AgBioForum, 9(2): 121-128.

Does Application Matter? An Examination of Public Perception of Agricultural Biotechnology Applications

Andrew J. Knight
Michigan State University

Whereas most research on public perceptions of genetically modified products have focused on first-generation biotechnologies and genetically modified foods, this paper examines public support for a variety of animal and plant agricultural biotechnology applications and explores whether the determinants of support for each application vary by knowledge, trust, benefits, and sociodemographic variables. The data for this study were gathered from 432 adults in a regional Southwestern telephone survey conducted from March 28 through May 4, 2004. The results revealed that the vehicle used (animal or plant) appears to outweigh both the function and type of application, although nonfood applications tended to receive higher support levels than genetically modified foods. Plant applications received higher support than animal applications. Additionally, the determinants for each biotechnology application were different, and their explanatory power varied by application. Only perceived benefits was significantly related to each biotechnology application.

Key words: benefits, biotechnology, cloning, functional foods, genetically modified animals, genetically modified foods, plant-made industrial products, plant-made pharmaceuticals, plant molecular farming.

Agricultural biotechnologies can be classified into three product lines. First, a majority can be termed as *first-wave* bioengineered products, where specific traits are added or enhanced to increase yields by making plants pest and disease resistant, hardier, and less energy intensive, which in turn increases farm profitability. First-wave applications have become widely adopted for some crops. For instance, 85% of soybeans, 45% of corn, and 76% of cotton grown in the United States in 2004 were genetically modified (Pew Initiatives on Food and Biotechnology [PIFB], 2004a). An estimated 54% of all canola and 50% of all papayas grown in 2001 were genetically modified (PIFB, 2004a).

First-wave products have not been limited to plants. About 17% of dairy cows in the United States were injected with a genetically modified (GM) version of a naturally occurring bovine growth hormone to increase milk production in 2001 (Barham, Foltz, & Moon, 2002; McBride, Short, & El-Osta, 2004). The British Broadcasting Company (2003) reported that the future of farming lies in cloning disease-resistant animals. Cloning exhibits human control of genes, as humans continue to develop methods to clone specific characteristics of animals or enhance nature through the addition of selected genes. This process enables humans to create "designer" insects and animals.

Several *second-wave* bioengineered products are now available. These products are referred to as "nutraceuticals" or "functional foods," in which specific traits are added or enhanced to increase nutrients or improve the taste of food crops or animals. Such products are being marketed as providing healthier and better tasting foods to consumers. For example, tomatoes are designed to produce more lycopene to lower cholesterol levels, "golden rice" was designed to enhance the level of vitamin A in rice to reduce the risk of blindness, and research is being conducted to reduce the bitterness in citrus fruits. In the case of animals, cloning could enhance the best traits of animals to produce more tender and tasty meat. Although information on the actual number of functional foods currently available is fleeting, estimates have suggested that the annual growth rate of the functional food market ranges from 10% to 20% and has been reported as the top food industry trend (Verbeke, 2005).

Third-wave bioengineered products comprise plants or animals that are grown or raised for nonfood purposes, such as plants or animals grown or raised for pharmaceutical, cosmetic, and industrial byproducts, which are harvested and processed into drugs, chemical compounds, and plastics. Often referred to as "plant molecular farming" or "biopharming," biotechnology advocates propose that these products will produce vaccines, antibodies, other pharmaceuticals, industrial enzymes, or bioplastics in greater quantity and at lower costs than traditional methods. Although only a few plant-made pharmaceuticals are currently on the market (such as Prodigene's Trypsin), several others are in clinical or field trials (Bio, 2006; Dey, 2004; Freese & Caplan, 2004; Stewart & Knight, 2005). Transgenic animal experiments involve applications such as growing human organs in animals (particularly pigs) for transplants, the mass production of drugs in cow's milk, and producing silk in goat's milk.

