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Consumer Views on Genetically Modified Crops

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ABSTRACT. Differences in consumer views about genetically modified crops have recently lead to trade disputes between the United States and the countries of the European Union. This paper uses a simple cost-benefit model to examine what factors influence consumer views on modified crops, and analyses them in an attempt to explain the observed difference between the American and European perspectives. Potential socio-economic, health and environmental effects interact with personal beliefs to shape consumer views. It is argued that most of the difference in opinions can be traced back to the lack of accurate information. There is a difference in the perceived costs nad benefits of genetically modified crops on the two continents because perceptions of the likelihood and magnitude of their possible effects are different.

I. Introduction

Scientists created the first genetically modified crop in 1983. Worldwide today, a land area equivalent to almost twice the area of the United Kingdom is planted with modified crops [International Service for the Acquisition of Agri-biotech Applications, 2000, 1]. 68 percent of that land is in the United States, and most of the remainder is in Argentina, Canada and China, with the rest of the world growing less than 1 percent of all modified crops [International Service for the Acquisition of Agri-biotech Applications, 2000, 1]. Over four fifths of the global transgenic crop area is planted with either soybeans or corn [International Service for the Acquisition of Agri-biotech Applications, 2000, 3]. The percentage of American soybean acreage planted with genetically modified varieties grew to over 50 percent in just four years after their commercial introduction [The Economist, 2000, 30]. Today about half of all soybeans, a third of all corn, and a large proportion of potatoes are genetically modified in the United States [Golden, 1999, 49]. It is estimated that about two thirds of all food products in a typical American supermarket contain genetically modified material, and most consumers readily buy these products [Jukes, 2001a].

In recent years, however, there has been a slowdown in the spread of genetically modified crops. On the other side of the Atlantic Ocean, consumers have grown more cautious about genetic modification. American soybean exports to the European Union plunged from 398 million bushels in 1997-98 to about 221 million bushels in 1999-2000, a drop of about 45 percent [The Economist, 2000, 30]. The decrease is attributed to the increasing European concerns about genetically modified

American soybeans. While in spite of the decreasing exports transgenic soybean acreage actually increased in 2000, the area planted with modified corn decreased [International Service for the Acquisition of Agri-biotech Applications, 2000, 2]. In a typical European supermarket, virtually no food product contains genetically modified material [Jukes, 2001a].

Consumer concerns have lead to extensive legislation on genetically modified crops in Europe. Europeans consider modified plants radically new. They believe that it is necessary to put appropriate safeguards in place to protect consumers [Jukes, 2001b, paragraph 1]. The American public, on the other hand, believes that genetically modified plants are not substantially different from conventional varieties. The introduction of modified organisms was not accompanied by significant new legislative regulation in the United States [Barnett, 1999, 647].

> People in the UK are astonished at how Americans seem indifferent to the [genetic modification] controversy. Don't they know how hazardous [genetically modified organisms] can be? Americans, in contrast are fascinated by the hysteria in the UK [McHughen, 2000, 111].

The sharp contrast in the attitude of American and European consumers is intriguing. Both the United States and the countries of the European Union are rich, industrialized democracies. They have a common historical root, similar cultures and religions. Thus, at first sight, the difference in public opinion about genetic modification is baffling. I set forth to determine what factors influence consumer views (and thus behavior) on genetically modified crops. A thorough analysis of these factors can give an insight into why American and European views differ, and explain how the current state of affairs has developed.

It is important to understand the processes that influence consumer views on genetic modification. Ultimately, consumers decide what crops will be grown. The concern of European consumers seems to be spreading, and demand for genetically modified crops has started to decrease in other parts of the world as well. The United States, being the largest supplier of such crops, could face significant market losses. Should American consumers turn against genetic modification, not only markets, but a potentially useful technology could be lost.

II. Background

Genetic engineering or genetic modification is the directed alteration of genetic material by intervention in genetic processes. The purpose of genetic modification is to change specific characteristics of an organism. Through genetic modification, it is possible to improve the taste or texture of a crop, to produce crops with higher yields, or to make a crop resistant to pests and herbicides. Some people believe that the technology is just an improved version of more traditional plant-breeding methods. After all, farmers have been modifying crops through selective breeding for thousands of years. Some proponents of genetic modification argue that it is a new, but not substantially different technique to attain a beneficial genetic change. There is, however, an important difference. Genetic modification generally includes the transfer of genes between different species, something not found in traditional agriculture. For example, it is now theoretically possible to identify the gene responsible for the production of antifreeze chemicals in arctic fish, and then to transplant it into tomatoes, making the plants frost resistant. Crops produced by the transplantation of genes from other species are called transgenic crops.

