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An Empirical Analysis of United States Consumers' Concerns about Eight Food Production and Processing Technologies

by
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Abstract
For a representative sample of U.S. consumers, we rank, correlate and explain ratings of concern toward eight food production and processing technologies (antibiotics, pesticides, artificial growth hormones, genetic modification, irradiation, artificial colors/flavors, pasteurization, and preservatives). Concern is highest for pesticides and hormones, followed by concern toward antibiotics, genetic modification and irradiation. We document standard relationships between many demographic, economic and attitude variables and the average concern level. Our main contribution is modeling relative levels of concern across technologies, where we find that key personal and household characteristics that yield little explanatory power for average ratings have sharp discriminatory power for relative ratings.

Keywords: food, technology, risk perception, consumers, seemingly unrelated regression.

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Introduction

Modern science is capable of generating incredible advances in food production and processing technologies that can produce more food, reduce costs and enhance attributes in ways not imagined only decades ago. However, due to the intimate and ubiquitous role that food plays in our life, the impacts of food production and processing on the environment, and the social and physical distance between consumers and the food production process, consumers scrutinize not only the cost and attributes of food but, increasingly, the technology and methods used in food production and processing.

The adoption of emerging food technologies or the rejection of existing technologies hinges on the outcome of this increasingly intense scrutiny. In this article we analyze the concerns that U.S. consumers express toward several prominent food production and processing technologies using data from a large, representative survey. First, consumer concerns across eight technologies (antibiotics, pesticides, artificial growth hormones, genetic modification, irradiation, artificial colors and flavors, pasteurization, and preservatives) are ranked. Second, correlations across the level of concern expressed for each technology are presented. Third, the economic, demographic and attitudinal variables that explain both the overall and relative level of concern with the eight technologies of interest are investigated.

Ranking the level of concern for each technology is of interest because the data are gathered from a representative sample of U.S. consumers; hence, it provides a view of which technologies are of greatest concern at the time the data were collected (summer 2002). The correlation across concern expressed for different technologies is of interest because it allows for speculation about the common elements of technologies that can

cause consumer reticence. Finally, exploring the demographic, economic and attitudinal correlates of expressed concern has several possible benefits. First, such analysis using U.S. data can be compared to similar analyses of data from other countries to look for commonalities and differences, i.e., are differences in expressed concern between the U.S. and European consumers due to a simple difference in demographics, attitudes or other characteristics? Second, how might U.S. consumer acceptance of technologies change over time as demographics shift or, alternatively, do niches of U.S. consumers currently exist that are more accepting of various technologies?

The remainder of the paper is organized as follows. First previous work analyzing consumer concern with food production and processing technologies is reviewed. Next the data and the statistical methods used to analyze the data are described. Then the results and accompanying discussion is presented. The final section provides conclusions and outlines avenues for future research.

Previous Research on Consumer Concern with Food Technologies

Many researchers have studied consumer attitudes, perceptions and acceptance of various food production and processing technologies with the bulk of recent efforts focused on genetic modification, irradiation, artificial hormones, and pesticides. Many studies document consumer demand for products differentiated with respect to a single technology (e.g., pesticides, Baker; hormones, Lusk, Roosen, and Fox; irradiation, Hayes, Fox, and Shogren; genetically modified foods, Teisl et al.) or several technologies (organic, Sylvander and Le Floc'h-Wadel). Several organizations have also conducted opinion polls to document public awareness and attitude towards various technologies

(Center for Science in the Public Interest, genetic modification; International Food Information Council, genetic modification; Abt Associates, Fox, Bruhn, and Sapp, several technologies; Gallop, several technologies). Closer in spirit to the current article are studies decomposing consumer attitudes and perceptions of one or more technologies (e.g., Govindasamy and Italia, pesticides; Verdurme and Viaene, genetic modification; Misra et al., irradiation; Grobe, Douthitt and Zepeda, bovine growth hormone; Dosman, Adamowicz, and Hrudey, additives and pesticides; Hoban, genetic modification; Frewer, Howard, and Shepherd, genetic engineering; Fife-Schaw and Rowe, several technologies).

