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What Consumers Don't Know about GM Food and How that Affects Beliefs

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Classification: Social Sciences/Social Sciences, Biological Sciences/Agricultural Sciences

Keywords: Genetically Modified Food, Labeling, Public Acceptance, Public Knowledge

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Abstract: In the debates surrounding biotechnology and genetically modified (GM) food, data from consumer polls are often presented as evidence for precaution and labeling. But, how much do consumers actually know about the issue? New data collected from a nationwide U.S. survey reveals low levels of knowledge and numerous misperceptions about GM food. Nearly equal numbers of consumers prefer mandatory labeling of foods containing DNA as do those preferring mandatory labeling of GM foods. When given the option, the majority of consumers prefer that decisions about GM food be taken out of their hands and be made by experts. After answering a list of questions testing objective knowledge of GM food, subjective, self-reported knowledge declines somewhat and beliefs about GM food safety increases slightly. Results suggest consumers think they know more than they actually do about GM food, and queries about GM facts cause respondents to re-assess how much they know. The findings question the usefulness of results from opinion polls as motivation for public policy surrounding GM food.

Introduction

Debate about biotechnology in plant research and about genetically modified (GM) food in the United States has intensified in recent years with mandatory labeling ballot initiatives appearing in California, Colorado, Connecticut, Maine, Oregon, and Washington. The Vermont legislature passed the first US mandatory labeling law for GM food (1), an action which has prompted competing legislation in the US Congress (2). At the heart of the debate is stated public opposition to GM food, and public opinion may be a proximate cause of policy (3). Indeed, public opinion polls are often used to characterize consumer sentiment and motivate more precautionary policies for GM food. Apparent consumer concern could lead to a climate that impedes particular research methods and lowers the potential return to investments in biotechnology applications.

The seemingly high level of public opposition is puzzling given the views of most scientists on the issue. It could be argued that gaps between science and the public has always existed (4) and is increasing (5). However, the gap is extraordinarily large regarding the safety of GM foods. Only 37% of US consumers believe GM food is safe to eat; by sharp contrast, 88% of scientist members of the American Association for the Advancement of Science (AAAS) believe GM food is safe to eat (6). The gap between public and scientific assessment of GM food safety was the largest among all issues studied by a recent Pew Research Center study; including: vaccines, climate change, and fracking (6). The divide may indicate a need for better science communication. However, previous research on the topic has shown that simply providing statements from the scientific community does not substantively change in beliefs about the safety of GM food, and in fact results in a backlash among a segment of the population (7, 8).

There are several psychological and behavioral-economic factors that may cause the public to form beliefs inconsistent with scientists. The world is full of uncertainty and consumers form beliefs subject to constrained time, information, and computational capabilities. These constraints often require consumers to employ heuristics, or rules of thumb, which can lead to biases when decisions concern uncertain risks, benefits, and consequences (9). Biases are perhaps more pronounced when consumers have little knowledge about an

issue that is contemporaneously covered by the media, as has been the case with GM food (10, 11). In addition to media, other social influences likely shape beliefs. For example, consumers are more likely form a belief about an issue that is reflective of others who share similar values, as suggested by cultural cognition theory (12). Moreover, consistent signaling from others within a group may cause some consumers to hold a belief that is perceived to be consistent with most scientists when it is not (13, 14).

We contribute to the understanding of public concern about GM food safety by examining consumer knowledge about genetics and agricultural production. While a large number of studies have asked questions about consumer knowledge (15, 16, 17), this survey delves into the issue more exhaustively and offers an insight into the level of knowledge of U.S. consumers about genetics and agricultural production. Furthermore, while framing effects of GM food labels has been assessed (18), this study relates consumer knowledge to the emerging policy issue of mandatory labeling. Moreover, unlike prior research, this paper shows how consumers' expressed knowledge and safety beliefs are affected by such questioning. The results described within are from a nationwide survey of over 1,000 U.S. respondents conducted in September 2015.

