

# Product Labeling and Consumer Perceptions of Foods Containing Bioengineered Ingredients: Exploratory Research Combining Eye-Tracking and Survey Data

B. Colclasure<sup>1</sup>, J. Spomer<sup>2</sup>, T. Ruth<sup>3</sup>

## Abstract

The National Bioengineered (BE) Food Disclosure Standard went into effect in the United States (U.S) in January 2022, requiring food manufacturers to disclose whether food offered for retail sale contains BE foods. Among several options, disclosures on food packaging can include text disclosure or an approved BE logo. We used eye-tracking instrumentation and digital images of food packages to compare college undergraduates' ( $n = 67$ ) visual attention of a BE text statement with a BE logo. We also used the theory of planned behavior (TPB) and trust in science in the development of a survey to explore students' perceptions toward and intention to purchase and consume BE foods. Findings indicated the over half of participants did not fixate on either the BE logo or text. For those who did, slightly more attention was given to the text. Overall, participants held favorable views toward BE but were neither likely nor unlikely in their intent to purchase BE foods. The TPB variables were significant in a model that can be used to explain nearly 65% of the variance in future intention to purchase and consume BE foods. No significant associations were found between logo or text attention allocation and survey variables.

## Article History



Received: October 9, 2025

Accepted: February 13, 2026

Published: March 13, 2026

## Keywords

cue utilization theory; genetically modified food; Theory of Planned Behavior; SDG-12: Responsible Consumption and Production; National Bioengineered Food Disclosure

- 
1. Blake C. Colclasure, Teaching Associate Professor, The University of Tennessee, 321D Morgan Hall, 2621 Morgan Hall Circle Drive, Knoxville, TN 37996, [bcolclas@utk.edu](mailto:bcolclas@utk.edu),  <https://orcid.org/0000-0002-8375-286X>
  2. Josh Spomer, Doane University Graduate, Doane University, 1014 Boswell Avenue, Crete, NE 68333, [jspomer929@hotmail.com](mailto:jspomer929@hotmail.com).
  3. Taylor K. Ruth, Assistant Professor, The University of Tennessee, 202 Agriculture and Natural Resources Building, 2431 Joe Johnson Dr., Knoxville, TN 37996, [truth3@utk.edu](mailto:truth3@utk.edu),  <https://orcid.org/0000-0002-5269-9154>

## Introduction and Problem Statement

Bioengineering has become more prevalent in agricultural production as societal and environmental impacts drive the need for yield improvements and greater sustainability (Buiatti et al., 2012). According to the Food and Drug Administration [FDA] (2022), a genetically modified crop had its DNA altered to produce a desirable trait. Genetically altered crops can be referred to as Genetically Modified Organisms (GMO), Genetic Engineered (GE) crops, or Bioengineered (BE) crops. Although there are a variety of BE crops containing unique traits (Buiatti et al., 2012), they are most prevalent in the United States as row crops such as corn and soybeans, where genetic alterations produce herbicide-tolerant traits (Bonny, 2015). Despite the United States Department of Agriculture and Agricultural Marketing Service approval of 13 BE crops, and scientific research showing that approved BE foods cause no adverse health impacts (FDA, 2022), an overall public mistrust has led to lack of appeal for BE food products (Hielscher et al., 2016; Ruth & Rumble, 2017). In fact, the public's personal values and moral traditions have been found to be as equally as important as scientific evidence when regarding their perceived safety toward BE food products (Hielscher et al., 2016).

Mandatory compliance of the National BE Food Disclosure Standard went into effect in the U.S. on January 1, 2022. The law requires food manufacturers, importers, and certain retailers to disclose information whether food offered for retail sale contains BE food ingredients (Agricultural Marketing Service, n.d.). The law requires food containing BE ingredients to include an approved logo, a written text description of BE content, web link, or a QR code that provides disclosure of BE food ingredients. The impact of labeling requirements for BE foods is largely unknown and has the potential to disrupt consumer perceptions and acceptance of food technologies in the United States (Caputo et al., 2025) with foreseeable global implications.

## Theoretical and Conceptual Framework

We used the Theory of Planned Behavior (TPB; Ajzen & Fishbein, 1980) to guide our study. The TPB describes that human behavior is heavily influenced by behavioral intention, which is determined by an individual's attitude toward the behavior, their normative belief or how they perceive others to view the behavior, and their belief in their own ability to complete the behavior (Ajzen, 1991). Ajzen (2016) applied his TPB to consumer economics, particularly in agricultural economics to illustrate that TPB variables can effectively be used to examine consumer intention and decision making to purchase food products; other researchers have also used the TPB to examine consumers' food intentions (Holt, 2014; Lorenz et al., 2015; Rainbolt et al., 2012)

In addition to the TPB, we applied cue utilization theory (Easterbrook, 1959) to our study. Cue utilization theory can be used to emphasize the role of cues or information signals (e.g., ingredients, packaging, brand) that consumers utilize to evaluate product quality and to make purchasing decisions (Guo et al., 2026; Zhang et al., 2026). Food label designs and consumers' familiarity with labels have been shown to influence consumers' intention to purchase food

products (Zafar et al., 2022). The labeling and packaging of purchasable goods should promote a positive image of the product and help to inspire consumers to purchase the product. The placement of imagery, label attractiveness, and text can affect how consumers interpret the information being presented on the label (Oaya et al., 2017). Food labeling with reference to genetically modified content has been found to increase consumers' risk perception and decrease purchase intention compared to no-label conditions (Hellier et al., 2012). Further, the number of new food products with GMO-free labels has continued to grow (Ryan et al., 2024), indicating the continuation of some consumer mistrust and avoidance of BE foods.