Several common findings emerge across these articles. In most, women perceived greater risks than men (Misra et al., 1995; Fox et al., 2001; Dosman et al., 2001, Grobe, Douthitt, and Zepeda). Misra et al. (1995) found that females treated food irradiation as more serious problem even though women had lower stated awareness of irradiation. Dosman et al. (2001) found that gender was the only variable that was robust across risk perception models estimated for food additives, food bacteria, and pesticides.

In some research household income is associated with risk perception (Misra et al., 1995; Dosman et al, 2001; Grobe, Douthitt and Zepeda). Lower income respondents generally perceived more risk than higher income respondents. Misra et al. (1995) found that education level significantly affects risk perception for irradiation and suggested that female respondents with less than a college education and low income treat irradiation as a more serious problem. Dosman et al. (2001) also suggest that highly educated respondents usually perceive less risk in the sphere of food safety.

Fox et al. (2001) included the presence of children in their study; Grobe, Douthitt and Zepeda included the presence of children younger and older than six years of age; and

Dosman et al. (2001) included the number of children. Both the presence of children and the number of children had significant effects. Households with children had more negative views of irradiation than households without children (Fox et al., 2001) and, as households had more children, they perceived more risk related with food safety (Dosman et al., 2001). Grobe, Douthitt and Zepeda find that only households with younger children had significantly higher perceived risks of bovine growth hormone.

Data and empirical methods

During the summer of 2002 a mail survey was administered to a nationally representative sample of 6,172 U.S. residents, which included an additional over-sample of 710 individuals from one researcher's home state. In total 2,387 individuals responded (38.7 percent). For the questions analyzed in this article, 1,656 respondents provided complete information, yielding an effective response rate of 26.8 percent.

For all analyses, the data are weighted to adjust for the over-sampling of residents from the researcher's home state. Except for race, survey respondents have characteristics similar to those of the U.S. adult population (Table 1). The differences in race may reflect a bias in our sampling frame or may reflect differences in the phrasing of the race question between our survey and the U.S. census.

In addition to standard income and demographic variables discussed earlier (age, education, race, gender, occupation), several attitudinal variables were collected that might correlate to concern about food technologies. These include the respondent's general concern with the food production and processing practices in the United States and foreign countries (not specifically related to technology); the respondent's tendency to read

nutrition labels; whether the respondent follows any type of special diet (e.g., low salt, low fat); whether the respondent regularly purchases organic foods; whether the respondent purchases food at farmers' markets or health food stores; and whether the respondent frequents food cooperatives or grows his/her own produce. Each response may be correlated with underlying concerns about specific food production and processing technologies and may help clarify our portrait of these concerns.

Beyond summarizing how respondents rated their concern for each of the eight technologies of interest (antibiotics, pesticides, artificial growth hormones, genetic modification, irradiation, artificial colors and flavors, pasteurization, and preservatives) and assessing correlation of concerns across these technologies, we will describe the relative rating of each technology as a function of income, demographic and other household and personal characteristics. We allow for the possibility that consumer concern for each technology is driven by a different set of explanatory variables, while simultaneously allowing for the error term for each explanatory model to be correlated. The resulting model for technology *i* is:

$$\tilde{y}_{i,k} = y_{i,k} - \bar{y}_k = X_{i,k}\beta_i + u_{i,k} \qquad i = 1,\cdots,S, \quad k = 1,\cdots,N \tag{1}$$

where $\tilde{y}_{i,k}$ is respondent *k*'s normalized rating of technology *i*, $y_{i,k}$ is respondent *k*'s raw rating of technology *i*, $\bar{y}_k$ is respondent *k*'s average rating of all eight technologies, $X_{i,k}$ is a vector of explanatory variables for technology *i*, β_i is a conformable vector of parameters to be estimated and $u_{i,k}$ a component determining the relative rating of concern for technology *i* that is not observed.

Raw ratings are responses to the following survey prompt: "Listed on this page are different items related to the way foods are produced or processed. Review the list and

rate how concerned you are with each item." The list included the following terms: antibiotics, pesticides, artificial growth hormones, genetically modified ingredients, irradiation, artificial colors or flavors, pasteurization, and preservatives. Only four questions and a cover letter preceded this set of questions, and none of these materials mentioned or described any of the eight technologies nor attempted to gauge individual awareness of any technology. Hence, responses should be considered 'top of the mind' reactions that rely upon the respondent's knowledge base at the time of the survey and not upon reaction to any information provided in the survey.

