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An Industry Perspective of All-native and Transgenic Potatoes

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Genetically modified (GM) potatoes were a market failure in North America in the 1990s. In spite of benefits to growers, processors, consumers, and the environment, concerns about GM potatoes are still prevalent. We surveyed people in the North American potato industry regarding their opinions of GM potato issues. Results suggest that: (1) growers may be more likely than consumers to accept GM potatoes and (2) all-native technology may be more acceptable than transgenic technology. Potato growers, females, Canadians, and former Monsanto GM potato customers were more likely to be optimistic about all-native GM potatoes. Proactive marketing of all-native potatoes with consumer attributes—and perhaps with the approval of an environmental group—could lead to market success in the future.

Key words: genetically modified foods, potatoes, intragenic, transgenic.

Introduction

Genetically modified (GM) crops can enhance producer profits, consumer health, and the environment. In spite of those attributes, anti-GM activists contributed to a market failure of GM potatoes in North America. Although growers have not planted GM potatoes there since 2002, the potato industry continues to invest in the technology. In March 2010, the European Commission approved a request from a biotechnology company (BASF) to commercially grow a GM potato (Amflora®) for non-food use in the starch industry. If that was a step toward GM potatoes re-entering the North American market, an understanding of industry concerns is important. To shed light on those concerns, we looked at the history of GM potatoes.

GM Potato Development

Two teams of Monsanto scientists began developing transgenic potatoes in the early 1990s. The Virus Team worked on resistance to potato leafroll virus (PLRV), while the Insect Team focused on the Colorado potato beetle (CPB). In 1991 the teams developed potatoes resistant to both pests (Kaniewski & Thomas, 2004; Perlak et al., 1993). Monsanto first commercialized the CPB-resistant potato and then followed with a product that included resistance to both CPB and PLRV.

The Insect Team used a synthetic *Bacillus thuringiensis* (Bt) gene to transform four potato varieties—Atlantic, Russet Burbank, Snowden, and Superior. Monsanto rolled out the GM potato for sale to commercial growers in 1995. The product was branded under the NewLeaf™ trademark and marketed by NatureMark, a wholly-owned subsidiary of Monsanto. In 1998 NatureMark commercialized the NewLeaf Plus, a transformation of the Russet Burbank variety that was resistant to both CPB and PLRV. The company had other GM potato products in development, including a potato resistant to late blight and a higher-solids potato that would absorb less cooking oil (Kaniewski & Thomas, 2004).

The year that Monsanto rolled out NewLeaf Plus marked the peak of GM potato production in North America (Figure 1). From 1,800 acres in 1995, North American GM potato plantings increased rapidly to 55,000 acres in 1998 (National Potato Council, 2002). Growers in the Canadian provinces and the northern tier of US states began to grow the NewLeaf potatoes for both fresh and processed potato markets. Plantings declined slightly to 45,000 acres in 1999, then fell rapidly, completely disappearing by 2002. The reason for this swift extinction was that quick service restaurants (QSRs) and processors suddenly refused to buy GM potatoes. This sent a powerful message to growers to stop planting them.

Benefits

NatureMark's GM potatoes provided benefits to farmers, processors, consumers, and the environment. Growers saved money on insecticides no longer needed to control CPB and the insect vectors that carry PLRV. Idaho growers saved $141 per acre on their NewLeaf Plus plantings, and growers in the Columbia Basin saved $164 per acre (Kaniewski & Thomas, 2004). Processors benefitted from a higher-quality raw product