Critics of the new BE disclosure standard have expressed concerns that the mandatory disclosure of BE foods could catalyze consumer confusion or misinformation regarding BE foods (Grego, 2018). For example, although disclosure mandates may be designed to inform consumers, they may lead consumers to make incorrect inferences regarding the harmfulness of the product (Bar-Gill et al., 2019; Hellier et al., 2012). As misinformation on the safety, nutritional value, and environmental impact of BE foods are already wide spread, particularly in online settings (Woodside, 2024), additional misinformation stemming from required labeling of these products may further lower public trust in science within agri-food systems (Chowdhury et al., 2023). Additionally, Caputo et al. (2025) posited the new BE disclosure law has the potential to impact consumers' willingness to pay for food products. However, contradicting this notion, Kolodinsky and Lusk (2018) estimated that mandated labeling of GE foods could reduce opposition to GE foods. Tims (2021) found that college students held a positive attitude toward GMO foods and the mandated BE label, indicating younger generations may be more receptive of BE labeling. Furthermore, Caputo et al. (2025) identified that out of BE disclosure options available to producers, consumers preferred the BE logo.

Demographics such as gender and age can influence perceptions toward BE foods. Ruth et al. (2019) found that males and individuals of younger generations held more positive attitudes toward GM science. Additionally, trust in science and scientists have been found to be positively associated with attitudes and acceptance of bioengineering (Ari et al., 2021; Marques et al., 2015; Scanlon, 2019).

Food producers who opt to utilize the BE logo or BE text on food packages could be providing consumers with visual cues that could impact purchasing decisions. Consumers' allocation to these cues might be dependent on their existing characteristics and beliefs. In this study we explored consumers' attention allocation of BE logos and BE texts on food packages along with their perceptions toward BE food consumption (i.e., attitude, subjective normative belief, perceived behavioral control, purchasing intention), demographics (i.e., gender) and beliefs (i.e., trust in science).

## Purpose

The U.S. National BE Food Disclosure Standard was passed into law in July 2016 and was mandated on January 1, 2022. The law requires disclosure of BE foods when used in food

products, including disclosure options of an approved BE logo or written text description of BE content on food packages. However, uncertainty exists on the impact of BE disclosure using these options. Food manufacturers, packaging designers, and agricultural communicators will need to understand the potential influences of these various labels on consumers' purchasing intent and behaviors as they make food labeling decisions. Therefore, we sought to explore if consumers devote attention to the BE logo/text and if their attention allocation is associated with their perceptions toward BE food products, trust in science, and personal characteristics. The objectives of this study were:

1. Compare visual attention between a BE logo and a BE text box on food labels of a product containing BE ingredients.
2. Determine consumers' trust in science and perceptions of BE food products.
3. Determine if gender, trust in science, and TPB variables can be used to predict consumers' intent to purchase BE food products.
4. Identify associations between variables of interest and visual attention of BE package labeling.

## Methods

Eye-tracking technologies that collect data on consumers' visual attention patterns have been previously used in agricultural education and communications to investigate viewers' attention toward advertisements, brand placements, and buying decisions (Leggette et al., 2018; Stanton & Fischer, 2020). In this study, during the Spring of 2023, we conducted quasi-experimental research using eye-tracking equipment and survey data with undergraduate students at Doane University, a small, predominately undergraduate university located in Nebraska. Due to the interactive and intensive nature of eye-tracking research, participant recruitment can be challenging. Prior eye-tracking research has used between 45 and 95 participants (Greussing et al., 2020; Hill et al., 2021), and therefore we sought a minimum of 45 participants using open recruitment.

### Research Design

A research lab and computer with Tobii eye-tracking was used to collect participant attention data for BE disclosures on food packages. Two digital food packages were designed using Adobe software. One food package contained the FDA-approved BE logo and the other contained approved language for BE text. The BE disclosures were placed identically on the bottom right-hand side of the food packages. Several additional digital food packages were designed to serve as distractor packages.