For each technology, respondents circled a number on a scale that ranged from one (not at all concerned) to three (somewhat concerned) to five (very concerned). Normalizing the raw ratings as described in (1) transforms a discrete rating variable to a continuous variable, which relieves the need for utilizing more involved estimation processes. Furthermore, it sharpens the interpretation of the estimation results to highlight relative differences in concern across technologies. A separate equation estimating $\bar{y}_k$ as a function of variables is also included to gauge general concern levels.

Contemporaneous correlation between the error terms across individual technology equations are allowed by implementing a seemingly unrelated regression (SUR) and testing for its relevance (i.e., test for a diagonal system covariance matrix) using a Lagrange multiplier test statistic. Some complications remain, however, because the normalized ratings suffer from some censoring, i.e., some individuals uniformly rated their concern for all technologies as 'very concerned' (about eight percent) or 'not at all concerned' (about one percent), suggesting they may have held differential concern toward the technologies but the response scale limited their ability to express this concern. We

drop these censored observations from the SUR estimation process, which yields consistent though inefficient estimates of the parameters. A simple double-hurdle tobit model is estimated on the average rating to accommodate this censoring in our attempt to describe the factors driving the average level of concern for all eight technologies.

Results

Rating the level of concern for all eight technologies

The average ratings of the eight technologies are listed in Table 2 and reveal the average state of concern for this sample of U.S. consumers during the summer of 2002. The ratings suggest pesticides and artificial growth hormones generated the most concern from U.S. consumers, while technologies such as pasteurization, artificial colors and flavors and preservatives generated significantly less concern. Antibiotics, genetic modification and irradiation raised intermediate levels of concern.

The two technologies of greatest concern share several commonalities. First, both artificial hormones and pesticides can reside in or on food eaten by consumers, though the exact amount that enters the body and the exact health impacts of this consumption remain uncertain. The use of both can also have spillovers for the environment, with popular press accounts of the appearance of both pesticides and artificial hormones in water supplies and the ecosystem. The higher average rating for pesticides may derive from its broader reach – nearly all non-organic fruits, vegetable and grains use pesticides – while artificial growth hormones are only issues for a subset of animal products.

The technologies of intermediate concern – antibiotics, genetic modification, and irradiation – have fewer ways of affecting the consumer or have attributes that may be

positive. For example, unlike pesticides and artificial hormones, the concern for antibiotics arises not from the possibility of direct consumption by consumers, but because some worry that widespread antibiotic use in animal agriculture will speed the general rate of antibiotic resistance. Consumers may also view antibiotic use to have some upside, i.e., improving the health of animals and, hence, the quality of animal products consumed.

Consumer concern about genetically modified ingredients tends to lie with unknown long-term concerns about human and environmental health, but consumers may also be aware of GM technologies that reduce environmental damage or food's healthfulness. Likewise, irradiation is seen by some as an efficient means for preserving food safety while others worry about its affect on food nutrient value and the environment.

The technologies of least concern are all 'well established' in the minds of most consumers. Preservatives and artificial colors/flavors are often revealed in ingredient lists and have not stirred much media attention since the 1970s while pasteurization is a well accepted technology associated with improving the safety of milk and other beverages.

Correlation of relative concerns across technologies

Nearly all correlation coefficients for the eight normalized ratings are significantly different from zero at the one percent level of significance (Table 3). Large, positive correlation exists among several clusters. The first cluster involves the technologies of lesser concern: relative concern for preservatives is positively correlated with relative concern for pasteurization and artificial colors and flavors. Two of the technologies with moderate concern ratings are positively correlated (genetically modification and irradiation) as are the top two technologies of concern (pesticides and hormones).

Relative concern for antibiotics is significantly correlated to relative concern for pesticides (though the absolute magnitude of the coefficient is rather small), but antibiotic concern is uncorrelated with concern for artificial hormones. Also, the relative ratings for antibiotics and genetic modification are negatively correlated despite the statistical similarity of absolute concern for both technologies. That is, the average rating of concern is almost identical but individuals rarely rated the two technologies on the same side of average. This suggests that different forces drive the concern behind each technology: a topic which will be explored in greater detail with the ratings models described below.

Ratings models

Eight models explaining relative ratings as a function of individual and household characteristics and the model of average concern across all technologies are presented in Table 4.

