**Ethical Issues Arising from Enviropigs**
**A Cooperative Learning Ethics Case Study**

**New Perspectives in Agricultural Biotechnology**
**University of Wisconsin – Madison Extension**
**November 19 – 20, 2002**

**Developed by Robert Streiffer and Sara Gavrell Ortiz**

## Background:

Manure from farm animals is an important natural fertilizer for the growth of crops, but manure from intensive hog farms is a serious environmental problem. Because it is high in phosphorous, it can lead to water contamination, algae blooms which harm aquatic life, and the production of greenhouse gases. Researchers at the University of Guelph have developed transgenic pigs, Enviropigs, that use plant phosphorus more efficiently. By producing the enzyme phytase in the their saliva, the pigs can degrade normally indigestible phytate, which would otherwise release phosphorous into the pigs' manure. As a result, the phosphorus content of the manure is reduced by as much as 75 percent.

Some groups claim that Enviropigs will produce substantial benefits to the environment, consumers, and pork producers. Others claim that these benefits are a smokescreen that will divert attention from the long-term unsustainability of intensive pork production, and that Enviropigs pose unacceptable risks to consumers and the environment.

One of the primary funders of the research, Agriculture and Agri-Food Canada (AAFC), is deciding whether to renew their funding of the research. In response to increased public sensitivity to the use of genetic engineering in agriculture, and in response to several recent news articles critical of the Enviropigs, the agency will convene a meeting with various stakeholders. AAFC arbitrators will hear testimony from the groups and decide whether to renew the funding. They will base their decision on whether the Enviropig project conforms to the agency's mission of providing "information, research and technology, and policies and programs to achieve security of the food system, health of the environment and innovation for growth" and for satisfying the new Agricultural Policy Framework (APF), which is "composed of five elements: food safety and food quality, environment, science and innovation, renewal, and business risk management."

All of the materials included are actual materials from news reports, science journals, or web sites. Some of them have been edited to remove discussion of topics not directly relevant to the Enviropigs. The only things I am asking you to make up are the idea that the AAFC is presently deciding whether or not to renew funding and that they would

convene a stakeholders group to get input on the decision. I don't have any idea how they actually decide what to fund or when the Enviropigs funding is up for renewal.

**The Format:**

After dividing into small groups representing the adjudicating group (the AAFC panel) and the stakeholders, each group should pick a representative to do their presentation. You will have 30 minutes to read the relevant materials and discuss how to present your case to the AAFC panel. Each stakeholder group will then have 3 minutes to present their case. After the presentation, the AAFC panel has 1 minute to ask a question, and the stakeholder group has 1 minute to respond. After all of the presentations are done, each stakeholder group will have 1 minute to ask questions of one other stakeholder group, with the questioned group having 1 minute to respond. Then the AAFC panel will adjourn and deliberate for 15 minutes. They will then return and take 5 minutes to present and justify their decision by drawing from those groups that supported their decision, and, indicating how they would respond to those groups that would not support their decision. The groups should then step back and discuss what they thought of the exercise. The entire exercise should take about 1.5 hours.

**Interest Groups:**

Students will be assigned to one of the following interest groups.

- Agriculture and Agri-Food Canada (AAFC) Panel
- Ontario Pork
- Friends of the Earth
- Organic Consumers  Association
- University of Guelph Scientists

**General instructions for all stakeholder groups:**
Begin by reading the description of your group's position, given below. You must frame your argument within the general framework specified in the description of your group's position. Although the description offers you some of the specific arguments you should consider, feel free to develop your own based on the materials for your group. Read the materials for your group, as well as any AAFC materials relevant for your argument. Generate moral and/or scientific reasons supporting your position. Plan to include both factual statements ("ENVIROPIGS produce substantially lower amounts of phosphorous in their manure") and moral principles ("The AAFC should endorse a project which will help reduce environmental harm." Formulate a strategy for briefly presenting your position to the AAFC panel in a persuasive manner, and be prepared to answer questions from the panel about your position. Choose one person to speak for your group. You will have three minutes to present your position.

**Instructions for the AAFC Panel (Group 1):**
You will be asked to decide whether to renew funding for the Enviropig project. Your verdict should be based on the extent to which the project is consistent with the Ministry's mission and APF. Use your time to decide what additional facts you need to make a good decision and what moral questions need to be answered. After you hear testimony from each group, you should ask them any questions that you think remain unanswered. After all the testimony, you will have time to deliberate. Select a representative to present and justify your decision.

**Instructions for Ontario Pork (Group 2):**
You represent some 4,200 hog producers in the province of Ontario and you are one of the funders for the Enviropig project. Ontario Pork has the exclusive right to license and distribute Enviropigs to producers worldwide. You will argue in favor of the Enviropigs project on the grounds that it will benefit both hog producers (by allowing those that want to reduce their environmental impact to do so; by allowing those who want to scale up their hog production to do so; and by opening up new markets in developing countries) and consumers (by giving them price savings and an environmentally friendly product).

**Instructions for Friends of the Earth International (Group 3):**
You represent an organization dedicated to protecting the environment and promoting sustainable agriculture. You will urge AAFC not to renew their funding on the grounds that Enviropigs, like many other products of genetic engineering, pose unacceptable risks to the environment by encouraging hog farms to scale up their production and by distracting them from more sustainable alternatives. Moreover, because you think that the use of genetically modified organisms only continues because of the unequal bargaining position wielded by large agribusiness companies, you will urge AAFC to refuse to give priority to industry over the environment.

**Instructions for Organic Consumers Association (Group 4):** The OCA is a grassroots non-profit public interest organization which deals with crucial issues of food safety, industrial agriculture, genetic engineering, corporate accountability, and environmental sustainability. You will argue against the Enviropig project on the grounds that Enviropigs, like many other genetically engineered products, have unacceptable food safety risks and goes against consumer preferences.

**Instructions for University of Guelph Scientists (Group 5):** You will argue that AAFC should continue funding the Enviropigs project because Enviropigs do not pose any significant food safety risk and will have substantial environmental benefits, both for intensive hog production facilities as well as for small-scale and third-world hog farmers.

**Reading List**
(readings follow below)

## Readings for all groups:

- Forsberg, C. W. “The Enviropig: An Environmentally Friendly Pig That Utilizes Plant Phosphorus More Efficiently”
- Schmickle, S. “Enviropig Raises A Whole New Stink” Star Tribune (Sep 30, 2002)
  Agriculture and Agri-Food Canada – Backgrounder (707 words)

## Readings for the AAFC Panel:

- Agriculture and Agri-Food Canada – Food Safety and Food Quality
- Agriculture and Agri-Food Canada – Environment
- Agriculture and Agri-Food Canada – Science and Innovation

## Readings for Ontario Pork:

- Ontario Pork – Background Information
- Ontario Pork – Facts and Figures about the Pork Industry
- Ontario Pork – Get the Fact
- Ontario Pork – Pork Producers and the Environment
- Ontario Pork – Angus Reid Study Delivers Canadians’ Attitudes towards Pork Production
- Vestel, L. B. “The Next Pig Thing” Mother Jones (Oct 26, 2001)
- Nickerson, “Making a Silk Purse from A Sow’s Droppings” Boston Globe (June 24, 1999)
- Reuters, “And This little Piggy Was Environmentally Friendly” (June 23, 1999)
- Forsberg, C. “The Enviropig Will Reach The Meat Counter, But When?” Ontario Farmer (Jan 1, 2002)

## Readings for the Friends of the Earth International:

- Friends of the Earth International- Mission Statement
- Vestel, L. B. “The Next Pig Thing” Mother Jones (Oct 26, 2001)
- Editorial, Minnesota Daily. “Enviropigs Will Not Help Environment” University Wire (Oct 30, 2001)
- Taylor, D. “A Less Polluting Pig” Environ Health Perspect 108, 2000
- Reuters, “And This Little Piggy Was Environmentally Friendly” (June 23, 1999)
- Halverson, M. “The Price We Pay for Corporate Hogs: Executive Summary and Overview,” (July 2000)

## Readings for the Organic Consumers Association

- Organic Consumers Association – Background Information
- Cummins, R. “Hazards of Genetically Engineered Foods and Crops” Organic Consumers Association
- D’Amato, L. “Enviropig Studies Search for Effects of Meat on Humans” Kitchener Waterloo Record (Aug 3, 2001)
- Kirsch, V. “Tainted Animal Feed Risk Downplayed by Federal Officials” The Guelph Mercury (Feb 19, 2002)
- Council of Canada. “Poll on Attitudes to Genetically Engineered Foods.” (March 31, 2000)

## Readings for the University of Guelph Scientists:

- University of Guelph Research. “Sensational Science or Science Fiction?”
- Forsberg, C. W., et al. “Pigs Expressing Salivary Phytase Produce Low-Phosphorous Manure” Nature Biotechnology (Aug 2001)
- Forsberg, C. “The Enviropig Will Reach The Meat Counter, But When?” Ontario Farmer (Jan 1, 2002)

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**The Enviropig: An Environmentally Friendly Pig That Utilizes Plant Phosphorus More Efficiently**

**Cecil W. Forsberg**
**August 31, 2001**

**[This document has been modified from its original form to include information from the article "Guelph Transgenic Pig research Program."]**

**A Biotech breakthrough at the University of Guelph in reducing the environmental impact of manure produced by pigs:** Researchers at the University of Guelph have developed transgenic lines of Yorkshire pigs trademarked **Enviropig**™ that use plant phosphorus more efficiently (Golovan et al., 2001a; Golovan et al., 2001b). Non-transgenic pigs are unable to use an indigestible form of phosphorus called phytate present in the cereal grain diet. Therefore producers add supplemental phosphate to meet the dietary phosphorus requirement for optimal growth and development. The novel trait of the **Enviropig**™ enables it to degrade the indigestible phytate and absorb the phosphate eliminating the need to supplement the diet with readily available phosphate, and as a consequence the phosphorus content of the manure is reduced by as much as 75%. Digestion of the phytate also leads to improvements in digestion of minerals, proteins and starch in the diet.

**The Environmental Problem:** Manure from farm animals is an important natural fertilizer for the growth of crops. The manure from monogastric animals such as pigs and chickens, contains a higher concentration of phosphorus than is suitable for repetitive field application because indigestible (phytate) phosphorus passes through the digestive tract of the animal while other nutrients are absorbed. Therefore, the phytate phosphorus is concentrated in the manure. Consequently, at high application rates of manure to land in areas of intensive pork production, the potential for pollution of local surface water and ground water with phosphorus becomes a serious problem (Sims et al., 1998). When runoff and leachate from drainage tiles of fields that have a high phosphorus content drain into ponds and streams extensive plant and algal growth occurs, tainting the water and robbing it of oxygen leading to death of fish and other beneficial aquatic organisms (Jongbloed and Lenis, 1998; Kornegay, 2001) . Although rare, if there is flooding and rupturing of manure storage reservoirs more serious situations can arise (Mallin, 2000) .

A low phosphorus concentration in fresh water systems is key to clean water because its absence limits algal growth (Hudson et al., 2000). If phosphorus is not present at a growth-limiting higher concentration extensive eutrophication can occur, leading to the production of methane and nitrous oxide potent greenhouse gases (Huttunen et al. 2001; Steenbergen, et al. 1993). Eutrophication arising from agricultural sources also occurs in estuaries and near shore marine environments with production of nitrous oxide (Naqvi et al., 2000). The projected growth of the livestock industry (Delgado et al., 1999; Tilman et al., 2001) is expected to accelerate environmental problems on a global scale. It therefore is critical that agricultural practices be modified to reduce such environmental impacts.

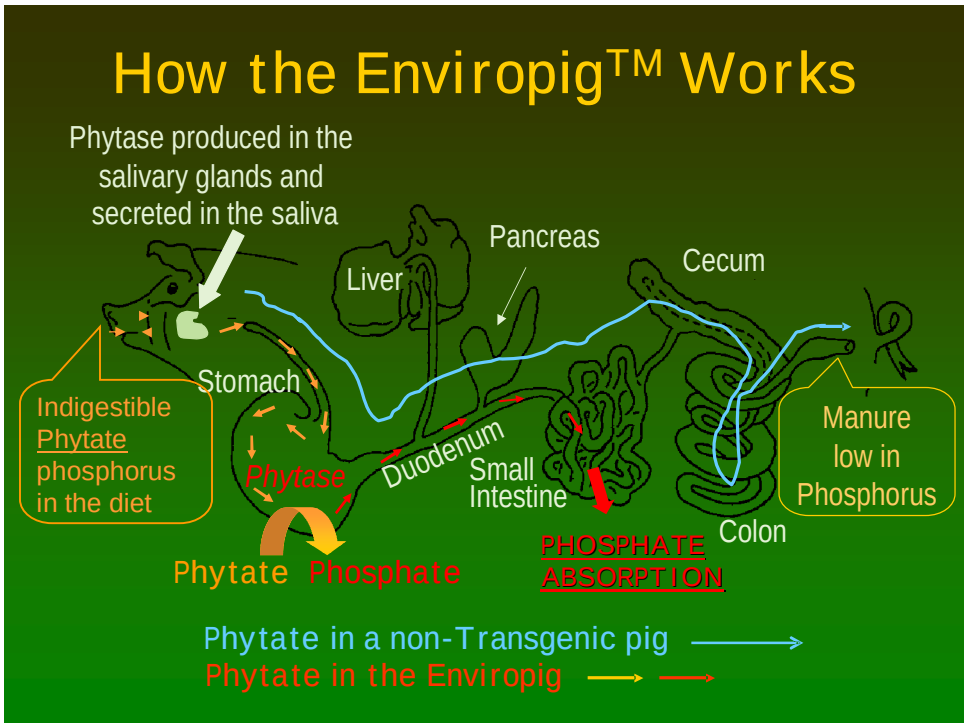
**The Current Strategy to Reduce the Phosphorus Content of Pig Manure:** The current practice to reduce excretion of fecal phosphorus by pigs is to decrease the supplemental phosphorus and to simultaneously include in the feed the fungal enzyme called phytase, which is available commercially. This enzyme acts to digest dietary phytate releasing phosphorus in the stomach of the pig. The net effect is improved phosphorus absorption in the small intestine by approximately 20 to 40% at phytase concentrations of 500 to 1000 Units per kilogram of feed (Ketaren et al., 1993; Simons et al., 1990). The reduced content of phytate in the small intestine decreases complexes formed between phytate and trace minerals, proteins and starch, thereby improving their absorption as well. Phytase is currently added to the swine diet in many countries.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



Currently crops are being developed that contain phytase in the seeds, however, there is a problem with stability of the enzyme during pelleting and storage. Research is also in progress on the development of phytate-reduced cereal grains, for example, corn that contains 65% less phytate (Raboy et al., 2000) which reduced the need for added phytase, however, supplementation was still beneficial for pigs (Sands et al., 2001) and poultry (Huff et al., 1998) . The potential of low phytate cereals is not fully resolved, since at least low phytate corn exhibits a lower germination and reduced yield as compared to unmodified lines of the corn.

**What is novel about the Enviropig?:** The Enviropig produces the enzyme phytase in the salivary glands that is secreted in the saliva. The enzyme acts in the stomach in the same way as fungal phytase added to the feed, except it is synthesized in larger quantities in the salivary glands (perhaps as much as 100,000 Units per kg of feed consumed) than the amount commonly added to the diet. The Enviropig was produced in the following way: A *transgene* constructed by linking a small portion of a mouse gene responsible for production of a salivary protein in the parotid, sublingual and submaxillary salivary glands to a phytase gene from a non-pathogenic strain of the common intestinal bacterium *Escherichia coli* (strain K12). This *transgene* was introduced into fertilized pig embryos, which were subsequently implanted into pseudopregnant surrogate sows. The offspring were tested for the presence of the gene by analysis of DNA from the piglets, and by testing saliva for phytase. Initially thirty-three different Enviropigs were produced with the same *transgene*. The transgene probably was introduced into a different location of the chromosome of each of these pigs, therefore, each pig is considered to be a different line. Several of these lines have been studied in more detail. They produce sufficient phytase to digest practically all of the phytate in a cereal grain diet. Phosphorus in feces from young grower pigs not supplemented with phosphate was reduced by 75% while that in finisher pigs was reduced by 56 to 67% when fed diets not supplemented with phosphate. The enzyme is reasonably stable and fully active in the stomach, but is degraded in the small intestine by pancreatic proteases, preventing excretion from the pig. Furthermore, because of the high specificity of the transgene promoter, the phytase is produced primarily in the salivary glands with only trace concentrations (less than 0.1%) in the major tissues such as muscle, liver, heart, skin, etc..



Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**Are the Enviropigs Healthy?:** All indications are that the pigs have a similar health status to that of non-transgenic pigs. They grow at rates similar to non-transgenic pigs and they appear to have similar reproductive characteristics.

**Benefits of the Enviropig TM:**

(i) They excrete as much as 75% less phosphorus in the manure as compared to non-transgenic pigs when fed a diet not containing supplemental phosphorus, producing a fertilizer with a higher ratio of nitrogen to phosphorus, which is better suited for long-term repetitive application to agricultural land. Pigs receiving a typical industry standard diet without supplemental phosphorus excreted fecal material with 64 to 67% less phosphorus.

(ii) They utilize practically all of the phosphorus present in soybean meal and do not require supplemental phosphate for growth on a standard diet consisting of corn, barley, wheat and soybean meal, with a saving of $1.14 per pig (CDN) for supplemental phosphorus, or an equal or greater saving in the cost of phytase. Furthermore, added phytase to the diet at the concentrations normally used does not release phosphorus from dietary phytate as effectively as the salivary phytase

(iii) We expect the pigs will utilize dietary trace minerals, proteins and starch more efficiently.

(iv) Because the **Enviropig** can utilize plant phosphorus efficiently it may be of great benefit in countries with low phosphorus resources, and which often lack currency for the purchase of phytase, and furthermore, which often lack the infrastructure for precise mixing and distribution of feed containing phytase.

**When will the Enviropig be available to Pork Producers?:** We predict it will be three to five years before this line of pigs will be available to swine breeders. The research is at an early stage, but some questions have been answered:

(i) The phytase gene is stably transmitted.

(ii) The phytase functions effectively in the stomach of the pig.

(iii) The phytase protein is largely limited to the salivary glands and to the digestive system as far as the small intestine. It is destroyed before it reaches the large intestine.

(iv) All indications are that the **Enviropig** exhibits similar growth and carcass characteristics to non-transgenic market pigs.

The Enviropigs are subject to the Canadian Environmental Protection Act (CEPA) under the auspice of Environment Canada. When these animals or samples of tissue, blood or even fecal samples are moved from one University of Guelph facility to another, under the present arrangement, tracking documents must be maintained for each animal and each sample collected from them. The animals are subject to the Health of Animals Act under the auspice of the Canadian Food Inspection Agency. When the phytase pigs reach the stage of testing to determine suitability as a food for humans, they will be subject to the Novel Food Regulations (http://www.hc-sc.gc.ca/food-aliment/) of the Federal Food and Drug Act under the auspice of Health Canada. These stringent requirements will assure that pork from these animals, will be safe when it is eventually approved for the consumer.

Publications forthcoming from Health Canada:

(i) Guidelines for the safety assessment of novel foods. Volume III. Genetically modified livestock animals and fish.

(ii) Guidelines for the slaughter and disposal of livestock animals and fish derived from modern biotechnology

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**Animal Welfare Issues:** All animal experiments are conducted following the strict guidelines of the Canadian Council on Animal Care (http://www.ccac.ca/. Guidelines on the production of transgenic animals may be downloaded from the site. Pigs are raised in accordance with the Canadian code of practice for environmentally sound hog production (http://www.canpork.ca/codes.html).