Despite the adoption of and continued experimentation with GM products, GM plants and animals remain controversial. For example, some wheat producers in both Canada and the United States have opposed the commercialization of GM wheat. Consumer, organic, and environmental groups, as well as grocery and food manufacturer associations, have raised questions about the containment, safety, and risks involved with some biotechnology applications—particularly plant-made pharmaceuticals (PMPs) and plant-made industrial products (PMIPs)—and have called for a zero-tolerance policy, which would effectively limit these GM crops to be grown in laboratories, greenhouses, or isolated fields. Because of the concerns raised by these groups, the number of biopharm field trials peaked in 2000, but evidence suggests that the number of field trials is once again increasing (Freese & Caplan, 2004; Jaffe, 2004). The genetic modification and cloning of animals have faced even more opposition from environmental groups.

The research question for this study is: Does application matter? Whereas most research on public perceptions of GM products have focused on first-generation biotechnologies and GM foods, this paper examines public support for a variety of GM animal and plant applications and explores whether the determinants of support for each application vary by knowledge, trust, benefits, and sociodemographic variables.

Previous Research on Perceptions of Biotechnology Applications

Most of the research on consumer perceptions of agricultural biotechnology applications has thus far been limited to GM foods. As such, there is a growing and rather substantial body of work on public perceptions of GM foods. As demonstrated in the introduction, however, a wide variety of new biotechnology-derived products are becoming available in the marketplace. As the goal of this study is to compare public support among a variety of agricultural biotechnology applications, the following literature review will focus on studies that have either compared public opinion about different biotechnology applications or examined public perceptions of second- and third-generation biotechnologies.

Hoban, Woodrum, and Czaja (1992) found that North Carolina residents indicated higher opposition to animal biotechnology applications than to plant applications. Frewer, Hedderley, Howard, and Shepherd (1997) noted that objections to biotechnology applications tended to vary by the vehicle used and not by the end use (i.e., food, agriculture, and medicine). For example, opposition to biotechnologies derived from animal and human sources was higher than applications derived from plants. In a review of surveys conducted in the early to mid 1990s, Hoban (1998) demonstrated that acceptance of biotechnology products varied by application. Human medicines, insect-protected crops, and herbicide-resistant cotton had the highest levels of acceptance (>60%), followed by disease-resistant animals (about 55%) and GM foods (about 34%).

Using 1996 Eurobarometer data, Gaskell (2000) analyzed seven biotechnology applications on four attributes—*useful*, *risky*, *acceptable*, and *encourage*. European respondents ranked genetic testing most positively, followed by medicines, bioremediation, clone human cells, crops, clone animals, and food. About an equal number of respondents perceived crops to be both useful and risky, and as less acceptable than genetic testing, medicines, bioremediation, and clone human cells. Clone animals and food were perceived negatively and as particularly risky and unacceptable. A 2004 survey conducted by PIFB (2004b) found that Americans were most comfortable with GM plants, followed by microbes, animals for foods, insects, animals for other purposes, and humans. It should be noted, however, that on a scale of 1 to 10, only plants had a mean comfort rating over 5, revealing that the American public is particularly uncomfortable with the genetic modification of animals, insects, and humans.

Compared to the number of studies on first-generation biotechnology applications and GM foods, the literature on consumer perceptions of second- and third-generation biotechnology applications is sparse. Three European studies on functional foods were located. Urala and Lahteenmaki (2004) discovered that respondents were willing to use some functional foods but not others. Respondents were likely to use juices that are probiotic, beverages with added calcium, cholesterol-lowering spreads, and sweets and chewing gum with xylitol. On the other hand, respondents were unlikely to use blood-pressure-lowering milk drinks, meat products with added fiber, and energy drinks. Cox, Koster, and Russell (2004) compared the intention to consume natural, supplement, sweetened, and GM functional foods. Respondents ranked GM functional foods significantly lower than the other types of functional foods. Verbeke (2006) found that acceptance of functional foods varied by taste. If functional foods taste good, a majority of respondents would accept them. However, if they taste worse than conventional foods, most respondents would not accept them.