The model of average concern across all technologies reveals several strong predictors. The strongest positive influence on average concern is the respondent's general stated level of concern about how food is produced in other countries (recall this question does not mention technology). Previous focus group work suggests that people with concerns about foreign produce often focus on the general level of sanitation of imported produce and animal products or the presence of chemical residues on imported produce (where respondents are often worried that other countries may allow application of chemicals currently banned in the United States, see Roe et al. for a more detailed discussion). Hence, if the latter element dominates the respondent's thinking, the positive relationship is quite logical: these individuals are generally concerned with technologies such as pesticides that could be consumed with foreign food. If the former element is the

true trigger of concern about foreign food production, the link to concern about food technologies is less obvious and may instead be linked to individuals who have reflected upon the interconnectedness of food systems, even across national borders.

A respondent that purchases organic food, reads nutrition labels and shops at farmers' markets or health food stores also provides higher average ratings. Each is intuitively linked to concerns about technology. Organic purchasing guarantees that many of the eight technologies are not used; organic and other 'natural' foods are often widely available in health food stores; and label readers are motivated to learn about the content of processed foods.

Controlling for the above lifestyle and concern characteristics, we find that several economic and demographic variables are significantly associated with average rating. Females and lower income respondents provided higher average ratings and, compared to those with the highest levels of formal education, individuals with a high school degree and some college education, provided significantly higher average ratings. Higher concern by female respondents is consistent with previous findings and may suggest greater female responsibility in food preparation, which persists despite significant increases in female workforce participation over the past decades. Lower income respondents may have less financial latitude to avoid undesirable technologies, e.g., be unable to afford organic foods, which minimize exposure to many technologies but cost more. The higher ratings from those with lower levels of formal education is also consistent with previous findings (Dosman et al.) and may be related to a perceived lower ability to comprehend emerging scientific findings concerning the safety of food technologies and, hence, less ability to selectively avoid only the technologies viewed as unhealthy.

Lower average ratings are associated with the oldest (> 65 years) and youngest (< 30 years) respondents. This is consistent with Teisl, Levy and Derby (1999) who found that health related awareness is lower when young, increases with age through middle age, and then decreases with further increases in age. Lower average ratings are also associated with households with older children (compared to no children); Caucasian respondents; higher income respondents; and respondents employed in food system occupations.

The youngest and oldest respondents may have low average concern due to discounting of potential negative consequences of the technologies. Young respondents may believe mitigation of cancer or other sequelae of dangerous technologies will be available in the future while older respondents may believe that other health issues may overshadow any consequences of food technologies.

Our finding that respondents with older children have lower levels of concern is inconsistent with previous literature. These households may be overwhelmed with other household food issues (e.g., cost, convenience) such that the underlying technology used in food production and processing is a secondary concern. Higher income respondents may feel that they have adequate resources to either avoid potentially unsafe technologies or to mitigate consequences in the future. Finally, those respondents employed in the food system may have more familiarity with the technologies, which can mitigate concern.

Explaining the relative levels of technology concern

The results of the average model, while interesting and generally intuitive, hide interesting details surrounding the relative concern expressed for each technology. Importantly, many of the individual and household characteristics that provide significant explanatory power for the average rating model do little to discriminate relative ratings

across technologies, while variables that do little to explain average ratings emerge as key predictors of relative ratings.

For example, consider respondents in the lowest category of formal education (Edu1). Compared to those with the highest levels of formal education, these respondents had a similar average concern for the technologies. However, these respondents have large differences in concern for individual technologies: they are much more concerned about pasteurization and preservatives than the highest education group and much less concerned about pesticides and hormones. When looking more broadly at the effect of education on concern, we find that lower levels of formal education are generally associated with higher concern for pasteurization, irradiation and preservatives and lower concern for antibiotics, hormones, and artificial colors and flavors. Education has little discriminatory power for assessing concern with pesticides and genetic modification. One interpretation might be that respondents with less formal education are relatively more concerned with older, more established technologies, such as pasteurization and preservatives while those with more formal education focus concern on recently publicized technologies such as hormones and antibiotics. However, relative concern for irradiation and artificial colors/flavors does not follow this intuition, suggesting this intuition provides only a partial explanation.

