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Exploring the Use of Infographics to Alter Consumer Opinions and Perceptions of Sustainability within the U.S. Beef Industry

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Abstract

The meat industry faces increasing scrutiny over its environmental impact, animal welfare practices, and role in sustainable food systems, often fueled by misinformation and lack of consumer understanding. The purpose of this research was to explore the effectiveness of using infographics to change negative or misinformed opinions about the beef industry. Effective science communication strategies, such as evidence-based infographics, offer a promising approach to conveying complex agricultural topics in a visually engaging and accessible manner. These communication devices are effective in visually informing audiences and simplifying the messages; however, there is not a large body of literature on infographic use in agricultural education. A survey was conducted to gather participants' subjective and objective knowledge about resource usage, their prioritization of sustainability issues to address, and their beef shopping habits. Participants then rated their agreement with statements about sustainability, grass-fed and conventional cattle, and hormone use. After viewing three infographics, they were reassessed on the same questions to determine any changes in opinions or knowledge. Results showed a significant increase in self-reported knowledge ($p < .001$) and positive increases in opinions and agreement on statements about sustainability in the beef industry ($p < .001$). Participants expressed lingering doubt about the hormone information and the over- or underinflation of statistics represented. Further research could include more specific infographics focusing on fewer topics to decrease information load and integrating more interactive elements into the infographics to increase participation and interaction.

Keywords

beef industry, consumer perceptions, infographics, sustainability

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Introduction

Less than 2% of Americans are directly involved in agriculture, and this limited involvement with food production can lead consumers to hold inaccurate perceptions of the agriculture industry and its practices (Yang et al., 2020; USDA ERS, 2023). A lack of knowledge can influence opinions and viewpoints, contributing to the erosion of social license for animal agriculture (Hampton et al., 2020). Although the industry has continued to improve its sustainability efforts, research shows that consumers struggle to fully understand sustainability and tend to focus mainly on the environmental aspect. Despite this heavy emphasis on the environment, many of these consumers are not knowledgeable about how to assess the environmental impact of their food choices (van Bussel et al., 2022; Elanco Animal Health, 2023). Despite this gap, there is a growing consumer interest in food production and its effects on animal welfare, environmental sustainability, safety, and social equity (Wilson & Lusk, 2020).

Agricultural sustainability is described in three key parts or pillars: social responsibility, economic viability, and environmental stewardship (NCBA, n.d.a). Sustainability focuses not only on the environmental footprint of the industry, but also on economic prosperity and the well-being of workers and communities within the industry (7 U.S.C. § 3103, 2018). While the beef industry actively works to mitigate its environmental impact and showcase the efforts of researchers and producers to reach sustainable goals, these efforts may go unnoticed in the media landscape and by the public. As more consumers turn to the internet and social media for information, it can be difficult for them to parse through the information overload to find reliable and accurate information about their food choices (Burnett et al., 2019; Sutherland et al., 2020).

Multiple industry, university, and non-profit resources on sustainability initiatives are available, but many are tailored more towards internal users and industry partners (USRSB, 2019; Elanco Animal Health, 2023). Agricultural communications research is investigating ways to address these concerns and disseminate information to non-agricultural audiences. Understanding consumer perceptions and opinions about food systems is crucial, as it provides industry and producers with valuable information to inform their production, marketing, and lobbying decisions (Schroeder et al., 2023). This also serves as an opportunity for agricultural communicators to more effectively reach segments of the public who may be uninformed or misinformed about food production and sustainable agriculture.

Consumer Perceptions of Sustainability and Food Choices

To address the knowledge gaps that consumers may have about animal agriculture, it is important to understand how consumers form their perceptions of the industry in the first place. Consumer judgements about food are often based on lay theories that may not be objectively correct (Walker Reczek, 2023). For example, a scientist would use scientific theories or carefully gathered data to problem-solve or explain how something works, but the average consumer might not have that scientific knowledge or firsthand experience with food production to draw their own conclusions. Therefore, many consumers rely on alternative sources, such as word of mouth and information from other channels, including social media (Walker & Reczek, 2023). In an interview with Neuroscience News, Dr. Uma Karmarkar from the University of California, San Diego, detailed her research on examining factors that both consciously and unconsciously influence people’s decision-making and purchasing behaviors, such as prices, brand recognition,

and the experience of shopping online versus in-person (Clark, 2024). According to Dr. Karmarkar, "brands can offer familiarity and confidence in situations where we're not so sure about which product to buy, and that confidence is rewarding at the level of the brain" (paragraph 23, Clark, 2024).

Web-based sources, particularly social media, are the most popular information sources for these consumers. These sources are easily accessible and do not exist behind a paywall like some scientific publications or journals; however, while easily accessible, these sources of information very often lack accurate and scientifically supported data, and there is a certain level of distrust (Sutherland et al., 2020; Lassoued et al., 2023). Despite the lack of scientific rigor, a study of 300 university students by Howard et al. (2017) found that students perceived Facebook and Twitter to be trustworthy sources of information. This shift in opinion regarding social media credibility may be attributed to the rise in "fake news" and misinformation, which has reached its peak during the recent presidential elections and the COVID-19 pandemic (Beauvais, 2022).

Information from outside the industry is often polarizing or conflicting, causing confusion for consumers when making purchasing decisions (O'Brien et al., 2023). Social media personalities with large followings who express critical or false views on agriculture pose a concern regarding this lack of factual information (Sutherland et al., 2020). If information presented through social media is the sole source of information or news for consumers, it can be assumed that they are uncertain about what to believe regarding animal agriculture and food production (Sutherland et al., 2020). This presents an opportunity for agricultural communicators to leverage the popularity of social media and disseminate information across various platforms to reach non-agricultural audiences (Locke et al., 2023; Bennett et al., 2024).