Materials and Methods

Data Collection Method

This study was approved by the institutional review board at the University of Florida. The survey was conducted online and was completed by a sample of 1,004 participants enrolled in an online panel maintained by Survey Sampling International© (SSI) and their associated partners. Opt-in online panels produce estimates that are as accurate as other data collection methods, like telephone surveys (19). The survey was fielded from September 16, 2015 through September 28, 2015. SSI prescreened participants by gender, education, and income to ensure the sample was representative of the U.S population. According to the 2012 U.S. Census Bureau, females represented 50.8% of the population, 28.2% of persons age 25+ held a Bachelor's degree, and the median household income was \$52,762. Our sample closely

matched these population statistics. Fifty-three percent of the survey sample was comprised of females, 35% percent held a Bachelor's degree, and the median income category was \$40,000 to \$59,999. Given the sample size, the margin of error is plus or minus 3.2% for dichotomous questions.

Survey Overview

For the sake of brevity, a brief overview of the questions asked are described below. Interested readers can find the specific questions asked by the survey and summary statistics for responses in the supplemental material. After consenting to take the survey, participants were asked 10 blocks of questions. Blocks two through eight were randomized across participants to minimize order effects. Questions associated with each block were as follows: 1) a question to determine subjective knowledgeable about GM food with responses varying on a five-point scale from "Very Unknowledgeable" to "Very Knowledgeable", a question that determined respondent level of agreement with a statement, "Food that has genetically modified ingredients is safe to eat" with responses varying on a five-point scale from "Strongly Disagree" to "Strongly Agree", and a question that measured confidence in the response to the previous agreement question; 2) a question that determined if respondents knew how many genes are altered by different plant breeding techniques (i.e., selection, hybridization, genetic marker assisted breeding, genetic modification, mutagenesis) with response categories "None", "1 to 9 genes", "10 or more genes", "Impossible to know", and "I do not know", and questions that determined knowledge about the proportion of corn and wheat acres planted with GM seed; 3) questions that tested knowledge about what crops on the market were GM, the purposes or outcomes associated with modification, and whether GM animals were currently being sold; 4) questions that tested knowledge about when GM crops were first grown, and the average time it takes for a GM crop or animal to be approved for human consumption; 5) questions that tested awareness of GM and non-GM herbicide tolerant crops; 6) questions that tested awareness of the time it takes to create a new variety of GM and non-GM corn; 7) questions that determined support or opposition for mandatory labeling of food and how the issue of

mandatory labeling should be decided; 8) questions that tested general knowledge of food DNA; 9) questions in block 1 were repeated; and 10) demographic questions.

Thus, we have within-subject measures of how self-reported subjective knowledge, beliefs about GM food safety and confidence in those beliefs changed after answering the questions asked in blocks two through eight. Participants were not informed of the correct responses to the questions asked, and therefore any changes in the within-subject measures were completely a result of self-reflection. Care was taken to word questions in an easy-to-read and understandable manner. Nevertheless, the issues are inherently technical in nature and may be difficult to answer correctly for many people. Nevertheless, it is important to understand the level of public knowledge about genetics and agricultural production, particularly when assertions are being made about consumer knowledge and preferences. Furthermore, responses to some of the questions asked may provide insight into why some of the public is not accepting of GM foods. For instance, there is a sentiment that GM is not natural because it alters genes in a lab; however, it is unclear whether people are averse to the altering of genes in general or averse to genes being altered in a lab setting that could not occur in nature.

Results

Prior to asking questions that tested knowledge about genetics and agriculture production, respondents were first queried about self-reported, subjective knowledge of GM food and beliefs about the safety of GM food. On a five-point scale, 8% rated themselves as “very knowledgeable” about GM food and the highest proportion, 32%, rated themselves as “somewhat knowledgeable” with the remaining 60% being undecided or not knowledgeable. Results regarding the safety of eating GM food aligned with previous studies (6, 8). Thirty-four percent believed GM food was *not* safe to eat, 34% believed it was safe, and 32%, were in the middle. Respondents in the middle were less confident in their beliefs about GM food safety ($P < 0.01$ Satterthwaite test).

Low levels of knowledge about genetics may invoke concerns about GM interfering with nature relative to other breeding techniques. Respondents were asked how many genes are

typically altered by various plant breeding techniques. The various breeding techniques queried were genetic marker-assisted breeding, genetic modification, hybridization, mutagenesis, and selection. The results are illustrated by Fig. 1. Approximately half of the sample indicated they did not know how many genes were altered for the various breed techniques. Nevertheless, beliefs about the number of genes altered was significantly dependent on breeding technique ($P < 0.01$, Pearson's Chi-squared test). Moreover, compared to the other listed breeding techniques, a significant proportion of respondents thought selection did not alter any genes (Tukey's test). Conversely, compared to genetic marker-assisted breeding, mutagenesis, and selection, a significant proportion of respondents thought GM altered 10 or more genes (Tukey's test). Thus, respondents associate GM with more genetic alteration, which is not consistent with actual practice because selection alters thousands of genes while GM typically alters a select few.

