

# **POTENTIAL ACCEPTANCE AND MARKETING OF CORN GENETICALLY MODIFIED TO REDUCE PHOSPHATE EMISSIONS**

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## **Abstract**

Nutrient pollution of streams, rivers, and bays, including the Chesapeake and Inland Bays, is an important environmental concern in Delaware. High phosphorus levels leached into surface and groundwater from agricultural operations are associated with eutrophication of water bodies. The economic impact of these environmental concerns includes decreased fishing and tourism. Costs of the current solution, mandatory nutrient planning programs, include farmers' use of expensive nitrogen only fertilizer and the poultry industry's use of expensive manure disposal outlets. Another possible solution exists in feeding poultry a genetically modified corn containing the enzyme phytase, which would lower the ratio of phosphorus in manure. This study seeks to examine potential acceptance of the GM corn by farmers and the poultry industry, and marketing of poultry raised on the feed as beneficial to the environment to consumers. The methodology involves surveys of Delaware corn farmers and consumers, and interviews with poultry industry companies. Implications include better environmental conditions, cost efficient use of poultry manure, and new ways to increase consumer acceptance of GM technology. The first two affect Delaware and similar states, while the last is of national significance.

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## **Background and Justification**

Delaware's water resources, like those of many states across the nation, are impacted by nonpoint source pollution. Phosphorus originating from fertilizer usage has been identified as a key factor in nonpoint source pollution. Rain induced runoff from land with excessive fertilizer and manure leads to over-enrichment of ground water, streams, and estuaries. The result is excess algae growth, large swings in bacterial populations, decreased dissolved oxygen levels, and ultimately, degraded water quality and biological resources.

In Southern Delaware, specifically Sussex County, there is a large and highly concentrated poultry industry. Field crops, such as corn, soybeans, and small grains, dominate the cultivated farm acreage in this county in part due to the influence of the poultry production industry. According to the Delmarva Poultry Industry, in 2002, approximately 68 percent of Delaware's cash farm income was from broilers. Delaware ranked seventh among the states in the pounds of broilers produced in 2002 with more than 1.5 billion pounds, up 3.3 percent from 2001. According to the most recent Census Bureau figures, Sussex County ranked first among America's counties in broiler chicken production. Poultry feed consisted of corn (72.5 million bushels of which 35.1 million bushels were Delmarva grown), soybeans (25.2 million bushels of which 13.1 million bushels were Delmarva grown), and wheat (79,000 bushels).

The combination of field-crop agriculture and animal-based agriculture in Southern Delaware has contributed to high phosphorus levels in soils. Nutrient pollution is an immediate concern to the Inland Bays and Chesapeake Bay as well as other streams and rivers in this region. In response to this problem, in June 1999 the state legislature enacted the Delaware Nutrient Management Law whereby any business operation that applied nutrients to greater than 10 acres or managed 8,000 pounds of animals was affected by the mandatory nutrient management or animal waste plan. Nutrient management practices include, for example, proper timing and methods of fertilizer (commercial and manure) application, planting of cover crops and vegetative buffer strips, and erosion control. By year-end 2002, approximately 50 percent of Delaware's farmland was managed according to Nutrient Management standards (Delaware Nutrient Management Commission). In areas where it is no longer possible to apply manure without creating water quality problems, the law requires farmers to sell or move the manure. Delaware exports approximately 70,000 tons of manure per year to alternative-use projects or to land in need of nutrients (U.S. Environmental Protection Agency). As a result of mandatory nutrient management, many farmers have adopted a phosphorus-limiting nutrient planning program. Instead of using the readily available chicken manure, farmers are applying more expensive nitrogen only sources of fertilizer, e.g., ammonia or urea.

A potential solution is the development and use of feed corn high in phytase, an enzyme with the ability to release phosphate from phytic acid. Chickens, monogastric animals, are unable to digest phytic acid, which is the primary storage form of phosphate in plants. This requires the addition of supplement phosphate to feed to achieve proper nutrient balance. In the chicken gut, however, phytate is readily digested by microbes releasing free phosphate, which is eliminated by the body's waste process. Phytase would allow for increased phosphorus conversion efficiency, reducing the need for additions to the feed, and thus reducing the ratio of phosphorus in the elimination process. This reduces the phosphorus level in the manure, changing the ratio to allow farmers to decrease the amount of nitrogen only sources of fertilizer without worrying about over application of phosphorus and thus reduce input costs. The development and use of high phytase feed corn would therefore help reduce the phosphorus mass balance.