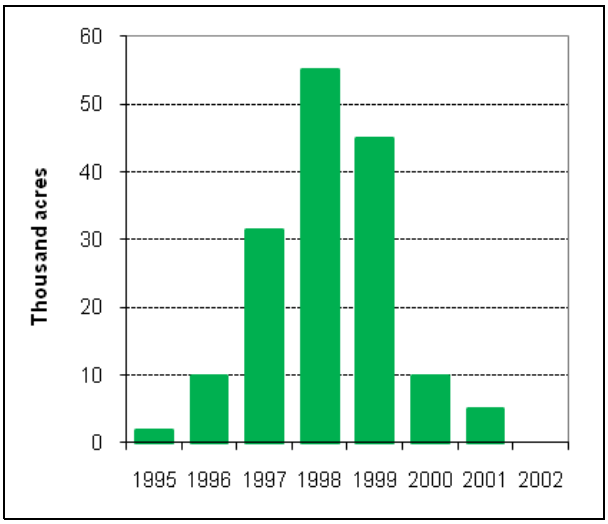

Figure 1. North American GM potato plantings.
Source: National Potato Council Yearbooks, 1995-2002.

free of the net necrosis (internal discoloring) caused by PLRV. Consumers received superior quality potato products at no increase in costs. The benefits, however, were not apparent to consumers who bought fries served by QSRs, where there was no brand identification tied to the GM potatoes.

The environment in Idaho and the Columbia Basin benefitted because nearly 2 million pounds of insecticides and 30,000 spray plane sorties were not needed on the NewLeaf fields (Kaniewski & Thomas, 2004). According to Phipps and Park (2002) and Brookes and Barfoot (2005), GM potatoes could significantly reduce the 2.6 million pounds of pesticides applied annually to the US potato crop. Other researchers also concluded that GM potatoes could increase grower profits and decrease pesticide use (Flannery, Thorne, Kelly, & Mullins, 2004; Marra, Pardey, & Alston, 2002).

GM potatoes also looked promising in developing countries. Potato tuber moth (PTM) is a serious potato pest in Africa and South America. Conventional control practices include the use of insecticides that poor farmers cannot afford, causing their potatoes to suffer severe losses in yield and quality. GM potatoes developed at Michigan State University were field tested in South Africa and Egypt and found to control PTM. Researchers found that these GM potatoes could increase food security, reduce food prices, increase farm profitability, and protect the environment (Guenthner, Araji, & Maredia, 2004). In South Africa, the use of GM potatoes would mean that commercial growers would save the costs of applying nine different insecticides to control PTM. Resource-poor farmers would have higher yields and better quality. Consumers would be able to buy an abundant supply of high-quality potatoes at lower prices.

Consumer Acceptance

Hoban (1999) found that consumers in two developed countries—Japan and the United States—were optimistic about biotechnology. He asked consumers about perceptions of six types of food-safety risks. In both countries pesticide residues caused the most concern and biotechnology the least. Those results suggest that there would be a market opportunity for GM potatoes that require less pesticide use. However, NewLeaf potatoes that required less pesticide use were only marketed for several years before being withdrawn. Guenthner (2002) claimed that societal acceptance of new technology follows predictable patterns and that more time was needed for consumers to accept GM potatoes. One problem was that McDonald's, McCain Foods, and other firms didn't give consumers a choice to reject or accept GM potatoes in the processed potato market.

Phillips and Corkindale (2002) cited NewLeaf potatoes as an example of effective proactive marketing of biotechnology products to consumers. That success, however, was limited to the market for fresh potatoes. It began when Monsanto implemented a consumer marketing effort in Prince Edward Island (PEI), Canada. PEI is a potato-producing region that had suffered fish deaths when pesticides applied to potato fields leached into rivers and coastal waters. In 1999, Monsanto proactively marketed their GM fresh potatoes, which offered reduced environmental risks. They made GM fresh potatoes available in PEI grocery stores and used advertising, publicity, point-of-sale information, and a toll-free phone line as marketing tools. The entire crop of GM fresh potatoes quickly sold out to PEI consumers at price premiums. The next year, McCain Foods—the world's largest frozen potato processor and a buyer of PEI potatoes—announced that they would stop buying GM potatoes for processing due to perceived consumer resistance. Although GM potatoes were a success in the fresh market, McCain's refusal to process GM potatoes helped eradicate the entire market for GM potatoes.