Consumers had the option to choose "I don't know" for the previous question. However, when forced to answer a question that asked if corn always contained the same genes before GM was possible, 49% of respondents thought corn had always contained the same genes. Further validating that some consumers have little knowledge of basic genetics were the responses to two other questions. Thirty-three percent of respondents thought non-GM tomatoes did not contain genes and 32% thought vegetables did not have DNA. Taken together, these results indicate that at least of a third of consumers have little to no knowledge about genetics.

The most widely adopted GM crops, relative to total production for a given commodity, are corn, cotton, papaya, soybeans, and sugar beets. Respondents were asked what crops on the market were GM. Fifty-five percent of the sample thought corn was GM, and corn was the only commodity to receive more than 50%. A much smaller proportion thought that cotton, papaya, and sugar beets were GM; 19%, 14%, and 18%, respectively. About a third, 34%, thought soybeans were GM. Approximately 15% of consumers thought all the crops that present as response options were GM; including carrots and onions, which 28% and 21% of respondents thought were GM. Thirty-two percent responded "I don't know."

Although respondents were more aware of GM corn than any other GM commodity, many respondents were not aware of the extent of GM corn adoption. In 2015, approximately 92% of all corn planted was GE (20). Yet, on average, respondents thought 56% (st dev = 24%) of corn planted was GM; they also thought 52% (st dev = 23%) of wheat planted was GM. Currently, there are no acres of GM wheat; nevertheless, consumers thought GM corn and wheat were adopted at similar levels. In addition to crops, 46% of sample thought there were GM animal food products on the market.

The commodities previously listed (i.e., corn, cotton, papaya, soybeans, and sugar beets) were modified to be resistant to insects, herbicide, or disease. The reason for modification of GM commodities may not be obvious to consumers. Respondents were asked why GM commodities on the market may have been modified. A majority of consumers thought GM commodities currently on the market were modified to be resistant to insects and disease; 53% and 52%, respectively. However, only 35% of consumers thought GM commodities on the market were modified to be resistant to herbicides. The result is curious in light of the recent, heightened public discussion and debate about the safety of glyphosate relative to that of pesticides.

After answering numerous questions that tested objective knowledge, the questions at the beginning of the survey on expressed knowledge and safety beliefs were repeated. Fig. 2 illustrates the change in subjective, self-reported knowledge for the sample. It is obvious that the mass shifts from the right (i.e., the knowledgeable categories) to the left (i.e., the neither and unknowledgeable categories) and there was a significant decrease in the number of respondents in the "Somewhat Knowledgeable" category. What is not obvious from the figure is how individual consumers flowed across these categories after answering questions. Paired t-tests indicated that after answering questions there were significant increases to the "Very Unknowledgeable" ($t = 2.68$) and "Neither Unknowledgeable/Knowledgeable" ($t = 3.54$) categories and significant decreases to the "Somewhat Knowledgeable" ($t = -4.69$) and "Very Knowledgeable" ($t = -3.86$) categories. Together, these results suggest consumers think they know more than they actually do, and queries about objective knowledge causes some respondents to re-assess how much they know.

Unexpectedly, simply asking objective knowledge questions slightly changed beliefs about GM food safety. Changes in beliefs are illustrated in Fig. 3. Consumers were significantly more likely to believe GM food was safe to eat after a series of questions that tested objective knowledge about genetics and GM food ($P < 0.01$, Student's t-test & Wilcoxon signed-rank test). At the individual level, there was a significant decrease to the "Disagree" ($t = -2.77$, Paired t-test) category and a significant increase to the "Strongly Agree" ($t = 2.49$, Paired t-test) category. While there was a modest change in beliefs, confidence in beliefs, on average, did not change after answering questions ($P = 0.84$, Student's t-test; $P = 0.95$ Wilcoxon signed-rank test). This was also true even when the sample was restricted to only those who had a change in belief ($P = 0.73$, Student's t-test; $P = 0.67$ Wilcoxon signed-rank test). However, consumers who changed safety beliefs were less confident both before ($P = 0.04$ Satterthwaite test) and after answering knowledge questions ($P = 0.02$ Satterthwaite test) than the consumer who did not have a belief change.