Each participant's gaze was first calibrated to the eye-tracking equipment (Stanton & Fischer, 2020). Next, each participant was shown six food packages on the computer screen in the order of one of two pre-determined, one minute, sequences. In each sequence, two of the packages included either the BE logo or BE text and four packages served as control conditions and distractors. Although web links or QR codes could be used on food packages to disclose BE content, we opted to not include these options in our study as they would require additional

consumer interaction beyond initial visual observation. An Area of Interest (AOI) of the same size was created using the Tobii software and placed over the BE logo and BE text. The AOIs allowed for the collection of data on the number of fixations and total gaze time each participant allocated toward the BE disclosures. Figure 1 illustrates example images shown on the computer screen with the eye-tracking apparatus. Participants were randomly assigned image sequencing as noted under Figure 1.

**Figure 1**

*Eye-Tracking Screens and Sequencing Shown to Research Participants.*

**A. Eye-Tracking Calibration Screen**



**C. Packaging with BE Text**



**B. Distractor Packaging Example**



**D. Packaging with BE Logo**



*Note.* Participants were randomly assigned one of the two sequences, A,B,C,B,B,D,B or A,B,D,B,B,C,B, such that first exposure to either the packing with BE logo or text was equal.

## Survey

Directly following eye-tracking procedures, participants completed a survey administered on Qualtrics. Existing scales used to measure variables found within the TBP (Rogers-Randolph et al., 2021; Ruth et al., 2019) were modified and applied to BE foods. Attitudes toward BE foods were measured by an eight item, five point bipolar semantic differential scale. Subjective normative beliefs were assessed through a five item, five point Likert scale. A similar five item, five point scale was used to measure perceived behavioral control. Future intention to purchase and consume BE foods was measured by a four item, five point Likert scale. Trust in science was measured through an adapted seven item, five point Likert scale (National Science Board, 2018; Rumble et al., 2020). Internal post-hoc reliability was found for all scales:  $\alpha = .913; .842; .701; .691; .815$  (Field, 2013). Demographic variables collected were year in school, gender, and race/ethnicity. The survey was reviewed by a panel of experts, and a pilot test was conducted

to ensure effective instrumentation of the eye-tracking equipment and content validity of the survey (Kerlinger, 1986).

### Data Analysis

Tobii software was used to measure each participant's number of fixations and gaze time within the AOI for each BE food package. Frequencies and gaze time, along with a heat map for average visual observations of the total package, were used to assess Objective 1. Descriptive statistics in the form of means and standard deviations were used to answer Objective 2. A multiple linear regression was used for Objective 3, and point-biserial correlations were used for Objective 4.

## Findings

A total of 67 participants were recruited and participated in April of 2023, exceeding our 45-participant benchmark. The completion rate was 100%. Most participants were male ( $n = 38$ , 56.7%) and White ( $n = 55$ , 82.1%). Ten participants (14.6%) identified as being of Spanish, Hispanic, or Latino ethnicity. Students majored in subjects across the university and were from diverse academic standings (Freshman:  $n = 21$ , 31.3%; Senior:  $n = 18$ ; 26.9%; Junior:  $n = 15$ ; 22.4%; Sophomore:  $n = 12$ ; 17.9%).

### O1: Compare Visual Attention between a BE Logo and a BE Text Box on Food Labels of a Product Containing BE Ingredients.

Data on respondents' fixations and total gaze time within the AOIs for the BE logo/text were compared. The number of fixations ranged from zero to six times per participant. Most respondents did not fixate on either the BE logo ( $n = 45$ , 67.2%) or BE text ( $n = 36$ , 53.7%). Table 1 illustrates the frequency of visual attention based on fixations per participant.

**Table 1**  
*Participant ( $n = 67$ ) Visual Attention Based on Fixations*

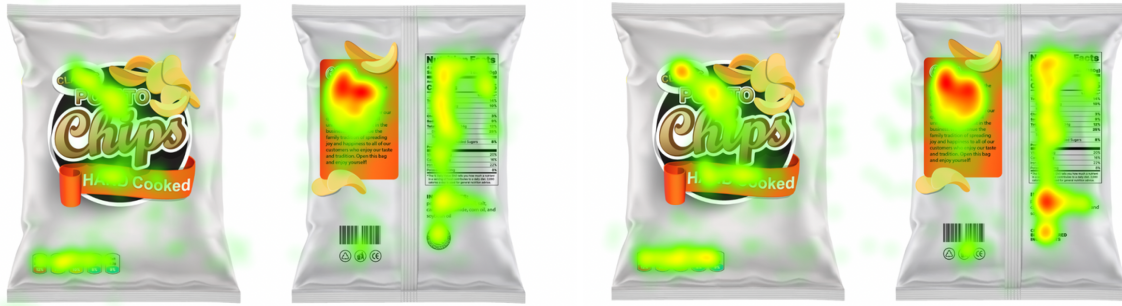
<i>Fixations per Participant</i>	<i>BE Logo</i>		<i>BE Text</i>	
	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>
0	45	67.2	36	53.7
1	7	10.4	13	19.4
2	4	6	8	11.9
3	7	10.4	3	4.5
4	3	4.5	7	10.4
5	0	0	0	0
6	1	1.5	0	0

For those who did view AOIs, the average attention allocation in milliseconds was 830.7 ( $SD = 575.3$ ) for the BE logo and 873.1 ( $SD = 534.3$ ) for the BE text. A heat map, as can be seen in Figure 2, was produced to visually compare attention allocation of the BE logo and BE text and other components of the product label. As can be seen, slightly more attention was given by

participants to the BE text as opposed to the BE logo, both positioned identically at the bottom right-hand corner on the backside of the chip packaging.