Despite the possibility of changing so many characteristics of an organism, the vast majority of crops have been modified for increased herbicide and pest resistance. Transgenic herbicide resistant crops have a foreign gene that makes them resistant to a particular group of powerful herbicides. Applying such herbicides on a field planted with resistant crops kills off weeds and other plants without harming the crop. This practice has the potential to dramatically improve weed control and thus crop yields.

Pest resistant crops usually have a gene from a bacterium transplanted in them. The gene causes the crops to produce the same proteins that make the bacteria toxic to pests. These toxins are highly specific to the larvae of certain pests, and supposedly have no effect on other organisms. Crops modified for pest resistance evoked great expectations since agricultural losses to pest damage are substantial worldwide.

Biotechnology is an expensive business. It is also a lucrative business. Genetically modified crops are usually developed by big multinational corporations that posses the skills and resources to undertake the necessary developments, rigorous testing and marketing [Nuffield Council on Bioethics, 1999, 122]. Such a multinational

corporation typically involves an agrochemical branch, a seed company, a food-processing company and a pharmaceutical company [Nottingham, 1998, 172]. To encourage them to engage in research and development, it is necessary to allow patents on their innovations. Without such intellectual property rights there would be no incentive to innovate because knowledge is a public good: it is non-rival and non-excludable. The main profit of these multinational companies comes from the sale of genetically modified crop seeds. Farmers who buy the seeds are prohibited from saving them from one year to another. They agree to buy new seeds if they want to grow transgenic crop the next year. A farmer benefits from modified crops because they increase yields, and decrease expenditures on herbicides and pesticides. The herbicides and pesticides transgenic crops need, however, are very specific. Multinational corporations that develop and sell the seeds also develop and sell the various chemicals used with those seeds. Patents thus assure a dependable stream of income for the inventors of transgenic organisms and related products.

III. Consumer Choice and the Cost-Benefit Model

Consumers make choices about genetically modified crops based on costs and benefits. The costs and benefits of consuming genetically modified crops are not limited to financial terms. Costs include such risks as the possibility of negative health effects from the production or consumption of genetically modified foods, adverse environmental effects, and ethical objections to genetic modification. Benefits may include the improved taste, texture and nutritional value of genetically modified food products.

As people consider the perceived costs and benefits of consuming genetically modified food products, they base their decisions on the relative magnitude of those costs and benefits. Two scenarios are possible. In one, the consumer can choose between consuming a genetically modified product and some other, conventional product. If the increase in benefits from choosing the genetically modified product instead of the conventional product is greater than the increase in costs, then the consumer will buy the modified product [Wohl, 1999, 32]. Costs and benefits certainly include all the potential risks and benefits of consuming the two products.

In the second scenario, there is no conventional substitute for the genetically modified product. The decision then is whether to consume

the good at all, and the cost-benefit analysis compares consuming the modified product with not consuming it. If the increase in benefits from consumption is greater than the increase in costs, then the consumer will again decide to consume the genetically modified product.

The model would work just fine if consumers had perfect information about all the factors involved. The problem is that they rarely have reliable information on genetically modified crops and on the technique of genetic modification in general. Therefore, they have to evaluate much of the risks and benefits of such products in a probabilistic sense. Risk in this case is not only the probability that some negative outcome will occur. The severity of the outcome, the amount of control people feel over the likelihood of the outcome, and whether or not the risk is faced voluntarily all influence the acceptability of risk [Wohl, 1999, 31]. Let us consider an action that has moderate benefits, but could have severe irreversible consequences, possibly even death. People will not be likely to undertake such an action no matter how small the probability of its occurrence. This suggests that the quantity and quality of information consumers have on genetically modified crops is an important part of the model, one that can influence the accuracy of its predictions.