Respondent race and gender also has widely varying influences on relative technology concern. Caucasian respondents (White) have greater relative concern for hormones, artificial colors/flavors and genetic modification and less relative concern for pesticides, pasteurization, and irradiation. Females provide lower relative ratings for pesticides and preservatives and higher relative ratings for pasteurization and irradiation.

Younger respondents (Age < 30) have higher relative concern for genetic modification while older respondents (Age > 65) have lower relative concern for GM technologies. The under 30 segment holds relatively high concern about irradiation and relatively low concern about preservatives while those over 65 provide relatively high ratings of antibiotics and preservatives and relatively low ratings to hormones.

Those in the lowest income category (Inc Low) hold significantly lower levels of concern about hormones than the middle income category (the omitted categorical variable) and significantly higher levels of concern for irradiation.

Those who listed high levels of general concern with the way food is produced and processed in the United States (Conc US) were significantly more concerned with antibiotics and significantly less concerned with artificial colors/flavors. This squares with the media accounts of excess antibiotic use in the United States while many European countries have moved to drastically limit antibiotic use in animal production systems. Those with higher levels of general concern for the way food is produced and processed in other countries (Conc Otr) had high concern for hormones and genetic modification but lower concerns for pesticides. This does not correspond with our anecdotal assessment that many such individuals worried about consuming imported foods with traces of banned chemicals, nor does it make much sense given that food produced in the United States is more likely to use hormones and genetic modification than food grown in other parts of the world. Hence, the indicator of concern about food production methods in other countries may reflect a greater level of concern about the interconnectedness of food systems rather than specific concerns about technologies.

An intricate pattern emerges when assessing relative concern for technologies across respondents differentiated by consumption patterns, e.g., organic consumers (Purch Org), farmers' market/health food store consumers (Farm Mkt), food cooperative members (Food Coop), and home-growth of vegetables (Grow Veg). Organic food consumers held higher levels of concern about both genetic modification and irradiation and lower concern for pasteurization. Respondents that frequent farmers' markets and health food stores have greater concern for antibiotics and hormones while less concern about irradiation.

Members of food cooperatives also hold higher levels of concern for genetic modification and lower levels of concern for pasteurization, though are more concerned about artificial colors/flavors, perhaps as food cooperatives tend to promote local food production and consumption with minimal processing. Artificial colors and flavors are a staple of more highly processed foods. Those who grew their own vegetables revealed significantly lower levels of concern for genetic modification, which is not surprising given that these individuals can control the type of seed planted in their own gardens.

Relative concern for antibiotics and genetic modification

We now focus on comparing the forces driving relative concern for antibiotics and genetic modification. While similar pair-wise comparisons could be drawn for any two of the eight technologies, this is an interesting example to elaborate because, as mentioned above, the two technologies received statistically similar average ratings yet their relative ratings were negatively correlated. On the surface, the two technologies have some striking differences. Antibiotic use is limited to animal agriculture while genetic modification is mostly associated with plant agriculture. Antibiotic concerns mainly derive from issues of increased resistance due to increased presence of animal antibiotics

in the environment while some consumers worry that consumption of genetically modified ingredients could have unforeseen health or environmental consequences. Both share the fact that consumers are increasingly aware of the general topic of concern but often lack much detail or are confused concerning the exact state of scientific understanding of the two technologies' potential for inflicting personal and societal damage.

Comparing the qualitative results between these two technologies' relative ratings parameters (column 1 and 6) reveals many conflicting influences. For example, those who are concerned about how food is produced in other countries (Conc Otr) have higher relative concern for genetic modification and lower relative concern for antibiotics. In terms of respondent purchasing habits, we find that an organic consumer (Purch Org) with membership in a food cooperative (Food Coop) has a higher relative concern about genetic modification but lower relative concern for antibiotics. Both technologies are outlawed under organic production standards in the United States, so the difference does not appear to arise from this fact.

Older respondents (Age > 65) differ in relative concerns; this group places more concern on antibiotics and less concern on genetic modification. Respondents with less formal education are also split on the relative concern for these two technologies with greater concern attached to genetic modification and less concern to antibiotics.