**Who is supporting the research?:** The research was supported by Ontario Pork, Ontario Ministry of Agriculture, Food and Rural Affairs through a contract to the University of Guelph, Natural Sciences and Engineering Research Council of Canada, Agriculture and Agri-Food Canada, and the Food Systems Biotechnology Center at the University of Guelph. The University of Guelph provides the expertise and facilities.

**Some Regulatory Issues:** I will make some personal comments regarding issues relating to the development of a protocol for assessing food safety of transgenic animals.

The Key Aspects of Novel Food Assessments:

1. The host organism.
2. The donor organism.
3. The modification process.
4. DNA analysis of the transgene.
5. The genetic stability of the modified organism.
6. Expressed material/effect.

I believe that the protocol for assessing transgenic plants can be applied to transgenic animal, except for the method of sampling tissues, pretreatment prior to sample analysis, and the extent of testing.

1. Will the assessment be performed on whole animals or tissues? With plants I understand that the whole raw seed is analyzed if the whole seed is to be eaten. In the case of fish I would assume that the whole animal might be ground and assessed because large pieces of the fish are eaten. However, in the case of animals, such as the **Enviropig** where organs, such as liver, kidney, or muscle are eaten separately there may be a desire to carry out assessment of separate organs rather than grinding up the whole carcass and sampling that. In the case of the **Enviropig** TM the salivary glands would be candidate organs to assess. In preparation for developing guidelines I recommend a broad survey of the published literature to assess the variation in composition between organs.
2. Pork and chicken meats are always cooked before consumption. Therefore I think it is reasonable that the samples should be cooked before testing. In contrast, plant samples are edible in the raw form and therefore sampling of the raw material is reasonable.
3. Some scientists have stated that transgenic animals will be more difficult to assess than transgenic plants because of their greater complexity. I contend that because the animal is more complex it will be easier to assess than plants. Arguments:
    a. Plants can produce toxic compounds without affecting their growth and appearance.
    b. Transgenic plants are normally tested for safety by feeding to animals. Therefore it may be argued that transgenic animals serve as their own internal control of food safety. Thus a healthy animal with a normal growth rate likely is safe to eat.
    c. I expect that after the first transgenic animal has been approved by the regulatory system, you will no longer need such a stringent analyses for vitamin content, amino acids composition etc. I suspect that a vitamin deficiency would affect the growth and would to symptoms before the content of a vitamin would have decreased dramatically. This comment leads to suggestion that it would be very useful to do an extensive literature survey of the nutritional literature to determine the relation between minimal requirements for essential nutrients and tissue composition of that nutrient. The survey will help to set a baseline for whether it is necessary to analyze the chemical composition of all tissues.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**Enviropig raises a whole new stink ; This genetically modified porker might be more pristine, but the environmental and ethical fight could get down and dirty.**

*Star Tribune*; Minneapolis, Minn.; Sep 30, 2002; Sharon Schmickle; Staff Writer;

**Sub Title:** [METRO Edition]
**Start Page:** 1A
**ISSN:** 08952825
**Companies:** Food & Drug Administration*Duns:***13-818-2175***Sic:****922190****Sic:****9400****Sic:****922190****Sic:****9400****Duns:****13-818-2175**

**Abstract:** *The problem occurs because ordinary pigs can't digest a form of plant phosphorus, an important dietary mineral, so farmers have supplemented feed with phosphorus in another form. The stuff from the plants goes into manure - and, all too often, into streams and lakes. As an alternative, some farmers supplement feed with an enzyme called phytase that helps the pig digest plant phosphorus.*

*Those first pigs have passed the trait to their offspring, and now more than 100 of the animals have been born, said Prof. John Phillips, a lead scientist on the team. The scientists have given the animals the trademark name* ***Enviropig****.*

*Thus,* ***Enviropig*** *causes jitters in some sectors of an already nervous meat industry, said Prof. Cecil Forsberg, another scientist on the* ***Enviropig*** *team. Many industry investors and one Canadian pork group have refused to get involved in the project, he said.*

**Full Text:**
*(Copyright 2002 Star Tribune)*

It seems like an invention straight from hog heaven: pigs with low-phosphorus poop.

Less pollution. Lower feed and cleanup costs for farmers. Maybe, eventually, less stink.

The pigs, created by genetic scientists in Ontario, could curb a serious pollution problem in Minnesota.

But these porkers aren't going to market anytime soon.

Instead, they stand at the center of the next fight over genetically modified food. And they represent tough tradeoffs for consumers.

The pigs are one of the first genetically modified livestock creations to be ready for scrutiny by regulators. Behind them in the scientific pipeline is a veritable Old MacDonald's barnyard of animals with genes manipulated to add traits such as leaner meat or disease resistance.

Creating the high-tech livestock is only the first hurdle. Next come questions of whether meat from the animals is safe to eat, whether consumers will eat it even if regulators deem it to be safe and whether the animals might pose unexpected environmental problems.

The U.S. Food and Drug Administration is preparing to rule next year on the first round of food-safety questions, John Matheson, an FDA senior regulatory review scientist said Thursday at a meeting in Dallas.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



The FDA co-sponsored the briefing on the technology, along with the Pew Initiative on Food and Biotechnology.

A green light from the FDA would shift the decision to farmers and food companies. Consumer groups already are warning them that the impending flare-up over this food will make the dispute over biotech plant crops look tame.

One big issue that hasn't been a factor in the crop debate is whether it is ethical to fiddle with the genes of animals, said Jean Halloran, director of the Consumer Policy Institute, a division of Consumers Union in New York. A farm animal is much closer to a human than is a cornstalk.

"We have no society for the prevention of cruelty to plants," she said at the FDA meeting.

Another unknown is what might be called the "yuck factor." Will bacon from a pig that has been given some mouse genes seem too weird to even make it to the breakfast table? We eat to sustain our bodies. But we also get emotional about food, associating it with love, tradition and religion.

"There are a lot of irrational buying decisions out there," Halloran said.

Scientists counter that the chemicals that make up genes are the same from mouse to pig to person. We eat them in one combination or another in most foods. What can differ are the proteins that a gene instructs an animal's cells to make.

Proteins from different species routinely are mixed at the dinner table. A club sandwich made with bacon, beef and turkey presents proteins from three species, and consumers relish the concoction.

However, some proteins introduced by gene splicing might be a problem. Someone who was allergic to eggs, for example, would want to know whether some component of an egg might, because of gene splicing, show up in a hamburger.

**Consumer tradeoffs**

Swapping genes from animal to animal isn't new. It was done in mice more than two decades ago. Since then, genes have been inserted into fish, rats, rabbits, sheep, goats, pigs, cows and chickens. The resulting transgenic animals have been sold for research - but never for food.

Companies developing the first line of animals for sale to farmers are betting that consumers will trust that the government would block any unsafe foods. They also predict that consumers will see good reasons to accept foods that win approval.

Those Canadian pigs embody the tradeoffs that consumers face.

With funding from pork producers, scientists at the University of Guelph in Ontario tackled a problem that plagues Minnesota farmers. Runoff of pig manure from fields is a major source of phosphorus that pollutes streams and lakes. It feeds algae that rob the water of oxygen needed to sustain fish and other aquatic life.

The problem occurs because ordinary pigs can't digest a form of plant phosphorus, an important dietary mineral, so farmers have supplemented feed with phosphorus in another form. The stuff from the plants goes into manure - and, all too often, into streams and lakes. As an alternative,

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



some farmers supplement feed with an enzyme called phytase that helps the pig digest plant phosphorus.

The Canadian scientists found a gene in an e-coli bacterium that produces phytase. From mice, they took a gene that directs the salivary glands to make enzymes. They spliced portions of the two genes together and put that package into pig embryos. The result was pigs that produce phytase in saliva and efficiently digest plant phosphorus.

Those first pigs have passed the trait to their offspring, and now more than 100 of the animals have been born, said Prof. John Phillips, a lead scientist on the team. The scientists have given the animals the trademark name Enviropig.

Papers the research team has published in peer-reviewed journals show that the genetic modification decreases phosphorus in the pigs' manure by as much as 75 percent. Phillips said the pigs are healthy and normal. The stink of the manure still is there, he said, but phosphorus plays a role in that too, and this research may provide clues to curbing the odor.

The next step will be to convince regulators that the meat is safe and the animals pose no environmental problems.

"No molecule in these animals will go unexamined," Phillips said.

The scientists are confident the animals will pass regulatory muster in the United States and Canada. What worries them more is the consumer judgment.

The University of Guelph has begun studying consumer reaction to the pigs, and it is finding that deep mistrust of current farm practices taints the attitudes toward new technology, Phillips said.

"People are very suspicious because they are concerned about how animals are raised on farms right now," he said. 'I don't think transgenic food production animals are going to be widely embraced until some of those concerns are addressed."

Consumers are so fed up with reports of chickens bred to be so plump they can't walk, and other controversial practices, that burger chains are monitoring the treatment of cattle and chickens they buy, said Joy Mench, an animal science professor at the University of California, Davis.

Thus, Enviropig causes jitters in some sectors of an already nervous meat industry, said Prof. Cecil Forsberg, another scientist on the Enviropig team. Many industry investors and one Canadian pork group have refused to get involved in the project, he said.

Pork producers in the United States have yet to weigh in.

"It's going to be a while before the consuming public is ready to get into the nuances of molecular genetics," said Eric Hentges, Vice President of technology and education for the National Pork Board. 'When my pork producers take on a new technology, they can't afford to be wrong. . . . We have as much at stake in this regulatory process as the consumer does."

Phillips takes a long view of Enviropig's future: "Twenty-five or 30 years from now, it will be out there, and the world will be a better place for it."

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**AAFC BACKGROUNDER**
**Overview of the Agricultural Policy Framework**

*The Government of Canada and the provincial and territorial governments are working with the agriculture and agri-food industry and interested Canadians to develop an architecture for agricultural policy for the 21st century. The objective is for Canada to be the world leader in food safety, innovation and environmentally-responsible production.*

*To realize this vision, governments have agreed in principle on an action plan for an agricultural policy framework composed of five elements: food safety and food quality, environment, science and innovation, renewal, and business risk management. The framework, which is based on the setting of common goals for each element, entails important benefits for the sector and ultimately the general public.*

*Accordingly, governments have launched a national dialogue about the policy direction with stakeholders and interested Canadians to develop the proposed policy approach.*

The Government of Canada, along with provincial and territorial governments and the agriculture and agri-food industry, is putting in place a comprehensive agricultural policy that will increase the profitability of the entire agri-food sector. The Agricultural Policy Framework (APF), cost-shared with the provinces, will provide the tools and the choices for producers to strengthen their businesses. It will allow them to meet the demands of consumers in Canada and around the world while responding to increased global competition and keeping up with rapid technological change. Linking the following elements together in a comprehensive approach will ensure that the Canadian agriculture and agri-food sector has a solid platform from which to maximize economic opportunities in the global marketplace.

***Food Safety and Quality***: Canada's agriculture and agri-food sector enjoys a global reputation for consistently delivering safe, high-quality food. Many players in the industry are already moving to adopt systems that will offer documented evidence of safety and quality to meet consumer demands. The APF will help industry develop these systems to trace their products through the entire food chain to consumers and expand food safety and quality monitoring at the production level. The food safety surveillance and information systems that governments currently have in place would be strengthened.

***Environment*** : Environmental stewardship is key to both the industry's long-term sustainability and its profitability. The industry is well aware of this and is already taking action to manage known environmental risks. The APF sets out areas where governments can provide help, including better information and research on the links between agriculture and the environment, the development of best management practices, and stepped-up action on environmental priorities on farms through agri-environmental scans and environmental farm plans.

***Renewal***: As agriculture is knowledge intensive, producers are increasingly engaging in continuous learning to keep pace with change. Renewal efforts include enhanced public and private business management and consulting services, management and marketing information to assist farmers to enhance their profitability, and networks to better link scientific advances to the creation of new economic opportunities.

***Science and Innovation***: Advances in science and technology have long been part of the success of Canada's agriculture and agri-food sector and one of the goals of the APF is to make the sector the world leader in innovation. The APF emphasizes the coordination of research and innovation efforts across governments, the sector and private research institutions to achieve maximum return on investments in the key areas of food safety, the environment and innovative production.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



***Gaining Recognition for Quality and Maximizing International Opportunities***: As global competition intensifies, we have to continually innovate to stay ahead of our competitors in meeting market demand. The first step is building the infrastructure to make Canada the world leader in food safety and food quality, environmentally responsible production and the creation of innovative agri-based products and services that meet or exceed market demands. The next step is gaining recognition at home and abroad for our success in being the world leader, and ensuring our industry has the access to foreign markets to make the best use of its global leadership in food production. The Government of Canada will continue to work with industry to advance the trade interests of the sector by developing targeted market strategies for key, fast-growing international markets while pursuing Canada's objectives in the World Trade Organization. This is the key to reaping maximum benefit from the APF for the sector.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**01. Readings for the AAFC Panel (word count: 2,895):**

1. Agriculture and Agri-Food Canada – Food Safety and Food Quality (1,104 words)
2. Agriculture and Agri-Food Canada – Environment (828 words)
3. Agriculture and Agri-Food Canada – Science and Innovation (963 words)

**Instructions for the AAFC Panel (Group 1):** You will be asked to decide whether to renew funding for the Enviropig project. Your verdict should be based on the extent to which the project is consistent with the Ministry's mission and APF. Use your time to decide what additional facts you need to make a good decision and what moral questions need to be answered. After you hear testimony from each group, you should ask them any questions that you think remain unanswered. After all the testimony, you will have time to deliberate. Select a representative to present and justify your decision.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# AAFC - Food Safety and Food Quality

**Food safety has always been important to consumers, but recent high-profile events around the world have raised their awareness and expectations.**

## Consumers are raising the bar for food safety and quality

Food safety has always been important to consumers, but recent high-profile events around the world, including outbreaks of mad cow disease in Europe, and concerns about bio-terrorism have raised their awareness and expectations. In addition, in areas other than safety, consumers are increasingly knowledgeable and discerning in their food purchases and are demanding greater choice.

To maintain their markets, suppliers of food and agricultural products are developing and implementing systems that demonstrate to both existing and potential consumers that they can deliver products within the demanded safety and quality specifications. At the same time, suppliers are taking advantage of these changing consumer dynamics to gain new markets and develop niche markets with potential price premiums. The proposed Agricultural Policy Framework (APF) aims to build on these efforts and help all producers to take similar steps and solidify Canada's reputation as a producer of safe, high-quality food. In working on these areas, it is critical to also look at the implications for other issues of concern to industry and consumers, such as regulatory harmonization within Canada and with key trading partners.

## Food safety systems are being strengthened

Until recently, efforts to improve food safety systems have primarily been at the processing level. For example, the processing industry has worked during the past decade to implement Hazard Analysis Critical Control Points (HACCP), a control and monitoring system that stresses prevention and correction of potential problems at each step of the manufacturing process.

The industry has been working proactively to develop national, voluntary, HACCP-based food safety programs for use on farms with financial support from Agriculture and Agri-Food Canada and the technical support from the Canadian Food Inspection Agency. Seventeen industry groups are developing plans that cover most of the major commodities, including livestock, poultry, horticulture and field crops. These actions, taken largely in response to customer demands, hold the potential to open new markets.

All activities of the food production and processing chain are interrelated. All parts of the continuum, therefore, need to have food safety systems in place in order to have a seamless, country-wide assurance system. Such a system is required to get the maximum benefit from these programs in international markets.

The Government of Canada, working with the provinces and territories, has agreed to officially recognize the administrative effectiveness and technical soundness of on-farm food safety programs, including the requirement to meet regulatory standards.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



This recognition will help foreign governments, buyers and consumers accept industry-led food safety programs on Canadian farms. This, in turn, could mean expanded markets for Canadian products.

## Quality assurance programs are also on the rise

In addition to food safety assurance, there is a growing market demand for the development of quality assurance systems to help industry secure new markets for agricultural products. Although industry must take the lead in implementing these systems, government could help maximize their acceptance in global markets through oversight and official recognition of these programs.

## Tracking and tracing provide safety and quality benefits

Outbreaks of diseases or pathogens within the food production and processing chain were once contained within small areas. Intensive farming and the increased movement of goods and people, however, have made them much more difficult to contain. As a result, outbreaks—whether from natural causes or bio-terrorism—can spread throughout a country and around the world in a remarkably short time.

Further complicating matters is the fact that as a product moves through the production and processing chain and beyond, its source becomes less and less defined. In a situation where there is an outbreak, a large quantity of the commodity must be removed from the market to offset the risk that some of the affected product would be missed.

"Ministers also acknowledge the importance of moving forward with identity preservation systems to track and trace products throughout the food chain."
*Federal-Provincial-Territorial Ministers of Agriculture Agreement in Principle on an Action Plan for an Agricultural Policy Framework, June 2001*

The further development of tracking and tracing systems could help solve this problem. These systems preserve the identity of a product as it moves through the food production and processing chain on a commodity-by-commodity basis. This information could be used to remove suspect products from the market quickly and effectively.

The benefits of these systems also extend beyond disease surveillance of animal populations or identifying contaminated batches of food products. The identity preservation feature of tracking and tracing also contributes to quality assurance programs, which industry could use to maintain existing markets and capture niche markets for premium products.

To be effective, however, tracking and tracing systems must be applied consistently and nation-wide, and work throughout the entire chain from producer to consumer. At present, these systems are at different stages of development across commodities and across the country. Government could help the development of such systems throughout the sector with research, coordination and oversight.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



### Tracking and tracing is a marketing advantage

The benefits of tracking and tracing are evident in the case of seed potatoes, where the ability to track production right through to final destination has allowed Canada to both manage disease problems and to access markets that demand quality assurance.

### An approach to enhanced food safety and food quality

To promote comprehensive and consistent implementation of food safety and quality assurance programs across Canada, the Ministers of Agriculture have committed to work together and with industry towards a set of common goals. Among the common goals being considered are:

- to protect human health by reducing exposure to food-borne hazards;
- to increase consumer confidence in the safety and quality of foods sold in Canada and/or exported;
- to improve ability to identify and respond to food safety issues and concerns;
- to increase ability to meet or exceed market requirements for food safety and quality;
- to support harmonized legislation and regulation to promote market access for domestic and export markets; and
- to provide value-added opportunities through the adoption of food safety and food quality systems.

To further encourage consistent implementation and to achieve these common goals, the following is being considered:

- to adopt food safety and food quality assurance systems, based upon HACCP principles, throughout the food continuum;
- to share critical food safety and surveillance information between all levels of government; and
- to implement comprehensive tracking and tracing systems throughout the food production and processing chain to meet public protection, consumer preference and commercial requirements.

Canada

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# AAFC - Environment

**Agriculture's long-term vitality and prosperity depend on its ability to co-exist sustainably with the natural environment.**

## Agriculture and the environment are closely linked

Agriculture's long-term vitality and prosperity depend on its ability to co-exist sustainably with the natural environment. Farmers understand this concept well.

Farming, however, has undergone significant changes in recent years. For example, producers are adapting to changing market demands, adopting new production technologies, and shifting towards larger, more intensive operations. While the full effects of these changes on the environment are not fully understood, recent studies show that some key pressures arising from agriculture, such as nutrient surpluses and emissions of greenhouse gases, have been increasing.

At the same time, public awareness and concern about these issues is growing. Canadians expect all economic sectors, including agriculture, to do their part to protect the environment. Canadian farmers recognize their responsibility as environmental stewards and are taking proactive measures.

The federal, provincial and territorial governments have been helping the sector meet its environmental goals for many years. There is an increasing need, however, for governments to work together with industry towards a comprehensive solution.