### Figure 2

Heat Map Comparing Participants' ( $n = 67$ ) Attention of BE Logo and BE Text



## O2: Determine Consumers' Trust in Science and Perceptions of BE Food Products

### Trust in science

Participants' trust in science was measured by a seven item, five point Likert scale. A high trust in science was observed, overall, as indicated by a grand mean of 4.32 ( $SD = 0.48$ ) out of 5.00. The item with the largest extent of agreement was "Scientific research is essential for improving the quality of human lives," with 93% ( $n = 62$ ) of respondents agreeing or strongly agreeing with this statement. Similarly, 90% ( $n = 60$ ) of respondents agreed or strongly agreed with the statement, "New technology used in medicine allows people to live better lives." The item with the lowest extent of agreement, but still with a high majority (87%;  $n = 58$ ) of participants indicating they agree or strongly agree, was, "Overall, modern science does more harm than good."

### Perceptions of BE food products

Scales related to the TPB variables were modified to measure participants' perceptions (attitudes, subjective normative beliefs, behavioral control, future intention) toward purchasing and consuming BE food products.

### Attitudes

A five point, eight item, bipolar semantic differential scale was used to measure participants' overall attitude toward food products containing BE ingredients. Each adjective pair contained a negatively framed and positively framed adjective (e.g. *Negative/Positive*) with five points between them. Negatively framed adjectives were scored as one and positive adjectives were scored as five. Several adjectives were reversed framed and coded to improve reliability.

The reported grand scale mean for attitudes was 3.63 ( $SD = 0.79$ ) out of 5.00, which can be interpreted that respondents held slightly positive attitudes, overall. The adjective pair with the lowest positive response was *Not Essential/Essential*, with a reported mean of 3.25 ( $SD = 0.93$ ),

followed by Unnecessary/Necessary ( $M = 3.60$ ,  $SD = 1.03$ ). The adjective pair with the highest positive response was *Not Acceptable/Acceptable*, with a reported mean of 3.99 ( $SD = 1.01$ ). The second most positive adjective pair was *Not Beneficial/Beneficial* ( $M = 3.81$ ,  $SD = 1.00$ ).

### ***Subjective Normative Beliefs***

Participants' perception toward how others feel about purchasing and consuming BE food products was measured through a five item, five point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). Respondents reported slightly positive normative beliefs, on average, as indicated by a grand scale mean of 3.67 ( $SD = 0.75$ ). The item with the highest extent of agreement was, "Most people who are similar to me purchase and consume food products containing bioengineered food ingredients," with 66% ( $n = 44$ ) of respondents agreeing or strongly agreeing to the statement. The item with the least positive normative belief was the reverse coded item, "It is expected that I avoid purchasing and consuming food products containing bioengineered food ingredients," however, 64% ( $n = 43$ ) of respondents still strongly disagreed or disagreed with this statement.

### ***Perceived Behavioral Control***

Respondents' belief in their own ability to purchase or not purchase food products containing BE foods was measured by a four item, five point Likert scale. Overall, respondents neither agreed nor disagreed in their own ability to purchase food products containing or not containing BE food ingredients ( $M = 3.40$ ;  $SD = 0.71$ ). Less than half of respondents ( $n = 32$ ; 48%) agreed or strongly agreed with the statement, "I am confident that I could avoid purchasing and consuming food products containing bioengineered ingredients." These results indicated that participants' may have believed that some food products contain BE food ingredients, and they are unable to distinguish these products from non-BE foods in their everyday food purchases and consumption.

### ***Future Intention***

Respondents' future intention to purchase and consume BE food products was measured by a four item, five point Likert scale. Overall, respondents reported being slightly more likely than unlikely, on average, in their future intention to purchase and consume BE foods. The grand mean for this scale was the lowest of all scales used in this study and was found to be 3.19 out of 5.00 ( $SD = 0.66$ ). Interestingly, nearly half ( $n = 33$ ; 49%) of respondents neither agreed or disagreed with the statement, "I intend to purchase and consume food products containing bioengineered ingredients." Furthermore, only 34% of respondents ( $n = 23$ ) agreed or strongly agreed with the statement, "I plan to purchase and consume food products containing bioengineered ingredients."