Public concern about the safety of GM food is often expressed by demands for mandatory labeling, however, the public may prefer to default to experts for decisions related to biotechnology if they are uncertain or believe themselves unknowledgeable. Respondents were asked several questions to determine preferences for labeling (see Fig.4). While 84% of respondents supported mandatory labeling for food containing GM ingredients (fig. 4A), there was also overwhelming support for mandatory labeling food containing deoxyribonucleic acid (DNA) (fig. 4D). Eighty-percent of consumers supported a label for food indicating the presence or absence of DNA, an absurd policy that would apply to the vast majority of foods in a grocery store.

Rather than asking whether consumers want mandatory labeling, a more instructive question might be how they believe such an issue should be decided. A question similar to that posed by (21) was applied to the case of labeling, and results indicate only 35% thought decisions about mandatory labeling should mainly be based on the views of average Americans, with the remainder believing the issue should be decided by experts (fig. 4B). Furthermore, only 8% thought the issue of mandatory labeling should be decided by ballot initiative, and the majority, 58%, thought the issue should be decided by the U.S. Food and Drug Administration

(fig. 4C). Therefore, although most consumers support a mandatory label for GM food, most consumers also thought the decision should be made experts with more knowledge. Indeed, as previous results suggest, consumers had little knowledge of basic genetics.

Discussion

Although many consumers claimed to be opposed to GM food, there was an overall lack of knowledge about GM food. Previous research determined providing consumers with information from the scientific community about the safety of GM food did not affect opposition (8). However, simply asking knowledge questions about GM food appears to have informed consumers that opposition was formed without adequate knowledge, subjective knowledge and beliefs did change.

Whether mandatory labels should be required for GM food is a highly contentious topic. In the debates surrounding mandatory labels, data from consumer polls are often presented as evidence for precaution and labeling. The results within indicate that consumer polls are not an adequate proxy for the decision of whether a mandatory label should be required. Consumers also express support for absurd policies like DNA labeling. Such statements of support either indicate low level of knowledge about basic genetics, or they may also indicate how consumers psychological handle difficult questions. It has been argued (22) that individuals attempt to economize on scarce cognitive resources by unconsciously substituting an easier question for a hard one. Rather than seriously weighing the pros and cons of a mandatory labeling, the similarity in responses to the DNA labeling question suggests people may instead be substituting these questions with a simpler question like, “do you want free information about a topic for which you know very little?” This psychological process would lead to similar levels of support to two very different policy questions.

In addition to asking whether people wanted mandatory GM labeling, respondents were also queried about their “meta” preferences for how such a decision should be made. When given the option, the majority of consumers prefer that decisions about mandatory labeling of GM food be taken out of their hands and be made by experts. This finding is consistent with