Two studies on plant molecular farming were located. Kirk and McIntosh (2005) surveyed 706 respondents in the Phoenix, Arizona area using three different samples: classroom questionnaires, public-venue interviews, and random telephone interviews. They found that about two thirds of respondents were likely to accept a vaccine produced in a GM tomato. Einsiedel and Medlock (2005) conducted four focus groups in four Canadian cities; they concluded that the overall impression of plant molecular farming was rather positive and that PMPs were viewed as more acceptable than PMIPs by the 48 attendees.

A review of the available literature shows that few studies have compared biotechnology applications and that few studies have attempted to uncover the determinants of support for a variety of biotechnology applications. Previous studies do indicate that support for biotechnology varies by the vehicle used, particularly between plants and other vehicles (e.g., animals and humans), and that biotechnology applications with health implications receive higher levels of support than other types of applications. As well, little is known about consumer perceptions of second- and third-generation biotechnology applications—particularly perceptions of US consumers. This study attempts to fill these gaps in the literature by systematically examining public perceptions of various first-, second-, and third-generation animal and plant biotechnology applications.

Variables Associated with Consumer Perceptions of Biotechnology

A review of previous studies reveals that knowledge, trust, benefits, and sociodemographic variables are associated with consumer perceptions of biotechnology. Frewer, Shepherd, and Sparks (1994) claimed that knowledge is important to understanding risk perceptions in the degree to which respondents know they are exposed to risk and how much the individual and science (regulatory agencies) know about the nature of risks. A consistent finding is that consumers have low levels of awareness and knowledge of biotechnology as well as low levels of engagement (Hallman, Adelaja, & Schilling, 2002; Hoban, 1996; Priest, 2000). Although some previous empirical studies have demonstrated that knowledge is positively related to perceptions of agricultural biotechnology applications (Harrison, Boccaletti, & House, 2004; Hoban et al., 1992; Hossain, Onyango, Schilling, Hallman, & Adelaja, 2003; Verbeke, 2005), House et al. (2004) claimed that the "impact of knowledge on consumer acceptance of GM foods has been measured in a number of studies with contradictory results" (p. 113), and its significance varies according to how it is measured.

Trust is a central explanatory variable in risk perception models. The importance of trust (and conversely distrust) was highlighted by Frewer et al. (1997) who wrote that "these questions [trust and credibility in information sources and risk regulators] must be addressed in any investigation of the importance of public attitudes to food science and subsequent impact on attitudes and behaviors" (p. 78). Despite the robustness of trust, Siegrist and Cvetkovich (2000) concluded that trust is only an important determinant of risk perception in the absence of knowledge. Thus, if a person is knowledgeable about a particular hazard, trust is either not significant or its influence is diminished considerably. As previous studies have documented that the public has low awareness and knowledge of biotechnology, it follows that trust in institutions will be an important predictor of perceptions about agricultural biotechnologies, as demonstrated in prior research (Harrison et al., 2004; Hoban et al., 1992; Hossain et al., 2003). Respondents who held more trust in institutions tended to have higher levels of support for biotechnology applications.

There is a common belief among proponents that the public will accept biotechnology if they perceive a benefit (Krueger, 2001). The link between biotechnology acceptance and perceived benefit has been found in previous studies (e.g., Frewer et al., 1997; Hossain et al., 2003; Urala & Lahteenmaki, 2004; Verbeke, 2005). In the case of functional foods, benefits have been conceptualized in terms of health benefits. It is hypothesized that those who view biotechnology as beneficial will have higher levels of support than those who view it as less beneficial or risky.