Technology exists to develop a high available phosphorus (HAP) hybrid corn. The current version has a yield reduction compared to other corn seed as it was modified from a lower yielding cultivar, which should be correctable in future generations. A second concern is that the production of feed pellets requires high temperature and existing phytases undergo dramatic losses in activity during this process. Lastly, phytase action is required during digestion that occurs in both the stomach and intestines, which present two different pH conditions. An ideal phytase would be active over a broad pH range. A possible solution to these problems is the use of genetic engineering. Plants produce endogenous phytases that are a part of their natural cycle of phosphate storage and release. Through the use of genetic engineering it is possible to modify an existing plant phytase to create an enzyme that would have the following properties: 1) temperature resistance appropriate for feed pelleting, 2) an extended pH range adjusted for the entire chicken digestive system, and 3) an enhanced ability to remove all phosphates on the phytase molecule.

For a new GM HAP corn to be successful, acceptance and marketing issues will need to be examined at each level of the marketing channel. These will each involve different aspects of the corn. Beginning with the consumer level, there is the question of willingness to purchase poultry products that have been fed GM ingredients. While this can be considered the vast majority of chickens already consumed within the U.S., surveys continue to show a lack of awareness of this on the part of much of the population. When asked, research has shown consumers to be significantly less likely to purchase chickens that have been fed GM feed (Bernard, Pan, and Pesek, 2003). That finding was for GM feed described solely as benefiting the farmer, whereas the GM HAP corn could be marketed as beneficial to the environment for the reasons described above. This proposal thus seeks to expand on current findings by assessing consumer acceptance of the use of GM feed when the benefit is couched in terms of helping the environment. This will be accomplished using a revised version of the survey discussed above. To date, few studies have looked at consumer acceptance of GM technology with benefits for consumers or the environment.

On the corn farmer level, there are different marketing and acceptance issues. GM products have long been accepted on the nation's farms with such successful products as

Roundup Ready soybeans and Bt corn. Whether or not farmers will accept and adopt GM HAP corn should depend instead on measurement of the costs and benefits. On the cost side, acceptance issues to be investigated will include farmer tolerance for differences in yields and in seed costs. On the benefit side, the issues will be the potential for a premium on their crop and the return to use of resulting poultry manure as fertilizer. These depend, obviously, on acceptance by the poultry industry itself, and their inclusion completes all the market levels necessary to perform a complete analysis.

## **Goals and Objectives**

The overall objective of this research is to examine the market potential for GM HAP corn. The specific goals for accomplishing this objective are to determine:

- 1) Attributes, such as seed price, yields, Bt-stacked, segregation requirements, and possible crop premiums, that farmers would desire in order to adopt GM HAP corn.
- 2) Poultry industry willingness to pay for GM HAP corn and potential cost savings for their operations from its adoption.
- 3) Consumer willingness to purchase chickens fed GM HAP corn, and if so, are they willing to pay a premium for the environmental benefit.

All three objectives work towards the program's research priorities in the area of competitiveness and new markets. The first two fit directly with the program in identifying new opportunities for traditional and non-traditional products and by-products of agricultural production, while the last addresses consumer preferences and response to marketing and labeling claims.

## **Work Plan**

The first and third goals will be accomplished through the use of surveys targeted to the respective population of interest, while the second goal will be done through personal interviews. The surveys will follow the guidelines of Salant and Dillman (1994) in order to maximize response rate. Specifically, an advance postcard will be sent announcing the survey. This will be followed shortly by a first mailing, including cover letter, survey, stamped return envelope and a token of appreciation in the form of \$1. At weekly intervals, a reminder postcard will be sent followed by a second full mailing to all that had not responded. Effort will be made to keep surveys as concise as possible to aid response. Additionally, draft versions of all surveys will be piloted on small groups of the target populations prior to mailings.

The first survey will be targeted towards corn farmers to assess the feasibility of farmer acceptance and adoption of the technology under different potential scenarios about its characteristics and abilities. The last is essential since this will be an *ex ante* investigation of adoption, conducted prior to being certain what characteristics new GM HAP corn may possess. Design of possible combinations of attributes will be conducted with technical consultation from Fraunhofer USA, Inc., which has been engaging in on-

going construction of GM HAP crops. Studies of *ex ante* are particularly important in a time when it is soon expected that many potential new GM crops may head towards the market.