### **O3: Determine if Gender, Trust in Science, and TPB Variables can be used to Predict Consumers' Intent to Purchase BE Food Products.**

A regression analysis was used to answer Objective 3. Before running the regression, all variables were checked for normality and multicollinearity. All variables fell within the acceptable range (+/- 2) for skewness and kurtosis indicating normality (George & Mallery, 2010). The threat for multicollinearity was addressed by checking the tolerance and variable

inflation factor (VIF) for variables. All variables had a tolerance above .1 (.62–.99) and a VIF below 10 (1.00–1.62), illustrating no threat to multicollinearity (Miles, 2005).

Our regression analysis yielded a model that could be used to explain 64.8% (Adj.  $R^2 = .648$ ) of the variance in future intention to purchase and consume food products with BE ingredients, which is a large effect size (Cohen, 1988). The F-test showed the model as statistically significant  $F(5, 61) = 22.49, p < .01$ . While trust in science and gender were not significant predictors in the model, the three variables in the TPB were significant. Participants' attitudes toward BE food products was a significant variable in the model ( $\beta = .555, p < .001$ ), such that more positive attitudes predicted a higher intention to purchase and consume food products with BE food ingredients. Similarly, subjective normative beliefs was also a significant variable ( $\beta = .304, p < .01$ ), such that more positive normative beliefs toward BE food products increased likelihood to purchase and consume BE foods. Lastly, perceived behavioral control was a significant variable in our model. Interestingly, our findings demonstrated that as participants perceived to have more control on whether they could purchase and consume BE food products, their future intention was lower ( $\beta = -.345, p < .001$ ). This could be explained in terms of participants' belief to whether they could differentiate food products containing BE ingredients from those not containing BE ingredients. Participants who believed they had more control (e.g., in their choice to purchase and consume) had lower intention to purchase BE products.

**Table 2**

*Multiple Linear Regression for Intent to Purchase and Consume Food Products Containing BE Food Ingredients*

<i>Predictor Variables</i>	<i>B (coefficient)</i>	<i>SE<sub>B</sub></i>	<i>β</i>	<i>t</i>	<i>p</i>
Constant	1.234	.572		2.156	.035
Trust in Science	.077	.122	.056	.632	.529
Gender	.052	.101	.039	.517	.607
<i>TPB Variables</i>					
Attitude	.468	.081	.555	5.749	<.001*
Subjective Norm	.270	.074	.304	3.642	.001*
Perceived Behavioral Control	-.323	.074	-.345	-4.364	<.001*

#### **O4: Identify Associations between Variables of Interest and Visual Attention of BE Package Labeling.**

Point-Biserial correlations were used to determine associations between attention allocation of BE logo/text and trust in science, gender, and TPB variables. The measure of attention allocation was one or more fixations (1) or no fixation (0). As presented in Table 3, no significant associations were found between BE logo attention allocation and measured variables nor BE text attention allocation and measured variables.

**Table 3***Associations Between BE Disclosure Through Logo or Text and Variables of Interest*

Variable	BE Logo		BE Text	
	$R^2$	$p$	$R^2$	$p$
Gender	.095	.445	-.156	.207
Trust in Science	-.069	.580	-.183	.139
<i>TPB Variables</i>				
Attitude	.083	.504	.042	.738
Subjective Norm	.050	.690	.076	.540
Perceived Behavioral Control	-.088	.478	.095	.443
Future Intention	.144	.246	-.012	.923

## Conclusions, Discussion, and Recommendations

The findings from this exploratory research demonstrated that consumers' visual attention allocation of BE information on food packaging, regardless of whether the information is presented as a logo or text, is considerably low when considering the whole food package. In fact, less than half of our participants gave visual attention to either the BE logo or text when given 10 seconds to observe the front and back of a food package. Slightly more attention was given to the BE text over the BE logo as illustrated by the number of fixations, average attention allocation in milliseconds, and generated heat map. The lack of visual attention given to BE information on packaging could demonstrate that our participants were largely not information seekers when looking at food packaging (Caputo et al., 2025). It is important to note that participants were not told the eye-tracking study was specifically on BE foods and were only prompted to look at the food packages like how they would in a grocery market, thus more closely mimicking real-life behavior and avoiding inflation of BE attention allocation.

The participants of our study, being undergraduate college students, had considerably high trust in science. When considering perceptions toward BE foods, our participants held positive attitudes and positive subjective normative beliefs toward the purchasing and consumption of food products containing BE ingredients, despite some moderate variability observed. These findings corroborate similar research that has reported on college students' views toward genetically altered food products (Ruth et al., 2016; Tims, 2021). Our findings were theory informing and supported Ajzen (2016), who described that the TPB variables can be used in consumer economics to model food purchasing decisions. Our findings indicated that TPB variables (attitudes, subjective normative beliefs, perceived behavioral control) were significant in the prediction of consumers' intention to purchase and consume food products containing BE ingredients. We found that as attitudes and normative beliefs increased, so did intention.