"Ministers, recognizing that environmental protection is a critical issue for citizens, as well as for the future viability of Canadian agriculture, agree to work towards a comprehensive plan for accelerated environmental action, fully covering all Canadian farms, that will help achieve measurable and meaningful environmental goals in the areas of water, air and soil quality, and biodiversity."
*Federal-Provincial-Territorial Ministers of*
*Agriculture Agreement in Principle on an Action Plan for an*
*Agricultural Policy Framework, June 2001*

## Agriculture's interaction with the environment must be better understood

New investments in our ability to understand, measure and report on the status of the agricultural environment would pay dividends by addressing public concerns and ensuring the long-term sustainability of farm operations. These efforts would also help identify where progress is being made and where improvement is needed.

If this information were readily available, farmers could make significant progress towards sustainable agriculture by adopting cost-effective management practices, and other decision makers could make better land use decisions. Accordingly, as governments develop new programs for agricultural sustainability, they should make the delivery of this information a priority.

## Environmental action must be comprehensive and coordinated

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



Coordinated action covering all farms in Canada would significantly improve the quality of the environment. Governments should provide tools for farmers to take advantage of new technologies and practices. They should also provide the tools for farmers to better understand the implications of their production decisions on the long-term sustainability of their farms. By providing effective, accessible programs, governments could assist farmers to make cost-effective investments in their farms.

Governments are already providing programs to the sector to varying extents. A consistent Canada-wide approach to agricultural sustainability, however, would demonstrate to buyers that Canadian agriculture and food products have been produced in an environmentally-responsible manner. Industry could use this advantage to capture new markets and seize a greater share of existing ones by improving the attractiveness of Canadian products. At the same time, a consistent approach would benefit all Canadians in all parts of the country with a cleaner, healthier environment.

## An approach to improved environmental performance on farms

Because of the many benefits associated with a consistent approach, the Ministers of Agriculture have committed to work together and with industry towards a set of common goals for improving environmental performance on farms. These meaningful and measurable goals aim to achieve improvements in the quality of our water, soil and air, and in biodiversity. Specific areas where progress towards these goals could be demonstrated are:

- Water: Reduce agricultural risks to the health of water resources. Key priorities are nutrients, pathogens and pesticides.
- Soil: Reduce agricultural risks to the health of soils. Key priorities are soil erosion and soil organic matter.
- Air: Reduce agricultural risks to the health of air and the atmosphere. Key priorities are particulate emissions, odours, and greenhouse gas emissions.
- Biodiversity: To ensure compatibility between biodiversity and agriculture, which is the primary user of farm land. Key priorities are wildlife habitat, species at risk, and economic damage to agriculture from wildlife.

To ensure progress towards the common goals, Ministers of Agriculture propose the following:

- Farm Planning: an increase in the use of environmental farm planning, regional environmental management plans, or equivalent increase in the coverage of such environmental plans;
- Nutrient Management: an increase in the use of beneficial manure management practices and fertilizer management practices, nutrient management plans and the degree to which nutrient application is in balance with need;
- Pest Management: an increase in the use of beneficial pest and pesticide management practices;
- Land and Water Management: a decrease in the number of bare-soil days on farm land, an increase in no-till or conservation tillage, and improved management of riparian areas, grazing lands and water use; and
- Nuisance Management: the adoption of better management practices to reduce odours and particulate emissions.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# AAFC - Science and Innovation

**The latest science developments offer many opportunities for the agriculture and agri-food sector.**

## Agriculture is applied science and innovation in action ...

The agriculture and agri-food sector has always been profoundly affected by science and technology. The farm practices of today could hardly be imagined 50 years ago. The agricultural production and processing chain—from farm inputs to consumption—is also evolving. In recent years, innovations and advances in science and technology have made the pace of change quicker than ever.

"We're on the verge of yet another revolution. Biology is transforming to a science based upon information... We're seeing the convergence of biotechnology with information technology. We're seeing the convergence of biotechnologies with materials technologies, and we're going to see the impact of biotechnology across all sectors of the economy. The new economy only comes from intensive research and development."
Peter A. Hackett, Vice-President of the National Research Council

## ... and it's changing rapidly

Rapid advances in such fields as biology and chemistry, combined with the ever-increasing power of new information and communications technologies, have fueled significant growth in the bioeconomy. At the same time, once distinct fields of enquiry such as plant and animal sciences, or environmental and health sciences and once distinct businesses such as agriculture, chemicals, health care and pharmaceuticals are converging. This convergence has accelerated the pace of research activity.....

## With change comes opportunity

The latest science developments offer many opportunities for the agriculture and agri-food sector. New applications for agricultural commodities are being developed such as nutraceuticals, sources of medicinal substances and renewable fuels. Taking advantage of these innovations could help to increase incomes through diversification of farm business, shift consumption from non-renewable to renewable resources, improve environmental practices and enhance food safety and quality systems.

"Ministers agree that innovation through the sound application of science and research will be key to creating additional economic opportunities for the agriculture and agri-food sector, strengthening environmental stewardship and improving food safety, as well as addressing many forms of risk."
*Federal–Provincial–Territorial Ministers of*
*Agriculture Agreement in Principle on an Action Plan for an*
*Agricultural Policy Framework, June 2001*

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



## Working together for success

Responsibility for innovation in the sector is shared by many players. The complex set of relationships that connect research and technology development to end users, including farmers, cuts across industry and government. The research component of innovation includes government research centres, colleges and universities, and private-sector laboratories.

"Ministers recognize that the benefits of the life sciences will be realized only through collaboration and coordination across many scientific disciplines and research organizations." *Federal–Provincial–Territorial Ministers of Agriculture Agreement in Principle on an Action Plan for an Agricultural Policy Framework, June 2001*

To get all players working toward the same goals, it is critical to strengthen the links and coordinate efforts among them. There are many joint efforts among the various institutions throughout the research and innovation chain, which are promoted by a broad spectrum of informal and formal arrangements. These collaborations could be strengthened and expanded.

## The right environment will foster innovation

To become the world leader in agriculture and agri-food, Canada must move quickly to encourage research and development and to quickly get the resulting innovations into the hands of farmers and other end users.

It is therefore important to foster a business environment that is conducive to research and development, and that encourages public and private funding of agricultural research and the early application of research results. This could be achieved through appropriate investments and close collaboration among all players in the innovation chain.

"Ministers also recognize that economic benefits will accrue to nations that first develop and bring to market new products and processes."
*Federal-Provincial-Territorial Ministers of Agriculture Agreement in Principle on an Action Plan for an Agricultural Policy Framework, June 2001*

Consumer and industry confidence is key to moving new products and technologies through the innovation chain. Strengthened stewardship would reinforce the confidence that consumers and stakeholders have in the safety, food quality and benefits of innovative products and practices.

Finally, the promise that science and innovation hold for Canadian agriculture is achievable only if the sector-producers, processors and distributors-know about and adopt innovative technologies and practices. It is crucial, therefore, to help the sector take advantage of the latest production and management techniques, including those that have food safety, food quality and environmental benefits.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



A new approach to levering science and innovation into excellence

Science and innovation are the cornerstone of all efforts to make the Canadian agriculture and agri-food sector the world leader and to support its future success and prosperity. With this in mind, Ministers of Agriculture have committed to work together and with industry towards a set of common goals to increase the economic benefits to producers and processors while positively contributing to the environment, health of consumers and Canada's economy. Among the common goals being considered are:

- to increase/realign investments to support the national science and innovation initiatives in the priority areas of the APF (i.e. the environment, food safety, renewal and risk management) and biomass, bioproduct and bioprocess research;
- to increase the amount of investment in agriculture and bioproducts (e.g. nutraceuticals) accessed from non-agricultural sources within Canada and elsewhere;
- to facilitate the adoption of new economic opportunities based on innovative agriculturally-based products and knowledge;
- to expand and strengthen linkages with the global science and innovation community so that Canada's agriculture and food industry can benefit from the international pool of scientific knowledge and discoveries;
- to improve communications and increase collaboration and coordination across market, policy and scientific disciplines, research organizations and throughout the agri-food value chain;
- to address human resources requirements of the sector; and
- to better utilize intellectual property from publicly supported research.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**02. Readings for Ontario Pork (word count: 5,151):**

1. Ontario Pork – Background Information (387 words)
2. Ontario Pork – Facts and Figures about the Pork Industry (607 words)
3. Ontario Pork – Get the Facts (730 words)
4. Ontario Pork – Pork Producers and the Environment (122 words)
5. Ontario Pork – Angus Reid Study Delivers Canadians' Attitudes towards Pork Production (411 words)
6. Vestel, L. B. "The Next Pig Thing" Mother Jones (Oct 26, 2001) (1,214 words)
7. Nickerson, "Making a Silk Purse from A Sow's Droppings" Boston Globe (June 24, 1999) (773 words)
8. Reuters, "And This little Piggy Was Environmentally Friendly" (June 23, 1999) (363 words)
9. Forsberg, C. "The Enviropig Will Reach The Meat Counter, But When?" Ontario Farmer (Jan 1, 2002) (544 words)

**Instructions for Ontario Pork (Group 2):** You represent some 4,200 hog producers in the province of Ontario and you are one of the funders for the Enviropig project. Ontario Pork has the exclusive right to license and distribute Enviropigs to producers worldwide. You will argue in favor of the Enviropigs project on the grounds that it will benefit both hog producers (by allowing those that want to reduce their environmental impact to do so; by allowing those who want to scale up their hog production to do so; and by opening up new markets in developing countries) and consumers (by giving them price savings and an environmentally friendly product).

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# Ontario Pork - Background Information

## Mission Statement

**Ontario Pork will:**

- Create the most favourable environment for the production and marketing of pork and;
- Maximize the benefits for producers through industry interaction.

**Strategic Aims & Objectives:**

- Enhance organizational effectiveness
- Maximize market opportunities
- Build consumer confidence
- Advocate producer interests
- Facilitate coordination within the industry

See also Vision and Mission Statement

## Our History

Ontario Pork represents the 4200 producers who market hogs in the province of Ontario. The Ontario Pork Producers' Marketing Board (OPPMB) was formed in 1946. A producer vote held in 1945 showed there was an overwhelming majority of hog producers in Ontario who favoured a producer-controlled organization. The provincial government enacted the Ontario Hog Marketing Scheme - 1946 under the Farm Products Control Act.

This legislation, now called the Farm Products Marketing Act, provides the legal authority for hog producers to organize and control their own affairs through the Ontario Pork Producers' Marketing Board. The Act and accompanying regulations empowers the Board to market hogs. It spells out how the Board can go about its business, including elections. (Legislation).

## Our Purpose

Ontario Pork represents pork producers in many areas, including hog marketing, consumer education, research, government representation, environmental issues, animal care and food quality assurance. The organization is also responsible for arranging for payment of hogs and, working cooperatively with the processors, arranging the trucking. Ontario Pork acts as the official spokes-group for the industry and is a source of information about the industry.

There are 30 county or regional pork producer associations (Producer Participation). The activities of the county groups include the promotion of pork on a local level. The counties within a zone also elect producers to serve as councillors. The councillors attend local, regional, and provincial meetings and are the grassroots voice of the organization.

Most importantly, councillors are responsible for electing from amongst themselves the 14 individuals who form the provincial Board of Directors.

The Board of Directors' primary task is to set policy and to provide staff with direction on Ontario Pork's operation and its services. The directors in this role become involved in a broad range of issues such as animal care, international trade, food safety, the environment and agricultural education. In this capacity the directors work with many other public and farm groups.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# Ontario Pork - Facts & Figures About the Pork Industry

## About Producers:

- In 2000 there were 4,473 pork producers in Ontario
- Canada had 12,905 pork producers in 2000.
- Pork producer numbers, like all farm numbers, have continually declined. Ontario pork producers have decreased steadily, down by 75% from 20,354 pork producers in 1979 (the last increase in numbers was in 1978).
- By far, the largest numbers of producers have decreased from the '0-50' hogs per year marketing range. This is not surprising, as today's farmers tend to specialize in one commodity, rather than the mixed farming of the past.
- Ontario's swine industry remains dominated by the family farm. Even in the largest sales categories, business corporations own only a small percentage of the pigs. The numerical "average" farm size is not the typical hog farm found in Ontario today.
- See also "Pork Industry Profile"

## Pig Numbers:

- Canada produced 20 million market hogs in 1998.
- Ontario produced 4.64 million market hogs in 1999. This is very close to previous highs reached in 1985 (4.56 million sold) and 1988 (4.65 million).
- The fewest market hogs sold in Ontario in the last 30 years was in 1975 with 2.47 million hogs marketed.

| Year | 1-50 hogs | 50-500 | 501-1000 | 1000+ | Total |
|---|---|---|---|---|---|
| 1978 Producers | 10,469 | 6,244 | 1,127 | 558 | 18,398 |
| Hogs | 153,224 | 1,123,876 | 778,457 | 973,723 | 3,029,280 |
| 1988 Producers | 5,067 | 5,177 | 1,581 | 1,263 | 13,088 |
| Hogs | 85,623 | 1,050,696 | 1,118,112 | 2,391,209 | 4,650,650 |
| 1998 Producers | 1,332 | 2,073 | 877 | 1,220 | 5,502 |
| Hogs | 22,741 | 472,432 | 630,009 | 3,115,639 | 4,240,821 |
| 1999 Producers | | | | | 5,099 |
| Hogs | | | | | 4,640,000* |

* estimate.

## Economic Contributions:

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



- Estimated total value of sales from Ontario hogs for 1999 was $525 million
- Ontario's pork industry as a whole contributed $3.3 billion and 42,000 jobs to the provincial economy in 1998.
- 1 in 7 jobs in Canada are in the agri-food sector.*

## Manure:
## Put things into perspective…The Nutrient Cycle

- Pigs produce manure. Manure is spread on the land to grow crops. Pigs eat the crops, and the cycle continues. Our goal is to manage that cycle properly by matching up the amount of manure and fertilizer to what the crop requires.
- Manure contains three major nutrients: nitrogen, phosphorous, potassium, and also adds valuable organic matter to the soil.
- Average manure spreading rate is 5000 gallons/acre, which is equivalent to 1/5 of one inch of rainfall (in volume)

- Ron Fleming, a researcher at Ridgetown College, completed a 12-month project in 1999 where he measured the amount of manure produced by hogs on 21 different farms, "The Average manure production for the wet/dry feeder barns was **3.24 liters per day** and for the dry feeder barns was **4.03 liters** (approximately 1 gallon) per day per hog."
- Average water usage (that requires treatment) for the average Canadian is 68 gallons (306 litres) per day.
- Animal Units: 1 animal unit = 4 market hogs
  = 5 sows
  = 20 weaner pigs

- "Intensive" agriculture is defined as 150 animal units or more (equivalent to 3000 weaners, 750 sows, or 600 market hogs).

## Water:

- Ron Fleming's research included drinking water meter readings taken daily in each of 21 barns. He reported that, "The average water requirement for the wet/dry feeder barns was **5.54 liters per pig per day,** which was significantly less than the **7.92 L/pig/day** average for the dry feeder barns."
- Water is not lost, but rather 'recycled' as nature intended for all creatures, as part of the water cycle.

## General:

- Over 98% of Canada's farms are family owned and operated.*
- Less than 3% of Canadians are farmers.*

* Source: Agriculture and Agri-Food Canada, 1996.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# Ontario Pork – Get The Facts!

Keep up the great work speaking up for the pork industry. Here are a few pointers on how to get your message out effectively. Check out the Ontario Farm Animal Council's website for some handy tips on How to Write a Letter to the Editor.

Try not to get too detailed in 'numbers' and technical arguments. Keep your message clear, with a simple example to back up your argument. One or two number facts can help dismiss the credibility (or lack thereof), of the article you're responding to. It is important to remember that economic arguments will never win over emotional subjects.

## About farmers:

- Farmers represent less than 3% of the total Canadian population and 13% of the rural population[1].
- 4,473 pork producers marketed hogs in Ontario in 2000.
- Canada had 12,905 pork producers in 1999.
- Canada had 276, 548 farms in 1996. Over 98% are family owned and operated. [1]
- 40% of Canada's farmers have a post-secondary education.[1]

## About pigs:

- Canada produced approximately 21 million market hogs in 1999.
- Ontario had sales of $525 million in 1999, from 4.64 million market hogs, close to previous highs reached in 1985 (4.56 million) and 1988 (4.65 million).
- The fewest market hogs sold in Ontario in the last 30 years was 2.47 million in 1975.

## In general:

- Ontario's pork industry contributed approximately $4.2 billion and 35,000 jobs to the provincial economy in 2000.
- 1 livestock unit = 4 market hogs = 5 sows = 20 feeder pigs
- "Intensive" agriculture is being defined as 150 livestock units or more. Equivalent to 3000 feeder pigs, 750 sows, or 600 market hogs.
- All mammals (including people) regularly excrete E.coli in their manure. It was a particular strain, E.coli 0157:H7, that caused the tragedy in Walkerton. This type of E.coli is most commonly found in ruminant animals. It is very rare for pigs to carry or shed E.coli 0157:H7.

## About manure:

- Average manure spreading rate: **3000 - 5000 gallons/acre** Equivalent to less than ¼ inch of rainfall in volume.
- Average manure production for market hogs varies from **3.24 liters to 4 liters** per day per hog. [2]
- Volume of manure & wastewater (including dilution liquid): Feeder pig - 7.1 litres, Human – 230 litres

## About water:

- Average water requirement for market hogs varies from **5.5 to 7.9 litres** per day [2]. You use

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**8 litres** of water to brush your teeth with the tap running.[3]

- The average Canadian uses **326 litres** of water a day[3] for regular household and garden use as follows: bathing – 35%, toilet - 30% , laundry 20%, drinking & cooking – 10%, cleaning – 5%.

**In other words, on average, per day:**

- Wastewater: A human produces 32 times more per day than a feeder pig.
- Solids: A feeder pig produces about four times more than a human.
- Nitrogen: A feeder pig produces two times more than a human.
- Phosphorous: A feeder pig produces about 6 ½ times more than a human.
- 3 feeder pigs excrete about as many E.coli organisms as 4 humans.

**Messages:**

- Today's farms are larger and more specialized than in the past. We operate our farm with the same care, commitment and values of the generations that have farmed before us.
- Environmental issues affect us directly as our families live, work, and play on our farms. It's our business and our way of life.
- Pigs produce manure, which is spread on the land to grow crops. Pigs eat the crops, and the cycle continues. Our goal is to manage that cycle responsibly, as we match nutrients to our crop requirements.
- Water is not lost, but rather 'recycled' as part of the natural water cycle.
- Responsible manure management should be a priority for farms of any sizes.
- Farmers are subject to provincial legislation such as the Environmental Protection Act and the Water Resources Act and can be prosecuted just like anyone else proven to have contaminated a water source.

1. *Statistics Canada, Agriculture Census, 1996.*
2. *Fleming, R., Hocking, D., MacAlpine, M., and Johnston, J., 1999. Investigation of manure production in typical 3-site hog facilities.*
3. *Environment Canada, 2000. www.ec.gc.ca/water*
4. *Ron Fleming, Ridgetown College - University of Guelph February 2000, Human Vs. Pig Comparison of Waste Properties, Email: rfleming@ridgetownc.uoguelph.ca*

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# Ontario Pork - Pork Producers & the Environment

- Ontario's farmers are world leaders in implementing proactive, on-farm environmental programs.

  Examples: Environmental Farm Plans, Nutrient Management Plans, Best Management Practices, Grower-Pesticide Safety Course, Odour reduction strategies

- Manure provides us with a valuable source of organic matter and nutrients for our crops. It always has been, and continues to be, the best fertilizer.

- Pork producers are committed to the environment. Environmental issues affect their families and their businesses directly and immediately. They live and work on the land, and drink the water.