Infographics

Infographics are a communication device that utilizes images, words, and other interactive elements to increase focus, information retention, cognitive processing, and future recollection, ultimately driving behavioral change (Traboco et al., 2022; Bhat & Alyahya, 2023). They combine textual information with visually and aesthetically pleasing visual aids to communicate information or messages that enhance comprehension (Traboco et al., 2022).

Infographics present information in ways that decrease the cognitive load on viewers, which is necessary for information to "stick" (Schnotz & Kürschner, 2007; Traboco et al., 2022). These communication devices are effective in visually conveying information and simplifying messages, thereby making the information more accessible to a wider audience (Traboco et al., 2022). Infographics are useful in instructional technology and design because they efficiently transmit information, knowledge, and conclusions to the media and public (Le & Pole, 2023). With social media being as popular as it is, using infographics to disseminate information on these platforms may achieve more exposure and traction (Traboco et al., 2022).

There has been an increase in the use of infographics in medical and educational studies, which can be attributed to the rise of social media and the fact that humans process visual content more quickly than text (Smith, 2016). The COVID-19 pandemic saw an increase in "flatten the curve" infographics, which served as a public health tool to educate and influence social distancing behaviors (Li & Molder, 2021). Infographics have also been used to help people distinguish between false information about vaccines (Domgaard & Park, 2021). Despite the extensive research and use of infographics in these sectors, there is a limited body of

literature on the use of infographics in the agricultural industries and agricultural education (Fischer et al., 2023; Gibbs et al., 2023). More specifically, a notable knowledge gap exists regarding the use of infographics in beef production and sustainability. Because infographics can lead to higher comprehension and retention, they may be a valuable tool for increasing agricultural literacy (Fischer et al., 2023). While prior studies have examined modalities, perception analysis, and change, as well as public understanding of beef, the use of narratives in science communication, or misinformation correction, few have focused on how animal scientists communicate complex or controversial science-oriented topics to non-expert audiences using evidence-based frameworks within infographics.

Theoretical Framework

The Elaboration Likelihood Model (ELM) is a persuasion theory that posits that attitude change occurs through two routes of elaboration processing: peripheral and central (Petty & Cacioppo, 1986). Attitudes are the general evaluations that people hold regarding their view on people (including themselves), objects, and issues (Petty & Cacioppo, 1986). Bainbridge Frymier (2021) defines persuasion in the context of a "receiver response," involving symbolic communication between two persons with the intent to change, reinforce, or shape attitudes, beliefs, or alter the behavior of the receiver. Petty and Cacioppo (1986) use "persuasion" to refer to a change in attitude after exposure to certain communication or information. Elaboration is defined as the amount of effort that someone is willing to use to process, evaluate, and remember a message, and then decide to accept or reject it (Petty & Cacioppo, 1986; Nickerson, 2023).

The central route of elaboration processing occurs when a person thoroughly considers the information presented, and it is likely to lead to long-term change (Petty & Cacioppo, 1986). This route uses data and facts to persuade and support an argument or stance (Nickerson, 2023). This processing route requires more effort than the peripheral route. The peripheral route is an indirect route with a lower level of elaboration; it doesn't require as much scrutiny as the central route, but still induces change (Petty & Cacioppo, 1986). When motivation or ability to process information is low or absent, then the peripheral processing route is more likely to be used. Processing through the central processing route is more likely for an attitude change to occur (Petty & Cacioppo, 1986).

ELM has successfully been used in previous research, which also incorporated the use of infographics (Lazard & Atkinson, 2015; Burnett et al., 2019; Lam et al., 2022). Lam et al. (2022) employed ELM to investigate elaboration in visual communication, and they discovered that infographics were more appealing, and respondents exhibited greater elaboration. Lazard and Atkinson (2015) used ELM to demonstrate that people engage more with infographics compared to messaging that only uses text or illustrations. Burnett et al. (2019) found that incorporating interactive elements into infographics leads to respondents exhibiting higher elaboration, which in turn increases attitude and cognition. These studies support the idea that infographics may present a more effective way to communicate valuable information, in this case about the beef industry, to the general public than other methods of information dissemination.

Purpose and Research Questions

The purpose of this study was to explore the effectiveness of using infographics to educate and change negative or misinformed perceptions about the beef industry.

RQ1: Will exposure to infographics increase participants' subjective knowledge about sustainability metrics and efforts in the beef industry?
RQ2: Will exposure to infographics improve negative opinions of the beef industry?
RQ3: Will exposure to infographics alter incorrect perceptions of the beef industry?
RQ4: Does exposure to the infographics increase participants' self-reported likelihood of engaging in specific behaviors related to the beef industry (e.g., supporting or communicating about the industry)?

Methods

This research study was approved by the Auburn University Office of Human Research, Protocol #24-885 EX 2405 in May 2024. The survey instrument was created using Qualtrics. The survey instrument consisted of a Likert scale, ranking questions, multiple-choice questions, and open-ended questions. These questions were modeled after previously published survey instruments and used information from peer-reviewed and industry resources on beef sustainability and facts and statistics of the beef industry (Ellison et al., 2017; Wilson & Lusk, 2020; Klopatek & Oltjen, 2022; Elanco Animal Health, 2023; Lassoued et al., 2023; Schroeder et al., 2023; NCBA, 2024). This instrument was reviewed by three professors familiar with conducting survey research in agriculture, and a pilot study was conducted with college-aged participants for editing purposes. Once editing of the survey instrument and the infographics was completed, the final survey was distributed through Prolific (Prolific Academic Ltd., London, England), a company that provides survey respondents for online research studies. This study aimed for a representative sample of the U.S. population.

