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GMO or GM No? Segmenting a Consumer Audience to Examine Their Perceptions of Genetically Modified Products

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Abstract

This study aimed to examine Tennessee consumers' perceptions of genetically modified (GM) products and how those perceptions and preferences differ based on consumers' characteristics. Survey respondents held overall neutral but slightly negative perceptions of GM products. While they agreed GM products could help increase food production, they also perceived GM products to cause illnesses such as cancer, autism, allergies, and gluten intolerance. Respondents also expressed beliefs that GM products are not good for the environment. Participants in the middle-income bracket had more positive perceptions of GM products than those in the lower and higher brackets. Respondents who always did the majority of the grocery shopping also had significantly more negative perceptions of GM products than respondents who were responsible for the majority of the grocery shopping about half the time. There should be targeted and simplified messaging for industry practitioners to reduce the information load. Specifically, research suggests GM messaging that emphasizes subjective norms, utilizes infographics, is congruent with consumer values, and highlights GM benefits rather than risks. Our results also indicate that information campaigns targeting different audience segments, namely income brackets, and grocery shopping responsibility, are viable solutions to increase consumer GM product perceptions.

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Introduction and Problem Statement

According to the U.S. Food and Drug Administration (2020), genetically modified (GM) organisms include animals, plants, and all microorganisms that are altered genetically using technology for transferring specific DNA from one organism to another, generally involving modifications to DNA. There are currently ten verified GM crops grown and sold in the United States (U.S. Food and Drug Administration [FDA], 2022). However, GM products have been the subject of much debate across the United States and other regions, especially regarding the safety of GM products for human consumption (National Academies of Sciences, Engineering, and Medicine [NASEM], 2016). Specifically, some are concerned that GM products can lead to allergies, autism, and gastrointestinal disorders (NASEM, 2016). Others have praised GM products for their economic and productivity contributions to farmers and community members (FDA, 2022).

There is substantial research regarding the pros and cons of GM products (e.g., NASEM, 2016; Ruth et al., 2018; Vecchione et al., 2014; Wunderlich & Gatto, 2015). However, methods to determine consumers' level of GM product understanding and how that understanding affects purchasing habits and perceptions of GM products are not yet concrete. Despite these challenges, researchers have maintained there is a need to examine U.S. consumers' perceptions of and attitudes toward GM technology in the food and agriculture sector (Gibson et al, 2022; Ruth et al., 2018). Such information can help direct future research and communication strategies on GM agricultural science (Ruth et al., 2018). Research to examine and better understand the variances in different consumer groups' perceptions of GM products is needed to help ensure the presence of a consumer market base capable of supporting GM technology.

Theoretical and Conceptual Framework

Audience segmentation and social marketing are often deployed to help utilize resources more effectively and ensure an initiative has a maximum impact (Andreasen, 2006). In agricultural communication research, such methods have been used to identify strategies to address issues or tailor messaging to specific subgroups (Gibson et al., 2022; Warner et al., 2017). Audiences can be segmented by various factors, such as gender, income, education, geographic region, race, and ethnicity. Rather than consider the "general consumer audience," researchers can apply concepts of segmentation to describe consumer groups and more effectively target communication messages. In this study, we used characteristics of income, education, shopper responsibility, knowledge level, and political affiliation to describe differences in consumers' perceptions of GM products. The following sections provide a synthesis of prior literature relevant to the grouping variables of interest selected for this study.

Knowledge and Education

In prior GM research, consumers' perceptions of GM products have been linked to content-specific factual knowledge of GM products (Vecchione et al., 2014), self-perceived knowledge

or familiarity (Rose et al., 2019), and a general understanding of science and the scientific process (Wunderlich & Gatto, 2015). Vecchione et al. (2014) found that adults in New Jersey with more knowledge of GM products were more likely to have a positive attitude about GM products and vice versa. However, Wunderlich and Gatto (2015) found that more than half of U.S. consumers knew very little about GM products.

While educational attainment may not speak to individuals' factual content knowledge of GM products (Rose et al., 2019), it may represent their general ability to comprehend scientific information to make informed decisions. Further, segmenting audiences and developing targeted messages based on GM knowledge levels can be difficult due to a lack of ability to identify how to best get GM product information to consumers. However, education and income can speak to broader, well-researched constructs like socioeconomic status or the use of different information sources that influence GM perceptions (Funk & Kennedy, 2016; Stanton et al., 2021; Wunderlich & Gatto, 2015).