- As stewards of the land, it is in our own best interest to preserve our resources for the farmers of the future, which is traditionally our own children.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



# Ontario Pork
# Angus Reid Study Delivers Canadians' Attitudes towards Pork Production

ETOBICOKE, December 16, 1999 ~ A national Angus Reid study has given Canadian pork producers an important benchmark of public opinion and a blueprint for future directions in the hog business. Provincial producer organizations across Canada commissioned the Angus Reid Group to learn more about the attitudes of Canadians toward the pork industry and its production practices.

Carried out in mid October, the poll compiled the opinions of 1,500 Canadians. The large sample of public opinion will form the basis for strategy in the coming years, and will be a benchmark against which future public attitude surveys can be measured.

"As farmers we recognize that we only represent a small percentage of the Canadian population. This study was instrumental to take the pulse of Canadians to help us focus on the issues of most importance to our customers, the consumer," says Will Nap, Chairman of Ontario Pork.

The purpose of the study was to gauge the awareness and attitudes of both rural and urban Canadians toward hog farm practices, and to identify the key issues and concerns of the public about pork production. Farmers, non-farmers, rural and urban Canadians were all represented in the extensive study.

"The fact that producers took the initiative to commission such a major study is positive proof of our concern and commitment to our customers," Nap says. "We were not surprised by the results, and in fact we've already been actually working as an industry on all of the issues raised in the study. The results will help us prioritize our resources towards the most important issues in the future."

The study found food safety, care and treatment of hogs, and economic viability of the farmer to be three major issues for Canadians. Nine out of 10 people surveyed said they felt today's pork is safe to eat, and 70 percent said they believe hogs are well treated. Canadians also expressed concern about the future economic survival of pork producers. The public was slightly less confident about the impact of hog farming on the environment.

"We will continue to move forward on these issues," stated Nap. "Our business depends on producing a safe food product, on maintaining a sustainable environment and on treating our animals well. This better understanding of public opinion means we can address their concerns more effectively in the future."

***-30-***

**Contact: Keith Robbins, Ontario Pork, Director of Communications Phone: (416) 621-1874**

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**The Next Pig Thing** Canadian researchers have developed a genetically-engineered pig that could help clean up a major source of water pollution -- but environmental groups want the swine squelched.

by Leora Broydo Vestel October 26, 2001

Once upon a time there were three little pigs. They were very special pigs. Their genes were engineered by scientists to make them less damaging to the environment than any of their swine brethren. And everybody lived happily ever after.

Or maybe not. The three pigs in question, developed by researchers in Canada and already patented as 'Enviropigs,' represent a unique dilemma for environmentalists. Major green environmental organizations are virtually unanimous in the view that genetically-modified products should be banned. But the Enviropigs address a major environmental problem -- one those same groups have been fighting for years.

At this point, while researchers and pig farmers have extolled the environmental benefit Enviropigs present, most of the leading environmental groups aren't following suit. While the hogs' virtues may be attractive to the green groups, their modified genes represent a vice too significant to overlook.

The crux of the debate centers around the manure pigs produce. Modern pig farming often involves raising thousands of swine in a single facility -- which can in turn generate thousands of tons of manure every year. That manure is then spread in fields or stored in "lagoons." The contaminants in the manure can spread from either fields or lagoons into water sources. In 1995, for instance, an eight-acre hog-waste lagoon in North Carolina burst, spilling 22 million gallons of manure into a nearby river and killing enormous numbers of fish. Concentrations of manure rank "among the greatest threats to our nation's waters and drinking water supplies," according to a recent Environmental Protection Agency study.

The Enviropig, developed at the University of Guelph in Ontario and introduced to the world in August, have been modified so that their manure contains up to 75 percent less phosphorus than the average swine. Several substances in pig manure cause environmental damage, but phosphorus is one of the major culprits. The presence of phosphorus in waterways can cause fish kills, biodiversity loss and foster the growth of toxic organisms, according to the EPA.

Unlike their predecessors, such as a salmon that are designed to grow faster, the Enviropig is the first animal engineered for environmental benefit. Not surprisingly, scientists and pork industrialists are thrilled, since proposed government limits on phosphorus output threaten the industry's growth. Ontario Pork, a trade association representing pig farmers in the Canadian province, calls the Enviropig "the biggest breakthrough in pig farming since the invention of the trough."

"The environmental barriers are the largest in terms of growing as an industry," says Clare Schlegel, chairman of Ontario Pork, which represents 4,400 hog farmers in the province and has been a primary funder of the Enviropig research. "[Pork producers] are being looked at as polluters -- this is one technology to show that we do care."

Environmentalists aren't buying it. The Sierra Club, which has made lobbying for controls on pig manure pollution a centerpiece of its clean water campaign, calls the Enviropig a load of hogwash.

"This is just another quick fix," says Laurel Hopwood, chair of Sierra Club's genetic engineering committee. "The way to reconcile [the problem] is to stop factory farming." Greenpeace and other

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



environmental groups have echoed the Sierra Club message, arguing that the only real solution is moving away from massive industrial-style hog-growing and instead raising fewer pigs in bigger outdoor spaces.

Other technical fixes also exist. Pigs don't digest most of the phosphorus in their grain-based diet, so it ends up in their manure. A new breed of corn, developed by a USDA researcher, reduces phosphorus in manure by up to 50 percent. A widely practiced strategy of adding the enzyme phytase to feed can also reduce phosphorus content by 56 percent.

"There are a lot of sustainable agriculture programs that offer real benefits to food security and to the environment that take far less resources than the biotech solutions being proposed," says Michael Khoo of the Union of Concerned Scientists.

The Guelph researchers addressed the problem by modifying the pigs' digestive abilities. They combined a bacterial gene which makes an enzyme that breaks down the form of phosphorus found in pig feed with a mouse gene that causes the enzyme to be secreted from an animal's mouth. The composite gene was then injected into one-celled pig embryos that were subsequently surgically implanted into a surrogate mother.

The results were the first three Enviropigs, which researchers named Wayne, Jacques and Gordie after famous Canadian hockey players. Today, Guelph houses more than 100 Enviropigs -- the result of three generations of breeding, and all of them have inherited the genetic trait that allows for the digestion of phosphorus. All produce manure that contains 60-75 percent less phosphorus than non-engineered pigs.

Apart from that helpful trait, "there's nothing we've seen so far that would indicate that there's any abnormality" with the pigs, says molecular biologist Dr. John Phillips, the lead researcher in the Enviropig project. Nonetheless, he adds, these piggies still must undergo three to five years of testing before they can go to market.

"These animals are going to be tested like no other animals have been tested before they're certified to go into the human food chain," says Phillips.

Pig farmers are apparently eager for the day when they can begin raising Enviropigs, saying they represent a particularly promising solution to the phosphorus problem. Some independent experts also think Enviropig is a solid bet. Dr. Joann Whalen a soil expert at McGill University in Montreal, Canada, thinks Enviropig is even better than a non-biotech solution to the phosphorus problem that she helped develop. Whalen found that mixing limestone in with hog manure could net a 50 percent reduction in phosphorus content. But, she says, this method is expensive and impractical, as the limestone has to be trucked in to farms and requires extensive manpower to spread.

"It's dealing with the problem after the fact," Whalen concedes. "[Enviropig] is definitely a much better approach -- it's more cost effective to have a pig that excretes less phosphorus."

Still, for virtually all major environmental groups, the matter boils down to the fact that they oppose the introduction of genetically-engineered organisms into the environment.

"The GMO issue is a deal breaker," says Melanie Shepherdson Flynn, an attorney with National Resource Defense Council's Clean Water Project. "It's an extreme solution without knowing what the result will be."

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



If Enviropig passes regulatory muster, the rights to the technology will be sold to pig breeders. But given the charged debate developing around it, Enviropig's path to the dinner table remains questionable.

"It's a technology that adds a great deal of value," says Schlegel. "But we're not interested in seeing the technology commercialized if the public is not interested in genetically modified foods."

If Enviropig passes regulatory muster, the rights to the technology will be sold to pig breeders. But given the charged debate developing around it, Enviropig's path to the dinner table remains questionable.

"It's a technology that adds a great deal of value," says Schlegel. "But we're not interested in seeing the technology commercialized if the public is not interested in genetically modified foods."

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**Making a silk purse from a sow's droppings; 'Transgenic' pig's manure hoped to ease environmental harm**

The Boston Globe - June 24, 1999, Thursday ,City Edition

BYLINE: By Colin Nickerson, Globe Staff

BODY: MONTREAL - The stink will stay, at least for now, but in a biotech breakthrough Canadian scientists have created a pig whose manure is expected to do far less harm to the environment than the poop of ordinary porkers.

The Enviropig, an achievement of genetic engineering by researchers at Ontario's University of Guelph, could go a long way toward making modern hog operations cleaner and more cost efficient.

Genetic tinkering with creatures and plants is nothing new. But the "transgenic" Yorkshire pigs - their cells containing DNA spliced from mice and a strain of bacteria - produced in labs at the university over the past two months are thought to be the first animals designed specifically to combat an environmental problem.

Scientists and farmers hope the three little Enviropigs, named in best Canadian tradition after hockey stars - Wayne, Gordie, and Jacques - will become progenitors of vast grunting herds yielding environmentally friendly excrement as well as pork chops, ham, and bacon.

Pig manure is heavy in phosphorus, and runoff from hog farms is a cause of pollution in rivers, streams, ponds, and lakes across Canada and the United States. Phosphorus robs water of the oxygen that sustains fish and other aquatic species, turning waterways into foul green pools of algae.

But the Enviropig, an official trademark taken out by the university, digests the phosphorus in cereal feed with much greater efficiency than run-of-the-mill swine.

The result: Pig poop that is cleaner, at least in the environmental sense. That makes it safer to spread on fields as fertilizer, and should reduce the contamination of surface water and underground springs caused by hog operations.

"Talk to a hog farmer, and you'll find that the environmental problems caused by pigs are just a huge, huge headache," said John Phillips, molecular biologist and one of three lead researchers on the Enviropig project, along with microbiologist Cecil Forsberg and doctoral student Serguei Golovan.

"The manure from our animals is superior," Phillips said.

That may sound amusing to a layperson, but for pig farmers the human-engineered breed of hogs may mark the biggest breakthrough since the invention of the feed trough.

"There's a lot of farmers going around today with big, happy smiles on their faces," said Harry Stam, who raises 12,000 pigs on his family farm in Jarvis, Ontario.

"Pork producers take a heavy rap, and if we can make ourselves better stewards of the land, that's cause for celebration," he said.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



Alas, for all the efforts of modern science, pig farms will still retain their most distinguishing characteristic: foul odor.

"We haven't eliminated the smell," acknowledged Phillips. "That's the next big step. But don't hold your breath, it's a long way off."

It is likely to be three to five years before the Enviropigs become available to hog farmers - and there are still lots of practical questions beyond the broad scientific-moral questions raised by genetic engineering itself. Will successive generations of Enviropigs be as plump and tasty as ordinary pigs? Will they consistently pass on the artificially-created "phosphorus-digesting" gene to offspring?

The new breed will have to be approved by Canadian environmental, health and food safety regulatory agencies before it is released to hog raisers in North America and beyond.

"We recognize there are lots of people who are going to be worried by this sort of science, and we want to put safety first," said Stam, who also serves as chairman of the research committee of the Ontario Pork Producers' Marketing Board, an organization of farmers that paid for some of the Guelph research.

Beyond the environmental benefits, pig producers see a big potential payoff from the Enviropig. Since the animals digest the phosphorus found in ordinary feed, there should be no need of the pricey mineral phosphorus additives fed to hogs on commercial farms in order to boost growth.

Ontario Pork officials calculate that raising Enviropigs could save the farmer an average of $1.19 in feed costs for each animal - a sum that translates into tens of millions of dollars a year in savings for the North American pork industry.

Moreover, there's a possible benefit for the developing world, where farmers cannot afford additives and therefore tend to produce scrawnier pigs.

Ontario Pork has exclusive license to distribute the pig to swine breeders and producers worldwide. "We're hoping this will be one special pig," said Stam. "These are pretty exciting days on the farm."

Copyright 1999 Globe Newspaper Company

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**And This Little Piggy Was Environmentally Friendly**
**TORONTO (Reuters)**
**June 23, 1999**

Canadian scientists have genetically engineered what they say is an environmentally friendly pig.

Researchers at the University of Guelph, Ontario, call it the Enviropig, and said Wednesday it should produce manure that is 20 to 50 percent lower in phosphorous than that from normal pigs.

Phosphorous pollutes rivers, streams and lakes because it promotes algae growth, which in turn robs water and fish of oxygen.

Enviropigs are Yorkshire pigs with pieces of DNA inside the nucleus of each cell that contains bits of mouse and bacteria.

In the past two months transgenic, or DNA-modified piglets by the names of Jacques, Gordie and Wayne -- named after Canadian hockey players -- have been born to surrogate sows.

This is likely the first time animals have been engineered to solve environmental problems, but the researchers admitted it was the profit motive that prompted pork producers to fund the project through the Ontario Pork Producers Marketing Board.

``Pork producers live under very stringent environmental regulations and can only raise so many hogs per hectare,'' said John Phillips, molecular biologist at Guelph University

If the phosphorous found in a pig's manure is reduced by 50 percent, then theoretically farmers can raise 50 percent more pigs and still meet environmental restrictions.

In North America, Europe and in some parts of Asia, the only thing holding back a farmer's hog output is the restrictions on phosphorous leaching into the water table, Phillips said.

``In the Netherlands, the environmental limitations on the number of animals they can raise per hectare of land is just squeezing that industry,'' he added.

The Enviropig is at least four years away from commercialization and will need to meet regulations for novel food under the Canadian Food and Drugs Act before being approved for human consumption.

Phillips said one of his three piglets will reproduce sometime in December, and researchers will wait for another generation to be born with the modified gene before butchering an animal to test meat quality.

Ontario Pork, which has invested C$270,000 to date on the project, has exclusive rights to license and distribute the pig to producers worldwide.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**ONTARIO FARMER Tuesday, January 1, 2002**
**Letters**
**The Enviropig will reach the meat counter, but when?**

**Dear editor:**
In the December 4th issue Tom Van Dusen asked where does the Enviropig fit in' to help the pork producer satisfy the proposed Nutrient Management Act, and still remain profitable?

To provide a refresher, manure from pigs and poultry is enriched in phosphorus, the major pollutant in areas of pork and poultry production. The Enviropig is designed to secrete in its saliva the enzyme phytase. This endows the pigs with the capability to utilize practically all of the phosphorus present in cereal grains.

This has two primary benefits: there is no need to add either supplemental phosphate or phytase enzyme to the diet, and second, the phosphorus content of the manure will be reduced by 60 to 80 per cent, which will allow manure to be spread on land at the same or greater rate than before and still meet stringent nutrient management requirements. Trials are in progress to determine whether the Enviropig manure has less odour.

Initial testing has documented that the transgenic phytase pigs are as healthy and grow as rapidly as other pigs. If the transgenic pigs appear healthy, why are they not in the food chain? Because of strict Canadian legislation including the Canadian Environmental Protection Act, the Novel Foods Act and the Health of Animals Act, which we fully support, and will necessitate extensive studies to document that the pigs have no deleterious effect on the environment, that they are healthy, and produce safe pork over an extended period of time.

Has industry shown interest in the Enviropig? Despite the tide of interest from the press, government and individuals throughout the world, no major player has come forward to sponsor the last hurdle for the Enviropig. However, we have had discussions with several swine breeders in Canada and with scientists in China who are keen to import the Enviropig.

There are good reasons for this wait and see attitude; first, there is the matter of cost, taking the first transgenic pig through the regulator process will be expensive and uncharted course, and second, the Enviropig is a GMO, and at least one major player in the pork industry is concerned that being associated with research and development on genetically modified pigs may leave the impression that their breeding stock is genetically modified, a factor which could have financial consequences.

When can we expect industry to take the Enviropig flag and run with it? The worst-case scenario is that the pork industry will not embrace the Enviropig until nutrient legislation is pressing the financial bottom line such that the continued profitability supersedes the concern over the GMO issue.

A factor that has been discounted is the flexibility of consumers when it comes to price shopping. Knowing that the pigs had been thoroughly tested, and if enviro-pork is a few cents cheaper than conventional pork, many consumers will go for the cheaper product. Some may even buy it because the Enviropig leaves a significantly smaller footprint in the environment.

The bottom line is yes the Enviropig is "hogtied in red tape'", however, be patient, its time will come, perhaps sooner than we expect.

**Cecil W. Forsberg, Professor,**
**Department of Microbiology, U. of Guelph**

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**03. Readings for the Friends of the Earth International (word count: 4,736):**

1. Friends of the Earth International- Mission Statement (227 words)
2. Vestel, L. B. "The Next Pig Thing" Mother Jones (Oct 26, 2001) (1,214 words)
3. Editorial, Minnesota Daily. "Enviropigs Will Not Help the Environment" University Wire (Oct 30, 2001) (478 words)
4. Taylor, D. "A Less Polluting Pig" Environ Health Perspect 108, 2000 (589 words)
5. Reuters, "And This Little Piggy Was Environmentally Friendly" (June 23, 1999) (363 words)
6. Halverson, M. "The Price We Pay for Corporate Hogs: Executive Summary and Overview," (July 2000) (1,865 words)

**Instructions for Friends of the Earth International (Group 3):** You represent an organization dedicated to protecting the environment and promoting sustainable agriculture. You will urge AAFC not to renew their funding on the grounds that Enviropigs, like many other products of genetic engineering, pose unacceptable risks to the environment by encouraging hog farms to scale up their production and by distracting them from more sustainable alternatives. Moreover, because you think that the use of genetically modified organisms only continues because of the unequal bargaining position wielded by large agribusiness companies, you will urge AAFC to refuse to give priority to industry over the environment.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete



**Friends of the Earth International Mission Statement**

Friends of the Earth International is a worldwide federation of national environmental organizations. This federation aims to:

- protect the earth against further deterioration and repair damage inflicted upon the environment by human activities and negligence;
- preserve the earth's ecological, cultural and ethnic diversity;
- increase public participation and democratic decision-making. Greater democracy is both an end in itself and is vital to the protection of the environment and the sound management of natural resources;
- achieve social, economic and political justice and equal access to resources and opportunities for men and women on the local, national, regional and international levels;
- promote environmentally sustainable development on the local, national, regional and global levels.

Friends of the Earth International has a democratic structure with autonomous national groups which comply with the guidelines established by the federation.

Friends of the Earth member groups are united by a common conviction that these aims require both strong grassroots activism and effective national and international campaigning and coordination. They see Friends of the Earth International as a unique and diverse forum to pursue international initiatives, taking advantage of the varied backgrounds and perspectives of its members.

By sharing information, knowledge, skills and resources on both the bilateral and multilateral levels, Friends of the Earth groups support each other's development and strengthen their international campaigns.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete



**The Next Pig Thing** Canadian researchers have developed a genetically-engineered pig that could help clean up a major source of water pollution -- but environmental groups want the swine squelched.

by Leora Broydo Vestel October 26, 2001

Once upon a time there were three little pigs. They were very special pigs. Their genes were engineered by scientists to make them less damaging to the environment than any of their swine brethren. And everybody lived happily ever after.

Or maybe not. The three pigs in question, developed by researchers in Canada and already patented as 'Enviropigs,' represent a unique dilemma for environmentalists. Major green environmental organizations are virtually unanimous in the view that genetically-modified products should be banned. But the Enviropigs address a major environmental problem -- one those same groups have been fighting for years.

At this point, while researchers and pig farmers have extolled the environmental benefit Enviropigs present, most of the leading environmental groups aren't following suit. While the hogs' virtues may be attractive to the green groups, their modified genes represent a vice too significant to overlook.