Previous *ex ante* adoption studies involving food biotechnology have been conducted. Probably the largest category of these looked at rBST, where its protracted approval process gave researchers years to formulate projections. Caswell, Fuglie, and Klotz (1994) reported 15 such studies, yielding a wide range of projections from 2 to 41% of dairy farms immediately adopting the technology. One reason for the range came from the differing information on performance and costs of rBST; information obviously not well understood prior to actual farm usage. Unfortunately, as noted by Lesser, Bernard, and Billah (1999), few past surveys offered different profiles of the product to be able to measure the sensitivity of the results. That study also discovered other lessons in the design and abilities of pre-adoption studies by comparing an *ex post* analysis of adoption of rBST with the *ex ante* projections of Lesser, Magrath and Kalter (1986).

Using the information gained from the experiences of the studies above, as well as knowledge of Delaware farmers from Bernard, Pesek, and Fan (2004) a survey will be designed and sent to full population of approximately 1,000 corn farmers in the state (USDA/NASS, 1998). The list will be assembled through the University of Delaware Cooperative Extension offices in each of the state's three counties and with the assistance of the Delaware Department of Agriculture. Typical difficulties involved with generating high response rates from farmers reported in Pennings, Irwin, and Good (2002) will be considered in implementation. These primarily include careful timing (arrival during non-busy season), keeping the survey relatively short, and having minimal need for farmers to check records to complete.

The main focus will be on identifying the attributes, seed price, yields, Bt-stacked, segregation requirements, and possible crop premiums, that farmers would desire in order to adopt GM HAP corn. By giving farmers different scenarios to consider, potential acceptance and adoption rates can be calculated for differing realizations of the technology. As noted, farmers have already largely accepted GM crops. National figures on plantings of Bt corn in 2003 was 29% in 2003, of which 4% were 'stacked' (meaning the corn was also GM to be herbicide tolerant) varieties (USDA/ERS, 2003). Thus, the Bt-stacked trait may prove crucial in adoption and acceptance. Similarly, any possible need for crop segregation and resulting costs would be a concern, while price and yields are obvious issues for any new seed.

An additional aspect of the analysis will be to consider the influence from the potential benefit from being able to use the manure from the poultry that had been fed feed containing the GM HAP corn. This likely benefit could be a major factor not typical for most adoption decisions. Existence could partially offset any price and yield concerns. The final set of information collected with the survey will be details of both the farm and the farmer. The former will include such aspects as farm size and use of other technologies while the latter will include the standard demographics such as age and

education. These will be similar to those used in an earlier survey of Delaware farmers (Bernard, Pesek, and Fan, 2004).

The second aspect of the research will be to examine acceptance issues on the poultry industry side. Since the integrators make decisions on feed, they rather than the actual growers will be the focus of the research. Information will be collected via personal contact with each of the three poultry companies in Delaware (Allen Family Foods, Mountaire Farms, and Perdue).<sup>1</sup> This and the corn farmer survey are closely interlinked since the demand from the industry will play a crucial role in the potential premium farmers may receive and thus strongly affect adoption. This aspect will be addressed in the integration of results.

The first part of the interviews will be in understanding the costs currently involved in feeding poultry and how these could change with available GM HAP corn. For example, eliminating the need to use supplement phosphorous could be a large cost saving. The second part will be in understanding the use and disposal of poultry manure. While the manure already is the farmers', the nutrient management plans discussed above force them to limit its application due to the already high phosphorous in the soils. This requires them to move the manure to a farm where phosphorous levels are not yet a problem or to give it to Perdue's AgriRecycle.

The last aspect will be a second survey, this to investigate the potential to market chicken fed GM HAP corn, including the possibility of consumer willingness to pay a premium. The survey will be sent to a random sample of 1,200 Delaware residents purchased from a firm such as USAData. The main methodological tool of this survey will be conjoint analysis. The survey will collect all the components for conjoint as well as appropriate demographic information. Implementation will be aided by its similarity to a survey already conducted by the investigators examining consumer willingness to purchase chickens produced with different attributes, including consumption of GM feed (Bernard, Pan, and Pesek, 2003). Findings included a small but significant decrease in willingness to purchase chickens fed GM feed. However, the feed was described as having GM traits beneficial solely to farmers and not to consumers or the environment.

Very few studies have examined consumer acceptance of GM foods with benefits beyond the farm. One study using economic experiments, Lusk, Moore, House, and Morrow (2002) found student subjects willing to pay only slightly more for corn chips GM to improve shelf life compared with those GM to benefit the farmer. However, they found the willingness to pay for the former almost the same as for a non-GM version. They suggest examination of consumer acceptance of GM foods with benefits beyond the farm is an area requiring much greater attention. Phillips and Corkindale (2002) suggest that better marketing, especially as products with benefits of more interest to consumers appear, will be essential for the future acceptance of GM foods.