IV. The Role of Potential Socio-Economic Effects

The most directly measurable aspect of the cost-benefit analysis is the economic effect of genetically modified products. The way genetically modified crops change the distribution of income will certainly affect consumer views of biotechnology. Genetic modification can increase the supply of crops, which should lead to a reduction in the price of food products. But it seems that, in general, genetic modification does not make food cheaper. This is probably because the technology is so expensive that any resulting price decrease is offset by its costs. Farmers have to pay a higher price for genetically modified seeds, they have to pay license and technology fees, and cover other costs associated with their contracts. They also have to make changes to the farming system designed to reduce the environmental risks associated with growing modified plants [Franks, 1999, 579]. These costs are passed on to consumers offsetting the price reduction from the increase in supply. It is often argued that the majority of genetically modified products confer benefits to multinational companies and the farming industry, and not to consumers.

Europeans are cautious about genetically modified food products because they perceive the risks associated with the consumption of such products to be too high compared to the benefits. In a sense, they are right. Today, consumers have little to gain from the majority of genetically modified crops. Virtually all of them are modified for herbicide or pest resistance, and both of these traits provide clear benefits to producers rather than to consumers. Modified soybeans and modified corn do not satisfy an important unmet consumer need; they simply increase the supply of crops that are already abundant. Even European consumers have accepted "vegetarian cheese" made of genetically modified crops because it provided something new and useful to them. In the eyes of many people, the benefits of vegetarian cheese outweighed the costs associated with its consumption.

Another crucial factor in the acceptance of products like the vegetarian cheese was consumer choice. People could choose between the conventional and the new product when they were side by side on the shelf in the store [Burke, 1998, 1845]. This is not true for most genetically modified crops such as soybeans and corn, and products containing them. In the United States genetically modified and unmodified crops are not kept separate. Mixing can occur any time during the harvest, storage, transportation and processing. There is little demand for segregation here, and the costs would be substantial. As a result, the United States has lost its European market for corn, and risks loosing the market for soybeans.

European consumers demand that they know which products contain genetically modified material so as to be able to make informed choices [Byrne, 2000, paragraph 25]. Their demand for this information has lead to legal regulation and the introduction of labeling laws.

Even though it is hard to find any, genetically modified food products have not been outlawed in Europe. True, the European Union has a number of laws in effect for the labeling of genetically modified food products, and they have become more rigorous over the years. Legislation introduced the 1 percent limit in January 2000, stipulating that any food product containing more than one percent genetically modified material has to be clearly labeled as such. There are now plans in the European Union to label food products not made of, but made with, the help of genetically modified organisms, and to extend the regulation to animal feed. The purpose of labeling laws was to please consumers concerned about modified products, and to provide them the information

necessary to make choices about such products. But labels made consumers aware of the presence of genetically modified material in food products, and they avoided them. Soon most supermarkets and food producers banned genetically modified crops from their own-brand products to stay competitive. It seems ironic that the European Union has a whole set of controls in place designed to allow the sale of genetically modified products–fully labeled–but these foods cannot be purchased [Jukes, 2001b, paragraph 39].

People often argue that increased yields brought about by genetically modifying crops are necessary to feed the expanding population in the developing world. Although it does not directly affect consumers in the United States and Europe, the argument can influence their opinion on genetic modification. Most people care about what happens in other parts of the world, and would derive some satisfaction just from knowing that the hungry in Sudan have more food than they did last year–an addition to the perceived benefits side of the equation. Therefore, if consumers here attach a positive value on the quality of life of the poor elsewhere, they will be more likely to embrace a technology that can help the poor. The argument for feeding the world population is powerful and convincing when presented along with statistics on the number of hungry children and the yield increases of modified crops, but it has a flaw. The underlying problem of world hunger is not a shortage of food. It is poverty. The 36 countries most seriously affected by hunger exported food to the United States in 1973–a trend that continues today [Ho, 1996, paragraph 9]. Even at the height of the 1984 famine in Ethiopia, the country exported oilseed rapeseed, linseed, cottonseed, coffee, meat, fruit and vegetables to Europe [Anderson, 1999, 57]. There is enough food produced on this planet so that no one would be left hungry. According to the United Nations' World Food Programme, we are already producing one and a half times the food necessary to provide an adequate diet for all people. Genetic modification of crops cannot solve the problem of world hunger. The extra yield would most likely be consumed in industrialized countries that already have more than enough food. This is recognized even in the areas affected by hunger. At a meeting of the United Nations Food and Agricultural Organization, representatives of 24 African countries delivered the following statement to the press:

> We …strongly object that the image of the poor and hungry from our countries is being used by giant multinational

> corporations to push a technology that is neither safe, environmentally friendly, nor economically beneficial to us [Anderson, 1999, 56].