Lastly, perceptions of risks vary by sociodemographic characteristics. Three studies have shown that consumer acceptance and approval of GM foods and crops are influenced by religious values (Biel & Nilsson, 2005; Evensen, Hoban, & Woodrum, 2000; Hossain et al., 2003). Consistent with these studies, it is expected that respondents who hold religious views would have lower support for biotechnology applications than those who are less religious. The safety concerns hypothesis states that women are more likely to be concerned about food and health risks than men because women are socialized to be primary care givers within the family (Davidson & Freudenberg, 1996). Although several studies found that demographic variables, such as gender and education, are related to acceptance of biotechnology applications and foods (Harrison et al., 2004; Hoban et al., 1992; House et al., 2004), these relationships varied in Hossain et al.'s (2003) study, as the significance of sociodemographics were dependent upon the individual application. In a review of functional food surveys, Verbeke (2005) found that functional food consumers tend to be female, well educated, and older.

Data and Methods

The data for this study were gathered in a regional Southwestern telephone survey conducted from March 28 through May 4, 2004 on alternate evenings. To insure the inclusion of both listed and unlisted telephone numbers, random-digit dialing (RDD) procedures were used to reach people. The sampling frame comprised a sample of five states: Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. The total sample size was 432 adults (18 years or older).

The dependent variables comprised eight statements about support for animal and plant biotechnology applications. Each statement represented a different biotechnology application with the goal of including a range of agricultural biotechnology applications. Of the four animal applications, two are first-generation biotechnology applications (FG), one is second-generation (SG), and one is a third-generation application (TG). Of the four plant applications, two are first-generation (FG) and two are third-generation (TG). For the plant applications, a differentiation was not made between first- and second-generation applications. There are particular problems in conceptualizing second-generation biotechnology applications. First, as functional foods are defined as adding a benefit (e.g., nutrition or taste) to foods, asking questions are problematic in that response bias may occur due to social desirability (Saher, Arvola, Lindeman, & Lahteenmaki, 2004). Second, because functional foods by definition add value to an existing food, it is difficult to decipher whether respondents are reacting to the perceived benefit or the genetic modification process. Third, not all functional foods are derived through biotechnological means.

Table 1. Mean ranking of support for agricultural biotechnology applications (*N* = 363).

Biotechnology application	*M*[a]	*SD*
Plants to produce pharmaceutical drugs	3.87	.865
Nonfood plants	3.63	.854
Plants to produce industrial products	3.40	.971
Animals to be resistant to diseases	3.33	.997
Fruits and vegetables	3.20	1.069
Animals to increase production	2.94	1.093
Animals to produce human organs	2.86	1.130
Animals to produce more tasty and tender meat	2.79	1.041

[a] Mean differences are statistically significant at $p \leq .001$.

A five-point Likert scale was used to measure the level of support for each application, where 1 = *strongly opposed* and 5 = *strongly support*. The four statements about animal applications were "Please tell me how strongly you oppose or support the genetic modification of animals to..." (a) "produce human organs" (TG); (b) "be resistant to diseases, such as Mad Cow" (FG); (c) "produce more tasty and tender meat" (SG); and (d) "increase production, like milk" (FG). The four statements about plant applications were "Please tell me how strongly you oppose or support the genetic modification of..." (a) "plants to produce industrial products such as plastics" (TG); (b) "nonfood plants, like cotton" (FG); (c) "plants to produce pharmaceutical drugs, like vaccines" (TG); and (d) "fruits and vegetables" (FG). Descriptive statistics for the dependent variables are presented in Table 1.

Knowledge was measured by adding together the responses of two questions: "How would you rate your knowledge about..." (a) "the genetic modification or cloning of animals?" and (b) "the genetic modification of plants?" Each knowledge question was measured on a scale of 1–4, where 1 = *not at knowledgeable*, 2 = *a little knowledgeable*, 3 = *somewhat knowledgeable*, and 4 = *very knowledgeable*. When added together the perceived knowledge scale ranged from 2 = *not at all knowledgeable* to 8 = *very knowledgeable*. Trust was measured by adding together the responses to four questions to create a scale from 4 to 20. The questions were "How would you rate the following groups in managing risks associated with biotechnology?" (a) government agencies, (b) farmers, (c) scientists, and (d) corporations. Each item was measured using a five point Likert scale, where 1 = *not at all confident* and 5 = *very confident*. Principal factor analysis with a varimax rotation showed that these items were measuring one underlying concept and the Cronbach alpha was .67.