Several factors drive relative concern for these technologies in the same direction. For example, respondents who tend to read labels (Nutr Label) view both technologies as a greater source of concern while those involved in food system jobs (Food Job), and may have more direct knowledge or awareness of developments concerning these technologies, provide lower relative ratings for both technologies. Also, younger respondents (Age <

30) and respondents with children between the ages of five and ten (Child 10) have heightened concern for both technologies.

Summary and Conclusion

For a representative sample of U.S. consumers, we rank, correlate and model ratings of concern toward eight food production and processing technologies. We find concern is highest for pesticides and hormones, followed by concern toward antibiotics, genetic modification and irradiation. Correlations among relative ratings generally reflect differences in raw ratings, with similarly (differently) rated pairs of technologies displaying positive (negative) correlation. Several pairs of technologies that received similar ratings across the sample (e.g., genetic modification and antibiotics), however, display a strong negative correlation, suggesting that individual respondents rated the two technologies quite differently though these differences were smoothed over in calculating the average in raw ratings.

Results from models that explain the average raw ratings across technologies are similar to many of the previous findings in the literature about consumer concern toward food risks. For example, we find respondents with higher levels of general concern and awareness towards food and food risks; are female; have less formal education and lower incomes; are middle-aged; or are of minority racial groups express greater concern toward food technologies on average. Contrary to some previous literature, we find respondents with young children have similar levels of concern as respondent with no children while households with older children express less concern than childless households.

Our exploration of the individual ratings of concern with each technology relative to the average rating reveals considerable heterogeneity in how personal and household characteristics affect stated concern. By design, no characteristic can drive relative concern in the same direction across all technologies because the concern toward each technology is expressed in relative terms. We reveal a wealth of differential effects of characteristics across relative concern towards technologies and show that variables that have little effect in explaining average concern toward food technologies may have considerable discriminatory power in explaining relative ratings across technologies.

Analysis of the relative ratings may provide insight into market niches that may be more accepting of certain types of technologies. For example, our models suggest that genetically modified products may be more acceptable to older consumers with occupational experience in the food system while irradiation might be most acceptable to more highly educated, Caucasian consumers who purchase food in alternative outlets (food cooperatives, farmers' markets, and health food stores). Food produced with artificial growth hormones might be most accepted, in a relative sense, by older consumers with lower incomes and less formal education.

Significant work remains towards understanding the roots of the myriad of results presented above, particularly with regard to how various personal and household characteristics impact relative concerns for various technologies. Greater insights may be possible if theories of risk communication and response are brought to bear on the current empirical regularities.

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Table 1. Socio-economic characteristics of respondents

	Survey	U.S. Census
Percent male	46	48
Average age	53	47
Average years of education	14	13
Percent white	89	75
Average household income	$60,900	$57,000

Table 2. Average raw ratings of concerns about food technologies[a, b, c]

Pesticides	4.17 a
Artificial growth hormones	4.00 b
Antibiotics	3.77 c
GM ingredients	3.73 c
Irradiation	3.58 d
Preservatives	3.21 e
Artificial colors/flavors	3.07 f
Pasteurization	2.77 g

[a] Raw ratings are as follows: 1 = not at all concerned, 3 = somewhat concerned and 5 = very concerned.

[b] Results sharing the same letter are not significantly different

[c] These results were first reported in a companion paper previously published by several of the authors.

Table 3. Correlation coefficients between normalized ratings (n=1,504)

	Antibiotic	Pesticides	Hormones	Pasteur.	Art. Col./Fla.	GM	Irradiation	Preserv.
Antibiotics	1.000							
Pesticides	0.071 (0.006)	1.000						
Hormones	0.021 (0.426)	0.080 (0.002)	1.000					
Pasteur.	-0.250 (0.000)	-0.263 (0.000)	-0.514 (0.000)	1.000				
Art. Col./Flav.	-0.152 (0.000)	-0.250 (0.000)	-0.235 (0.000)	-0.070 (0.006)	1.000			
GM	-0.123 (0.000)	-0.130 (0.000)	0.358 (0.000)	-0.398 (0.000)	-0.258 (0.000)	1.000		
Irradiation	-0.265 (0.000)	-0.094 (0.000)	-0.052 (0.046)	-0.191 (0.000)	-0.217 (0.000)	0.147 (0.000)	1.000	
Preserv.	-0.222 (0.000)	-0.188 (0.000)	-0.451 (0.000)	0.352 (0.000)	0.112 (0.000)	-0.434 (0.000)	-0.314 (0.000)	1.000