V. The Role of Potential Health Effects

It is said that health is priceless. Though the saying is obviously not true in an economic sense (just think of all the smokers) consumers would say their health is worth a lot to them. Anything that affects health has the potential to affect consumer behavior. Although long-term, large-scale tests to establish the safety of modified food products have yet to be done, researchers have identified several ways in which genetically modified crops can have an effect on health [Tangley, 1999, 40]. Positive effects certainly increase the perceived benefits of genetic modification, and negative effects increase its perceived costs.

Scientists have lately discovered that although ultimately genes determine the characteristics of an organism, they function in a complex, interconnected system. Introducing a single foreign gene can have an unpredictable effect on the expression of other genes. As a result, it is impossible to alter one single characteristic of an organism, and scientists fear that adverse health effects could emerge from inadvertently changing some non-target characteristic of a crop. Genetic modification could switch on a gene that, in addition to making a plant herbicide resistant, is responsible for the production of natural plant toxins. It is possible that manipulating such a gene could change the level of toxins in plant tissues in unexpected ways [Tangley, 1999, 40]. Not detecting the change before approval for human consumption could pose a threat to human health. For example, transgenic soybeans containing a peanut gene could cause allergic reactions in people allergic to peanuts. Although extensive regulations are in place to identify and report any known proteins that could be problematic, unknown allergies could theoretically slip through the system [Tangley, 1999, 40]. However, a protein that is not allergenic in one food does not suddenly become allergenic in another [McHughen, 2000, 161]. Foreign genes might also alter the nutritional value of crops. A study found that concentrations of certain compounds, believed to protect against heart disease and cancer, were lower in genetically modified soybeans than in conventional soybeans [Tangley, 1999, 40].

Finally, there are fears that marker genes used in the process of genetic modification can spread to bacteria living in the human gut. Gene

transfer with present technologies is rather inefficient, and marker genes are needed in the process to determine whether the transfer has been successful. They usually code for antibiotic resistance. Should they spread to microbes, antibiotic treatments would become less effective. Although marker genes could exacerbate public health problems, there are more direct reasons (such as physicians prescribing unnecessary antibiotics, patients not completing the prescribed drug therapy and natural populations of resistant bacteria) of growing antibiotic resistance [McHughen, 2000, 186].

The other side of the human health issue is the argument that we can genetically modify crops to reach some desired health effect. Rice has been genetically modified to contain pro-vitamin A and iron, and bananas have been modified to contain hepatitis B vaccine. We could also neutralize allergens in some plants by applying our knowledge of genetics, and modifying them to develop varieties lacking the allergenic proteins [McHughen, 2000, 161]. Such crops provide clear benefits to consumers, and, even though the risk of negative health effects from unpredictable changes is still present, consumers are more likely to accept them. As we would expect, organisms engineered for medical purposes have not met the same public opposition as those engineered for agriculture because they provide obvious benefits.

Genetic modification can be safer than traditional breeding in some instances. Farmers often cross-pollinate different varieties of a crop so as to create a new variety that expresses the beneficial traits of both parent plants. Because the new plant inherits thousands of genes from each variety, it will likely have unexpected or unintended traits as well. It can take many years of experimentation before a successful hybrid is created. Identifying the gene responsible for the expression of a beneficial trait, and transferring that single gene into the other variety is a much more efficient process. A Brazilian beekeeper created killer bees when he crossed European and African bees. He was trying to combine their useful traits in a new variety, but the bees inherited the wrong attributes. Genetic modification allows for more control, and it may have achieved the desired result without creating killer bees.