An unexpected finding was that as participants had more perceived behavioral control on whether they could purchase and consume BE foods or avoid them, their purchasing and consumption intention was reduced. In other terms, when belief of control was empowered, they would choose BE alternatives. This reversal effect of perceived behavioral control is similar

to the findings from choice experiments where consumers favored non-BE products over BE products when provided BE disclosures through labeling (Caputo et al., 2025; Hellier et al., 2012). The labeling of BE foods provides consumers with more autonomy to select or not select BE food products. Consumer autonomy is likely encouraged when packaging includes the BE logo or BE text to disclose BE ingredients, as opposed to a QR code or weblink which requires additional consumer action to identify if BE foods are present. In our study, visual attention to either the BE logo or BE text was low and not associated with participants' perspectives toward BE foods or trust in science. However, using the BE logo or text on food products may dissuade purchasing if consumers become information seekers toward BE information due to scientific misinformation (Bar-Gill et al., 2019), heightened perceived risk (Hellier et al., 2012), knowledge of mandatory disclosure, and/or value conflicts (Hielscher et al., 2016).

Our findings yielded no significant associations between individual characteristics or perceptions of BE foods and attention allocation of BE logo or text information on food packaging. However, we acknowledge that a significant limitation to our study is that we utilized a small sample of college students through open recruitment, and therefore our findings are not generalizable. However, this study's findings still provide practitioners with useful insight into how this mandatory labeling might impact product sales in the future. Food manufacturers and product packaging designers likely do not need to invest a lot of energy debating between the inclusion of the text-only label versus the BE logo as little visual attention was given to either of these labels. The BE text did yield slightly more attention compared to the logo though, which is likely due to respondents reading text versus glancing over a logo they may not have been familiar with. If food manufacturers are targeting a group of consumers who are not high information seekers, the inclusion of the BE text would likely make it more clear to consumers the BE ingredients were included in the product compared to the use of the logo. None-the-less, although mandatory labeling and disclosure of BE foods provides consumers with more autonomy, it may increase misinformation and lower trust in science within agri-food systems (Bar-Gill et al., 2019; Chowdhury et al., 2023). To influence positive purchasing intent of BE products, manufacturers will need to partner with agricultural communicators and marketers. Specifically, they should work together to develop outreach and communication campaigns that aim to improve both attitudes and perceptions of normative beliefs related to BE food.

While college students provided us an easily accessible group of participants for this exploratory eye-tracking study, other groups, such as primary household shoppers should be recruited in larger studies to fully examine the impact of BE disclosures on food packages. This is particularly important as other groups, including the public, have been reported to have an overall mistrust toward genetically altered food products (Hielscher et al., 2016; Ruth & Rumble, 2017). Future eye-tracking research could also include participants who are information seekers (Caputo et al., 2025), in addition to using variations in BE logo/text size and placement. Consumers' exposure time to food packages likely vary in real-world settings. Future research could integrate eye-tracking glasses and in-store shopping environments to provide more realistic purchasing scenarios than what can be provided with on-screen pictures and stationary eye-tracking equipment.

Lastly, as acceptance of BE foods continues to evolve in multidirectional ways around the world (Delwaide et al., 2015; Woźniak-Gientka et al., 2022), the implications of government-mandated food disclosure laws should continue to be examined at globally specific areas. In particular, mandated logos or text on food packaging may influence consumer acceptance of food technologies which can have implications on agricultural development, production, trade, and supply chain.

## Acknowledgments

**Funding Information:** No external funding was received.

**Conflict of Interest:** There are no conflicts of interest.

**Previous Dissemination:** This scholarship has been presented at the Association for International Agricultural and Extension Education 2024 Conference.

**Artificial Intelligence:** Artificial intelligence tools were not used in this scholarship.

**Author Contribution Statement:** **B. Colclasure** – conceptualization, methodology, software, validation, formal analysis, writing – original draft, writing – review & editing, visualization, supervision; **J. Spomer** – conceptualization, methodology, software, formal analysis, investigation, writing – original draft, project administration; **T. Ruth** – conceptualization, methodology, validation, resources, writing – review & editing, visualization.

## References

- Agricultural Marketing Service. (n.d.). *BE disclosure*. USDA. <https://www.ams.usda.gov/rules-regulations/be>
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Ajzen, I. (2016). Consumer attitudes and behavior: The theory of planned behavior applied to food consumption decisions. *Italian Review of Agricultural Economics*, 70(2), 121–138. <https://doi.org/10.13128/REA-18003>
- Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Prentice-Hall.
- Ari, E., Yilmaz, V., & Olgun, M. (2021). The effect of trust benefit and risk perception of GM foods on behavior intention: A study on university students. *Journal of Economy Culture and Society*, 64, 297–312. <https://doi.org/10.26650/JECS2021-930755>