Income

Income and educational attainment are examined due to consistent correlations between the two (Bjorklund & Jantti, 2020; Zwick & Green, 2007). Observed relationships between income and GM attitudes or perceptions have varied across prior research, though extant research focuses on non-US consumer perceptions (Cui & Shoemaker, 2018; Hwang & Nam, 2021). For example, Cui and Shoemaker (2018) found that higher-income Chinese consumers were significantly more likely to oppose GM products than those in lower-income groups. Hwang and Nam (2021) had similar results in a Korean sample. The present research attempts to fill in the U.S.-based research gap.

Political Affiliation

Politics have long influenced the advancement and dissemination of GM products, both in the United States and other countries, through regulatory approaches and audience-driven news media coverage of GM technology (Lucht, 2015; Pjesivac et al., 2020). In a meta-analysis of GM media coverage, Pjesivac et al. (2020) maintained that news messages in conservative areas were often framed around GM's and other biotechnology's economic potential. In contrast, news messages in more liberal regions highlighted potential environmental concerns and health risks of GM technology. Due to the political landscape surrounding GM products, a consumer's party affiliation may provide insight into their understanding and perceptions of GM products (Lucht, 2015; McFadden, 2016).

Shopper Responsibility

Shopping responsibility can be an indicator of familiarity regarding exposure to GM products. Wunderlich and Gatto (2015) found those who were more familiar with GM products were more resistant to bioengineering methods. However, Grunert et al. (2004) observed an increase in positive attitudes toward GM products after participants were exposed to a positive sensory experience with such products.

Purpose

This study aimed to examine Tennessee (TN) consumers' perceptions of GM products as well as investigate how these perceptions and preferences differ based on consumers' characteristics. Further, this research was conducted to inform the best approaches to marketing products to target audiences. Four objectives guided this study:

1. Describe the demographic characteristics of respondents
2. Describe TN consumers' perceptions of GM products
3. Describe TN consumers' self-perceived knowledge of GM products
4. Determine if statistical differences exist in TN consumers' perceptions of GM products based on self-perceived knowledge of GM products, education level, income, political affiliation, and shopper responsibility

Methods

A third-party company, Qualtrics, was contracted to recruit respondents and obtain a non-probability opt-in sample of TN residents. Qualtrics and panel partners employ digital fingerprinting technology and IP address checks to avoid duplication and ensure validity when obtaining non-probability opt-in samples in market research (European Society for Opinion and Market Research, 2019). The population of interest was TN residents aged 18 or older. The online link to the questionnaire was distributed to a total of 1,115 TN residents. Respondents who did not complete all items of the instrument, did not select the appropriate answers to attention filters (e.g., select "strongly agree" for this answer), or did not fall within the parameters of being a TN resident of 18 years of age or older were excluded from analyses. Useable responses were obtained from 501 residents for a 44.93% participation rate.

The questionnaire included 13 items and was divided into three sections to capture participants': (a) perceptions of GM products; (b) self-perceived knowledge of GM products; and (c) demographic characteristics, including education level, income bracket, political affiliation, and shopper role/responsibility. A researcher-developed questionnaire was reviewed by a panel of three faculty members with experience in survey design and science communication and marketing for readability, layout and style, clarity of wording, and accuracy of scientific content (Colton & Covert, 2007). Revisions were made to the original questionnaire to remove double-barreled questions, improve readability, and ensure construct items had clear positive or negative perception implications. The panel deemed the final instrument acceptable. In addition, a pilot test was conducted with 50 respondents to ensure survey item validation, check for low-quality responses, assess initial scale estimates for the instrument's constructs ($\alpha = .81$), and identify any other errors associated with survey flow and readability. Internal consistency reliability estimates for the instrument's construct (i.e., GM perceptions) were calculated for the pilot and primary data using Cronbach's alpha (Field, 2013). The pilot reliability estimates for the GM perceptions construct was .81 and was deemed acceptable.