As defined earlier, risk is the probability that some negative outcome will occur. Risks are statistically assessed from our past experiences [Nottingham, 1998, 175]. In other words, our experiences influence our expectations. Genetic modification is such a new technology that we cannot apply this familiar principle to assess its risks. There is, however,

another way in which experiences play a role in shaping expectations. It is our experiences with food safety and food regulation in general. If such experiences in the United States and the European Union are different, public perception of risks will be different. Different perceived risks, in turn, imply that the costs going into the cost-benefit equation will not be the same in the two areas. Suppose that poisoning from new food products is more common in Britain than in the United States. One reason might be inadequate measures that control the introduction of new products. British consumers then will likely be more cautious about new technologies in the food industry. In this way, different experiences can potentially account for some of the difference in views about genetic modification.

In fact, European experience with food safety has been worse than in America. In 1986 bovine spongiform encephalopathy, or mad cow disease, started to decimate cows in Britain. This frightening disease prompted people to ask whether it was safe to eat British beef. The government assured them that the species barrier would prevent human infection, and that the disease was not a threat to consumers. Since then, the human death toll has risen to over 80 in Britain. Scientists now fear that because of the long incubation period, it may take years before the major human epidemic starts. Estimates for the eventual number of fatalities range from 10 thousand to over 130 thousand–with the lower range considered more likely. Previous food scares like the mad cow disease, listeria in diary products, and dioxins in chicken, eggs and meat made European consumers distrustful of the government and the effectiveness of scientific risk assessment. People in the European Union therefore perceive that the risk of negative health effects is higher, and they tend to be more cautious.

VI. The Role of Potential Environmental Effects

People are increasingly concerned about the environment and the effect human activity has on it. It has been shown that, ceteris paribus, there is a positive relationship between income and the demand for environmental quality. Thus, consumers in wealthier countries can be expected to be more concerned about the environment than consumers in less wealthy countries. People in both the United States and the European Union probably place a relatively high value on the quality of the environment.

A major concern is that off-farm environmental effects of genetic

modification will not be internalized in private decisions [Mooney, 1999, 439]. The release of transgenic crops can lead to a number of different negative externalities including irreversible environmental damage. Accurately estimating the probability that environmental problems will occur, however, is not possible because of the lack of sufficient information. We only have a limited amount of previous experience with the release of genetically modified organisms into the environment.

It is often believed that crops modified for herbicide resistance allow for a reduction in the use of herbicides. Genetically engineered soybeans, for example, are resistant to a powerful, broad-spectrum herbicide that kills off all other plants. Thus, modified soybeans allow for a single application of a powerful herbicide instead of several applications of less effective chemicals. However, subjecting weeds to a single herbicide helps them become resistant quickly. Research indicates that an Australian weed species developed resistance to such a broad-spectrum herbicide after only 10 sprayings in 15 years [Anderson, 1999, 26]. Other studies indicate that the number of herbicide resistant weeds increased by about 100 species worldwide between 1990 and 1998 [Mooney, 1999, 438]. Increasing resistance, in turn, will require farmers to increase herbicide usage to attain the same results. Although genetically engineered crops can decrease the use of herbicides in the short run, it is likely that their long-term effect will be quite the opposite. The increasing application of powerful herbicides would have undesirable effects on the environment and human health–both things that people tend to value.

Pest resistant crops pose still other ecological risks. Genetically engineered pest resistant crops are able to produce a natural toxin, called Bt toxin that affects particular insect species. Farmers have sprayed this organic chemical on their fields for half a century because it provides a safe form of biological pest control. In contrast to the occasional spraying, however, transgenic crops continuously produce the toxin, and insects are more likely to develop resistance to it with constant exposure. There have already been signs indicating that certain pests are becoming resistant. If target species become resistant to the Bt toxin, then both genetically modified crops and traditional spraying techniques will lose their effectiveness. Crops engineered for pest resistance could thus deprive the world of one of its most important biological pesticides.

To their surprise, scientists found that two species with different numbers of chromosomes can cross. Until recently, they believed that

genes were unlikely to spread from transgenic crops to weeds, but it is possible that modified genes can jump through the species barrier. Several laboratory and field experiments have demonstrated that genes can spread from modified crops not only to related wild species, but also to unrelated ones. Crops modified for herbicide or pest resistance can pass on the trait to weeds, possibly leading to the development of so-called "superweeds." Once modified crops are introduced into the environment, it is impossible to recall or contain them. They can reproduce, react to environmental changes and interact with other species [Anderson, 1999, 35]. Furthermore, it is also possible that the modified organisms themselves can turn out to be invasive, and become detrimental to existing wildlife. Genetically modified fish from Norwegian fish farms have escaped, and, because of their advantageous traits, started to outnumber the wild variety. In certain areas, there is now a serious threat that the wild variety will soon disappear. The same kind of invasiveness is even more likely to happen in plant species. The ecological consequences of such interactions and developments are unpredictable.