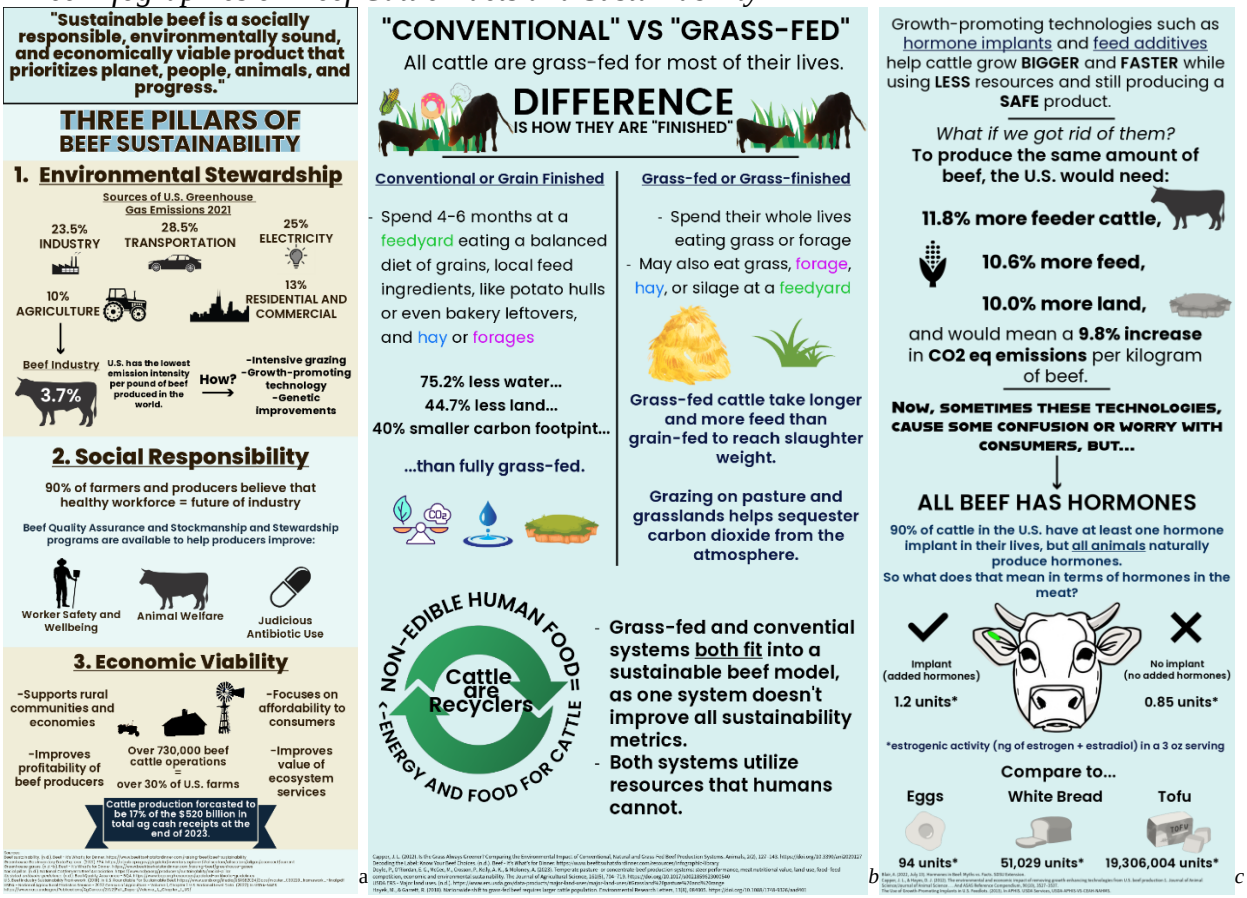
After the demographic questions, the survey was divided into four sections. The first included questions about diet and shopping habits (Table 1 and Table 2). The second section asked respondents about their opinions and perceptions of the beef industry, including their ranking of topics related to beef sustainability by level of concern (Table 3). Then using subjective and objective methodology similar to Wilson and Lusk's (2020) study on consumer knowledge of redundant labels, respondents were given a Likert scale matrix asking to rank how knowledgeable they consider themselves to be on the topics of the beef industry's GHG emissions, water usage, land usage, growth or efficiency promoting technologies, and sustainability efforts in the industry (Table 4). These responses were then compared to respondents' objective knowledge in a series of multiple-choice questions about facts about the U.S. beef industry's resource usage and other statistics (Capper, 2012; Capper & Hayes, 2012; EPA, 2021; Klopatek & Oltjen, 2022; Rotz, 2023). Following this multiple-choice section, two Likert scale matrices with internal consistency determined by Cronbach's α, asking to rate their agreement with statements pertaining to sustainability in the beef industry on a 5-point scale (Pallant, 2020; Sheposh, 2024).

After completing this section, respondents viewed three infographics. Research has shown that pictographs are more effective in enhancing information recognition and design recall than other visual aids, such as bar charts and pie charts (Fischer et al., 2023). The color schemes

and other information presentations were also modeled after the previously mentioned studies and are reflective of infographics currently used on social media. Infographic information was included based on recurring topics identified in the literature review, as well as resources from commodity groups and the government.