Respondents' perceptions of GM products were assessed using eight items reflective of commonly reported positive and negative perceptions of GM products held by consumers (e.g., "GM organisms are bad for your health" and "GM organisms help increase food production"). Responses were collected using a five-point Likert scale, and a construct mean was computed. The internal consistency reliability estimate for this scale was $\alpha = .88$. To assess self-perceived GM knowledge, respondents were asked how they would describe their knowledge of GM products using a 5-point ordinal scale. Lastly, demographic items included the categorical variables: income, educational attainment level, political affiliation, and shopper role. Shopper role was assessed using a single item in which respondents indicated how often they do the majority of the grocery shopping on a 5-point ordinal scale.

Data for objectives one, two, and three were analyzed using descriptive statistics. For research objective four, one-way analysis of variance tests (ANOVA) were employed. A statistical significance level of .05 was established a priori for all statistical tests. Tukey's HSD post hoc tests were used when variances were equal, with Games-Howell used for unequal variances (Field, 2013). Before employing one-way ANOVA, Levene's test was utilized to ensure the assumption of equality of error variances was not violated. Robust tests of equality of means included Welch's statistic for tests that failed the assumption of homogeneity of variance.

Exclusion, selection, and non-participation biases are limitations of non-probability opt-in sampling methods (Baker et al., 2013). Due to such limitations, caution should be used when attempting to generalize the findings of this study. Instead, these findings should be considered based on the study's sample to contribute to the larger literature on GM food. A lack of quota sampling was also a limitation of this study, as the population sample included considerably more female respondents than male respondents, which is not reflective of the TN population. The remaining demographic characteristics were reflective of the state population. Due to the approach of audience segmentation, these findings can still provide valuable insight regarding GM perceptions among specific demographic groups. Due to attempts to draw a sample reflective of the demographic characteristics of the state population, unequal group sizes caused limitations in this study, particularly regarding the violation of ANOVA assumptions. Future research of this nature intended to segment consumer audiences should perhaps be designed with quotas set for grouping variables over state population characteristics.

Findings

Objective One

Objective one was to describe the demographic characteristics of respondents in this study. This objective provides context for the audience segmentation procedures used in the data analysis. Respondents in this study were primarily female ($f = 378$; 75.4%), white ($f = 408$; 81.4%), and between the ages of 20 to 29 ($f = 101$; 20.2%) and 30 to 39 ($f = 130$; 25.9%; Table 1). The largest number of respondents reported having completed high school ($f = 150$; 29.9%) or some college ($f = 142$; 28.3%) as their highest level of education, and most ($f = 423$; 84.4%) made less than $80,000 annually. Additionally, more than half of respondents ($f = 279$; 55.7%)

reported doing most of the grocery shopping in their household. Most respondents self-identified as Republican (*f* = 166; 33.1%), Democrat (*f* = 147; 29.3%), or politically moderate (*f* = 216; 43.1%). Table one provides a complete breakdown of the demographic characteristics of respondents.

Table 1

Demographic Characteristics of Respondents

Variable	*f*	*%*
Gender		
Male	111	22.2
Female	378	75.4
Age		
18 to 19	10	2.0
20 to 29	101	20.2
30 to 39	130	25.9
40 to 49	85	17.0
50 to 59	76	15.2
60 to 69	69	13.8
70 to 79	29	5.8
80+	1	0.2
Ethnicity		
Hispanic/Latino(a)/Chicano(a)	12	2.4
Not Hispanic/Latino(a)/Chicano(a)	489	97.6
Race		
White	408	81.4
Black	67	13.4
Asian	7	1.4
American Indian	2	0.4
Multi-racial	16	3.2
Other	1	0.2
Education		
Less than 12th grade (did not graduate high school)	22	4.4
High school graduate (includes GED)	150	29.9
Some college, no degree	142	28.3
2-year college degree (Associate, technical, etc.)	65	13.0
4-year college degree (Bachelor's, etc.)	82	16.4
Graduate or professional degree (Master's, Ph.D., MBA, etc.)	40	8.0

Income		
$24,999 or less	144	28.7
$25,000 to $49,999	175	34.9
$50,000 to $74,999	104	20.8
$75,000 to $149,999	60	12.0
$150,000 to $249,999	15	3.0
$250,000 or more	3	0.6
Political affiliation		
Republican	166	33.1
Democrat	147	29.3
Independent	110	22.0
Non-affiliated	69	13.8
Political beliefs		
Very liberal	37	7.4
Liberal	78	15.6
Moderate	216	43.1
Conservative	113	22.6
Very conservative	57	11.4
Residence		
A farm in a rural area	32	6.4
Rural area, not a farm	160	31.9
Urban or suburban area outside of city limits	159	31.7
Subdivision in a town or city	109	21.8
Downtown area in a city or town	41	8.2
How often do you do the majority of the grocery shopping in your household?		
Never	5	1.0
Sometimes	42	8.4
About half of the time	70	14.0
Most of the time	105	21.0
All the time	279	55.7