The crux of the debate centers around the manure pigs produce. Modern pig farming often involves raising thousands of swine in a single facility -- which can in turn generate thousands of tons of manure every year. That manure is then spread in fields or stored in "lagoons." The contaminants in the manure can spread from either fields or lagoons into water sources. In 1995, for instance, an eight-acre hog-waste lagoon in North Carolina burst, spilling 22 million gallons of manure into a nearby river and killing enormous numbers of fish. Concentrations of manure rank "among the greatest threats to our nation's waters and drinking water supplies," according to a recent Environmental Protection Agency study.

The Enviropig, developed at the University of Guelph in Ontario and introduced to the world in August, have been modified so that their manure contains up to 75 percent less phosphorus than the average swine. Several substances in pig manure cause environmental damage, but phosphorus is one of the major culprits. The presence of phosphorus in waterways can cause fish kills, biodiversity loss and foster the growth of toxic organisms, according to the EPA.

Unlike their predecessors, such as a salmon that are designed to grow faster, the Enviropig is the first animal engineered for environmental benefit. Not surprisingly, scientists and pork industrialists are thrilled, since proposed government limits on phosphorus output threaten the industry's growth. Ontario Pork, a trade association representing pig farmers in the Canadian province, calls the Enviropig "the biggest breakthrough in pig farming since the invention of the trough."

"The environmental barriers are the largest in terms of growing as an industry," says Clare Schlegel, chairman of Ontario Pork, which represents 4,400 hog farmers in the province and has been a primary funder of the Enviropig research. "[Pork producers] are being looked at as polluters -- this is one technology to show that we do care."

Environmentalists aren't buying it. The Sierra Club, which has made lobbying for controls on pig manure pollution a centerpiece of its clean water campaign, calls the Enviropig a load of hogwash.

"This is just another quick fix," says Laurel Hopwood, chair of Sierra Club's genetic engineering committee. "The way to reconcile [the problem] is to stop factory farming." Greenpeace and other

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



environmental groups have echoed the Sierra Club message, arguing that the only real solution is moving away from massive industrial-style hog-growing and instead raising fewer pigs in bigger outdoor spaces.

Other technical fixes also exist. Pigs don't digest most of the phosphorus in their grain-based diet, so it ends up in their manure. A new breed of corn, developed by a USDA researcher, reduces phosphorus in manure by up to 50 percent. A widely practiced strategy of adding the enzyme phytase to feed can also reduce phosphorus content by 56 percent.

"There are a lot of sustainable agriculture programs that offer real benefits to food security and to the environment that take far less resources than the biotech solutions being proposed," says Michael Khoo of the Union of Concerned Scientists.

The Guelph researchers addressed the problem by modifying the pigs' digestive abilities. They combined a bacterial gene which makes an enzyme that breaks down the form of phosphorus found in pig feed with a mouse gene that causes the enzyme to be secreted from an animal's mouth. The composite gene was then injected into one-celled pig embryos that were subsequently surgically implanted into a surrogate mother.

The results were the first three Enviropigs, which researchers named Wayne, Jacques and Gordie after famous Canadian hockey players. Today, Guelph houses more than 100 Enviropigs -- the result of three generations of breeding, and all of them have inherited the genetic trait that allows for the digestion of phosphorus. All produce manure that contains 60-75 percent less phosphorus than non-engineered pigs.

Apart from that helpful trait, "there's nothing we've seen so far that would indicate that there's any abnormality" with the pigs, says molecular biologist Dr. John Phillips, the lead researcher in the Enviropig project. Nonetheless, he adds, these piggies still must undergo three to five years of testing before they can go to market.

"These animals are going to be tested like no other animals have been tested before they're certified to go into the human food chain," says Phillips.

Pig farmers are apparently eager for the day when they can begin raising Enviropigs, saying they represent a particularly promising solution to the phosphorus problem. Some independent experts also think Enviropig is a solid bet. Dr. Joann Whalen a soil expert at McGill University in Montreal, Canada, thinks Enviropig is even better than a non-biotech solution to the phosphorus problem that she helped develop. Whalen found that mixing limestone in with hog manure could net a 50 percent reduction in phosphorus content. But, she says, this method is expensive and impractical, as the limestone has to be trucked in to farms and requires extensive manpower to spread.

"It's dealing with the problem after the fact," Whalen concedes. "[Enviropig] is definitely a much better approach -- it's more cost effective to have a pig that excretes less phosphorus."

Still, for virtually all major environmental groups, the matter boils down to the fact that they oppose the introduction of genetically-engineered organisms into the environment.

"The GMO issue is a deal breaker," says Melanie Shepherdson Flynn, an attorney with National Resource Defense Council's Clean Water Project. "It's an extreme solution without knowing what the result will be."

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



If Enviropig passes regulatory muster, the rights to the technology will be sold to pig breeders. But given the charged debate developing around it, Enviropig's path to the dinner table remains questionable.

"It's a technology that adds a great deal of value," says Schlegel. "But we're not interested in seeing the technology commercialized if the public is not interested in genetically modified foods."

If Enviropig passes regulatory muster, the rights to the technology will be sold to pig breeders. But given the charged debate developing around it, Enviropig's path to the dinner table remains questionable.

"It's a technology that adds a great deal of value," says Schlegel. "But we're not interested in seeing the technology commercialized if the public is not interested in genetically modified foods."

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**HEADLINE: Enviropigs will not help environment**
**BYLINE Editorial, Minnesota Daily**
University Wire
October 30, 2001
SECTION: EDITORIAL
LENGTH: 471 words
SOURCE: U. Minnesota
DATELINE: Minneapolis

BODY: In the near future, a side of bacon might be more than just pig. It will probably contain some mouse and a little bit of an E. coli bacterium too. The reason: Canadian scientists genetically designed a pig by injecting genes from an E. coli bacterium and a mouse into a single-cell pig embryo. And this new combination is in demand. These transgenic pigs excrete manure containing 50 to 75 percent less phosphorous -- a chemical the EPA says is a major threat to our nation's water and drinking supply. The pigs, trademarked Enviropigs, will be the first genetically modified farm animals to reach the market anywhere in the world, their creators at Ontario's University of Guelph believe. Microbiologist Cecil Forsberg, involved in the project, said the Enviropig is "for sure, the first modified farm animal engineered to solve an environmental problem."

Lilian Schaer, a spokeswoman for Ontario Pork -- a marketing group that represents 4,500 pig producers and has financially supported the genetic research, agrees. "A pig that produces less phosphorous would be a dream pig from just about everyone's point of view," she said.

These pigs, however, have nothing to do with cleaning up the environment and everything to do with increasing profits.

In 1950 the average hog sales per farm were about 31. Now 105 farms raising more than 50,000 pigs each account for 40 percent of the U.S. hog industry, according to the Minneapolis based Institute for Agriculture and Trade Policy. And the only thing keeping these farms from getting larger is their inability to dispose of large quantities of manure in a manner adhering to the Clean Water Act. But now that the phosphorous levels can be lowered, don't expect these large farms to sit back and applaud themselves for being more environmentally conscious. Instead they will increase their farms' sizes until the hazardous effects of the manure again straddle the regulatory limits set forth by the Clean Water Act.

Although this might lower the price of pork, it does nothing to address the current environmental issues and in fact only compounds many of them. Currently, the hog industry poses a grave threat to humans. Their antibiotic-laced feed creates bacteria resistant to human antibiotics. The large hog farms emit greenhouse gasses and nitrogen gas, which can radically change the surrounding ecosystem. The increased number of Enviropigs will exacerbate these problems.

Swine will eat anything they are given. Unfortunately, the byproduct of this behavior threatens both the environment and humans. Even though scientists claim they can minimize the harm of these insatiable appetites, don't be fooled. The intent here is not to protect the environment, but rather exploit regulations and increase profits.

(C) 2001 Minnesota Daily via U-WIRE

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**A Less Polluting Pig**
**David Taylor**

Environmental Health Perspectives Volume 108, Number 1, January 2000

There's good news in the fight against farm pollution, say researchers in the Department of Molecular Biology and Genetics at the University of Guelph in Ontario, Canada. In August, John Phillips, Cecil Forsberg, and Serguei Golovan announced a new kind of pig that makes better use of phosphorus, a nutrient that in high concentrations can deplete oxygen levels in waters downstream. Phosphorus runoff from livestock farms has been blamed for killing aquatic life and creating algae blooms in lakes and rivers. By identifying a gene that promotes recovery of phosphorus in a pig's digestive tract, Phillips and his colleagues say they have devised a pig that pollutes less.

For Phillips, a professor of molecular biology and genetics, phosphorus waste was an obvious focus for swine research. Farmers like to use hog manure as fertilizer because it is rich in nutrients, but because pigs cannot completely digest the phosphorus in their diet, their manure contains much higher concentrations of phosphorus than of other nutrients. When runoff carries the manure downstream, the excess phosphorus fuels extremely high algae growth. "It's not just a local problem, it's an international problem," Phillips says.

Other efforts to reduce phosphorus runoff from livestock farms have sought to decrease the amount of phosphorus in feed grains. Victor Raboy, a plant geneticist with the U.S. Department of Agriculture (USDA) Agricultural Research Service in Aberdeen, Idaho, developed and tested low-phytic-acid corn and found that by making phosphorus easier to absorb, the amount that ends up in hog manure is reduced. Vincent Varel, a microbiologist at the USDA's Roman L. Hruska U.S. Meat Animal Research Center in Clay Center, Nebraska, says that the corn feed (being released commercially in cooperation with Pioneer Hi-Bred International) may be more versatile than the enviropig because the corn can be fed to any pig as well as to poultry.

Varel notes another benefit of nutritional approaches over genetic solutions: the public's discomfort with genetically modified (GM) products. Most European countries require labels to specify GM ingredients. In Europe, public suspicion over the health effects of GM products is running high and was heightened by a trade flap between the United States and the European Union last June in which the European Union imposed a ban on imports of hormone-treated beef and other GM foods from the United States. Varel says the issue "could be a negative factor in selling enviropig products."

Critics say that the enviropig marks only a stopgap solution to farm pollution. Jane Rissler, a plant pathologist and senior staff scientist with the Union of Concerned Scientists, a nonprofit organization based in Washington, DC, says, "The solution to the hog production [waste] problem is not to genetically engineer pigs but to return to a more sustainable form of farming." According to Rissler, today's large hog "factories" will likely merely use the enviropig to boost hog densities at their facilities, packing more hogs into the same size facility while still complying with total phosphorus runoff limits. What's more, the effect on the hogs' long-term health is still unclear. Phillips points out, however, that enviropigs will also be useful on low-density hog farms and in less developed countries, where inadequate phosphorus in pigs' diet limits their growth.

Farmers will have to wait several years to compare enviropigs with low-phytic-acid feed. Phillips says that farmers won't be able to get enviropigs from breeders for three years or so, and it's too early to say how much they will cost.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**And This Little Piggy Was Environmentally Friendly**
**TORONTO (Reuters)**
**June 23, 1999**

Canadian scientists have genetically engineered what they say is an environmentally friendly pig.

Researchers at the University of Guelph, Ontario, call it the Enviropig, and said Wednesday it should produce manure that is 20 to 50 percent lower in phosphorous than that from normal pigs.

Phosphorous pollutes rivers, streams and lakes because it promotes algae growth, which in turn robs water and fish of oxygen.

Enviropigs are Yorkshire pigs with pieces of DNA inside the nucleus of each cell that contains bits of mouse and bacteria.

In the past two months transgenic, or DNA-modified piglets by the names of Jacques, Gordie and Wayne -- named after Canadian hockey players -- have been born to surrogate sows.

This is likely the first time animals have been engineered to solve environmental problems, but the researchers admitted it was the profit motive that prompted pork producers to fund the project through the Ontario Pork Producers Marketing Board.

``Pork producers live under very stringent environmental regulations and can only raise so many hogs per hectare,'' said John Phillips, molecular biologist at Guelph University

If the phosphorous found in a pig's manure is reduced by 50 percent, then theoretically farmers can raise 50 percent more pigs and still meet environmental restrictions.

In North America, Europe and in some parts of Asia, the only thing holding back a farmer's hog output is the restrictions on phosphorous leaching into the water table, Phillips said.

``In the Netherlands, the environmental limitations on the number of animals they can raise per hectare of land is just squeezing that industry,'' he added.

The Enviropig is at least four years away from commercialization and will need to meet regulations for novel food under the Canadian Food and Drugs Act before being approved for human consumption.

Phillips said one of his three piglets will reproduce sometime in December, and researchers will wait for another generation to be born with the modified gene before butchering an animal to test meat quality.

Ontario Pork, which has invested C$270,000 to date on the project, has exclusive rights to license and distribute the pig to producers worldwide.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete



**The Price We Pay for Corporate Hogs**
**Executive Summary and Overview**

**Marlene Halverson**
**Institute for Agriculture and Trade Policy**
**July 2000**

The industrialization of U.S. animal agriculture has pressed on, unabated, for half a century, gradually changing the faces of American farming and rural communities. The changes wrought by industrialization are occurring in all of animal agriculture. This report focuses on the impacts of hog factories.

The industrialization of hog farming has been attributed in great part to inexorable advances in science and technology and the freedom afforded economic development by an unfettered marketplace. Indeed, some experts see current industry structure as simply "what has evolved out of the marketplace,"[1] the inevitable result of impersonal, irresistible economic forces triggering a kind of "natural selection" process over which we are powerless to do anything but go with the flow.

Writing about mega-hog factory Seaboard Corporation's move to Guymon, Oklahoma, however, authors from the North Central Regional Center for Rural Development note that the move was hardly due to market forces at work. Describing the over $60 million in publicly supported incentives that drew Seaboard to Guymon and helped it build its facilities and train its workers, they note:[2]

*Guymon is a case of state-directed, rather than market-driven introduction of new economic activity.*

The chink in the armor of the natural selection theory is that the industrialization process is not impersonal or natural or necessary. It, too, has been engineered. Says rural sociologist Doug Constance:[3]

*It is very important that we do not accept the industrialization process, the industrialization of agriculture, as something natural, as something inevitable, as something determined. It is no such thing. It is a plan. It is a plan for certain people to benefit and others to pay.*

The industrialization of hog farming has taken place in a political-economic environment or context in which the quality of natural resources, the quality of human and animal life, the safety and quality of our food, and the quality of life for future generations are valued lower than short-term economic gain.

The choice as to whether or not to change the political-economic context in which American agriculture operates that is, the set of laws, regulations, penalties, incentives, and community expectations influencing agricultural development is a political choice. We can change the political-economic context, within which structural change in agriculture occurs, and thereby change its direction. For the good of the planet, our response to the changes the industrialization process in agriculture is invoking must not be hands-off.

**Summary of Parts 1 through 7**

…

II. *Putting Lives in Peril*

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



Part Two: Putting Lives in Peril, describes two major health hazards associated with factory farming: workplace dangers and antibiotic resistance.

*Workplace dangers:* Manure from animal factories is liquefied when massive quantities of groundwater are used to flush the buildings where the animals are housed. The resulting "slurry" may be stored temporarily in cement pits under the slatted floors of the barns or in outdoor structures, and emptied once or twice a year by being spread or sprayed onto land. The problems result from the anaerobic (absence of free oxygen) nature of manure that has been liquefied by the addition of water. Decomposition of liquid manure by anaerobic bacteria during storage and treatment produces and emits nearly 400 volatile organic compounds. Gaseous emissions from the anaerobic decomposition of liquefied manure have led to human and animal fatalities. Dusts inside intensive confinement facilities have led to respiratory illnesses among farmers and farm workers. These problems, too, have been known at least since 1964. Yet, waste handling technologies remain essentially the same and still no Occupational Safety and Health Administration (OSHA) standard exists for work in intensive confinement buildings or around manure pits. Instead, the industry and land grant university focus has been on ways to control liquid manure odors. Little research or technology development effort has focused on the readily available alternative forms of animal waste management that do not produce deadly manure gasses in the first place, such as raising hogs and cattle on pasture or using solid floors and ample bedding in indoor environments.

…

III. *Building Sewerless Cities*

Part Three: Building Sewerless Cities describes the impacts on water quality resulting from the separation of animals from the land. At one time, crop and livestock production were complementary enterprises on farms. Most of the nutrients originating from the soils of a given area were returned to that same area. Animals' living quarters were bedded with hay or straw and, when soiled, the bedding was removed to a manure heap where it composted, killing most of the pathogens that may have been present in the manure. Under such conditions, environmental problems arising from animal production activities, when they sometimes occurred, were minimal and relatively easily solved by improving management or taking other, relatively low-cost, remedial measures.

Environmental problems were exacerbated when specialization separated livestock production from the land and the availability of cheap, mineral fertilizers made it possible to produce crops without manure nutrients. Today, most farm animals are concentrated in large holdings on small acreages and are raised under intensive conditions resembling manufacturing processes. Animal feeds generally come from areas far away from the industrialized livestock farm. Manures from these "animal factories" may be handled as wastes or surpluses to be disposed of, rather than as valuable soil amendments, and may be applied to the land in quantities far exceeding the nutrient needs of crops. Quantities of liquid waste can be enormous. At a single site in Missouri, one hog factory produces fecal waste equivalent to that of a city of 360,000 people.

Earthen manure storage basins have leaked manure onto cropland and into streams, killing the life in them. Some leaks were found to be deliberate; others were unintentional – minor accidents or widespread catastrophes. Either way, it seems clear that the liquid manure storage technology is fundamentally unsafe.

Besides the plant nutrients nitrogen, phosphorus, and potassium, liquid manure also contains bacterial and viral pathogens, parasites, weed seeds, heavy metals, and even antibiotics, disinfectants, and insecticides, when these are present on the farm. In 1988, an expert panel

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



convened by the World Health Organization identified liquid manure spreading as a critical pathway by which salmonellae and other pathogens are transferred to the natural environment.

Part Three concludes by noting that options exist for safer, more environmentally-friendly hog production using pastures (outdoor production) and deep-bedding (indoor production) that are within the financial range of independent family farmers. Being more management-intensive than capital-intensive, these other options, if mandated, could also allow independent family farmers to compete with larger operations on a playing field that favors hands on husbandry and management over capital.

## IV. *Part of the Pig Really Does Fly*

Part Four: Part of the Pig Really Does Fly describes the air quality impacts of animal factories and recommends solutions. Neighbors of hog factories report not being able to go outdoors or let their children play outdoors due to odors from nearby hog factories. Some report lining their windows and fireplaces with plastic to keep the stench from coming into their homes. Animal factories need not be large to create a problem. Increasingly, to save on labor and because the technology is almost exclusively recommended by the industry and land grant universities, smaller farmers have adopted liquid manure handling systems and create the same detrimental effects, albeit on a smaller scale. Recent studies have shown that dusts and gases responsible for hog factory odors are having serious respiratory impacts on nearby residents.

As much as 70 to 80 percent of the nitrogen in a liquid manure storage facility changes from liquid to ammonia gas and escapes into the atmosphere. The gaseous ammonia returns to earth, precipitated from the atmosphere by rain. Nitrogen-enriched rainfall contributes to excessive algae growth and can damage or alter natural habitats, for instance, causing nitrogen-loving plants to replace the existing flora in a given area. Methane is a significant greenhouse gas that is emitted by liquid manure storage.

The most significant contribution to the reduction in greenhouse gasses that farms can make is to change manure management. The change can go in two directions: away from liquid manure and open lagoon storage toward more costly and complex management systems, such as electricity generation from methane, or toward ecologically sound and less complex management systems, such as manure handling incorporating straw or other natural bedding and composting. The latter direction is least costly for small livestock farms and not only reduces greenhouse gases, but replenishes the soil carbon.

## V. *Hog Factory in the Back Yard*

Part Five: Hog factories have divided communities, neighborhoods, and families. In most cases the people who feel the strongest impacts from hog factories are people who have lived in their rural homes for most, if not all, of their lives, many of whom farm or have farmed, with livestock, as well.