Figure 1

Three Infographics on Beef Cattle Facts and Sustainability [a,b,c]



[a] Sources for infographic 1: NCBA n.d.a; NCBA, n.d.b.; EPA, 2021; Beef Quality Assurance, n.d.; USRSB, 2019; USDA NASS, 2022. [b] Sources for infographic 2: NCBA, 2022; Capper, 2012; Hayek & Garrett, 2018; Doyle et al., 2023; USDA ERS, n.d. [c] Sources for infographic 3: Blair, 2022; Capper & Hayes, 2012; USDA APHIS, 2013.

After viewing the three infographics respondents were given the same Likert matrices about their knowledge and their level of agreement with the statements to see if their answers changed after viewing (Tables 4 and 5) (Li & Molder, 2021). To test recall, the respondents were then given three questions about a specific piece of information from each infographic. Respondents were then given the opportunity to view each infographic again and click the area of each one they found the most influential, which would produce a 'heat map' to visualize the areas of interest. This is an interactive element of the infographic to increase elaboration, as stated in Burnett et al. (2019).

Finally, to ascertain if the infographics and information provided were influential or persuasive enough to change or influence behaviors after viewing, respondents were asked if they were more likely to support the industry, if they would be more likely to engage in

conversations about the industry, and if they were interested in learning more about the beef industry. The final questions invited respondents to indicate if there were any topics or statistics on the infographics with which they disagreed or doubted. The data collected on Qualtrics was exported to Excel and SPSS and analyzed using paired t-test analysis, descriptive statistics, and frequencies. Significance was set at $p < .05$.

Results

Demographics, Diet, and Shopping Habits

Data collection took place on September 19, 2024, and lasted approximately 24 hours. During this time, a total of 1,053 responses were collected. The data was cleaned, and any surveys that left full pre- or post-Likert matrices unanswered were eliminated. Additionally, any surveys completed in under 5 minutes were also excluded. After this process was complete, a total of 961 usable responses were included in the statistical analysis conducted for this study. Table 1 presents the results on the demographics and questions regarding beef consumption and its frequency.

Table 1

Demographic Data (N = 961)

Characteristic	*M*	*f*	%
Age	45.93		
Gender			
Female		489	50.9
Male		452	47.0
Other		14	1.5
Prefer not to say		6	0.6
Racial Identity			
White		716	
Black or African American		150	
American Indian or Alaskan Native		29	
Asian		89	
Native Hawaiian or Pacific Islander		5	
Prefer not to say		36	
Education			
High school or less		127	13.2
Some college, associate degree, or vocational training		334	34.8
Bachelor's degree		365	38.0
Master's degree		101	10.5
Doctoral/professional degree		34	3.5
Urban-rural Classification			
Rural		202	21.0
Suburban		528	54.9
Urban		231	24.0
Eat Beef			

Characteristic	*M*	*f*	%
No		46	4.8
Yes		913	95.0
Missing response		2	0.2
How often do you consume beef?			
Never		46	4.8
A few times per year/special occasion		46	4.8
Once or twice a month		147	15.3
Once a week		263	27.4
More than twice a week		404	42.0
Daily		55	5.7
Primary Grocery Shopper			
Yes		841	87.5
No		120	12.5
Do you ever purchase beef?			
Yes		804	95.6
No		37	4.4

Note: due to rounding, frequencies may not equal 100%

People from rural areas eat beef more frequently than those from urban and suburban areas (p = .007; p = .011). Participants who do not eat beef and shared in the open response stated they avoid it for ethical, environmental, or health reasons. Of the participants who purchase beef (n = 804), some indicated that they do not consume it themselves, but as the primary grocery shopper, they do purchase it for the household. Participants in this sample ranked freshness, quality, and cut or type of beef as the top three important characteristics when purchasing beef products. The least important were the presence of animal welfare labels, the animal's diet (if it was grass-fed or grain-fed), and the presence of sustainability labels. Table 2 shows the average ranking of each attribute, with the lower the score, the higher the ranking.

Table 2

Rank of Importance of Qualities or Attributes When Purchasing Beef

Quality or Attribute	*M* (In Rank Order)
Freshness	2.49
Quality	3.02
Cut or type of beef	4.60
Price	4.82
Fat content/leanness	5.77
USDA grade	6.03
Production location (locally grown/raised)	8.53
Hormone or antibiotic-free	8.78
Brand	8.83
Animal welfare labels	9.10
Animal diet: grain-fed vs grass-fed	9.21
Sustainability labels	10.83

Perceptions of the Industry

News stations or televised news programs (*n* = 232), social media (*n* = 196), and internet searches (*n* = 149) were the most popular sources of news about beef and agriculture, followed by word of mouth (*n* = 116) and food labels (*n* = 112). Respondents were given the option to type in an "other" answer (*n* = 41), with two respondents saying they get their information from local farmers or their friend who raises beef cattle; 11 people said some variation of online news stories or news sites; two said documentaries, and four mentioned NPR or the radio. Two people said they do their own personal research, while eight said they do not see or search for news on agriculture or the beef industry. The remaining responses were variations of "not applicable" or listed the allotted choices. Table 3 presents the frequencies and percentages of respondents ranking what they consider most important to address in terms of sustainability in the beef industry, with the lower the mean score, the higher the importance.