- Bar-Gill, O., Schkade, D., & Sunstein, C. R. (2019). Drawing false inferences from mandated disclosures. *Behavioural Public Policy*, 3(2), 209–227. <https://doi.org/10.1017/bpp.2017.12>
- Bonny, S. (2015). Genetically modified herbicide-tolerant crops, weeds, and herbicides: Overview and impact. *Environmental Management*, 57(1), 31–48. <https://doi.org/10.1007/s00267-015-0589-7>
- Buiatti, M., Christou, P., & Pastore, G. (2012). The application of GMOs in agriculture and in food production for a better nutrition: Two different scientific points of view. *Genes & Nutrition*, 8(3), 255–270. <https://doi.org/10.1007/s12263-012-0316-4>
- Caputo, V., Kilders, V., & Lusk, J. L. (2025). The effect of the National Bioengineered Food Disclosure Standard (NBFDS) on consumer preferences and acceptance of bioengineered and gene-edited food. *Food Policy*, 130, 102770. <https://doi.org/10.1016/j.foodpol.2024.102770>
- Chowdhury, A., Kabir, K. H., Abdulai, A., & Alam, M. (2023). Systematic review of misinformation in social and online media for the development of an analytical framework for agri-food sector. *Sustainability*, 15(6), 4753. <https://doi.org/10.3390/su15064753>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum.
- Delwaide, A. C., Nalley, L. L., Dixon, B. L., Danforth, D. M., Nayga, R. M., Van Loo, E. J., & Verbeke, W. (2015). Revisiting GMOs: Are there differences in European consumers' acceptance and valuation for cisgenically vs. transgenically bred rice? *PLoS ONE*, 10, e0126060. <https://doi.org/10.1371/journal.pone.0126060>
- Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, 66(3), 183–201. <https://doi.org/10.1037/h0047707>
- Field, A. (2013). *Discovering statistics using IBM SPSS* (4th ed.). Sage Publications.
- Food and Drug Administration. (2022, July). *GMOs and your health*. <https://www.fda.gov/media/135280/download>
- George, D., & Mallery, M. (2010). *Using SPSS for Windows step by step: A simple guide and reference*. Allyn & Bacon.
- Grego, C. (2018). The gm food debate: An evaluation of the national bioengineered food disclosure standard and recommendations for the United States based on food justice. *Seattle University Law Review*, 41(3), 1003–1034. <https://digitalcommons.law.seattleu.edu/sulr/vol41/iss3/6/>

- Greussing, E., Kessler, S. H., & Boomgaarden, H. G. (2020). Learning from science news via interactive and animated data visualizations: An investigation combining eye tracking, online survey, and cued retrospective reporting. *Science Communication*, 42(6), 803–828. <https://doi.org/10.1177/1075547020962100>
- Guo, Z., Mustafa, M., & Ning, Y. (2026). Color and shape matter: How visual design features of front-of-package warning labels influence attractiveness perception, healthfulness perception and purchase intention. *Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity*, 31, Article 14. <https://doi.org/10.1007/s40519-026-01812-0>
- Hellier, E., Tucker, M., Newbold, L., Edworthy, J., Griffin, J., & Coulson, N. (2012). The effects of labeling design characteristics on perceptions of genetically modified food. *Journal of Risk Research*, 15(5), 533–545. <https://doi.org/10.1080/13669877.2011.646288>
- Hielscher, S., Pies, I., Valentinov, V., & Chatalova, L. (2016). Rationalizing the GMO debate: The ordonomic approach to addressing agricultural myths. *International Journal of Environmental Research and Public Health*, 13(5), 476. <https://doi.org/10.3390/ijerph13050476>
- Hill, N., Elliot, M., & Meyers, C. (2021). Navigating transparent pork production: Analyzing visual attention of the Maschhoffs website. *Journal of Applied Communications*, 105(1). <https://doi.org/10.4148/1051-0834.2352>
- Holt, J. A. (2014). *The effect of media channels on consumers' intentions to buy local food: An exploration of the theory of planned behavior and media channel perceptions* (Publication No. 3716876). [Doctoral dissertation, The University of Florida]. University of Florida ProQuest Dissertations & Theses.
- Kerlinger, F. N. (1986). *Foundations of behavior research* (3rd ed.). Holt, Rinehart, and Winston.
- Kolodinsky, J., & Lusk, J. L. (2018). Mandatory labels can improve attitudes toward genetically engineered food. *Science Advancements*, 4(6). <https://doi.org/10.1126/sciadv.aag1413>
- Leggette, H. R., Rice, A. H., Carraway, C., Baker, M. A., & Conner, N. (2018). Applying eye-tracking research in education and communication to agricultural education and communication: A review of literature. *Journal of Agricultural Education*, 59(2), 79–108. <https://doi.org/10.5032/jae.2018.02079>
- Lorenz, B. A., Hartmann, M., & Simmons, J. (2015). Impacts from region-of-origin labeling on consumer product perception and purchasing intention—causal relationships in a TPB based model. *Food Quality and Preference*, 45, 149–157. <https://doi.org/10.1016/j.foodqual.2015.06.002>
- Marques, M. D., Critchley, C. R., & Walshe, J. (2015). Attitudes to genetically modified food over time. How trust in organizations and th emedia cycle predict support. *Public Understanding of Science*, 24(5), 601–618. <https://doi.org/10.1177/0963662514542372>