Part Five describes the ways in which corporate hog factory owners have used the public's sympathy for family farmers to obtain exemptions for their activities from local zoning laws and from county and state regulations. For example, thirty states have enacted laws exempting farm animals from protection under their anti-cruelty statutes. "Strategic lawsuits against public participation," or SLAPP suits, can be brought against citizens who protest siting of animal factories in their communities. In at least 13 states, agricultural disparagement laws, popularly known as "veggie libel laws," protect food products and production processes from "disparagement." The very laws enacted to protect small farmers from frivolous complaints serve to protect corporate hog factories from well-grounded complaints over their much larger impacts on the environment and on public health and welfare. Such laws erode democratic processes.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



Public policies supporting hog factories and excusing them from bad behavior also help create an illusion that hog farming is industrializing because technological advances have increased the efficiency (that is, have reduced per-unit costs of production) of larger, more concentrated operations. How many of these efficiencies are based on the ease with which public policies allow hog factory operators to pass off unwanted costs of doing business onto neighbors and society (i.e., make others pay) have not been quantified. It is becoming clear, however, that by helping hog factories avoid the expenses associated with socially responsible practices, such protections give hog factories leeway to grow and squeeze independent family hog farmers out of the market.

**References**

[1] Barboza, D. (2000, April 7). Smithfield's fast rise makes regulators wary. The New York Times.

[2] North Central Regional Center for Rural Development. (1999). Bringing home the bacon: The myth of the role of corporate hog farming in rural revitalization. A report to the Kerr Center for Sustainable Agriculture. Weatherford, OK: The Kerr Center for Sustainable Agriculture.

[3] Constance, Doug. (1998). Interview, And On This Farm. 26-minute video. Burnsville, MN: Field Pictures, Inc.

[4] Harrison, R. (1964). Animal Machines: The New Factory Farming Industry. London: Vincent Stuart Publishers, Ltd.

[5] U.S. Department of Agriculture. (1998, January). A time to act: A report of the USDA National Commission on Small Farms. (Miscellaneous Publication 1545, p. 9.) Washington, DC: U.S. Department of Agriculture.

[6] National Research Council. (1998). The use of drugs in food animals: Benefits and risks. Washington, DC: National Academy Press.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**04. Readings for the Organic Consumers Association (word count: 3,455):**

1. Organic Consumers Association – Background Information (319 words)
2. Cummins, R. “Hazards of Genetically Engineered Foods and Crops” Organic Consumers Association (1,658 words)
3. D’Amato, L. “Enviropig Studies Search for Effects of Meat on Humans” Kitchener Waterloo Record (Aug 3, 2001) (523 words)
4. Kirsch, V. “Tainted Animal Feed Risk Downplayed by Federal Officials” the Guelph Mercury (Feb 19, 2002) (607 words)
5. Council of Canada. “Poll on Attitudes to Genetically Engineered Foods.” (March 31, 2000) (348 words)

**Instructions for Organic Consumers Association (Group 4):** The OCA is a grassroots non-profit public interest organization which deals with crucial issues of food safety, industrial agriculture, genetic engineering, corporate accountability, and environmental sustainability. You will argue against the Enviropig project on the grounds that Enviropigs, like many other genetically engineered products, have unacceptable food safety risks and goes against consumer preferences.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**Background Information: The Organic Consumers Association (OCA)**

The OCA is a grassroots non-profit public interest organization which deals with crucial issues of food safety, industrial agriculture, genetic engineering, corporate accountability, and environmental sustainability. We are the only organization in the US focused exclusively on representing the views and interests of the nation's estimated ten million organic consumers.

Our US and international policy board is broadly representative of the organic, family farm, environmental, and public interest community.

The Organic Consumers Association was formed in 1998 in the wake of the mass backlash by organic consumers against the U.S. Department of Agriculture's controversial proposed national regulations for organic food. Through the OCA's SOS (Save Organic Standards) Campaign, as well as the work of our allies in other organizations, the organic community was able to mobilize 280,000 consumers to send in letters and emails to the USDA. In this project the OCA worked in cooperation with hundreds of natural food stores, consumer co-ops, Community Supported Agriculture groups, and farmers markets, as well as thousands of individual volunteers across the country--a relationship which has continued through the present time.

Our political program is the Food Agenda 2000-2010: a three point platform calling for

(1) a global moratorium on genetically engineered foods and crops;
(2) a phase-out of the most dangerous industrial agriculture and factory farming practices; and
(3) the conversion of American agriculture to at least 30% organic by the year 2010.

Our web site, research, and media team are considered by reporters and radio talk show hosts to be among some of the nation's top experts on food safety and organic food. Our media team provides background information, interviews, and story ideas to TV and radio producers and journalists on a daily basis--from national TV networks to the alternative press. Our field organizers provide advice and coaching to grassroots activists across the nation and coordinate our network of 10,000 volunteers.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


**Hazards of Genetically Engineered Foods and Crops**
**Why We Need A Global Moratorium**
**by Ronnie Cummins, Organic Consumers Association**

The technology of Genetic Engineering (GE) is the practice of altering or disrupting the genetic blueprints of living organisms-plants, trees, fish, animals, humans, and microorganisms. This technology is wielded by transnational "life science" corporations such as Monsanto and Aventis, who patent these blueprints, and sell the resulting gene-foods, seeds, or other products for profit. Life science corporations proclaim that their new products will make agriculture sustainable, eliminate world hunger, cure disease, and vastly improve public health. However, these gene engineers have made it clear, through their business practices and political lobbying, that they intend to use GE to monopolize the global market for seeds, foods, fiber, and medical products.

GE is a revolutionary new technology that is still in its early experimental stages of development. This technology has the power to break down the natural genetic barriers-not only between species-but between humans, animals, and plants. Randomly inserting together the genes of non-related species-utilizing viruses, antibiotic-resistant genes, and bacteria as vectors, markers, and promoters-permanently alters their genetic codes.

The gene-altered organisms that are created pass these genetic changes onto their offspring through heredity. Gene engineers all over the world are now snipping, inserting, recombining, rearranging, editing, and programming genetic material. Animal genes and even human genes are randomly inserted into the chromosomes of plants, fish, and animals, creating heretofore unimaginable transgenic life forms. For the first time in history, transnational biotechnology corporations are becoming the architects and "owners" of life.

With little or no regulatory restraints, labeling requirements, or scientific protocol, bio-engineers have begun creating hundreds of new GE "Frankenfoods" and crops. The research is done with little concern for the human and environmental hazards and the negative socioeconomic impacts on the world's several billion farmers and rural villagers.

An increasing number of scientists are warning that current gene-splicing techniques are crude, inexact, and unpredictable-and therefore inherently dangerous. Yet, pro-biotech governments and regulatory agencies, led by the US, maintain that GE foods and crops are "substantially equivalent" to conventional foods, and therefore require neither mandatory labeling nor pre-market safety-testing.

GE food and fiber products are inherently unpredictable and dangerous-for humans, for animals, the environment, and for the future of sustainable and organic agriculture. As Dr. Michael Antoniou, a British molecular scientist points out, gene-splicing has already resulted in the "unexpected production of toxic substances... in genetically engineered bacteria, yeast, plants, and animals with the problem remaining undetected until a major health hazard has arisen". The hazards of GE foods and crops fall into three categories: human health hazards, environmental hazards, and socio-economic hazards. A brief look at the already-proven and likely hazards of GE products provides a convincing argument for why we need a global moratorium on all GE foods and crops.

**Toxins & Poisons**

GE products clearly have the potential to be toxic and a threat to human health. In 1989, a genetically engineered brand of L-tryptophan, a common dietary supplement, killed 37 Americans. More than 5,000 others were permanently disabled or afflicted with a potentially fatal and painful blood disorder, eosinophilia myalgia syndrome (EMS), before it was recalled by the Food and Drug Administration (FDA). The manufacturer, Showa Denko, Japan's third largest

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


chemical company, had for the first time in 1988-89 used GE bacteria to produce the over-the-counter supplement. It is believed that the bacteria somehow became contaminated during the recombinant DNA process. Showa Denko has paid out over $2 billion in damages to EMS victims.

In 1999, front-page stories in the British press revealed Rowett Institute scientist Dr. Arpad Pusztai's explosive research findings that GE potatoes are poisonous to mammals. These potatoes were spliced with DNA from the snowdrop plant and a commonly used viral promoter, the Cauliflower Mosaic Virus (CaMv). GE snowdrop potatoes were found to be significantly different in chemical composition from regular potatoes, and when fed to lab rats, damaged their vital organs and immune systems. The damage to the rats' stomach linings apparently was a severe viral infection caused by the CaMv viral promoter apparently giving the rats a severe viral infection. Most alarming of all, the CaMv viral promoter is spliced into nearly all GE foods and crops.

Dr. Pusztai's path breaking research work unfortunately remains incomplete. Government funding was cut off and he was fired after he spoke to the media. More and more scientists around the world are warning that genetic manipulation can increase the levels of natural plant toxins or allergens in foods (or create entirely new toxins) in unexpected ways by switching on genes that produce poisons. Since regulatory agencies do not currently require the kind of thorough chemical and feeding tests that Dr. Pusztai was conducting, consumers have now become involuntary guinea pigs in a vast genetic experiment. Dr. Pusztai warns, "Think of William Tell shooting an arrow at a target. Now put a blind-fold on the man doing the shooting and that's the reality of the genetic engineer doing a gene insertion".

**Food Allergies**

In 1996, a major GE food disaster was narrowly averted when Nebraska researchers learned that a Brazil nut gene spliced into soybeans could induce potentially fatal allergies in people sensitive to Brazil nuts. Animal tests of these Brazil nut-spliced soybeans had turned up negative. People with food allergies (which currently afflicts 8% of all American children), whose symptoms can range from mild unpleasantness to sudden death, may likely be harmed by exposure to foreign proteins spliced into common food products. Since humans have never before eaten most of the foreign proteins now being gene-spliced into foods, stringent pre-market safety-testing (including long-term animal feeding and volunteer human feeding studies) is necessary in order to prevent a future public health disaster.

Mandatory labeling is also necessary so that those suffering from food allergies can avoid hazardous GE foods and so that public health officials can trace allergens back to their source when GE-induced food allergies break out.

In fall 2001, public interest groups, including Friends of the Earth and the Organic Consumers Association, revealed that lab tests indicated that an illegal and likely allergenic variety of GE, Bt-spliced corn called StarLink, had been detected in Kraft Taco Bell shells, as well as many other brand name products. The StarLink controversy generated massive media coverage and resulted in the recall of hundreds of millions of dollars of food products and seeds.

**Damage to Food Quality & Nutrition**

A 1999 study by Dr. Marc Lappe published in the Journal of Medicinal Food found that concentrations of beneficial phytoestrogen compounds thought to protect against heart disease and cancer were lower in GE soybeans than in traditional strains. These and other studies, including Dr. Pusztai's, indicate that GE food will likely result in foods lower in quality and

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


nutrition. For example, the milk from cows injected with rBGH contains higher levels of pus, bacteria, and fat.

**Genetic "Bio-Invasion"**

By virtue of their "superior" genes, some GE plants and animals will inevitably run amok, overpowering wild species in the same way that exotic species, such as kudzu vine and Dutch elm disease have created problems when introduced in North America. What will happen to wild fish and marine species, for example, when scientists release into the environment carp, salmon, and trout that are twice as large, and eat twice as much food, as their wild counterparts?

**Socioeconomic Hazards**

The patenting of GE foods and widespread biotech food production threatens to eliminate farming as it has been practiced for 12,000 years. GE patents such as the Terminator Technology will render seeds infertile and force hundreds of millions of farmers who now save and share their seeds to purchase evermore-expensive GE seeds and chemical inputs from a handful of global biotech/seed monopolies. If the trend is not stopped, the patenting of transgenic plants and food-producing animals will soon lead to universal "bioserfdom" in which farmers will lease their plants and animals from biotech conglomerates such as Monsanto and pay royalties on seeds and offspring. Family and indigenous farmers will be driven off the land and consumers' food choices will be dictated by a cartel of transnational corporations. Rural communities will be devastated. Hundreds of millions of farmers and agricultural workers worldwide will lose their livelihoods.

**Ethical Hazards**

The genetic engineering and patenting of animals reduces living beings to the status of manufactured products. A purely reductionist science, biotechnology reduces all life to bits of information (genetic code) that can be arranged and rearranged at whim. Stripped of their integrity and sacred qualities, animals that are merely objects to their "inventors" will be treated as such. Currently, hundreds of GE "freak" animals are awaiting patent approval from the federal government. One can only wonder, after the wholesale gene altering and patenting of animals, will GE "designer babies" be next?

**What Can You Do?**

The OCA advocates the following Food Agenda 2000-2010 as the foundation for our local-to-global campaign work:

- A Global Moratorium on all Genetically Engineered Foods and Crops. These products have not been proven safe for human health and the environment and they must be taken off the market.
- Stop Factory Farming. Begin the phase-out of industrial agriculture and factory farming-with a goal of significantly reducing the use of toxic chemicals and animal drugs on conventional farms by the year 2010. This phase-out will include a ban on the most dangerous farm chemicals and animal feed additives (antibiotics, hormones, and rendered animal protein) as well as the implementation of intensive Integrated Pest Management Practices (decrease the use of toxic pesticides and chemical fertilizers through natural composting, crop rotation, cover crops, use of beneficial insects, etc.).
- Convert American Agriculture to at least 30% organic by the year 2010. We demand government funding and implementation of transition to organic programs so that at least 30% of US agriculture is organic by the year 2010-with a strong emphasis on production for local and regional markets by small and medium-sized organic farmers.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


# "Enviropig" Studies Search for Effects of Meat on Humans

**August 3, 2001**
**Kitchener Waterloo Record**
**Luisa D'Amato**

**GUELPH** - Scientists have, according to this story, made a genetically engineered pig, but no one has quite figured out how to test that pig to make sure it's safe to eat.

The new "enviropigs" -- those genetically modified porkers who carry an extra gene that causes them to have less phosphorus in their manure -- will be the first animals to be tested under Health Canada's guidelines for genetically modified foods.

These pigs, being raised at the University of Guelph, hold the promise of being environmentally friendly. The extra gene causes bodily changes that help them digest the phosphorus in their feed instead of excreting it, which means cleaner, more drinkable lakes, rivers and streams.

But the pigs' arrival also brings science to uncharted waters. Guelph microbiologist Cecil Forsberg, who helped create the pigs, was cited as saying that technology is moving "faster than a slim government agency can move," and it's not clear, for example, how to test the pork to ensure it's safe.

The story says that Forsberg is working with federal government scientists to develop a policy to test genetically modified meat and that currently, a policy exists only for plants, which are biologically less complex. The extra gene causes production of the enzyme phytase, which lets the pig digest phosphorus in its feed. Trace amounts of phytase have been found elsewhere in the pig's body. There's a chance that humans might have allergic reactions to it, and also to the E. coli bacteria and mouse genes that were used to make the extra gene. But it's difficult to test for allergic reactions, especially on a substance that hasn't caused a reaction in humans before. You can't test on mice or rats because their immune systems are so different from humans.

All these questions are part of what concerns other scientists, who say there isn't enough testing on genetically modified foods, and we can't be sure they're safe.

Hugh Lehman, a retired philosophy professor from the University of Guelph, was quoted as saying, "To me, it's very risky. Very small chemical differences can have profound implications. If it's anything people are going to eat, there should be extensive and rigorous testing," The story says that Lehman was among a group of high-ranking scientists who publicly warned earlier this year that our existing food supply could be contaminated by genetically engineered crops that haven't been tested rigorously enough.

In a recent interview, Lehman quoted the work of a Scottish scientist who noticed abnormalities in rats that were fed genetically engineered potatoes. But Doug Powell, a University of Guelph professor of plant agriculture who is scientific director of the Centre for Safe Food in Guelph, was quoted as saying that research "has been largely repudiated" by other academics and that genetically engineered foods are subjected to much higher safety requirements and testing than new foods that are developed by traditional breeding practices.

Meanwhile, Forsberg said the new enviropigs appear to be physically normal, and he believes they'll be declared safe to eat within five years.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


**Tainted animal feed risk downplayed by federal officials**

Copyright 2002 Toronto Star Newspapers, Ltd.

The Guelph Mercury
February 19, 2002 Tuesday Final Edition
Pg. A1
By Vik Kitsch

Procedures have been modified at the University of Guelph since the carcasses of genetically engineered "enviropigs" were accidentally dumped into animal feed.

Last Tuesday the university told the Canadian Food Inspection Agency 11 genetically modified piglet carcasses were mistakenly taken to a rendering plant.

The CFIA, Environment Canada and Health Canada immediately launched investigations.

The federal health department concluded there was no significant risk to human health, CFIA biotechnology division biologist Louise Laferriere said Monday.

"They said there's no real risk to consumers," said Laferriere.

The CFIA is the lead investigating group on the issue.

Health Canada spokesperson Andrew Swift said the release "represents minimal risk to human health" because of the small quantity of material involved.

But Council of Canadians activist Nadege Adam responded genetic engineering is such a new science that no one can guarantee there's little risk.

"How can they say that it's safe? We don't know that it's safe. What's the risk Canadians are being exposed to?" Adam asked.

The piglets were part of a research project, headed by microbiologist Cecil Forsberg, to create less polluting pig waste.

The pigs carry an extra gene producing an enzyme called phytase. It causes the pigs to excrete less phosphorus in their manure. The aim is cleaner waters near farm operations.

Phosphorus promotes algae, which kills marine life by depleting oxygen.

Laferriere said 11 piglets, which either were stillborn or died shortly after birth, were stored in the freezer of a university research facility and destined for incineration.

Incineration is required by law, she said. "It's supposed to be contained. It's not supposed to get out," Laferriere said.

Laferriere said the wrong carcasses were taken to a rendering plant, though she couldn't say when the error occurred. The university discovered it and informed authorities that day, she noted.

The carcasses were added to 675 tonnes of meat cooked at the rendering plant.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


The batch was sold to feed mills, where it was made mainly into food for laying hens.

Some became feed for turkeys and chickens destined for the kitchen table.

"We're continuing our investigation into the destination of that feed," said Laferriere, adding the CFIA will try to recall it.

As to the food chickens and turkeys that received the feed, Health Canada has determined the risk to people consuming them is slight, she continued. She said the novel enzyme in the piglets breaks down after five minutes of exposure to temperatures of 100 degrees Celsius.

Laferriere said rendering cooks meat at 120 to 130 degrees C. for two hours.

Therefore, there won't be a recall of the chickens and turkeys, said Laferriere.

Adam argued the poultry products shouldn't be sold. "When in doubt, you don't take a chance."

University of Guelph research vice-president Alan Wildeman said the incident occurred at the university's Ridgetown College campus, where some of the enviropig research is done.

It's not yet clear when the carcasses were taken by a rendering plant employee, but it likely happened in January, said Wildeman.

He stressed the university has relocated the enviropig freezer to another, secure site so such a mistake can't be repeated.

He didn't dismiss the situation, however. "Certainly, we view this as a very important, very serious incident," said Wildeman.

He added the enviropig research will continue, despite the breach. "It is an important research project and is addressing a very serious environmental problem in the agricultural industry."

Laferriere added Environment Canada is seeking ways of ensuring the incident is not repeated.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


**The Council of Canada**
**Poll on Attitudes to Genetically Engineered Foods**
**Results of Environics Poll on Canadian Consumer Attitudes to Genetically Engineered Foods**

March 31, 2000

Environics Research Group was commissioned by The Council of Canadians to conduct a national poll on consumer attitudes to genetically engineered foods. The telephone poll, which surveyed 902 Canadians between December 22, 1999 and January 16, 2000, is accurate within 3.3 percentage points, 19 times out of 20.