Perhaps the rapid decline of GM potatoes was one reason that some researchers included potato products in their consumer GM-acceptance studies. In one study, 86% of Canadian consumers said that they would be willing to pay a price premium for "heart-healthy" GM potato chips (West, Gendron, Larue, & Lambert, 2002). Another team conducted experimental auctions and

found that consumers bid higher prices for potato chips that were labeled as GM-free (VanWechel, Wachenheim, Schuck, & Lambert, 2003). When consumers were given more information, whether negative or positive about genetic modification, they increased their bids for chips presumed to have been made with GM potatoes.

Fresh potatoes were the focus of several other GM acceptance studies. Loureiro and Hine (2002) analyzed consumer willingness-to-pay for three types of fresh potatoes—organic, local, and GM-free. The Colorado consumers were willing to pay the highest premium for locally produced potatoes and the lowest premium for GM-free potatoes. Huffman (2003) conducted experimental auctions for three food products—vegetable oil, tortilla chips, and fresh russet potatoes. He found that consumers were willing to pay more for GM-free products. In a related study, researchers showed that information from environmental groups reduced GM-potato bids, but that those differences disappeared when participants were given verifiable, third-party information that disputed the environmental groups' claims (Huffman, Shogren, Rousu, & Tegene, 2003). Using the same experimental auction procedure, Rousu, Huffman, Shogren, and Tegene (2003) found that participants bid less for potatoes that tolerated some GM content, but that there was no difference in values between products showing 1% and 5% tolerance.

All-native Technology

Consumer acceptance of biotechnology varies among products. Participants in a consumer survey conducted by Lusk and Sullivan (2002) expressed a strong acceptance for using molds to make penicillin. Compared to the 94% who rated that penicillin technology acceptable, only 62% found it acceptable to use GM pigs to provide tissue to transplant in humans. In the same project, the researchers asked about willingness to consume a vegetable transformed with seven different types of genes. At the low end, the acceptance rate for using genes from a virus, fungus, bacteria, or animal ranged from 14% to 23%. At the high end there was an 81% acceptance rate for a product that used genes from the same vegetable.

Cisgenesis is the process of transferring genes between plants that could be conventionally bred. Some researchers have investigated that type of gene transfer in potatoes (Rommens, 2007). Haverkort et al. (2008) suggested that cisgenisis could be used to control potato late blight (*Phytophthera infestans*) and speculated that societal resistance to the environmentally-unfriendly fungicides used to control late blight could lead to acceptance of cisgenic technology. Current European Union regulatory policy does not recognize a difference between cisgneics and transgenics. Jacobsen and Schouten (2008) recommend that cisgenesis should be considered as a tool for conventional breeding and be exempted from EU regulations on GM products.

Other researchers refer to cisgenic technology as intragenics, or all-native transformation. Rommens, Ye, Richael, and Swords (2007) documented the benefits of improving the storage characteristics of the Ranger Russet potato variety using this technology. Another study advocated intragenic technology because it eliminates the problem of undesirable traits (such as poor agronomic or cooking attributes) that transgenic potatoes can carry (Rommens, Haring, Swords, Davies, & Belknap, 2007). In this article, the term "all native" refers to cisgenic transformation, and "transgenic" refers to technology using markers and genes from other species.

Objectives and Methods

The objectives of this study are to

1. understand current potato industry attitudes regarding GM potatoes,
2. analyze differences in opinions regarding all-native and transgenic potatoes, and
3. determine the characteristics of respondents who are optimistic about all-native potatoes.

We hypothesized that the majority of people in the potato industry would have a favorable attitude toward GM potatoes. One reason for this is that acceptance of other GM plant products (canola, corn, cotton, and soybean) has increased since the first introduction of GM potatoes to the market. A second hypothesis was that all-native potatoes would be regarded more favorably than transgenic potatoes. A third hypothesis was that demographic data could help explain respondent opinions regarding all-native technology.