- Miles, J. (2005). Tolerance and variance inflation factor. In B. Everitt & D. Howell (Eds.), *Encyclopedia of statistics and behavioral science*. Wiley.  
<https://doi.org/10.1002/0470013192.bsa683>
- National Science Board. (2018). *Science and technology: Public attitudes and understanding*. NSF. <https://www.nsf.gov/statistics/2018/nsb20181/>
- Oaya, C. Z. T., Newman, O., & Ezie, O. (2017). Impact of packaging on consumer buying behavior in Nasarawa State. *International Journal of Sciences: Basic and Applied Research*, 36(4), 28–46. <https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/view/8083>
- Rainbolt, G. N., Onozaka, Y., & McFadden, D. T. (2012). Consumer motivations and buying behavior: The case of the local food system movement. *Journal of Food Products Marketing*, 18(5), 385–396. <https://doi.org/10.1080/10454446.2012.685031>
- Rogers-Randolph, T., Lundy, L. K., Telg, R. W., Rumble, J. N., Myers, B., & Lindsey, A. B. (2021). To post or not to post? Factors influencing state FFA officers' social media behaviors. *Journal of Applied Communications*, 105(1), Article 5. <https://doi.org/10.4148/1051-0834.2362>
- Rumble, J. N., Wu, Y.-L., Tully, K., Ruth, T. K., Ellis, J. D., & Lamm, A. J. (2020). A mixed-methods comparison of self-reported and conversational trust in science. *Journal of Applied Communications*, 104(4), Article 2. <https://doi.org/10.4148/1051-0834.2371>
- Ruth, T., Rumble, J., Gay, K., & Rodriguez, M. (2016). The importance of source: A mixed methods analysis of undergraduate students' attitudes toward genetically modified food. *Journal of Agricultural Education*, 57(3), 145–161.  
<https://doi.org/10.5032/jae.2016.03145>
- Ruth, T. K., & Rumble, J. N. (2017). What's in a name? the influence of persuasive communication on Florida consumers' attitude toward genetically modified food. *Journal of Applied Communications*, 101(2), Article 7. <https://doi.org/10.4148/1051-0834.1006>
- Ruth, T. K., Rumble, J. N., Lamm, A. J., Irani, T., & Ellis, J. D. (2019). Are American's attitudes toward GM science really negative? An academic examination of attitudes and willingness to expose attitudes. *Science Communication*, 41(1), 113–131.  
<https://doi.org/10.1177/1075547018819935>
- Ryan, C. D., Henggeler, E., Gilbert, S., Schaul, A. J., & Swarthout, J. T. (2024). Exploring the GMO narrative through labeling: Strategies, products, and politics. *GM Crops & Foods*, 15(1), 51–61. <https://doi.org/10.1080/21645698.2024.2318027>
- Scanlon, M. A. (2019). *Trust in science and attitudes regarding genetically modified organisms in U.S. adults*. [Doctoral dissertation, Barry University, Barry University], ProQuest Dissertations & Theses.

- Stanton, C., & Fischer, L. (2020). Let's focus in: A guide to eye tracking technology in agricultural communications research. *Journal of Applied Communications*, 104(2), Article 11. <https://doi.org/10.4148/1051-0834.2320>
- Tims, K. (2021). *Scientific knowledge shaping perceptions of bioengineered food among undergraduate students*. [Master's thesis, The University of Maine], DigitalCommons@UMaine.
- United States Department of Agriculture. (n.d.). *List of bioengineered foods*. Agricultural Marketing Service. <https://www.ams.usda.gov/rules-regulations/be/bioengineered-foods-list>
- Woodside, J. (2024). Misinformation in U.S. food and agriculture: A policy analysis of impacts and recommended solutions. *Journal of Food Law and Policy*, 20(1), Article 4. <https://doi.org/10.54119/jflp.veyx2185>
- Woźniak-Gientka, E., Agata, T., Milica, P., Anna, B., Dennis, E., Nick, V., Godelieve, G., Selim, C., Nagmeh, A., & Tomasz, T. (2022). Public perception of plant gene technologies worldwide in the light of food security. *GM Crops & Food*, 13(1), 218–241. <https://doi.org/10.1080/21645698.2022.2111946>
- Zafar, M. Z., Shi, X., Yang, H., Abbas, J., & Chen, J. (2022). The impact of interpretive packaged food labels on consumer purchase intention: The comparative analysis of efficacy and inefficiency of food labels. *International Journal of Environmental Research and Public Health*, 19(22), 15098. <https://doi.org/10.3390/ijerph192215098>
- Zhang, J., Wu, Z., Hu, Y., Li, Y., Wang, J., & Hu, J. (2026). Ugly outside, healthy inside: How packaging information labels shape consumer perceptions of imperfect fruits. *Food Quality and Preference*, 138, Article 105832. <https://doi.org/10.1016/j.foodqual.2025.105832>

© 2026 by authors. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).