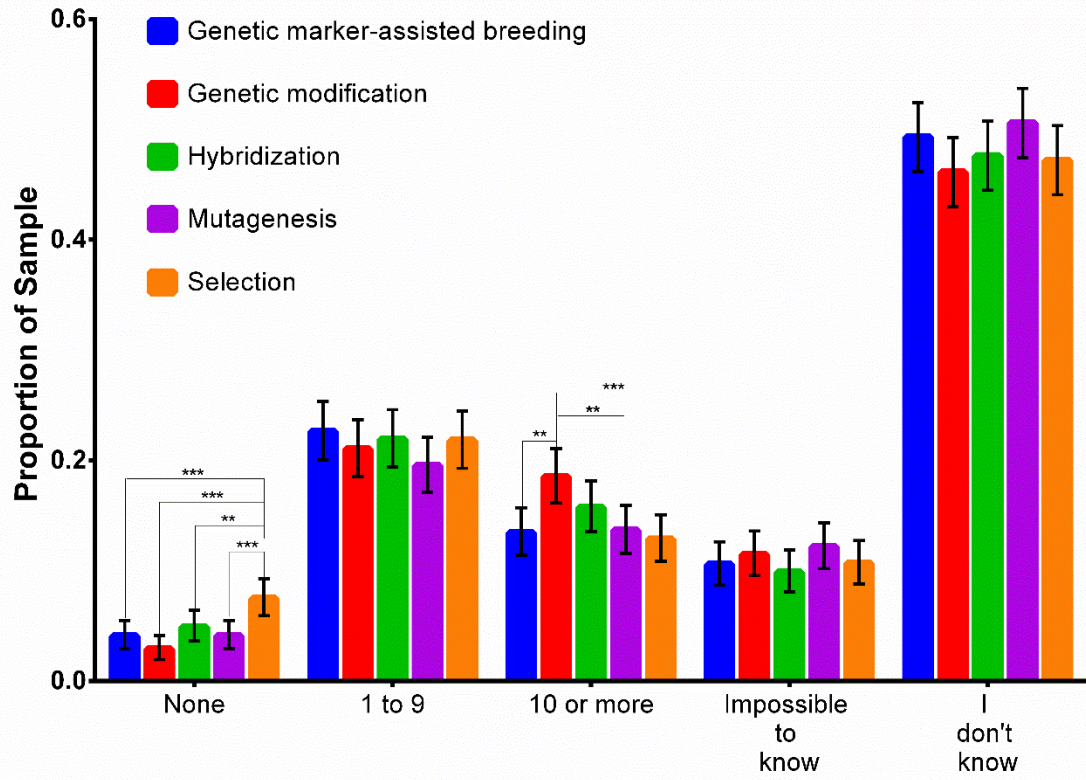
the notion that consumers' self-assessed knowledge of the topic is low. Consumers routinely defer to experts on complex decisions (e.g., for retirement advice, filing taxes, or selling a house). Indeed, the choice to defer to an expert is itself an admission of knowledge inadequacy.

After a bit of reflection, and hindsight bias, it seems obvious that consumer polls may not be a proximate cause for policy. It is unlikely someone would give a negative answer to a question that involves zero cost and may provide future benefit. Possibly confirming this idea was the result that nearly equal numbers of consumers prefer mandatory labeling of foods containing DNA as do those preferring mandatory labeling of GM foods.

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Note: Significant differences were determined using Tukey's test. *** and ** represent 0.01 and 0.05 levels of statistical significance, respectively.

Figure 1. Consumer Beliefs about the Number of Genes Altered by Various Breeding Techniques