We collected data by surveying people in the potato industry. The one-page survey form consisted of nine statements and three questions. For the nine statements, respondents choose whether they strongly agreed, agreed, neither agreed nor disagreed, disagreed, or strongly disagreed. The first two questions asked about producer traits and consumer traits that would be important for GM potatoes. The last question was an open-ended question about barriers to GM potato acceptance

Table 1. Profession and geographic location of GM potato survey respondents.

Profession	Colorado	Manitoba	PNW	Totals
Agribusiness	4	27	9	40
Grower	28	58	10	96
Other*	12	26	6	44
Total	44	111	25	180

** Includes scientists, educators, government, and grower association employees*

in the United States and Canada. Demographic information regarding the respondents' age, gender, and profession was also collected on the form. Respondents also indicated whether they had grown NatureMark's GM potatoes. For statistical analysis, we converted the answers to the first nine questions to a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

We conducted surveys in three potato-producing regions: Colorado, Manitoba, and the Pacific Northwest (PNW). We collected the Colorado survey data at a San Luis Valley potato conference in February 2009 and the Manitoba data at a potato conference in Brandon in February 2010. The PNW survey data was collected during personal interviews in June and July 2009. More than half the respondents were growers (Table 1). Ten were females and 34 had produced NatureMark potatoes. The average age was 45; the youngest respondent was 21 years old and the oldest was 70.

For Objective 3 (to determine the characteristics of respondents who are optimistic about all-native potatoes), we developed the following model.

$$AN_i = f(A_i, G_i, L_i, N_i, P_i, S_{ij}),$$

where

AN_i = sum of Likert scale answers to survey Statements 1 and 2

A_i = age of respondent

G_i = gender of respondent (dummy variable, value = 1 for male, 0 for female)

L_i = location of respondent (dummy variable, value = 1 for United States, 0 for Canada)

N_i = former NatureMark grower (dummy variable, value = 1 for yes, 0 for no)

P_i = profession of respondent (dummy variable, value = 1 for grower, 0 for other)

S_{ij} = Likert scale answers to survey Statements 5-9

We used ordinary least squares (OLS) in Microsoft Excel to estimate the model.

Results

The first four survey statements dealt directly with the transgenic versus all-native issue (Table 2). Respondents indicated that growers are more likely to accept all-native than transgenic. Nine out of 10 respondents agreed (or strongly agreed) with Statement 1 that "all-native GM potatoes will be accepted by potato growers," but only 63% agreed that growers would accept transgenic GM (Statement 3).

The consumer acceptance questions did not ask the participants to respond as consumers. Instead, we asked for their opinions about consumer acceptance in general. The opinions of those surveyed were that growers are more likely to accept either type of GM potato than are consumers. Only 9% of the participants strongly agreed that consumers would accept all-native technology, and only 2% strongly agreed that consumers would accept transgenic. Adding the strongly agree and agree categories, the numbers were 49% and 17%, respectively.

Responses to Statements 5-9 (Table 2) shed light on some other issues related to GM acceptance. While 74% of respondents agreed that GM potatoes with consumer traits would increase total potato demand (Statement 5), only 29% agreed that GM products must have consumer benefits to be accepted (Statement 8). Nearly eight of 10 respondents agreed that non-governmental organizations (NGOs) will influence GM acceptance (Statement 6). Sixty-three percent agreed that all-native GM technology could have prevented the NatureMark market failure (Statement 7). Two-thirds said they would be willing to plant GM potatoes in the future (Statement 9).

Survey Questions 10 and 11 dealt with desirable traits that would be important to incorporate into GM potatoes. The top two producer traits were disease resistance and insect resistance. The NewLeaf Plus potato had both disease and insect-resistance traits, so grower needs may not have changed much since that product was introduced in 1998. The top three consumer traits—nutrition, cancer fighting substance, and vitamins—are all health related. In response to the open-ended question (#12) regarding problems with GM potatoes, more than half the respondents wrote in something about consumer acceptance.