[a] p-values are in parentheses

Table 4. Model of normalized ratings of technology concern and average technology concern[a,b]

	Antibiotic	Pesticides	Hormones	Pasteur.	Art. Col./Fla.	GM	Irradiation	Preserv.	Average[C]
Constant	0.281***	1.062***	-0.036	-0.126	-0.416***	-0.374***	-0.262**	-0.129	1.214***
	(2.38)	(11.33)	(-0.31)	(-0.89)	(-3.26)	(-3.56)	(-2.24)	(-1.48)	(9.94)
Conc US	0.058***	-0.014			-0.074***		0.030		0.417***
	(2.86)	(-0.83)			(-3.45)		(1.53)		(20.63)
Conc Otr	-0.036*	-0.054***	0.057***	-0.028	0.022	0.063***		-0.025	0.916***
	(-1.86)	(-3.28)	(3.22)	(-1.23)	(1.08)	(3.70)		(-1.46)	(5.19)
Purch Org	-0.037			-0.090***	0.035	0.034*	0.059***		0.779***
	(-1.58)			(-3.71)	(1.53)	(1.78)	(2.57)		(3.63)
Nutr Label	0.011		0.039**	-0.087***	0.024	0.014			0.656***
	(0.51)		(2.10)	(-3.52)	(1.09)	(0.76)			(3.21)
Female		-0.124***		0.079*	-0.046	0.049	0.109***	-0.068*	0.245***
		(-3.47)		(1.78)	(-1.08)	(1.33)	(2.58)	(-1.89)	(6.48)
Age < 30	0.003		-0.010		-0.106	0.133**	0.199***	-0.218***	-0.151**
	(0.04)		(-0.16)		(-1.40)	(2.11)	(2.62)	(-3.13)	(-2.23)
Age > 65	0.139***		-0.130***		0.027	-0.088*	-0.035	0.086*	-0.899**
	(2.54)		(-2.75)		(0.48)	(-1.89)	(-0.62)	(1.67)	(-1.84)
Child 5	-0.046		0.053	0.013	-0.101**	0.044	0.068	-0.031	0.279
	(-1.01)		(1.23)	(0.25)	(-2.22)	(1.06)	(1.46)	(-0.72)	(0.69)
Child 10	0.086*		0.004	-0.109*	0.022	0.095**	0.036	-0.133***	-0.858**
	(1.84)		(0.08)	(-1.95)	(0.47)	(2.20)	(0.75)	(-2.96)	(-2.07)
Child 18	-0.003		-0.018	-0.050	-0.015	0.046	0.048	-0.009	-0.508*
	(-0.08)		(-0.61)	(-1.36)	(-0.46)	(1.60)	(1.49)	(-0.30)	(-1.81)
Grow Veg		0.056		-0.057	0.057	-0.079**	0.068	-0.044	0.333
		(1.46)		(-1.20)	(1.26)	(-2.02)	(1.49)	(-1.14)	(0.83)
Food Coop	-0.260			-0.360*	0.483***	0.365***	-0.227		0.109
	(-1.44)			(-1.87)	(2.67)	(2.44)	(-1.29)		(0.73)
Farm Mkt	0.082*	-0.026	0.081**				-0.137***		0.726*
	(1.89)	(-0.75)	(2.22)				(-2.89)		(1.65)

