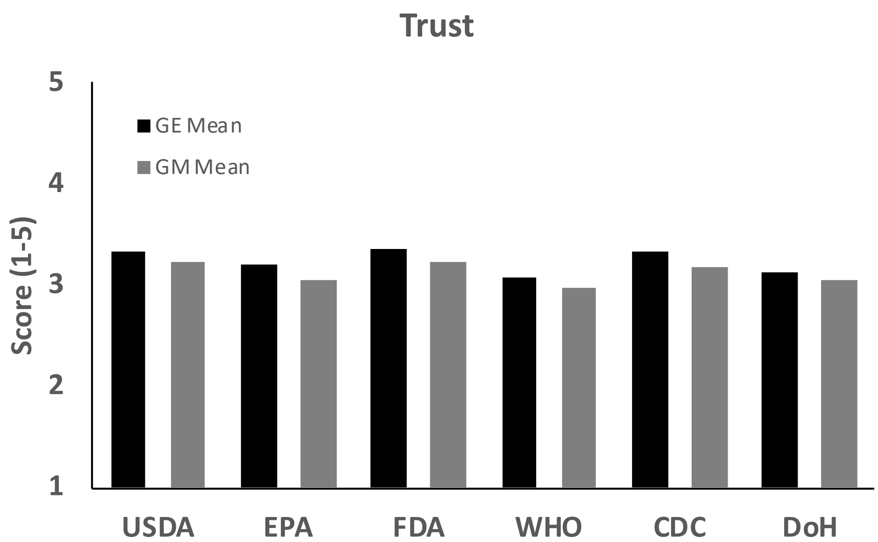

Figure 16: Average Trustworthiness of a Message about GE & GM

Appendix C

LABEL SEEKING BEHAVIOR

Figure 17: Frequency to Look for GM Labels

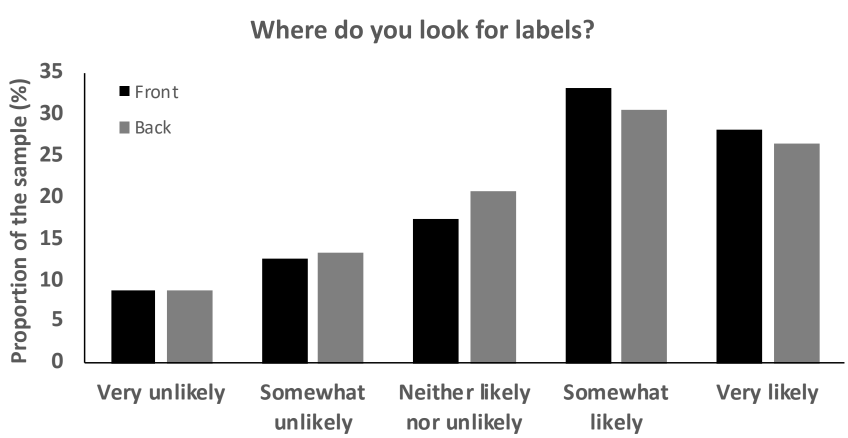

Figure 18: Likelihood to Look at the Front or Back of a Package for Labels

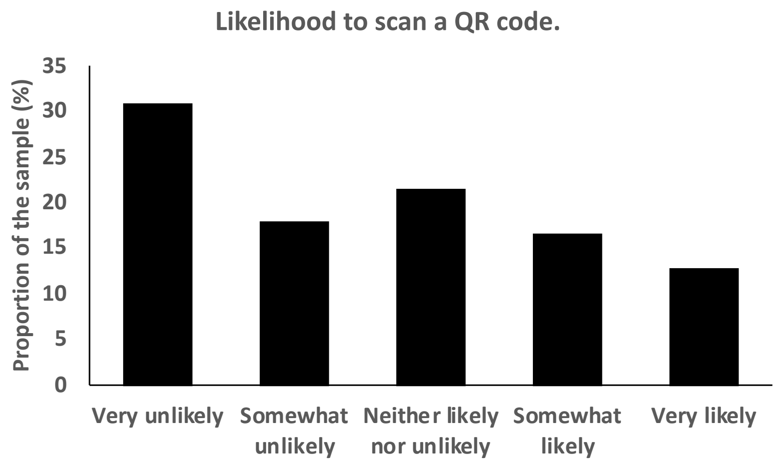

Figure 19: Likelihood to Scan a QR Code on a Food Product for Information

Appendix D

CHOICE EXPERIMENT EXAMPLES

Figure 20: Choice Experiment Example Vegetable Oil Question in Symbol Treatment

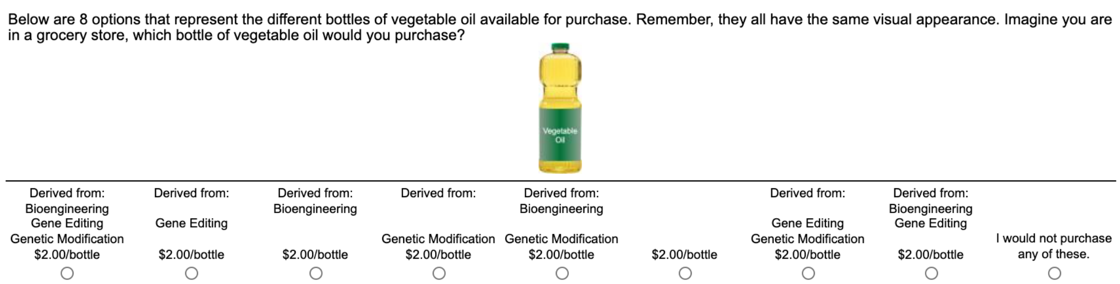

Figure 21: Choice Experiment Example Vegetable Oil Question in Text Treatment

Example of labels used in the choice experiment

Name of Label	Avocado Symbol Treatment	Avocado Text Treatment	Vegetable Oil Symbol Treatment	Vegetable Oil Text Treatment
Image of Food				
Prices	$1, $2, $3 / avocado	$1, $2, $3 / avocado	$2, $4, $6 / bottle	$2, $4, $6 / bottle
No Label				
Bioegnineered		Bioegnineerd		Derived from: Bioegnineering
Gene Edited	Gene Edited	Gene Edited	Derived from: Gene Editing	Derived from: Gene Editing
Geneticallly Modified	Genetically Modified	Genetically Modifed	Derived from: Genetic Modification	Derived from: Genetic Modification
Bioegnineered + Gene Edited	Gene Edited	Bioegnineered Gene Edited	Derived from: Gene Editing	Derived from: Bioegnineering Gene Editing
Bioegnineered + Genetically Modified	Genetically Modified	Bioegnineered Genetically Modified	Derived from: Genetic Modification	Derived from: Bioengineering Gene Editing
Gene Edited + Genetically Modified	Gene Edited Genetically Modified	Gene Edited Genetically Modified	Derived from: Gene Editing Genetic Modification	Derived from: Gene Editing Genetic Modification
Bioegnineerd + Gene Edited + Genetically Modified	Gene Edited Genetically Modified	Bioengineered Gene Edited Genetically Modified	Derived from: Gene Editing Genetic Modification	Derivied from: Bioegnineering Gene Editing Genetic Modifcation