Five societal benefit variables were included in the analysis. Respondents were asked to state whether they strongly disagreed, disagreed, neither agreed nor disagreed, agreed, or strongly agreed with each of the following statements, where 1 = *strongly disagree* and 5 = *strongly agree*: "Biotechnology will benefit farmers and rural communities," "Biotechnology is necessary to feed the world's population," "Genetically modified foods will be more nutritious than traditional foods," "Genetically modified foods are as safe as traditional foods," and "Genetically modified foods will provide consumers with more food choices." Principal factor analysis with a varimax rotation showed that these items were measuring one underlying concept, and the Cronbach alpha was .75, so the individuals items were added together to create a scale from 5–25, where higher values indicated higher benefits.

Sociodemographic variables included in the analysis were religiosity, age, gender, race, and education. Religiosity was measured by asking respondents "Do you consider yourself to be...?" where 1 = *not at all religious*, 2 = *slightly religious*, 3 = *moderately religious*, or 4 = *very religious*. Females were coded 0 as the reference category and males were coded 1. Race was measured by asking respondent's their race/ethnicity with the following categories: Caucasian/White (coded 0 as the reference category), Black/African-American, Hispanic, and other. Education was also measured by asking respondents their educational level measured categorically. Respondents with a high school degree or less were coded 0 and used as the reference category; the other two categories were some postsecondary and a bachelor's degree or higher. Descriptive statistics for the independent variables are presented in Table 2.

Table 2. Descriptive statistics for independent variables.

Independent variable	*M*	*SD*	Range
Knowledge	3.97	1.474	2–8
Trust	11.81	3.570	4–20
Benefits	15.61	3.357	5–25
Religiosity	3.08	.835	1–4
Age	45.57	16.414	18–89
Gender (1 = male)	.38	.485	0–1
Race (ref = white)	.72		
Black	.13	.341	0–1
Hispanic	.11	.308	0–1
Other	.04	.194	0–1
Education (ref = high school or less)	.31		
Some college or college diploma	.37	.481	0–1
Bachelor's degree or higher	.32	.470	0–1

Findings

The means for the eight biotechnology applications are presented in Table 1. ANOVA results showed that differences in the mean scores were statistically significant at $p \leq .001$, as illustrated in Table 3. In general, plant applications garnered higher support than animal applications. The results also show that the vehicle used (i.e., plant or animal) appears to overshadow both the function (i.e., health or food) and type of application (i.e., first-, second-, or third-generation biotechnology), although nonfood applications tended to receive more support than GM foods.

In order to examine the relationships between perceived knowledge, trust, benefits, and sociodemographic variables and support for each biotechnology application, OLS regression analysis was used. Standardized coefficients are presented in Table 4 so that the results of each model can be compared with one another. The only variable significantly related to all biotechnology applications was benefits. Support increased with perceived benefits. Perceived knowledge was positively related to the genetic modification of animals to produce human organs but negatively related to the genetic modification of animals to produce more tasty and tender meat. Although support for GM animals to produce human organs increased with higher reported knowledge of biotechnology, support for GM animals to produce more tasty and tender meat decreased with higher reported knowledge. Trust was positively related to GM animals to increase production, GM plants to produce pharmaceutical drugs, and GM fruits and vegetables. Support for these applications increased with higher trust levels.

The significance of the sociodemographic variables varied by application. Education appeared to have the strongest effect on support as it was related to all but three applications—GM animals to increase production, GM plants to produce industrial products, and GM nonfood plants. In general, support increased with educational attainment. Gender was related to two animal applications—produce more tasty and tender meat and to increase production. In both instances, males had higher levels of support than females. Religiosity was only significantly related to GM animals to produce

Table 3. ANOVA *F*-values for agricultural biotechnology applications.