Regression analysis results revealed that six of the 10 variables in the model were statistically significant (Table 3). Results also suggest that females, potato growers, Canadians, and former NatureMark growers were more likely to have a favorable opinion of all-native potato acceptance. Respondents whose opinions about Statements 5 and 9 were higher on the Likert scale

Table 2. Respondent opinions regarding statements about GM potato acceptance.

Statement	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
1. All native GM potatoes (gene transfer only within the potato species) will be accepted by potato growers.	41%	49%	7%	2%	1%
2. All native GM potatoes (gene transfer only within the potato species) will be accepted by consumers.	9%	40%	30%	20%	1%
3. Transgenic GM potatoes (gene transfer across species) will be accepted by potato growers.	18%	44%	20%	14%	3%
4. Transgenic GM potatoes (gene transfer across species) will be accepted by consumers.	2%	15%	23%	44%	16%
5. GM potatoes with consumer-beneficial traits could increase potato demand.	18%	56%	18%	7%	2%
6. Non-government organizations, such as Greenpeace and the World Wildlife Fund, will influence GM potato acceptance.	32%	45%	12%	8%	3%
7. If NatureMark had used all native GM technology, a market failure would have been less likely.	14%	49%	17%	16%	3%
8. GM products must have consumer benefits to be accepted.	5%	24%	36%	29%	5%
9. I would be willing to grow GM potatoes in the future.	26%	41%	25%	5%	3%

Table 3. Multiple regression analysis of factors that influence respondent opinions about all native GM.

Explanatory variable	Coefficient	T-value
Intercept	5.15	7.6
Gender	-1.27	-2.8
Location	-0.31	-1.5
NatureMark	0.23	1.2
Profession	0.57	2.6
Statement #5	0.46	3.3
Statement #9	0.41	3.8
R-square	0.56	

(more agreeable) were also more likely to be optimistic about all-native GM potato acceptance. Respondent age and opinions about Statements 6, 7, and 8 were not statistically significant.

Discussion and Conclusions

Since potato growers (especially former NatureMark growers) were more likely to be optimistic about all-native potatoes, they might see greater opportunities than the respondents who were in the non-growing part of the potato industry. In response to the open-ended question about barriers to GM acceptance, one Canadian grower wrote that some people in the other segments of the potato industry were paranoid about GM technology. Some growers seem eager for GM potatoes to re-enter the North American market, and they see all-native potatoes as the preferred product to do that. During the discussion at the Manitoba meeting, some said they and other Canadian growers have been planting other GM crops and would welcome the opportunity to grow all-native potatoes.

Participants who more strongly agreed with the following statements were also more likely to be optimistic about all-native potatoes.

- GM potatoes with consumer traits could increase potato demand.
- I would be willing to grow GM potatoes in the future.

Willingness to grow GM potatoes logically corresponds with an optimistic attitude about all-native technology. Those respondents who agreed that GM potatoes could increase consumer demand were also more likely to agree that all-native potatoes would be found acceptable. Perhaps they see all-native as a product that can help stop the recent decline in potato demand.

Survey results are consistent with what Rommens et al. (2007) found regarding differences in perceptions toward acceptance. They surveyed 779 consumers and found that 70% supported all-native technology versus 26% who supported transgenic. Since we did not survey consumers, our results cannot be directly compared, but we found that potato-industry respondents also thought that all-native would be more acceptable.

For some people, GM acceptance may be a moral issue. Myskja (2006) addresses the issue of moral objections of genetically modifying plants. He discussed the appeal of an all-native breeding technique since it does

not cross species borders, implying that the public may feel more comfortable about a "natural" GM potato variety. Perhaps NGOs that have taken an anti-GM stance might support all-native technology in the future.

Phillips and Corkindale (2002) described a GM alliance between two unlikely entities. In 1996, Monsanto and Greenpeace agreed to develop an affinity card made from GM cornstarch. Although Greenpeace backed out of the contract and took an anti-GM position, the approach of an alliance between a biotechnology company and an environmental group might happen again. An all-native potato with consumer benefits (such as low acrylimides) marketed with the approval of an environmental group could open the market for GM potatoes in North America.

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