The following questions were asked of people who said they were somewhat or very familiar with "genetically engineered" or "genetically modified" foods:

- **Q 1. Do you strongly agree, somewhat agree, somewhat disagree or strongly disagree with each of the following statements:**
  - **a. I worry about the safety of genetically engineered foods**
    48% Strongly agree
    27% Somewhat agree
    **75% TOTAL AGREE**
    13% Somewhat disagree
    11% Strongly disagree
    **24% TOTAL DISAGREE**
  - **b. Genetically engineered foods should always be labelled as such.**
    87% Strongly agree
    8% Somewhat agree
    **95% TOTAL AGREE**
    2% Somewhat disagree
    2% Strongly disagree
    **4% TOTAL DISAGREE**
  - **c. Consumers should be able to buy food that is not genetically engineered.**
    80% Strongly agree
    15% Somewhat agree
    **95% TOTAL AGREE**
    3% Somewhat disagree
    1% Strongly disagree
    **4% TOTAL DISAGREE**
  - **d. I would prefer to buy non-genetically engineered foods, even if they were slightly more expensive.**
    45% Strongly agree
    26% Somewhat agree
    **71% TOTAL AGREE**
    15% Somewhat disagree
    11% Strongly disagree
    **26% TOTAL DISAGREE**

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


- **Q 2. How confident are you in the federal government's ability to protect the safety and health of Canadians when it comes to genetically engineered food? Are you…?**
  11% Very confident
  33% Somewhat confident
  **44% TOTAL CONFIDENT**
  33% Not very confident
  23% Not at all confident
  **56% TOTAL NOT CONFIDENT**
- **Q 3. Do you strongly agree, somewhat agree, somewhat disagree, or strongly disagree that Canada should be able to refuse to import genetically engineered foods from other countries if there are concerns about health or environmental safety?**
  84% Strongly agree
  10% Somewhat agree
  **94% TOTAL AGREE**
  2% Somewhat disagree
  4% Strongly disagree
  **6% TOTAL DISAGREE**

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**05. Readings for the University of Guelph Scientists (word count: 7,751):**

1. University of Guelph Research. “Sensational Science or Science Fiction?” (4,252 words)
2. Forsberg, C. W., et al. “Pigs Expressing Salivary Phytase Produce Low-Phosphorous Manure” Nature Biotechnology (Aug 2001) (2,953 words w/o references)
3. Forsberg, C. “The Enviropig Will Reach The Meat Counter, But When?” Ontario Farmer (Jan 1, 2002) (544 words)

**Instructions for University of Guelph Scientists (Group 5):** You will argue that AAFC should continue funding the Enviropigs project because Enviropigs do not pose any significant food safety risk and will have substantial environmental benefits, both for intensive hog production facilities as well as for small-scale and third-world hog farmers.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


**Sensational Science or Science Fiction?**
**University of Guelph Research**

OVER THE PAST SIX MONTHS, Canada's national newspapers and other media have featured headline stories debating the pros and cons of food biotechnology, and the controversy is destined to continue for some time yet.

Most scientists involved in genetic research would argue that the ability to shortcut the evolutionary process is indeed sensational, but answering the second part of the question is not a matter for science alone to debate. People must be able to trust the food they eat, and that trust is based on human perceptions that are influenced by ethical values, economics and politics, as well as by scientific evidence.

**M**any U of G researchers -- animal and crop scientists, molecular biologists, food researchers, consumer studies experts, economists and philosophers -- are contributing their expertise to the debate on food biotechnology in an effort to provide consumers with information to make informed choices.

**Anticipated benefits**

**W**hy do proponents support the use of genetically engineered (GE) organisms in food production? Guelph scientists involved in transgenic work point to several environmental and health benefits. Among the current generation of these products are transgenic plants with built-in resistance to pests, meaning they don't need to be sprayed with pesticides. "Advances mean we could eventually have less land under cultivation and less of the environmentally harmful effects of farming," says Prof. Alan Wildeman, Molecular Biology and Genetics, director of the University's new Food System Biotechnology Centre (FSBC).

**O**fficially opened in January, the centre is an interdisciplinary initiative that could receive up to $25 million in funding, including an initial $6 million provided last year by the Ontario Research and Development Challenge Fund, a provincial research support program matched by the private sector and the University.

**T**ransgenic plants -- and potentially, transgenic animals -- are expected to help boost food production for a growing world, and Wildeman says research is under way at Guelph to develop crops containing livestock vaccines and medications that can be grown by farmers rather than manufactured. Researchers predict the next generation of GE organisms will have additional benefits for human nutrition and health -- in foods that lower cholesterol and blood pressure levels to avert heart attacks, for example.

**T**o many, we are at the brink of a scientific revolution.

**T**hat "revolution" is the product of an evolution in plant and animal breeding that has taken place over tens of thousands of years, but it was just over a century ago that Gregor Mendel first studied the mechanism of inheritance in plants.

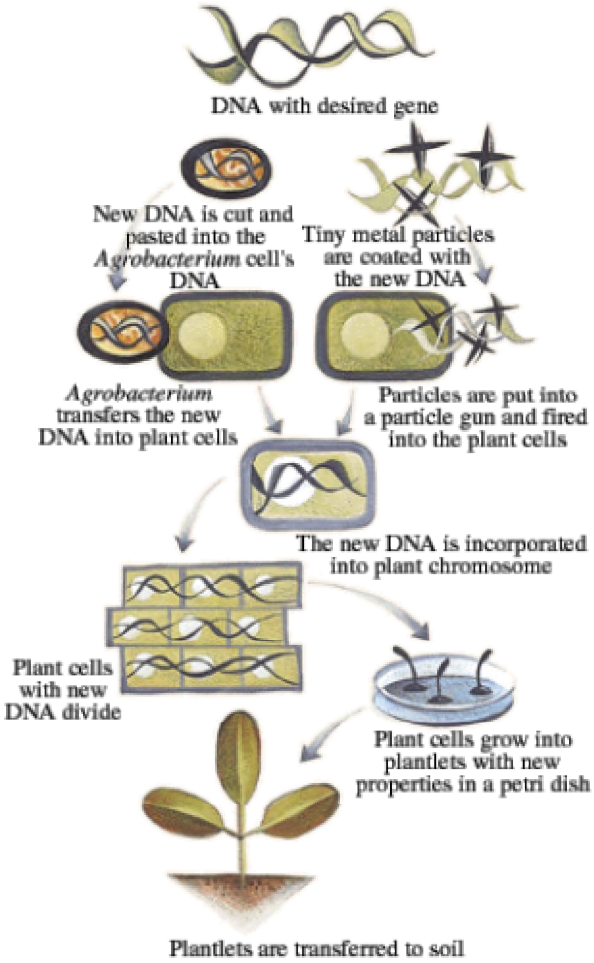
**T**hat scientific knowledge advanced selective breeding programs like those initiated at Guelph in the early 1900s by Prof. Charles Zavitz, who developed several dozen new varieties of field crops.

**Two Methods for Delivering DNA into Plant Cells**

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete



Scientists use a bacterium that normally infects plants to carry a desired gene into a plant cell (left), or the gene is injected under force into the cell (right). The end result in both techniques is a transgenic plant.




**P**rof. Larry Erickson and U of G colleagues in the Department of Plant Agriculture are developing "super plants" to provide extra protein in livestock rations or to trigger an immune response in animals as a cheaper and more efficient alternative to injectable vaccines. In the latter case, they use the tools of genetic engineering to create transgenic plants meant to confer immunity when fed to animals.

**T**he accompanying illustration shows two methods scientists use to insert a desired gene into a plant cell. The most intriguing uses the bacterium Agrobacterium tumefaciens as a carrier. In nature, Agrobacterium tumefaciens invades a plant and infects it with crown gall disease. When using the bacterium to genetically modify plants, scientists remove the disease-causing parts of Agrobacterium's DNA and replace them with genes carrying the characteristics scientists want transferred to the plant.

**F**or example, to protect pigs against transmissible gastroenteritis, researchers insert a gene from the virus into the DNA of Agrobacterium. This hybrid genetic material is then injected into plant

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


tissue, where it integrates into the plant's DNA. The mature plant containing the gene produces a protein that, when fed to pigs, stimulates an immune response against gastroenteritis.

**B**ecause this gene transfer technique would not work with cereal grains until recently, an alternative technique called particle bombardment was developed. Researchers mix foreign DNA with gold particles, then "fire" the mixture into a dish containing the plant tissue.

**I**n both cases, the plant cells grow into plantlets that can be potted in soil and will grow into a mature plant displaying the new characteristic. Collecting seeds from the new plant will carry the trait forward into successive generations.

**S**imilar concepts underlie the development of transgenic alfalfa and white clover in a project by Profs. Reggie Lo, Microbiology, Patricia Shewen, Pathobiology, and Judith Strommer, Plant Agriculture, to "vaccinate" cows against the bacterium that causes shipping fever. A form of pneumonia that is particularly debilitating to cattle under stressful conditions such as stockyard crowding, the disease costs North American producers $600 million to $1 billion a year in veterinary fees, drugs and losses due to death.

**T**he Guelph trio is investigating genetic engineering as a cheaper and more effective alternative to an injectable vaccine, Presponse, which was developed by Shewen about a decade ago. Having shown that the bacterial proteins are indeed expressed by the first generation of plants raised in Strommer's lab, they say the next step is to develop stable lines of the transgenic plants for commercial production. When the legume is fed to cattle, the bacterial gene would enter the cow's tonsils and travel to the lungs, where it would trigger an immune response to the disease.

**V**irtually all the foods we eat today have been genetically modified through selective breeding, says Prof. Gord Surgeoner, Environmental Biology, and president of Ontario Agri-Food Technologies, a non-profit organization based in Guelph. "Fruits, vegetables, chickens, cattle, etc., bear little resemblance to their wild ancestors." In fact, crop scientists contend that selective breeding is one reason we don't have major food shortages today.

**W**hat is new about the genetic modification of plants and animals is that scientists now have the ability to speed up the process of genetic transformation and even move genes between species.

**How does gene transfer happen in the laboratory?**

**I**n both of these cases, the transgenic plants are digested in the gut, leaving no residues in meat or milk. That's different from the result of the process used to make transgenic pigs or "Enviropigs," which are genetically engineered to digest dietary phosphorus more efficiently in hopes of solving the biggest environmental problem facing hog producers.

**B**esides saving producers the cost of readily digested phosphorus supplements, animals able to digest the element in their regular diet will excrete up to 50 per cent less phosphorus. Farmers use high-phosphorus pig manure for fertilizer, but the substance washes into lakes and streams, where it promotes the growth of algae.

**P**rofessors Cecil Forsberg, Microbiology, and John Phillips, Molecular Biology and Genetics, along with graduate student Serguei Golovan constructed a fusion transgene for use in making transgenic pigs by splicing the promoter-enhancer region from a mouse salivary gland protein gene together with the protein-coding region from a bacterial gene specifying the enzyme phytase. This composite gene, which was designed to direct the secretion of phytase into the saliva of pigs, was first tested in a mouse model: the transgene was inserted into one-celled mouse embryos and the embryos then transferred into surrogate mothers. Offspring were then tested for the presence of phytase in their saliva.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete

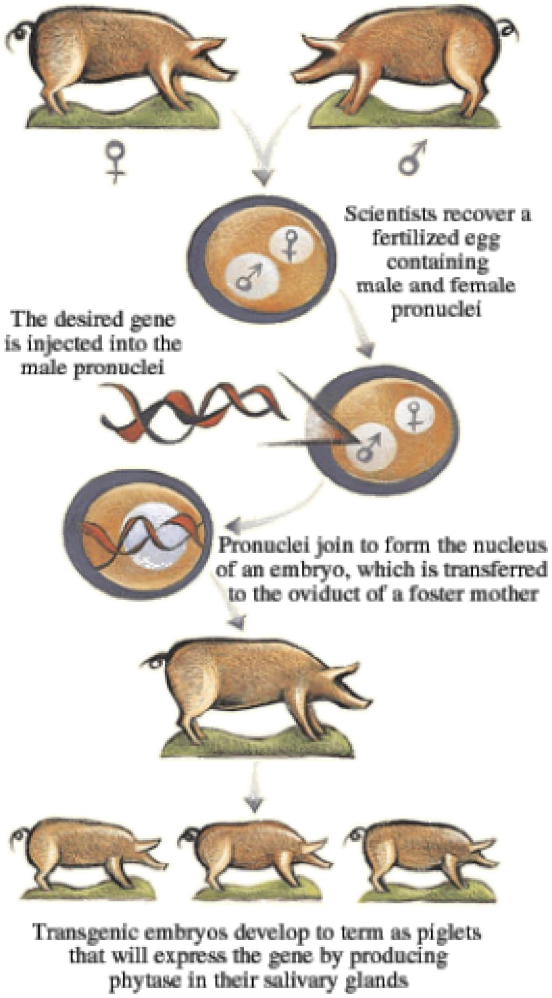


**W**ith successful expression of the transgene in the saliva of transgenic mice, they then repeated the process with one-celled pig embryos which were then transferred into surrogate sows. Piglets born beginning last summer are producing phytase in their saliva. This allows them to digest phosphorus in their normal feed, thereby avoiding the need for costly phosphorus feed supplements. More importantly, the level of environmentally hazardous phosphorus in their manure is greatly reduced, making them much more environmentally friendly.

**P**hillips and Forsberg emphasize that the real test will come this spring when the first offspring from the Enviropigs will be born. If these offspring carry the transgene from their parents, then the research team will put their novel herd of Enviropigs through a series of exhaustive tests to determine just how successful the pigs are at recovering phosphorus from their feed, and any possible side effects to the genetic modification.

**Producing Enviropigs**

Researchers borrow a gene from E. coli bacterium that produces a phytase enzyme, inject it into a fertilized egg, and rely on the animal's normal reproductive system to deliver transgenic pigs.



Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete


**D**NA was discovered in 1953, and in only 30 years, scientists developed the technology to transfer pieces of DNA between organisms. The first transgenic plant -- a tobacco plant resistant to an antibiotic -- was produced in 1983. Field testing of genetically engineered plants resistant to insects, viruses and bacteria began in 1985, and in 1994, the Flav'r Sav'r tomato, designed to resist rotting, became the first whole genetically engineered food to be approved for sale in the United States. It was followed in less than two years by Monsanto's herbicide-resistant soybeans and Bt corn that is protected from the corn borer.

**A**t U of G, these advanced technologies have led to the recent development of transgenic crops containing bits of weakened viral DNA that will serve as edible vaccines for livestock and a pig genetically engineered to produce "environmentally friendly" manure (see story on page 10).

**T**he agricultural industry seems to have embraced GE technology. The U.S. Department of Agriculture estimates that half of the country's last soybean crop and one-third of its corn crop used genetically engineered seed. In Ontario, farmers used transgenic seed on 35 per cent of corn, 20 per cent of soybeans and 60 per cent of canola grown last year.

**A**cross Canada, growers now have access to more than 30 varieties of transgenic crops, including corn, canola, soybeans, potatoes, cotton, flax, wheat and tomatoes.

**Biotech opposition**

**F**or the past six months, the media have been bringing us a transgenic revolution of a different kind, being waged on the field of public opinion. Think of that towering, menacing ear of corn erected by Greenpeace protestors in downtown Montreal during January's meeting of negotiators on the biosafety protocol on trade in genetically engineered products.

**T**he monster image may be larger than life, but the depth of consumer concern over GE foods should not be underestimated. Speaking at a recent conference to mark the official opening of the FSBC, Guelph food science professor Mansel Griffiths, director of the Canadian Research Institute for Food Safety, said that eight out of 10 people polled by Angus Reid had heard of genetically engineered foods, and about 65 per cent said they would be less likely to buy a particular food if they knew it had been genetically altered.

**O**ther polls suggest consumers have only a marginal understanding of the concept of biotechnology, and Prof. Larry Milligan, vice-president (research), says much of the current media coverage adds to that misunderstanding. GMO (genetically modified organism) has become the accepted acronym for genetic engineering, when the literal meaning is quite different, he says.

**O**pposing GM foods would include virtually everything on the dinner table, as Surgeoner pointed out, but Milligan says most consumer concerns are more likely focused on the transfer of genetic material in the laboratory, specifically between different species. "We all agree that people must trust what they eat," says Surgeoner. "Clearly, the process of modifying genetic material to improve foods must be subject to strict regulatory oversight."

**H**e believes that's already being done in Canada and says the country's food supply "has an enviable reputation for safety and reliability based on a regulatory system for the assessment and approval of all foods marketed in Canada, including those produced through biotechnology."

**S**keptics have capitalized on widespread public ignorance about the science and regulation of so-called GMOs, calling them "Frankenfoods" and conjuring up images of mad scientists running amok in laboratories. This couldn't be further from the truth, says Wildeman.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


"It's important to understand that researchers do not randomly transfer genes about which they know nothing. There is a great amount of basic research conducted on a specific gene before it can be selected for transference."

**P**rof. Larry Erickson, Plant Agriculture, says activist organizations like Greenpeace have stirred up fears over the imponderables, such as what might happen in crossing species barriers and mixing, say, viral DNA with alfalfa genes. He and his colleagues, however, point out that the mixing of DNA even across species is routine and often benign. "The human genome consists of a high proportion of copies of viral DNA," says Prof. John Phillips, Molecular Biology and Genetics. Pointing, for example, to lengthy and apparently meaningless stretches of the human genetic code that incorporate portions of DNA from retroviruses that have co-existed with humans since time immemorial, he says: "There's a mistaken perception that the genomes of individual species are pure and pristine."

**O**ther academics like Prof. Ann Clark, Plant Agriculture, say essentially no effort is being devoted to assessing the potential risks and side effects of consuming and introducing transgenic organisms into the environment. "Biotechnology is exciting science, and there's a lot of potential for understanding gene-to-gene interactions," she says, "but this is also a very costly technology. While we spend vast amounts of society's resources -- and researchers' time -- to service the biotech industry, we are not developing the capability to ask or answer other, potentially more fruitful, questions."

**A** specialist in pasture management and an advocate of organic farming, Clark raises issues like genetic pollution, food-safety testing and possible environmental side effects of introducing GE plants. She questions the real benefits of GE to the farming community, and flags the issues of liability and accountability should health or environmental risks actually materialize.

**A**ccording to a recent story in the *Western Producer*, a farmer in northern Alberta who has planted three herbicide-resistant types of canola since 1997 found volunteer canola in his field last year that was resistant to three separate herbicide families. Cross-pollination from crops genetically engineered to resist herbicides is blamed for producing the triply resistant weeds. Because canola pollen can move great distances, this threat exists even on farms that have not grown GE canola, says Clark, raising real issues about the commercial viability of this technology. She notes this is just one example of how a technology "brought prematurely to market is externalizing the true costs of production, involuntarily, onto neighboring farmers."

**O**ther people oppose biotechnology for political reasons, including antipathy toward the multinationals that make genetically engineered seed. Prof. Karl Meilke, Agricultural Economics and Business, says there are a number of organizations opposing GMOs "that have an agenda where health and safety are, in fact, not at the top of the list. They are 'anti-Big Business' first and foremost and use the GMO issue to drive their agenda against companies like Monsanto and Novartis."

**F**rom a business point of view, it makes sense to patent and protect technologies in which you've made substantial investments, although some scientists have warned that stringent guarding of intellectual property will signal the end of public plant-breeding programs -- the kind of research that Zavitz began at Guelph.

**Global concerns**

**G**riffiths says several common concerns have surfaced during citizens' consensus conferences on genetic engineering held recently in Canada, Australia and Europe. These concerns involve regulatory measures, control of multinationals, harmonizing of standards and legislation, and labelling of GE products. Those issues were also discussed in Montreal, where representatives of

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


about 135 countries adopted a protocol that says an importing country must be notified in advance if a company brings in GE seeds, because they will be introduced into the environment, but not if the commodities -- corn, soybeans -- are intended for livestock or human consumption.