Table 3

Rank of Importance of Items to Address in Beef Industry Sustainability (n = 958)

	1 (Most important)	2	3	4	5	6 (Least important)	*M*
Animal welfare	290 (30.3%)	225 (23.5%)	165 (17.2%)	102 (10.6%)	114 (11.9%)	62 (6.5%)	2.70
Animal wellness	118 (12.3%)	355 (37.1%)	180 (18.8%)	96 (10.0%)	136 (14.2%)	73 (7.6%)	3.00
Affordability or availability	285 (29.7%)	77 (8.0%)	167 (17.4%)	60 (6.3%)	69 (7.2%)	300 (31.3%)	3.47
GHG emissions	157 (16.4%)	96 (10.0%)	149 (15.5%)	203 (21.2%)	90 (9.4%)	263 (27.5%)	3.80
Land resource usage	49 (5.1%)	91 (9.5%)	156 (16.3%)	259 (27.0%)	304 (31.7%)	99 (10.3%)	4.02
Water resource usage	59 (6.2%)	114 (11.9%)	141 (14.7%)	238 (24.8%)	245 (25.6%)	161 (16.8%)	4.02

Note: due to rounding, frequencies may not equal 100%

Animal welfare, animal wellness, and affordability or availability of beef ranked the highest, and GHG emissions and land and water resource usage ranked the lowest. Table 3 shows that resource usage and protection ranked lower than animal welfare considerations, which is interesting, as the environmental aspects of sustainability rank the lowest in this survey, whereas Peano et al. (2019) found the opposite, with consumers considering the environmental aspect the most important. Oesterreicher et al. (2018) also found that millennial consumers were most worried about the environment.

The objective knowledge section, consisting of four multiple-choice questions that mirror the information in the infographic, showed that more than half of the respondents answered each question correctly. However, two out of the four subjective vs. objective questions indicated that respondents overstated their knowledge. A total of 36.3% claimed to be knowledgeable about the U.S. beef industry's GHG emissions, 25.9% claimed to be knowledgeable about water usage, 30.3% claimed to be knowledgeable about land usage, and 34.7% of respondents claimed to be knowledgeable about growth-promoting technologies. Compared to the objective knowledge questions, 40.0% of respondents correctly answered that 3.7% of the U.S. GHG emissions is from the beef industry (EPA, 2021), and 34.6% correctly answered that it takes approximately 273 gallons of water to produce one pound of boneless beef (Klopatek & Oltjen, 2022; this number was converted from the 2,275 liters of blue water per kilogram of boneless beef reported, as the United States does not use the metric system and gal/lb would be more understood by this audience). In contrast, 25.9% and 31.2% of respondents correctly answered that conventionally raised beef uses 44.7% less land than fully grass-fed beef and that it would take 385,000 more animals to produce the same amount of beef if the U.S. were to remove growth-promoting technologies (Capper & Hayes, 2012).

RQ1: Will exposure to infographics increase participants' subjective knowledge about sustainability metrics and efforts in the beef industry?

A paired samples t-test was performed to evaluate whether there was a difference between the pre-infographic viewing self-assessed knowledge and the post-infographic viewing self-assessed knowledge (Table 4). The self-assessed knowledge subscale is a 5-item 5-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree), that demonstrated excellent reliability (Cronbach's α pre-knowledge = .90; Cronbach's α post-knowledge = .91).

Table 4

Mean Response to Level of Self-assessed Knowledge Before and After Viewing Infographics

"I am knowledgeable about…"	Before Infographic	After Infographic	*N*	Difference
"…the U.S. beef industry's GHG emissions."	2.84	3.53	961	-.70***
"…the U.S. beef industry's water usage."	2.63	3.43	957	-.80***
"…the U.S. beef industry's land usage."	2.72	3.49	954	-.77***
"…the technologies used to improve beef cattle efficiency."	2.86	3.54	960	-.68***
"…sustainability efforts in the beef industry."	2.68	3.56	953	-.89***

***$p < .001$

There was a statistically significant increase in self-assessed knowledge after viewing the infographics in all five topics described in the study ($p < .001$). Males reported a higher pre-viewing self-assessed knowledge than females on GHG emissions, water usage, and land usage ($p < .001$). There were no differences between rural, urban, and suburban respondents in all the specified areas except urban respondents claiming a higher level of knowledge in the beef industry's water usage and sustainability efforts than the suburban respondents ($p < .001$; $p = .014$, respectively). Previous studies have shown that rural-residing people tend to be more knowledgeable about agriculture than suburban and urban people, so it interesting that this sample of rural respondents did not consider themselves significantly more knowledgeable than their counterparts (Frick et al., 1995; Harmon & Maretzki, 2006; Dale et al., 2017; as cited by Wilson & Lusk, 2020).

RQ2 and RQ3: Will exposure to infographics improve negative opinions of the beef industry? Will exposure to infographics alter incorrect perceptions of the beef industry?

A paired samples t-test was performed to evaluate whether there was a difference in agreement between pre- and post-infographic viewing regarding statements about beef's environmental footprint and growth-promoting technologies (Table 5). These were separate 4-item 5-point Likert-type scales, ranging from 1 (strongly disagree) to 5 (strongly agree), with both demonstrating adequate reliability (Cronbach's α pre- and post-environmental footprint = .62 and .66, respectively; Cronbach's α pre- and post-growth-promoting technologies = .71 and .80, respectively). Three of the statements' pre- and post-viewing differences refer to RQ2: "I believe that the U.S. beef industry is sustainable; I am not worried about added hormones in beef; and growth-enhancing technologies are safe to use on animals intended for human consumption." These statements were worded to be opinionated statements for the participants to rate their agreement or disagreement. The remaining statements in Table 5 pertain to RQ3, specifically addressing the correction of incorrect perceptions about the beef industry and its production.