Objective Two

Objective two was to describe respondents' perceptions of GM products. The mean score for respondents' overall perceptions of GM products was 2.89, with scores ranging from 1.00 to 4.88 (*SD* = .75; Table 2). Analysis of individual GM perception items revealed respondents agreed that GM products help increase food production (*M* = 3.58; *SD* = .97). However, respondents also somewhat agreed GM products can cause illnesses such as cancer, autism, allergies, and gluten intolerance (*M* = 3.33; *SD* = 1.07) as well as disagreed that GM products are good for the environment (*M* = 2.81; *SD* = 1.04; Table 2).

Table 2

Respondents' Level of Agreement with Characteristics of GM Products

Item	*M*	*SD*
Genetically modified organisms help increase food production.	3.58	.97
Genetically modified organisms can cause illnesses such as cancer, autism, allergies, and gluten intolerance.[a]	3.33	1.07
Genetically modified organisms are bad for your health.[a]	3.32	1.05
Genetically modified organisms are harmful to pollinators.[a]	3.31	.91
Genetically modified organisms provide safe, sustainable alternatives for consumption.	3.01	1.07
Genetically modified organisms are beneficial.	2.96	1.06
Genetically modified organism are good for the environment.	2.81	1.04
Genetically modified organisms are more nutritious than other products.	2.63	1.01
Construct *M* = 2.89; *SD* = .75		

Note. Response scale: 1 = strongly disagree; 2 = somewhat disagree; 3 = neither agree nor disagree; 4 = somewhat agree; 5 = strongly agree

[a] Denotes items reverse coded for inclusion in construct mean calculation

Objective Three

Objective three was to describe respondents' self-reported knowledge of GM products. Regarding GM knowledge, more respondents (*f* = 204; 40.7%) self-identified as slightly knowledgeable compared to other knowledge categories (Table 3). Few respondents (*f* = 12; 2.4%) self-identified as extremely knowledgeable about GM organisms.

Table 3

Frequency Distribution of Respondents' Degree of Knowledge of GM and Organic Products

Item and Responses	*f*	%
Knowledge of GM organisms		
Not knowledgeable at all	137	27.3
Slightly knowledgeable	204	40.7
Moderately knowledgeable	121	24.2
Very knowledgeable	27	5.4
Extremely knowledgeable	12	2.4

Objective Four

Objective four sought to examine statistically significant variances in respondents' perceptions of GM products based on self-perceived knowledge of GM products, education level, income, and political affiliation. No significant variance in GM perceptions were observed between self-perceived GM knowledge groups [$F(4,496) = .866.$, $p = .45$], education level groups [$F(5, 495) = 1.49$, $p = .19$], or political affiliation groups [$F(4, 496) = 2.22$, $p = .07$].

However, significant differences in GM perceptions were observed between income groups, $F(5, 495) = 2.51$, $p = .029$ (Table 4). Tukey's HSD post hoc revealed respondents in the income group of $25,000 to $49,999 had significantly less positive perceptions of GM products than respondents in the $50,000 to $74,999 group and $75,000 to $149,999 group (Table 5). Additionally, the GM perceptions of respondents with an income of $250,000 or higher were significantly less positive than those in the $50,000 to $74,999 group and the $75,000 to $149,999 group.

Significant differences in GM perceptions were also observed based on respondents' degree of grocery shopping responsibility. Levene's test was significant for shopper role ($p = .003$); therefore, Welch's robust *F*-statistic was reported, $F (4, 496) = 3.21$, $p = .027$ (Table 4). Games-Howell's multiple comparisons revealed that respondents who did the majority of the shopping half of the time (GM perceptions $M = 3.12$; $SD = .68$) had significantly higher GM perceptions than those who always did the majority of the shopping for their household ($M = 2.80$; $SD = .81$; $p = .01$; Table 5).