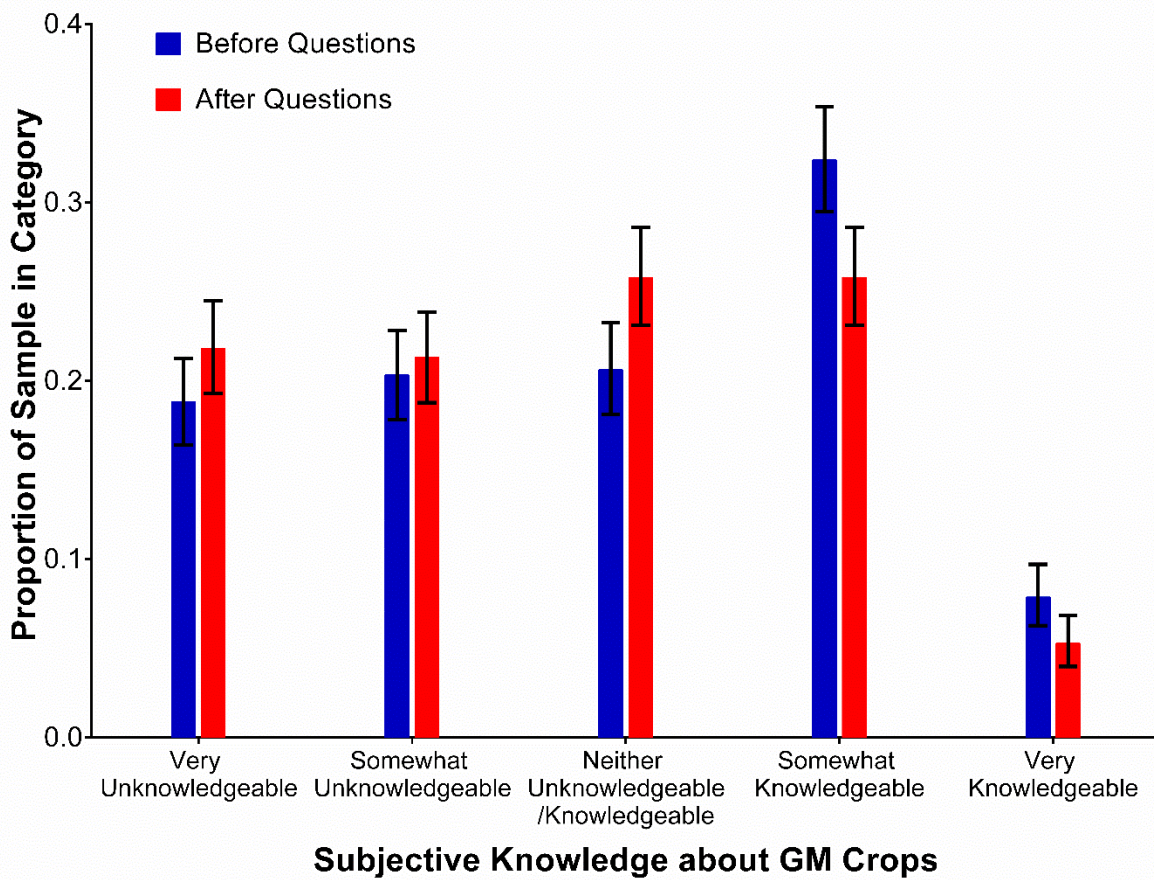


Figure 2. Subjective Knowledge Before and After Answering Questions about GM Crops

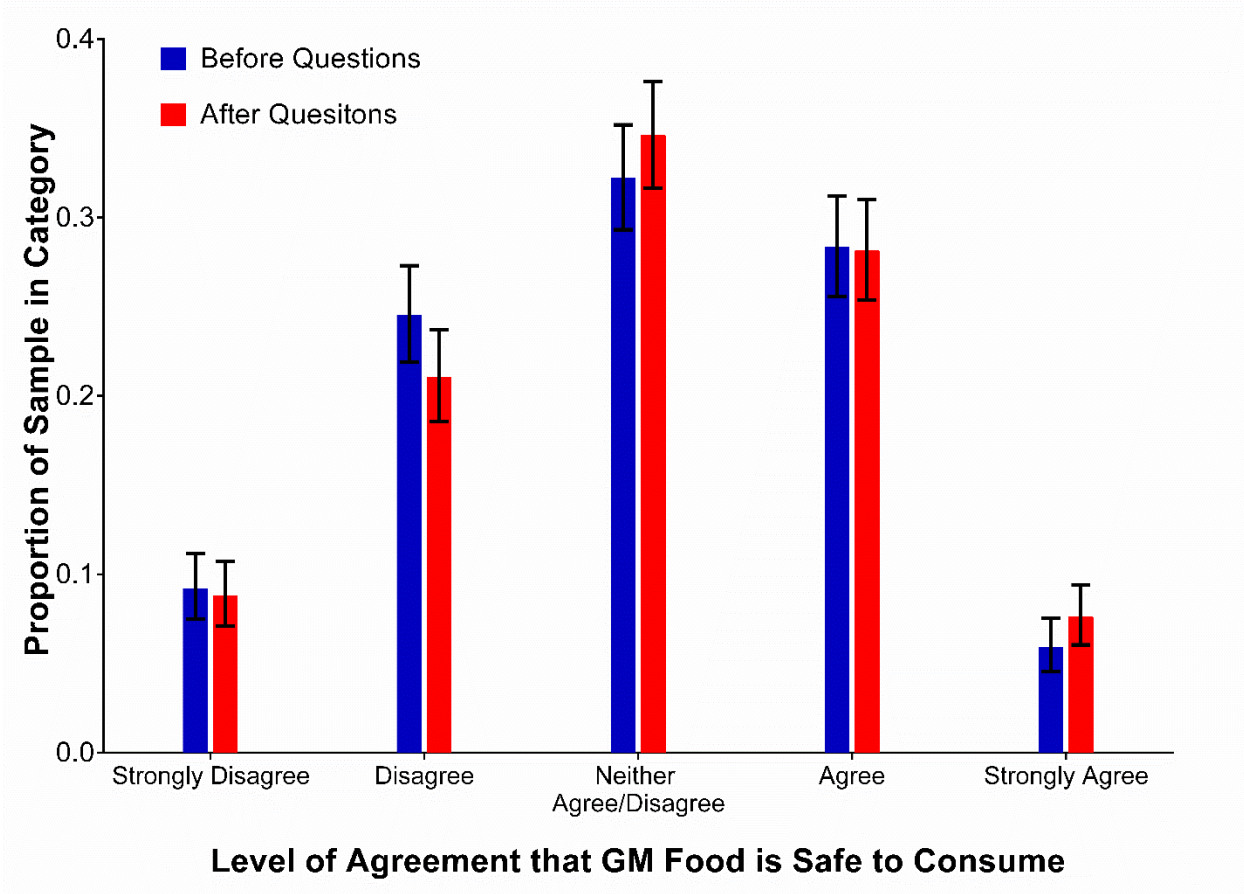


Figure 3. Beliefs about Safety of Consuming GM Food Before and After Answering Questions about GM