Table 5

Mean Response to Level of Agreement to Statements Before and After Viewing Infographics

Statement	Before Infographic	After Infographic	*N*	Difference
"I believe that the U.S. beef industry is sustainable."	3.11	3.59	961	-.49***
"The beef industry has a relatively small contribution to GHG emissions compared to other industries in this country."	3.03	3.74	959	-.72***
"Conventionally raised beef uses fewer natural resources than 100% grass-fed beef."	3.25	3.79	957	-.54***

Statement	Before Infographic	After Infographic	*N*	Difference
"Conventionally raised cattle spend the majority of their lives eating grass or forages."	2.88	3.25	956	-.37***
"I am not worried about added hormones in beef."	2.39	2.93	960	-.54***
"If someone is worried about hormones in food, beef is a low-hormone food choice."	2.64	3.37	960	-.73***
"If the beef industry stopped using all growth-enhancing technologies, it would be less environmentally and economically sustainable."	3.01	3.57	960	-.56***
"Growth-enhancing technologies are safe to use on animals intended for human consumption."	2.66	3.24	960	-.57***

***p<.001

There was a statistically significant increase in agreement with all the statements about the beef industry's environmental footprint and growth-promoting technologies ($p < .001$). The largest changes in agreement were seen in the statements "the beef industry has a relatively small contribution to GHG emissions compared to other industries in this country," and "if someone is worried about hormones in food, beef is a low-hormone food choice."

In the pre-infographic Likert questions, rural respondents and urban respondents believe that the industry is more sustainable than the suburban respondents ($p = .002$; $p = .017$). Rural respondents agreed more than the suburban and urban respondents that the beef industry has a small GHG contribution compared to other industries ($p < .001$; $p = .026$). Urban respondents had a higher agreement than rural and suburban respondents that conventionally raised cattle spend the majority of their lives eating grass or forages ($p < .001$; $p < .001$) and also had a higher agreement that growth-enhancing technologies are safe to use on animals intended for human consumption ($p = .003$; $p = .002$). Urban respondents are less concerned about added hormones in beef than suburban respondents (p = .026), and urban respondents agree more with the statement that eliminating those technologies would reduce the environmental sustainability of the industry ($p = .015$). Urban respondents agreed more than rural respondents with the statement that conventionally raised cattle use fewer natural resources than 100% grass-fed beef ($p = .036$). From these results, urban respondents tended to have a more positive opinion of the beef industry and rated themselves as more knowledgeable about it. Furthermore, females tended to have a lower post-exposure agreement with these statements, particularly those that focus on hormones in beef ($p < .001$).

Extrapolating only the non-beef consumers, a difference was observed in the significance of the pre- and post-viewing opinions. Exposure to the infographics still resulted in an increase in agreement with all the statements; however, non-beef-eating respondents tended to have a lower pre-viewing opinion than the overall sample, except in the question about the safety of growth-promoting technologies. Their post-viewing opinions also remained negative toward the industry.

There were three statements for which the non-beef consumers increased their agreement beyond the middle of the scale. Despite this portion of the sample holding more negative views of the beef industry, exposure to the infographics was persuasive enough to statistically increase their perceptions and opinions.

Table 6

Mean Response of Non-beef Consumers to Level of Agreement to Statements Before and After Viewing Infographics (n = 46)

Statement	Before Infographic	After Infographic	Difference
"I believe that the U.S. beef industry is sustainable."	1.91	2.41	-.50***
"The beef industry has a relatively small contribution to GHG emissions compared to other industries in this country."	2.20	2.98	-.78***
"Conventionally raised beef uses fewer natural resources than 100% grass-fed beef."	2.85	3.50	-.65***
"Conventionally raised cattle spend the majority of their lives eating grass or forages."	2.07	3.04	-.97***
"I am not worried about added hormones in beef."	2.30	2.57	-.27
"If someone is worried about hormones in food, beef is a low-hormone food choice."	2.20	2.98	-.78***
"If the beef industry stopped using all growth-enhancing technologies, it would be less environmentally and economically sustainable."	3.00	3.37	-.37*
"Growth-enhancing technologies are safe to use on animals intended for human consumption."	2.28	2.70	-.42**

*$p < .05$, **$p < .01$, ***$p < .001$

The recall questions asked respondents to recall a piece of information from each infographic. A total of 48.9% of respondents correctly recalled that transportation is the main source of GHG emissions in the U.S.; 59.3% correctly recalled that tofu has the highest estrogenic activity of the foods mentioned, and 42.7% correctly recalled that conventionally raised beef uses 75.2% less water than grass-fed beef.

RQ3 asked if exposure to these infographics would alter incorrect perceptions of the beef industry. Therefore, the open-response question at the end of the survey allowed respondents to

identify any information presented in the infographics that they still did not agree with or were not convinced of its accuracy after participating. Of the 161 responses, over one-third indicated a variation of "none" or discussed topics that were not presented in the content of the survey. Eight respondents stated they would need to do more research before fully agreeing or disagreeing, with one respondent stating they "are not adequately knowledgeable about the beef industry to make an informed comment." There were also 16 comments that stated some information felt misleading or misrepresented, with four comments specifically labeling it as propaganda. One respondent stated, "The information needs to be compiled by an outside source with no ties to the industry."

The remaining responses expressed disagreement with the presentation of the estrogen information, the differences between grass and grain-fed animals, and the pillars of sustainability. A total of 56 comments mentioned estrogen, phytoestrogen, or growth promotants. The most common sentiment was that they were unsure or disagreed with the use of growth hormones in beef cattle. Another common concern was the comparison of the hormones in tofu and meat, with one respondent calling it "disingenuous" and another saying it is an "absurd exaggeration." A total of seven responses disputed the differences in grass and grain-fed cattle, with most sharing, "I don't believe conventional is more sustainable than grass-fed."