Variable	Human organs	Resistance to diseases	Tasty meat	Increase production	Industrial products	Nonfood plants	Pharma drugs	Fruits & vegetables
Human organs		21.58	10.52	7.78	8.46	10.34	7.01	7.00
Resistance to diseases	21.58		22.34	18.06	4.72	10.83	8.43	5.15
Tasty meat	10.52	22.34		60.82	8.40	9.59	7.58	21.68
Increase production	7.78	18.06	60.82		9.28	12.75	10.42	27.47
Industrial products	8.46	4.72	8.40	9.28		39.75	22.71	14.68
Nonfood plants	10.34	10.83	9.59	12.75	39.75		25.65	12.75
Pharma drugs	7.01	8.43	7.58	10.42	22.71	25.65		18.07
Fruits & vegetables	7.00	5.15	21.68	27.47	14.68	12.75	18.07	

Note. Mean differences are statistically significant at $p \leq .001$.

Table 4. Standardized regression coefficients for the relationship between support for various agricultural biotechnology applications and knowledge, trust, benefits, and sociodemographics (*N* = 351).

	Animal applications				Plant applications			
	Human organs	Resistance to diseases	Tasty meat	Increase production	Industrial products	Nonfood plants	Pharma drugs	Fruits & vegetables
Knowledge	.188***	.026	-.164***	-.069	.076	.030	.086	-.036
Trust	.038	.030	.109	.152**	-.035	-.053	.108*	.116*
Benefits	.168**	.250***	.369***	.343***	.373***	.353***	.348***	.441***
Religiosity	-.157**	-.084	-.031	-.033	-.002	.003	-.032	-.022
Age	-.045	.083	.090	.068	-.016	-.094	-.014	-.012
Gender (1 = male)	.051	.094	.165***	.198***	.004	-.001	-.031	.022
Race (ref = white)								
Black	-.067	-.012	.007	-.016	-.071	-.191**	-.014	-.006
Hispanic	-.035	-.045	.023	.060	.024	.057	.053	.151**
Other	-.072	-.035	-.061	-.065	-.104*	-.147**	-.014	-.014
Education (ref = high school or less)								
Some college	.159**	.133*	.119*	.108	.050	.105	.127*	.099
Degree or higher	.198***	.184**	.117*	.051	.079	.089	.087	.132*
Constant	1.767***	1.814***	.619	.474	1.614***	2.472***	1.951***	.532
R^2	.184	.135	.232	.240	.182	.216	.196	.278

$^*p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

human organs. Support decreased with religiosity, illustrating that religious respondents had higher opposition to using animals to produce human organs than respondents who were less religious. Conversely, race was only significantly related to plant applications, although the results varied by application. Respondents who indicated that their race or ethnicity was other had lower levels of support for GM plants to produce industrial products and GM nonfood plants than whites. In addition, blacks had lower levels of support for GM nonfood plants than whites. Hispanics had higher support levels for GM fruits and vegetables than whites. Age was not related to any of the eight applications.

Discussion

Does application matter? The answer appears to be yes, as the results revealed that the vehicle used (i.e., animals or plants) appears to outweigh both the function and type of application, although nonfood applications tended to receive higher support levels than GM foods. Additionally, the determinants for each biotechnology application were different and their explanatory power varied by application. Only perceived benefits was significantly related to each biotechnology application. This finding supports the view that consumers will accept biotechnology applications if they perceive benefits. However, the interpretation for the significance of other variables is not straightforward, as clear patterns are difficult to discern. Contrary to expectations, the results cannot be explained simply by application functions, types, or vehicles. If this is the case, then what do the results mean?