Monoculture crops have adversely affected biodiversity and food security ever since their introduction. Genetically modified crops are likely to make things even worse. Biological diversity is the basis of ecological stability. The more diverse a community of plants and animals, the better chance it has to survive various ecological disturbances. Genetic uniformity leads to vulnerability [Anderson, 1999, 53]. The same principles apply in agriculture. The more genetic variation there is within agricultural systems, the more likely they will be to withstand ecological challenges such as droughts, floods, a proliferation of pests and diseases. The main cause of the infamous Irish potato famine in the 19th century was that farmers cultivated only a few species of potato. Because of the genetic uniformity, one disease could affect the whole potato crop in Ireland. The same disease struck in Latin America with less dire consequences. Farmers there grew over 40 varieties of potatoes, and the genetic diversity saved most if the crop: the disease affected only a few varieties [Anderson, 1999, 53]. Biological diversity is therefore a basic requirement for food security. Genetically modified crops are designed for monocultures, and by decreasing biodiversity they make food supplies even less dependable. In their statement to the press, the representatives of the 24 African countries at the United Nations Food and Agricultural Organization meeting addressed the issue of biodiversity and food security as well:

> …we think that [gene technology] will destroy the diversity, the local knowledge and sustainable agricultural systems that our farmers have developed for millennia and that it will thus undermine our capacity to feed ourselves [Anderson, 1999, 56].

Agricultural intensity in the countries of the European Union is a more serious environmental problem than it is in North America. Some experts believe that, with proper regulation, genetic modification has the potential to alleviate environmental problems caused by intensive agriculture. They argue that while additional food is not always necessary, additional land is always demanded [McHughen, 2000, 107]. Yield increases achieved by genetic modification make it possible to produce the same amount of food on a smaller land area, and could allow re-conversion of some of the agricultural land to wildlife areas. The problem is that such an outcome is unlikely without governmental regulation. Shouldn't this argument make Europeans more apt to accept modified crops? Probably so. But it is little known, and the common belief is that genetic modification intensifies agriculture.

As we have seen, research on the possible environmental effects of transgenic crops lags behind the development of new varieties [Anderson, 1999, 42]. In 1998, an international group of scientists, environmental activists, government officials and lawyers met in Wisconsin and acknowledged our limited knowledge of the environmental implications of genetically modified organisms:

> …it is necessary to implement the Precautionary Principle: When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically [Anderson, 1999, 33].

The potential environmental effects of genetic modification are the same all over the world. The increased use of synthetic herbicides, the development of superweeds and the loss of biodiversity have the same implications for American and European consumers. From this standpoint, Europeans should not be more concerned about biotechnology than Americans. The crucial difference is that, because of all the factors

that make Europeans more worried about genetic modification, they generally hear more about the potential ecological risks. Environmental groups such as Greenpeace are more active in Europe, and have a greater influence on the society there. They effectively disseminate information on the environmental dangers gene technology poses. Regardless of whether the information is accurate, the result is that European consumers perceive the probability of ecological disaster to be higher. When weighing the costs and benefits associated with genetic modification, the perception of higher environmental risks makes Europeans less likely to accept transgenic crops.

VII. The Role of Information

From the discussion so far, it should be clear that our knowledge of the effects of introducing genetically modified crops is not complete. From this perspective, the basic philosophy of Neoclassical economics supports the European view of genetically modified organisms. Neoclassical economics argues that we should not interfere with a natural system until we can clearly demonstrate that the interference is beneficial. When we do not know enough about the system it is quite possible that a disturbance will lead to unintended negative consequences. To make things even worse, the limited amount of accurate information we have is not readily available to consumers. Much of it is either distorted or not covered at all by the sensationalist mass media.