RQ4: Does exposure to the infographics increase participants' self-reported likelihood of engaging in specific behaviors related to the beef industry (e.g., support, communicating about the industry)?

The behavior section aimed to explore whether respondents were more likely to engage in certain actions after viewing the infographics (Table 7). This used a 7-item, 5-point Likert-type scale, from 1 (strongly disagree) to 5 (strongly agree), demonstrating good reliability (Cronbach's $\alpha = .87$). Table 7 shows that most respondents agreed or strongly agreed with statements about their likelihood to change or modify behaviors after viewing the infographics. They also mostly agreed or strongly agreed that they learned something and were interested in learning more about sustainability in the beef industry. Respondents most strongly agreed that they had a better understanding of sustainability in the beef industry after participating in the survey, with 92.5% agreeing or strongly agreeing. It is also encouraging that 72.8% agreed or strongly agreed that they felt more comfortable discussing these topics after taking part in the study. For each statement, 20% or fewer participants disagreed or strongly disagreed. This, along with the percentage of participants who supported engaging in positive behaviors or becoming more knowledgeable, shows a generally positive reception to the information presented and highlights this research's potential to influence behavior and knowledge.

Table 7

Post-test Behavior and Interest

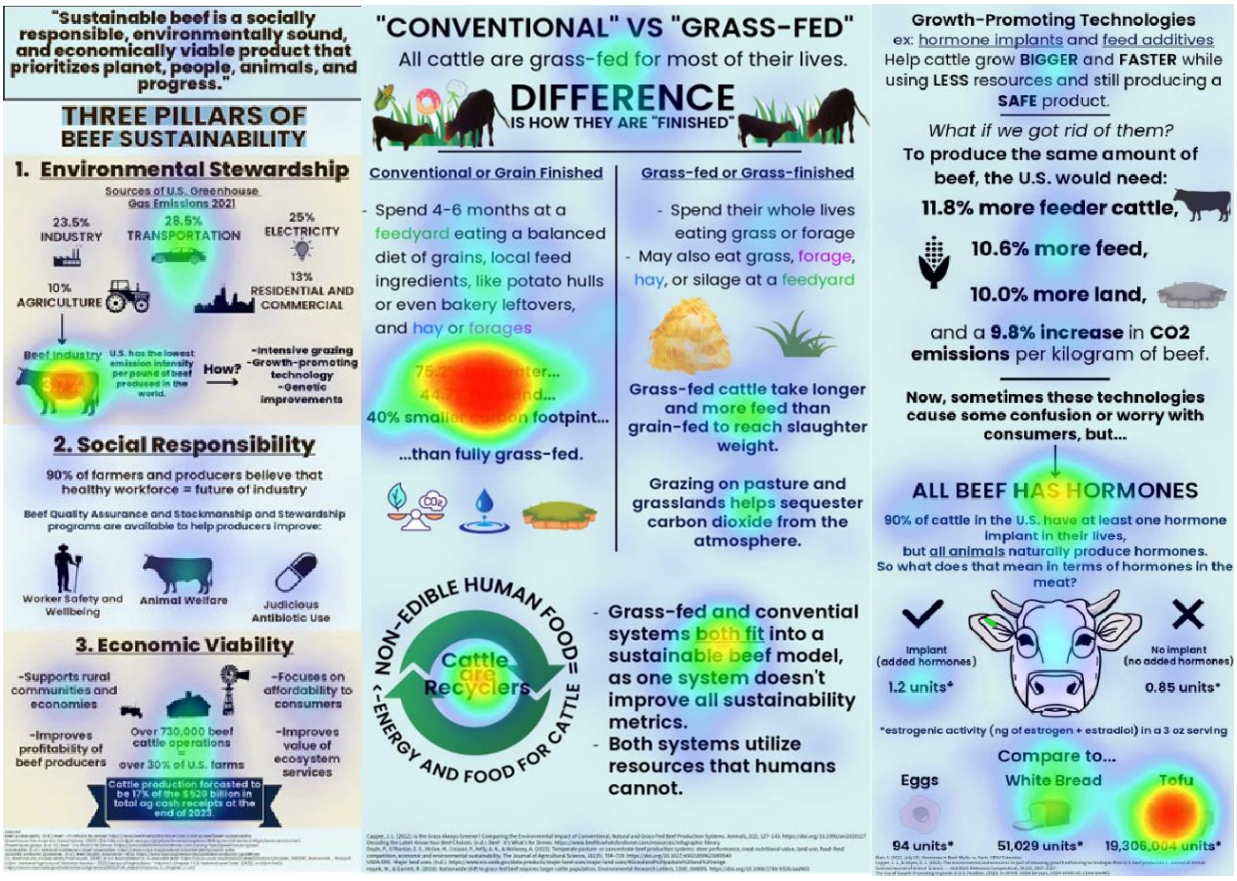
Statement	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	*N*	*M*
"I am more likely to support the beef industry."	41 (4.3%)	91 (9.5%)	258 (27.1%)	426 (44.7%)	137 (14.4%)	953	3.55
"I am more comfortable having a conversation with others about the beef industry."	21 (2.2%)	73 (7.7%)	165 (17.3%)	567 (59.6%)	126 (13.2%)	952	3.74
"I am more likely to engage in conversations with others about the beef industry."	44 (4.6%)	143 (15.0%)	267 (28.0%)	397 (41.7%)	101 (10.6%)	952	3.39
"I have a better understanding of sustainability in the beef industry."	16 (1.7%)	35 (3.7%)	112 (11.8%)	598 (62.9%)	190 (20.0%)	951	3.96
"I learned something about the beef industry."	5 (0.5%)	12 (1.3%)	55 (5.8%)	524 (55.2%)	354 (37.3%)	950	4.27
"I am interested in learning more about the beef industry."	38 (4.0%)	115 (12.1%)	230 (24.2%)	432 (45.5%)	135 (14.2%)	950	3.54
"Overall, I am satisfied with the U.S. beef industry."	49 (5.2%)	96 (10.1%)	240 (25.3%)	421 (44.5%)	141 (14.9%)	947	3.54