This research is consistent with Fischoff and Fischoff's (2001) observations that grouping together different biotechnology applications for the sake of simplifying summaries will likely serve us poorly. As they state, "citizens should distinguish among [biotechnologies] varying in their current attractiveness and future promise" (pp. 155–156). The results also support their conclusions that different people have different views about biotechnologies (as demonstrated by the sociodemographic differences) and that people are probably employing complex evaluative schemes in their responses. Although the variance explained varies among the applications, the highest explanatory is only 28% for GM fruits and vegetables. This suggests that other determinants not included in these models must also be considered. For example, moral issues may be triggered as biotechnology directly affects the human concerns of food, health, environment, and nature (Juanillo, 2001). The message for industry, marketers, and communication specialists is that one message is unlikely to fit all. It is likely that different biotechnology applications will elicit different responses from different people; the trigger mechanisms may be different for different applications. An illustration is that religiosity was only associated with support for GM animals to produce human organs, and that application struck a particular nerve with religious respondents. A limitation of the results is that the sample comprised southern US states; thus, the results may be not be representative of the US population.

References

Barham, B.L., Foltz, J.D., & Moon, S. (2002). rBST adoption in the United States: A retrospective look at a "juggernaut" agricultural biotechnology. *Choices* (Summer), 15-19.

Biel, A., & Nilsson, A. (2005). Religious values and environmental concern: Harmony and detachment. *Social Science Quarterly, 86*(1), 178-191.

Bio. (2006). *Plant-made pharmaceuticals: Frequently asked questions*. Washington, DC: Biotechnology Industry Organization. Available on the World Wide Web: http://www.bio.org/healthcare/pmp/factsheet2.asp.

British Broadcasting Corporation. (2003). Clone offers vision of farming future. Available on the World Wide Web: http://news.bbc.co.uk/2/low/science/nature/1077903.stm.

Cox, D.N., Koster, A., & Russell, C.G. (2004). Predicting intentions to consume functional foods and supplements to offset memory loss using an adaptation of protection motivation theory. *Appetite*, *43*, 55-64.

Davidson, D., & Freudenberg, W. (1996). Gender and environmental risk concerns: A review and analysis of available research. *Environment and Behavior, 28*(3), 302-339.

Dey, B. (2004). *Are we ready for PMPs?* Mumbai: Pharmabiz.com. Available on the World Wide Web: http://www.pharmabiz.com/article/detnews.asp?articleid=21817&sectionid=46.

Einsiedel, E.F., & Medlock, J. (2005). A public consultation of plant molecular farming. *AgBioForum*, *8*(1), 26-32. Available on the World Wide Web: http://www.agbioforum.org

Evensen, C., Hoban, T., & Woodrum, E. (2000). Technology and morality: Influences on public attitudes toward biotechnology. *Knowledge, Technology, & Policy, 13*(1), 43-57.

Fischoff, B., & Fischoff, I. (2001). Publics' opinions about biotechnologies. *AgBioForum*, *4*(3&4), 155-162. Available on the World Wide Web: http://www.agbioforum.org

Freese, B., & Caplan, R. (2004). *Biotech industry 'plant-made pharmaceutical' (PMP) risk profile.* Washington, DC: U.S. PIRG. Available on the World Wide Web: http://www.uspirg.org/reports/RiskyBusiness.pdf.

Frewer, L.J., Hedderley, D., Howard, C., & Shepherd, R. (1997). Objection mapping in determining group and individual concerns regarding genetic engineering. *Agriculture and Human Values, 14*, 67-79.

Frewer, L., Shepherd, R., & Sparks, P. (1994). The interrelationship between perceived knowledge, control and risk associated with a range of food-related hazards targeted at the individual, other people and society. *Journal of Food Safety, 14*, 19-40.

Gaskell, G. (2000). Agricultural biotechnology and public attitudes in the European Union. *AgBioForum*, *3*(2&3), 87-96. Available on the World Wide Web: http://www.agbioforum.org.

Hallman, W., Adelaja, A., & Schilling, B. (2002). *Public perceptions of agricultural biotechnology in the United States in 2001*. New Brunswick, NJ: Food Policy Institute.

Harrison, R. W., Boccaletti, S., & House, L. (2004). Risk perceptions of urban Italian and United States consumers for genetically modified foods. *AgBioForum, 7*(4), 195-201. Available on the World Wide Web: http://www.agbioforum.org.