I would not purchase any of these.	I would not purchase any of these.	I would not purchase any of these.	I would not purchase any of these.	I would not purchase any of these.

Figure 22: Example of Labels used in the Choice Experiment

Appendix E

IRB APPROVAL LETTER

Institutional Review Board
210H Hullihen Hall
Newark, DE 19716
Phone: 302-831-2137
Fax: 302-831-2828

DATE:	January 5, 2021
TO:	Brandon McFadden, PhD
FROM:	University of Delaware IRB
STUDY TITLE:	[1351707-4] Determining Antecedents To Consumer Acceptance Of Scientific Information To Develop Educational Approaches On Gene-Editing Technologies
SUBMISSION TYPE:	Amendment/Modification
ACTION:	DETERMINATION OF EXEMPT STATUS
EFFECTIVE DATE:	January 5, 2021
REVIEW CATEGORY:	Exemption category # *(2)*

Thank you for your Amendment/Modification submission to the University of Delaware Institutional Review Board (UD IRB). According to the pertinent regulations, the UD IRB has determined this project is EXEMPT from most federal policy requirements for the protection of human subjects. The privacy of subjects and the confidentiality of participants must be safeguarded as prescribed in the reviewed protocol form.

This exempt determination is valid for the research study as described by the documents in this submission. Proposed revisions to previously approved procedures and documents that may affect this exempt determination must be reviewed and approved by this office prior to initiation. The UD amendment form must be used to request the review of changes that may substantially change the study design or data collected.

Unanticipated problems and serious adverse events involving risk to participants must be reported to this office in a timely fashion according with the UD requirements for reportable events.

A copy of this correspondence will be kept on file by our office. If you have any questions, please contact the UD IRB Office at (302) 831-2137 or via email at hsrb-research@udel.edu. Please include the study title and reference number in all correspondence with this office.

INSTITUTIONAL REVIEW BOARD

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