Table 4

ANOVA Summary Table of GM Perceptions by Income Bracket and Shopper Responsibility

	SS	*df*	*MS*	*F*	*p*	Eta (η^2)
Income Bracket						
Between Groups	7.02	5	1.40	2.51	.029	.025
Within Groups	276.72	495	.559			
Total	283.74	500				
Frequency of Doing Majority of Grocery Shopping						
Between Groups	6.69	4	1.67	3.21*	.027	.024
Within Groups	277.04	496	.559			
Total	283.73	500				

* Denotes Welch's *F* reported

Table 5

Descriptive Results of GM Perceptions by Income Bracket s and Shopper Responsibility Groups

	GM Perception		95% Confidence Interval	
Variable	*M*	*SD*	Lower bound	Upper bound
Income bracket				
$24,999 or less	2.88	.71	2.77	3.01
$25,000 to $49,999	2.77	.75	2.66	2.88
$50,000 to $74,999	3.00	.80	2.84	3.15
$75,000 to $149,999	3.03	.73	2.83	3.15
$150,000 to $249,999	2.83	.80	2.39	3.27
$250,000 or more	2.04	.87	-.16	4.25
Frequency of doing majority shopping role				
Never	2.93	.87	1.82	4.03
Sometimes	3.04	.63	2.84	3.23
About half the time	3.11	.68	2.95	3.28
Most of the time	2.85	.66	2.72	2.90
Always	2.88	.75	2.81	2.94

Conclusions, Discussion, and Recommendations

The findings from this research provide insight into developing educational and marketing communication materials that enhance consumers' knowledge and understanding of GM products. This is particularly useful for communicating GM product information, as there has been an abundance of misinformation and concerns among consumer groups. First, respondents held overall neutral but slightly negative leaning perceptions of GM products. While they agreed GM products help increase food production, they also believed that GM products could harm the environment and cause illnesses such as cancer, autism, allergies, and gluten intolerance. These results show that while some information about the actual characteristics of GM products is reaching the public, the public is also being exposed to and retaining beliefs in misconceptions. Public intake of truth mixed with non-truth in GM-related information may be due to "information overload," where the public is exposed to so much information they cannot process fact from non-factual information (Li, 2017). As such, industry practitioners should target and simplify messages to reduce the information load. Specifically, research suggests using GM messaging that (a) emphasizes subjective norms (Silk et al., 2005), (b) utilizes infographics (Lee et al., 2021), (c) is congruent with consumer values (Fischer et al., 2021), and (d) highlights GM benefits rather than risks (Pham & Mandel, 2019).

Second, very few respondents self-identified as very or extremely knowledgeable about GM products; most respondents self-reported "slight" to "moderate" knowledge of GM products.

We found no significant variance in GM perceptions between self-perceived knowledge groups. Some prior research has shown that self-reported knowledge does not directly correlate to attitudes toward GM products (Rose et al., 2019) or willingness to use GM products (Lu, 2016). This may also explain why the present study did not find significant differences in GM perceptions across education levels. More importantly, U.S. consumers report relying on the internet for GM information (Funk & Kennedy, 2016), often using sources that are not fact-checked and peer-reviewed, which leaves room for misinformation and can negatively impact consumers' future science information gathering and product purchasing behavior. Therefore, where individuals receive their GM product information, and the content of those messages, may impact consumer opinions on science topics and purchasing behaviors more than self-perceived knowledge does. Future research should explore this topic further.

Lastly, audience segmentation can be a viable approach to enhancing consumers' GM product perceptions (Burke et al., 2020; Guenther et al., 2018; Silk et al., 2005). The results of the present study provide examples of audience characteristics, namely income and grocery shopping responsibility, that could be targeted by information campaigns. Respondents in the lowest and highest income groups ($25,000 to $49,999 and $250,000 or more) reported the most negative perceptions of GM products compared to other income categories. Additionally, respondents who indicated doing most or all grocery shopping had more negative perceptions than those who sometimes or never helped with shopping. Consumer shopping roles are a beneficial consumer category to target, as this information is readily available via online and in-store consumer account data. Therefore, communication campaigns designed to improve GM product perceptions that target income and shopping groups with negative GM product perceptions may be a helpful audience segmentation strategy. Analyses of perception formation should be the focus of future studies to inform why perceptions vary between income and shopping frequency groups. However, further studies will be needed to understand how the public receives, processes, interprets, and retains information about GM products to inform future communications efforts more precisely.

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