Hoban, T. (1996). Trends in consumer acceptance and awareness of biotechnology. *Journal of Food Distribution Research,* Feb., 1-10.

Hoban, T. (1998). Trends in consumer attitudes about agricultural biotechnology. *AgBioForum*, *1*(1), 3-7. Available on the World Wide Web: http://www.agbioforum.org.

Hoban, T., Woodrum, E., & Czaja, R.. (1992). Public opposition to genetic engineering. *Rural Sociology, 57*(4), 476-493.

Hossain, F., Onyango, B., Schilling, B., Hallman, W., & Adelaja, A. (2003). Product attributes, consumer benefits and public approval of genetically modified foods. *International Journal of Consumer Studies, 27*(5), 353-365

House, L., Lusk, J., Jaeger, S., Traill, W.B., Moore, M., Valli, et al. (2004). Objective and subjective knowledge: Impacts on consumer demand for genetically modified foods in the United States and the European Union. *AgBioForum*, *7*(3), 113-123. Available on the World Wide Web: http://www.agbioforum.org.

Jaffe, G. (2004). *Sowing secrecy: The biotech industry, USDA, and America's secret pharm belt*. Washington, DC: Center for Science in the Public Interest. Available on the World Wide Web: http://www.cspinet.org/new/pdf/pharmareport.pdf.

Juanillo, N.K. (2001). The risks and benefits of agricultural biotechnology: Can scientific and public talk meet? *American Behavioral Scientist*, *44*(8), 1246-1266.

Kirk, D.D., & McIntosh, K. (2005). Social acceptance of plant-made vaccines: Indications from a public survey, *AgBioForum*, *8*(4), 228-234. Available on the World Wide Web: http://www.agbioforum.org.

Krueger, R.W. (2001). The public debate on agrobiotechnology: A biotech company's perspective. *AgBioForum*, *4*(3&4), 209-220. Available on the World Wide Web: http://www.agbioforum.org.

McBride, W.D., Short, S., & El-Osta, H. (2004). The adoption and impact of bovine somatotropin on U.S. dairy farms. *Review of Agricultural Economics*, *26*(4), 472-488.

Pew Initiative on Food and Biotechnology. (2004a). *Factsheet. Genetically modified crops in the United States*. Washington, DC: Author. Available on the World Wide Web: http://pewagbiotech.org/resources/factsheets/display.php3?FactsheetID=2.

Pew Initiative on Food and Biotechnology. (2004b). *Overview and findings: 2004 focus groups & poll*. Washington, DC: Author. Available on the World Wide Web: http://pewagbiotech.org/research/2004update/.

Priest, S.H. (2000). US public opinion divided over biotechnology? *Nature Biotechnology*, *18*, 939-942.

Saher, M., Arvola, A., Lindeman, M., & Lahteenmaki, L. (2004). Impressions of functional food consumers. *Appetite*, *42*, 79-89.

Siegrist, M., & Cvetkovich, G. (2000). Perception of hazards: The role of social trust and knowledge. *Risk Analysis, 20*(5), 713-719.

Stewart, P. & Knight, A. (2005). Trends affecting the next generation of U.S. agricultural biotechnology: Politics, policy and plant made pharmaceuticals. *Technological Forecasting & Social Change, 72*(5), 521-534.

Urala, N. & Lahteenmaki, L. (2004). Attitudes behind consumers' willingness to use functional foods. *Food Quality and Preference*, *15*, 793-803.

Verbeke, W. (2005). Consumer acceptance of functional foods: socio-demographic, cognitive and attitudinal determinants. *Food Quality and Preference*, *16*, 45-57.

Verbeke, W. (2006). Functional foods: Consumer willingness to compromise on taste for health? *Food Quality and Preference*, *17*, 126-131.

Author's Note

Andrew J. Knight is a Visiting Assistant Professor at the Food Safety Policy Center, Michigan State University. The author would like to thank the Arkansas Biosciences Institute for funding this research.