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<sup>1</sup> Please note that the timing of this proposal corresponds directly with the appearance of avian influenza in the state. A letter of support from Perdue was being arranged and support from the other two was pending at the point that the crisis arrived. If permissible, we will submit these at a later point after the problems have abated.

Indeed, there has recently been increased consumer interest in versions of products that are better for the environment, or reduce the damage caused in typical production. 'Eco-labeling' has been the term given to the voluntary indication of such attributes on these products. Loureiro, McCluskey, and Mittelhammer (2001) note increased use of these labels in the U.S. with such examples as the Green Seal and Energy Star programs and many other regional movements such as California Clean Growers. The improved environmental conditions detailed above with the use of GM HAP corn feed would make such a label feasible and worthy of considering.

Previous research findings suggest marketing benefits to this approach exist. Blend and van Ravenswaay (1999) looked at eco-labeled apples and determined 40% of consumers would be willing to pay a substantial premium. Loureiro, McCluskey, and Mittelhammer (2001) followed by looking at consumer preferences for regular, eco-labeled, and organic apples. They found an intermediate demand for eco-labeled did exist. As they note, many of the same segment of consumers should be interested in eco-labels and organics. A GM product with an eco-label would create an interesting contrast since GM products are by current definition not organic. To the best of our knowledge, this would be the first study analyzing consumer response to a product with both the GM trait and yet marketed as friendly to the environment.

The last task will be to go beyond the individual analyses by integrating results from the three components. Desired prices and attributes across the segments of the marketing channel will be compared for possible inconsistencies that could make acceptance infeasible, even if individual analyses suggested otherwise. Thus it will only be by comparing findings across the sections that the complete picture of the potential acceptance and marketing of GM HAP corn should be clear. The possible economic benefits to all sides will be apparent after this final stage.

### *Timeline*

Given the three sections to be designed, completed and analyzed, a two-year time frame is proposed. The focus of year one will be on the survey of the corn farmers and interviews of the poultry integrators, while the second year focus will be on the consumer side, integrating results, and preparation of articles and final reports. More specifically, the suggested timeline is:

#### *Year One*

##### FALL

- Review of related literature
- Training of graduate student
- Development of survey for corn farmers
- Generation of mailing list of corn farmers

##### WINTER

- Mail corn farmer survey

##### SPRING

- Analyze results of corn farmer survey
- Conduct poultry industry interviews

#### SUMMER

- Analyze poultry industry responses
- Purchase mailing list of Delaware consumers
- Develop consumer survey

#### *Year Two*

#### FALL

- Mail consumer survey
- Present corn farmer and poultry industry results at professional conference
- Prepare and submit journal article on first two goals

#### SPRING

- Analyze consumer survey results
- Integrate results from all three surveys

#### SUMMER

- Present consumer survey results at professional conference
- Prepare and submit journal article on consumer survey results
- Prepare and submit final report

### **Expected Outcome**

Success of this project will be measured in a number of ways. The primary factor of success will be in determining the market feasibility of GM HAP corn. If success is achieved and the corn is adopted on the farm side and accepted on the consumer side, there should be large improvements in environmental conditions in southern Delaware. As noted, this work should be applicable to other states with similar concerns and thus be considered to contain national benefits as well. Measuring if this goal is achievable will first include knowledge of the attributes required for it to reach the highest acceptance among corn farmers and the poultry industry. Answers here will also be beneficial to biotechnology research companies by helping them more clearly focus research and development. This is of great importance in a field where successful creation of a new GM crop is an expensive undertaking, and understanding here will aid efficiency in effort.

The next expected accomplishment would be a better understanding of consumer acceptance of GM foods with traits beyond those viewed as beneficial solely to farmers. In particular, it will be discovered if an eco-label would be accepted on a GM food product. As it is expected that the next wave of GM crops will be ones with benefits beyond the farm, and little research has been conducted in this area, these answers will be useful to those throughout the food chain from farmers to retailers and consumers.

Success will also be measured in terms of presentations, publications, and in the education process of the research's graduate student. Starting with the first two, results will be shared in three main ways. First will be by presentation of results at two major professional conferences. Second will be in a minimum of two refereed journal articles. Both the presentations and articles will be divided between the farmer and industry sides,

and the consumer side. Third, integrated results will be shared with completion of the final report. Lastly, expected outcomes will include educational benefits for a MS student. These include the completion of a thesis based on this research, at least one of the presentations at a professional conference, and assistance in the preparation of at least one of the articles. The student will be involved in all stages of the research from design to implementation to analysis.

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