Note: due to rounding, frequencies may not equal 100%

Three heat map questions, one for each infographic, asked respondents to choose one area of each infographic that they considered the most impactful. Areas with more interaction or clicks appear "hotter" or more red, and areas with fewer interactions displayed colors on the other end of the color spectrum (Qualtrics, 2024). On the infographic explaining the three pillars of sustainability, the image of the cattle representing the industry's GHG emissions had the most interaction. Other notable areas of interest were the transportation industry's GHG emissions and the economic pillar, specifically the number of beef cattle operations in the U.S. Respondents clicked the statistics comparing the resource usage of conventionally fed cattle with that of grass-fed cattle. The graphic "cattle are recyclers" and its explanation were yellow-orange, showing another area of high interaction. The third infographic about growth-promoting technologies and hormones showed the bottom half of the image with the most clicks, with the information about tofu's estrogenic activity displaying a very saturated red.

Figure 2

Heat Map Results Showing the Most Impactful Components of Each Infographic



Discussion and Conclusions

The current study was guided by four research questions, all focusing on the effects of infographics on respondents' knowledge, attitudes, and beliefs regarding the beef industry in the United States. Based on the Elaboration Likelihood Model (ELM), the findings showed that exposure to beef-related infographics significantly increased respondents' subjective knowledge, perceptions, and opinions about the U.S. beef industry. Additionally, these respondents demonstrated a significant rise in their willingness to engage in behaviors they believe support the U.S. beef industry. These results align with previous studies using ELM and infographics and further support that the Elaboration Likelihood Model is a useful framework for explaining the reasons behind the observed changes and the potential of infographics to make complex, science-based information more accessible to the public. (Lazard & Atkinson, 2015; Burnett et al., 2019; Lam et al., 2022).

However, it is essential to note that while most of these changes were statistically significant, some of the findings need to be considered in the proper context. Specifically, Table 4 shows a significant positive increase in self-assessed knowledge, with the average ranking shifting from “disagreement” to “neither agree nor disagree.” Tables 5 and 6 also show statistically significant positive increases in agreement with every statement; however, the means

still indicate disagreement or neutral feelings toward each topic. For example, while respondents expressed less concern about the use of hormones in beef after exposure to the related infographic, the mean response remained below 3.00, indicating a general disagreement with the statement used in the infographic and potentially the use of hormones in beef production. Furthermore, the mean responses to all statements clustered around the midpoint of the scale, indicating an average neutral opinion toward the statements. The non-beef consumers indicated more negative opinions than the overall sample, and there were specific areas of sustainability that remained negative. Participants expressed lingering doubts, specifically about the hormone information and the possible misrepresentation of statistics.

The findings related to hormones were notable and contrasted with the results of previous studies, such as Lassoued et al. (2023), who found that hormone-free labels on beef had no significant influence on the purchasing process. Howard et al. (2017) also noted that university students are only "relatively concerned" with the use of growth hormones in cattle. In this study, respondents ranked hormone labels eighth in importance when purchasing beef (Table 2), yet the hormone content of beef appeared to be the most debated information in the infographics. It seems, based on the current study, that there is a discrepancy in the literature regarding perceptions of hormone use in the U.S. beef industry, or that perhaps sentiment towards the topic is shifting. In any case, more research is needed to fully understand perceptions of hormone use in beef.

Limitations and Future Research

As with all research, the limitations of the current study should be acknowledged, as they also present opportunities for future researchers to expand on this work and add to the knowledge about the use of infographics and consumers' understanding of and attitudes towards the U.S. beef industry. For example, more data is needed about hormone use in the beef industry and the related consumer perceptions. There is disagreement in the existing literature, including this study, regarding attitudes toward hormone use in beef and its influence on American consumers' purchasing decisions. Since information about how other countries produce beef is more accessible—for instance, the European Union bans the use of growth hormones in beef production—attitudes toward hormone use in the U.S. may change over time. This phenomenon might be best studied through a continuous, multi-year effort to establish a baseline and track potential shifts over time. It is important to note that one limitation of this study was the absence of questions linking attitudes toward hormones to future buying decisions, which could be addressed in future studies.

Another major limitation is that the current study provides a snapshot in time and does not allow for ongoing observation of whether any changes observed in the respondents are permanent. In other words, although statistically significant changes were identified after respondents were exposed to the infographics, we cannot determine if those changes are lasting or how durable they might be if the same respondents encounter conflicting information later. Measuring such long-term, lasting change is essential, especially considering how easily and frequently people are exposed to information through multiple channels, such as social media, TV, and radio ads. Future research should address this gap.

Another potential limitation comes from the design of the infographics themselves. While great care was taken by to create infographics that were scientifically accurate, it is certainly possible that overall design, the colors used, and even the type of font used may have skewed the

impact of the infographics on the respondents. Future research may be well served by engaging with design professionals to help create infographics for use in future studies, or even to design studies that aim to measure the potential impact of specific design elements on respondents and their ability to recognize, absorb, and retain information related to the beef industry.

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