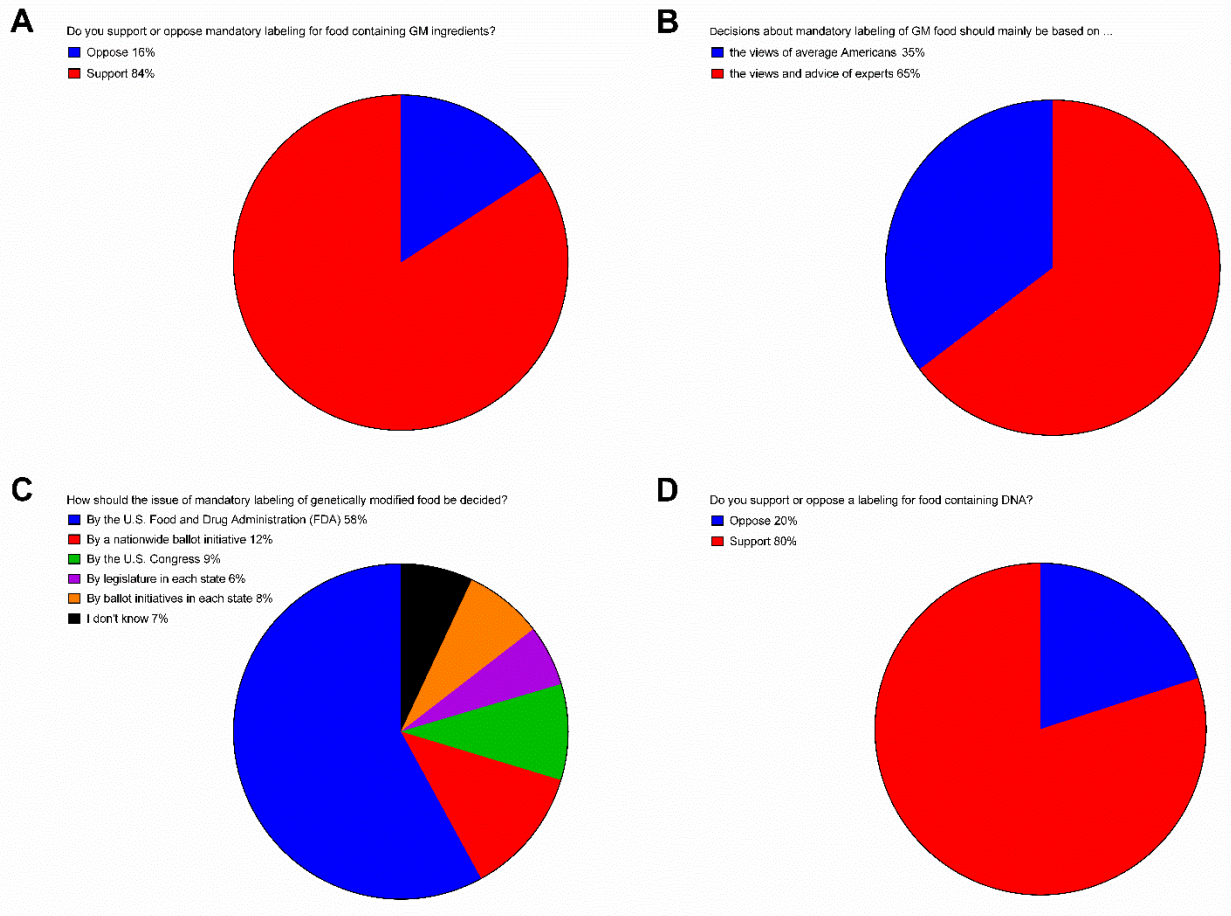


Figure 4. Views about Mandatory Labeling