	Antibiotic	Pesticides	Hormones	Pasteur.	Art. Col./Fla.	GM	Irradiation	Preserv.	Average[C]
No Diet	-0.069*		0.083**				0.069	-0.082**	-0.406
	(-1.71)		(2.32)				(1.63)	(-2.19)	(-1.00)
Edu1	-0.096	-0.126	-0.272***	0.514***	-0.136	0.003	-0.072	0.185*	0.114
	(-0.88)	(-1.40)	(-2.54)	(3.85)	(-1.21)	(0.03)	(-0.63)	(1.74)	(1.15)
Edu2	-0.256***	0.011	-0.096	0.274***	-0.166***	0.077	0.180***	-0.022	0.319***
	(-3.85)	(0.19)	(-1.45)	(3.32)	(-2.41)	(1.25)	(2.55)	(-0.35)	(5.10)
Edu3	-0.106*	-0.060	-0.101	0.242***	-0.112*	0.002	0.056	0.078	0.186***
	(-1.67)	(-1.13)	(-1.63)	(3.09)	(-1.71)	(0.03)	(0.84)	(1.28)	(3.18)
Edu4	-0.022	-0.037	0.005	0.009	-0.077	0.115*	-0.014	0.019	0.558
	(-0.33)	(-0.66)	(0.08)	(0.12)	(-1.13)	(1.90)	(-0.20)	(0.30)	(0.94)
White		-0.124**	0.154***	-0.151**	0.121*	0.138***	-0.139**		-0.197***
		(-2.27)	(2.71)	(-1.98)	(1.78)	(2.56)	(-2.28)		(-3.42)
Food Job	-0.125*		0.050			-0.115*		0.191***	-0.236***
	(-1.73)		(0.82)			(-1.85)		(2.62)	(-3.19)
Inc Low			-0.156*				0.156*		0.324***
			(-1.92)				(1.92)		(3.32)
Inc High			0.019				-0.019		-0.168***
			(0.49)				(-0.48)		(-3.26)
	System weighted R^2: 0.036								σ: 0.734 LogL: -1836 Consistent R^2: 0.42[d]

[a] ( ) are t-values.
[b] *: significant under 90% confidence level. **: significant under 95% confidence level. ***: significant under 99% confidence level.
[c] The *t*-values reported with the average estimates are asymptotic *t*-values (Judge et al., 1988).
[d] R^2 value associated with the consistent estimator of the average rating, which involves dropping 152 observations with values of '1' or '5' for an average rating and estimating the model using OLS.

Appendix: Definition of explanatory variables

Variable	Description
Conc US	Concern about the way foods are produced and processed in the United States on a five point scale with 1 implying 'not at all concerned,' 3 implying 'somewhat concerned' and 5 implying 'very concerned'.
Conc Otr	Concern about the way foods are produced and processed countries other than the United States on a five point scale with 1 implying 'not at all concerned,' 3 implying 'somewhat concerned' and 5 implying 'very concerned'.
Purch Org	The frequency of purchase of organic food on a five point scale with 1 implying 'never' and 5 implying 'always'.
Nutr Label	The frequency of reading of food nutrition labels on a five point scale with 1 implying 'never' and 5 implying 'always'.
Female	Qualitative variable (Male=0, Female=1)
White	Qualitative variable. 1 if Caucasian, 0 otherwise.
AGE	Qualitative variables. AGE <30: 1 if age ≤ 30 years. AGE 30-65 1 if 30 < age ≤ 65 years, 0 otherwise. AGE >65: 1 if age > 65 years, 0 otherwise.
EDU	Qualitative variables. Edu1: 1 if 0-11 years, 0 otherwise. Edu2: 1 if 12 years (high school graduate or equivalent), 0 otherwise. Edu3: 1 if 1-3 years college (some college), 0 otherwise. Edu4: 1 if college graduate, 0 otherwise. Edu5: 1 if more than an undergraduate degree, 0 otherwise.
Child 5	Number of children ≤ 5 years old.
Child 10	Number of children 6 to 10 years old.
Child 18	Number of children 11 to 18 years old.
Grow Veg	1 if household grows own vegetables, 0 otherwise.
Farm Mkt	1 if respondent shops at a farmers' market or health food store regularly, 0 otherwise.
Food Coop	1 if respondent is a member of a food cooperative, 0 otherwise.
No Diet	1 if respondent follows no dietary restrictions,[$] 0 otherwise.
Food Job	1 if respondents works in certain food system jobs,[b] 0 otherwise.
Income	Qualitative variable. Inc Low: 1 if income is < $5,000 per year, 0 otherwise. Inc Med: 1 if income is between $5,000 and $95,000, 0 otherwise. Inc High: 1 if income is > $95,000, 0 otherwise.

[a] Dietary restrictions include diabetic diet, low fat diet, high fiber diet, food allergies/sensitivities, vegetarian diet, low sodium diet, kosher sodium diet, and others.

[b] The fields include large scale conventional farming, small scale conventional farming, large scale organic farming, small scale organic farming, dairy farming or livestock farm, food processing, grocery store, cook, caterer or restaurant owner, other agricultural or food processing work.