As a result, public debate on genetic modification is frequently based on myths and emotions rather than on a sound scientific foundation. A recent survey shows that only 40 percent of respondents in the United Kingdom recognize that conventional, non-modified tomatoes also contain genes. The other 60 percent probably believes that biotechnology contaminates food with genes and DNA [McHughen, 2000, 9]. It is hard to imagine that consumers can make informed choices about modified food products, labeled or not, as long as such misconceptions prevail.

A study published in the *New England Journal of Medicine* in January 1998 reveals another disturbing finding. The researchers examined the opinions of several authors on a controversial medical issue concerning the side effects of certain drugs. Then, they classified the authors according to the level of their financial ties to the producers of those drugs. The study found an extremely strong correlation between the opinions and financial ties of authors. It suggests that we cannot expect

impartial advice from people whose careers are linked to interest groups on one side of an argument [Anderson, 1999, 94]. Since much of the research on transgenic crops is done by the same companies that develop the crops, there is a reason to view even expert information on biotechnology critically. If consumers are aware of this, the source of their information can influence their opinion on genetically modified crops.

The introduction of mandatory labeling for genetically modified products in Europe was seen as a significant victory for concerned consumer groups. Their main argument for labeling laws focused on the role labels play in providing information to consumers and thus enable them to make informed choices. It is now clear that indiscriminate labeling will not enable informed choice [McHughen, 2000, 213]. The mandatory labeling of all modified products is inefficient. It implies that we are concerned with the method of genetic modification, not with individual products. But clearly, not all genetically modified organisms present an equal risk. Having the same label on all products hinders making informed choices by grouping very different products into the same category. European consumers interpreted 'genetically modified' labels as warning signs, and avoided all modified foods.

VIII. The Role of Personal Beliefs

Since biotechnology has the potential to change our lives so fundamentally, it is hardly surprising that much of the debate on it is filled with emotions. Some people oppose genetic modification not because they think its products pose a risk to their health or environment, but simply because they believe it is intrinsically wrong and unnatural. I am not aware of the existence of universal ethical principles that would tell us what we ought or ought not do with genetic modification, but I believe that every person has the right to live according to her or his belief.

It is possible that to some people all products of genetic modification are unacceptable. Others may have no problem with modified organisms except those that contain human genes (although no such organism exists at present). Vegetarians could be concerned with plants containing animal genes, and different religious groups could be anxious about products containing genes from a sacred or despised animal. Indiscriminate labeling in Europe makes these groups aware of modified

products, but does not identify the sort of modification that was used. Unable to determine whether the consumption of a certain genetically modified product contradicts their beliefs, people are more likely to avoid all modified food. Perhaps the American public is unaware of the extent to which modified ingredients have entered their diet, and the issue appears less pressing to them [Nuffield Council on Bioethics, 1999, 82].

It also seems that the basis of anxiety is somewhat broader in Europe. Europeans tend to target the technology of genetic modification itself, while in the United States, if anxiety arises, it is usually concentrated on specific products [McHughen, 2000, 105].

IX. Conclusion

The spread of genetically modified crops has come to a standstill. Proponents of genetic modification now fear that widespread defections from genetically modified crops will bring the technology to a halt before it can fulfill their dreams [The Wall Street Journal, 1999, A1]. Growing consumer concerns about genetic modification have led to a sudden decrease in European imports of modified plants. As the main producer, the United States suffered significant losses from losing the European market. Consumers in both the United States and the European Union make choices based on costs and benefits. Their different behavior has to reflect a difference in the costs and benefits they associate with genetic modification. A number of factors can influence consumers' perception of these costs and benefits. Potential social, health and environmental effects all play a role, and interact in a complex manner. A recurring problem has been the lack of accurate information on the probability and magnitude of the effects. It may be little help to ask for the advice of the most knowledgeable scientists because the most competent people are rarely completely independent of industrial ties [McHughen, 2000, 174]. The main difference between the United States and Europe is that European consumers believe that the probability of adverse effects occurring is higher. To them, severe potential risks have to be balanced against seemingly small benefits with the majority of transgenic crops. Whether right or wrong, consumer beliefs determine what they buy. What consumers buy, in turn, determines what farmers produce. An understanding of the factors that affect consumer views is therefore important to predict their behavior.

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