**T**he earlier Uruguay Round of trade talks basically said that "you can do whatever you want as regards food safety on a domestic basis, but if you want to exclude imports on the basis of health concerns, you have to have some scientific evidence to do so," says Meilke, adding that although the evidence has been lacking, the rhetoric has not. "If GMOs aren't safe, we shouldn't be growing them. If they are safe, we should be trading them."

**I**n practice, some food manufacturers and retailers, fearing consumer backlash, have stopped using some transgenic food ingredients. And a recent report from the University of Saskatchewan also suggested that in addition to the 15 countries of the European Union, another 26 countries are considering whether or not to develop a system for labelling GE foods.

**N**orth American farmers are worried about GMO opposition in Europe and Japan and the resulting announcements by major corn and grain mills on this continent, as well as reports from high-profile companies such as McCain's and Seagrams that they will no longer accept genetically engineered products. Faced with the loss of important international markets, farmers are left wondering whether there is still an economic advantage to growing transgenic crops and, in some cases, are scrambling to buy non-GM seed that's in short supply for the next growing season.

**D**uring the recent FSBC gathering in Guelph, Surgeoner spoke about his membership on a committee -- an initiative of the Canadian Council of Grocery Distributors, Canadian General Standards Board and the Consumers' Association of Canada -- that is developing a national standard for voluntary labelling of foods produced through biotechnology. He says voluntary labels would give consumers the choice to buy or avoid foods with GM ingredients, unlike the concept of mandatory labelling, which he says would be costly and complicated to administer.

**Food-safety guarantees**

**A**ccording to Guelph faculty, two questions are central to the debate over genetically engineered foods: Is there a risk in eating them and, perhaps as important, do people think there's a risk in eating them? "No one's saying this food is absolutely risk-free," says Surgeoner. "You can't guarantee zero risk with anything."

**H**e notes that today's number-one health risk from food is posed not by genetic engineering but by overeating. Number two is food-borne illnesses resulting from natural pathogens such as E. coli, salmonella and listeria. Says Prof. Doug Powell, Plant Agriculture: "Several million Canadians are sickened and a couple of hundred are killed each year from food- and water-borne illness. Not one has ever been linked with genetic engineering. While vigilance is warranted with any new technology, the excessive concern about genetically engineered foods trivializes efforts of farmers, processors, distributors and consumers to enhance the safety of the food supply."

**A**dds Prof. Karen Finlay, Consumer Studies: "People use herbal remedies without questioning them, despite the fact they undergo no testing. People assume that because they're health-oriented, they've been tested. They haven't. They're assumed to be somehow safe because they're 'natural.'"

**I**n fact, says Griffiths, biotechnology may be used to improve food safety, including detecting pathogens, improving epidemiology and surveillance, and learning more about the development of pathogens causing food-borne illnesses. His centre is an interdisciplinary group of more than 50 university and government scientists established with an $8-million grant from the Canada

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


Foundation for Innovation, the Ontario Innovation Trust and industry partners to study food safety and provide information to a food-policy centre also being developed at Guelph.

**P**owell points to the need to inform consumers about the regulations and practices that govern biotechnology and food safety. "There is one country in the world that has a mandatory safety assessment of new and novel foods -- whether derived through genetic engineering, mutagenesis breeding, new enzymes, whatever -- rightly focusing on the safety of the end product rather than how that end product was derived. It is Canada. Others should follow suit."

**H**e recently joined a new federal advisory committee intended to brief federal cabinet ministers on ethical, social, regulatory, scientific, environmental and health aspects of biotechnology, and says testing of transgenic plants includes field trials to understand putative environmental risks and whether the crop performs as expected. For some crops, animal feeding trials are required, as well as nutritional, toxicological and molecular studies. Since 1993, genetically engineered foods have been regulated in Canada in the same way as any new food produced by conventional methods.

**H**ealth Canada and the Canadian Food Inspection Agency (CFIA) are both involved in assessing the safety of new food products, guided by the premise that genetically engineered foods are substantially equivalent to traditionally bred organisms and lend themselves to well-defined risk-assessment methods and principles. As the CFIA points out, regulators frequently have more knowledge about GMOs than about naturally grown foods.

**T**he result? "We have not seen a single food-safety outbreak attributable to any genetically modified food that has passed through Canada's regulatory system," says Surgeoner. "That covers GM corn, canola, soybeans -- the products approved since 1994."

**T**hat assurance isn't good enough for retired botany professor Ann Oaks, who chuckles at the Health Canada assumption that GE foods are "substantially equivalent" to non-GE foods, "but they are different enough to qualify for a patent." She says Health Canada assessment panels rely on tests conducted in industry laboratories, and to her that is not as reliable as conducting the tests in independent labs. She also advocates food-safety testing that is as stringent as the procedures used to assess new pharmaceutical products, which check for allergens, immune system responses and growth responses.

"**G**enetic engineering is a cutting-edge science that we don't fully understand. We need to do much more basic research and move more slowly in the commercialization of GE products. It's easier to solve problems that arise during testing than to correct health problems that may occur in the general population after products have been in the marketplace for several years."

**Ethics and education**

**R**esearch into Canadian consumer attitudes and perceptions about genetic engineering is sorely lacking. Finlay hopes to address that gap through a proposal she's preparing for a new cross-disciplinary communications research facility in Guelph's new Food Institute. Along with colleagues at U of G, other Canadian universities and the Food Policy Institute in the United Kingdom, she plans to study biotechnology as the first order of business.

"**W**hen it comes to GMOs, we know neither levels of consumer awareness nor consumer attitudes," she says. "We also don't know how it may vary by different demographics -- urban versus rural, age groups, parents versus children. All we're hearing from at the moment are very vocal special-interest groups. Different regions of Canada -- Ontario, Quebec, the West -- will probably have very different consumer views on biotech. The mandate of the unit will be to determine what consumers need to know to feel safe. We can discover that through research."

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


**E**lsewhere at Guelph, the FSBC plans to hire a bioethicist -- to be based in the Department of Philosophy -- to address this critical issue where U of G researchers figure prominently. "Some critics have chosen to simply label all biotechnology bad, amazingly enough not in spite of our ignorance, but because of it," says Wildeman. "The attitude seems to be that we don't know enough about it, so let's ban it. Our view is that we need to proceed carefully. It's important to examine the science and ethics of specific biotechnology projects. GMOs are no more 'all bad' than all pharmaceutical research is all bad. We believe that in hiring a bioethicist, we will enlist a clear analytical thinker who can present both the positive side of what we'd like to do and any potential negative aspects."

**A**dds Prof. David Sparling, Agricultural Economics and Business: "To inform the public about GMOs, we need to communicate the pros and cons. Then, if the public perceives there are enough benefits, they will be willing to assume the risks and continue to consume food that is genetically engineered."

**S**ome might argue that, here in Canada, we don't need biotechnology. Sparling acknowledges that although GE products "aren't necessary from an economic point of view, they are attractive from an economic point of view." But he points to the next generation of genetically engineered foods that will provide additional health benefits. Canadian consumers may want to take advantage of these benefits themselves and also see their country reap the economic benefits of maintaining a pre-eminence in the development of new genetic technologies for world consumption.

**I**n the developed world, where life expectancies have nearly doubled in a century, advances in health and safety have eliminated or reduced many major human health risks. Not so in other parts of the world. "Those of us in rich countries are a little jaded, I think," says Meilke. "Some might say: 'So what if my Wheaties cost two cents less per box thanks to GMOs?' It isn't going to be you or I starving. But in poorer countries, those costs are enormously important. Over the long term, in the developing world, not developing GMOs could have life-and-death implications."

**A**dds Wildeman: "Not all GMOs are created for corporate wealth, as the critics would maintain. Many projects, including those under way at Guelph, are designed to improve our health, the environment and the economic well-being of farmers."

**A**ll these issues are under discussion at U of G, where ongoing research programs and new initiatives concerned with food safety and regulation, consumer confidence, and the economic and ethical implications of genetic engineering will help ensure that the Canadian public and policy-makers receive the information they need to assess this new technology.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



**August 2001 Volume 19 Number 8 pp 741 - 745**

# Pigs expressing salivary phytase produce low-phosphorus manure

**Serguei P. Golovan[1, 2], Roy G. Meidinger[2], Ayodele Ajakaiye[3], Michael Cottrill[1], Miles Z. Wiederkehr[4], David J. Barney[4], Claire Plante[5], John W. Pollard[5], Ming Z. Fan[3], M. Anthony Hayes[6], Jesper Laursen[7, 8], J. Peter Hjorth[7], Roger R. Hacker[3], John P. Phillips[2] & Cecil W. Forsberg[1]**

1. Department of Microbiology, University of Guelph, Guelph, Ontario, Canada, N1G 2W1
2. Department of Molecular Biology and Genetics, University of Guelph, Guelph, Ontario, Canada, N1G 2W1
3. Department of Animal and Poultry Science, University of Guelph, Guelph, Ontario, Canada, N1G 2W1
4. Arkell Swine Research, University of Guelph, Guelph, Ontario, Canada, N1G 2W1
5. Department of Population Medicine, University of Guelph, Guelph, Ontario, Canada, N1G 2W1
6. Department of Pathobiology, University of Guelph, Guelph, Ontario, Canada, N1G 2W1
7. Institute of Molecular and Structural Biology, Aarhus C University, C F Mollers Alle Bldg 130, DK-800 Aarhus C Denmark.
8. Present address: DAKO A/S, Immunocytochemistry Department, Produktionsvej 42, DK-2600 Glostrup, Denmark.
**Correspondence should be addressed to** C W Forsberg. e-mail: cforsber@uoguelph.ca **and** J P Phillips. e-mail: jphillip@uoguelph.ca

**To address the problem of manure-based environmental pollution in the pork industry, we have developed the phytase transgenic pig. The saliva of these pigs contains the enzyme phytase, which allows the pigs to digest the phosphorus in phytate, the most abundant source of phosphorus in the pig diet. Without this enzyme, phytate phosphorus passes undigested into manure to become the single most important manure pollutant of pork production. We show here that salivary phytase provides essentially complete digestion of dietary phytate phosphorus, relieves the requirement for inorganic phosphate supplements, and reduces fecal phosphorus output by up to 75%. These pigs offer a unique biological approach to the management of phosphorus nutrition and environmental pollution in the pork industry.**

The main challenge for agriculture in this century is to sustain and increase food production without degrading the environment[1]. In agriculture, global animal phosphorus pollution is a serious and growing problem[1], and the application of manure as fertilizer to land exceeds that of inorganic fertilizer or other anthropogenic fluxes[2]. High-phosphorus manure from monogastric animals[3] such as pigs and poultry arises from the inherent inability of these animals to digest plant phytate (*myo*-inositol 1,2,3,4,5,6-hexakis dihydrogen phosphate), which accounts for up to 80% of phosphorus in common cereal grains, oil seed meals, and by-products[4, 5]. Dietary supplementation with bioavailable mineral phosphate is therefore required to achieve optimal growth of animals[6]. The traditional practice of meeting nutritional requirements through phosphorus supplements has been nutritionally successful but environmentally counterproductive. As a consequence of runoff into streams and rivers, excess phosphate from manure applied as fertilizer nourishes eutrophication of phosphate-limited ecosystems[7, 8], which in turn produces algal blooms, oxygen depletion, disruption of food webs, death of fish and aquatic animals, and increased production of potent greenhouse gases[9-11].

Different strategies have been devised for reducing or eliminating the need for mineral phosphorus supplementation of the swine diet. The feeding of animal by-products such as meat meal or bone meal, which have phosphorus digestibilities up to 87% (ref. 12), or of processed food wastes, has had a long history. However, concern about the spread of animal disease[13, 14] has forced a transition to plant sources of phosphorus. The feeding of low-phytate corn, which

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


reportedly improves the bioavailability of phosphorus from 9% to 62% (ref. 15), may become an option if varieties with suitable agronomic traits can be developed[16]. The most widely practiced strategy is to supplement feed with phytase, an enzyme that releases phosphate from phytate[8]. This practice has led to reductions in fecal phosphorus reportedly as high as 56% (ref. 17).

Transgenic augmentation of the natural repertoire of digestive enzymes with phytase could in principle relieve monogastric animals from the dependence on high-value specialty feedstuffs for bioavailable phosphorus. We recently demonstrated the feasibility of this approach with transgenic mouse models, using the salivary gland to deliver the highly active, low-pH optimum, and protease-resistant *Escherichia coli* phytase into the digestive tract[18, 19]. In a separate study we also demonstrated that inclusion of *E. coli* phytase in poultry diets is as efficacious as adding the commercial fungal phytase[20].

We now report the development of transgenic pigs producing salivary phytase. These pigs seem to require almost no inorganic phosphate supplementation for normal growth and excrete up to 75% less fecal phosphorus than non-transgenic pigs.

## Results

Using the PSP/APPA transgene[18] (parotid secretary protein promoter linked to the *E. coli appA* phytase gene), we produced 33 transgenic founder ($G_0$) piglets, of which 14 produced 5 to 6000 U/ml of phytase in the saliva at 7–11 days of age. Fifteen produced less than 5 U/ml, and four lacked detectable salivary phytase activity. These 33 different lines of transgenic pigs were generated from the microinjection of 4,147 pronuclear embryos with an efficiency of 0.8%. The transgene copy numbers were 35 and 2 for lines WA and JA, respectively, the lines that have received the most study. Transgenic $G_1$ progeny have been obtained from 13 founder lines, and farrowings are continuing for the remaining lines. Of 6 litters sired by founder boar 167-02 of line WA, 25 of 53 piglets were transgenic. This line of transgenic pigs showed the highest phytase activity at birth of all lines. The activity of phytase produced by $G_1$ piglets from these farrowings ranged from 341 U/ml to greater than 10,077 U/ml with a median of approximately 2,000–3,000 U/ml, which was two- to fivefold higher than that of most other lines. It should be noted that accurate determination of phytase activity in saliva samples is confounded by several factors, including feed and water consumption before sampling and fluctuations in saliva production.

The presence of phytase activity in saliva indicated the potential for phytate digestion. To determine whether salivary phytase actually promotes the digestion of phosphorus from dietary phytate, we tested transgenic $G_1$ pigs from line WA with a median salivary phytase averaging 2,420 U/ml in nutritional trials with soybean meal containing 53% phytate phosphorous as the sole source of phosphorus. Soybean meal was chosen as the dietary source of phytate because it is a commonly used feed ingredient and it has a comparatively high concentration of phytic acid phosphorus[21]. The true digestibility of phosphorus in the test diets by both weanling and growing-finishing transgenic pigs approached 100%, compared with approximately 50% for non-transgenic pigs (Table 1). The phosphorus content of fecal matter from transgenic weanling and growing-finishing pigs fed these diets was reduced by as much as 75% and 56%, respectively, compared with that of their non-transgenic counterparts (Fig. 1). As almost all of the dietary phosphorus was digested and absorbed, the residual phosphorus in fecal matter probably arose mainly from endogenous sources. The concentration of phosphorus in fecal matter of the growing-finishing pigs was higher than that of the weanling pigs. This was probably because of higher fermentative loss of organic matter such as non-starch polysaccharides in the well-developed large intestines of the growing-finishing pigs arising from the slower rate of passage of the contents. The slightly higher content of phosphorus in the fecal material of pigs receiving the lower level of soybean meal might have arisen from lower dilution with non-digestible components of dietary soybean meal. Greater phytase inactivation caused by a lower pH of the stomach contents expected at the lowest concentration of dietary soybean meal also may have been a contributing factor.

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


The digestive effect of salivary phytase was further tested by feeding $G_1$ transgenic finishing pigs from founder line JA a standard finishing diet not supplemented with inorganic phosphate. In this experiment, fecal phosphorus was reduced by 67% in boars ($n$ = 7) and 64% in gilts ($n$ = 4) compared with that in non-transgenic sibling boars and gilts fed the same ration. This difference would probably be greater had the comparison been made with non-transgenic pigs fed the standard finishing diet supplemented with inorganic phosphorus. The average (± s.e.m.) salivary phytase activities of the boars and gilts at the time of sampling were 198 ±71 and 182 ±48 U/ml, respectively. The growth rate expressed as days to reach 100 kg was 145.8 ±1.8 and 145.5 ± 3.0 days for the boars and gilts, respectively, compared with a herd value of 147 days for non-transgenic pigs receiving similar rations except that they contained supplemental phosphate.

The distribution of phytase in tissues from line WA $G_1$ pigs was analyzed by enzymatic and immunohistochemical methods. High phytase activities were detected in the parotid, sublingual, and submaxillary salivary glands, whereas low but substantial activities were found in tissues from the fundus region of the stomach and from the duodenum (Table 2). There was substantial phytase activity in the contents of the stomach, duodenum, and ileum, but not in the contents of the cecum or colon of weanlings. The phytase activities of comparable tissues from weanling pigs differed from one another, but were higher than those of the growing-finishing pigs. The feature common to both weanling and growing-finishing pigs was the very low phytase activity in the "major" tissues, exemplified by skin, muscle, heart, and liver. Similar tissue distributions of phytase were found for lines JA and GO (data not shown). Comparable tissues from a non-transgenic pig contained no detectable phytase activity.

The distribution of immunohistochemically detectable phytase protein in various tissues of transgenic pigs (Fig. 2) corresponded to the distribution of phytase enzymatic activity (Table 2), with the parotid, sublingual, and submaxillary glands showing comparatively intense immunohistochemical staining and with no staining of muscle. Expression was consistently found in protein-producing serous cells in the acini of the salivary glands. Milk from the founder sow CA405-02 that had farrowed transgenic piglets was negative for phytase. All tissues of transgenic pigs sampled for phytase expression seemed normal by gross morphological examination and detailed histological analysis.

Phytase purified from saliva of $G_o$ boar WA167-02 showed both acid phosphatase and phytase activities with a specific activity for phytate hydrolysis of 1,400 U per mg protein. Although the apparent mass of purified phytase analyzed by sodium dodecyl sulfate–polyacrylamide gel electrophoresis was 55 kDa, the mass determined by mass spectral analysis was 50 kDa, compared with 44.7 kDa for phytase synthesized by *E. coli*[19]. The increase in mass of the salivary phytase was due to N-glycosylation, as shown by glycoprotein staining and reduction in size after treatment with N-glycosidase F (data not shown). Like the unglycosylated enzyme from *E. coli*, salivary phytase retained more than 90% of its activity after incubation with a 1,000-fold excess of pepsin at a pH of 2.5 for 6 h, but only 10% of its activity after incubation with a mixture of trypsin, chymotrypsin, and elastase at a pH of 7 for 6 h.

Saliva samples from 12 phytase-positive transgenic $G_1$ pigs from different lines were analyzed by western blotting using a monoclonal antibody against the *E. coli*-produced phytase. The antibody reacted only with the putative 55-kDa phytase (data not shown). The 55-kDa-phytase band from some pigs was smeared, indicating variation in the glycosylation of enzyme molecules. Tissue samples from growing-finishing lines WA and JA were also analyzed for phytase protein by western blotting. Phytase protein with an apparent mass of 55 kDa was detected in the saliva and parotid, sublingual, and submaxillary glands as well as in the stomach contents of a growing-finishing pig of line WA (Fig. 3), although the apparent levels in the stomach and sublingual glands were much lower than those in the parotid and submaxillary glands. The sublingual phytase seemed to have a slightly higher mass than the phytase in other tissues, which may have resulted from increased glycosylation of sublingual phytase compared with the phytase in other salivary glands—a characteristic previously reported for the mouse and rat[22, 23]. The increased

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents


glycosylation may have partially blocked the monoclonal antibody-binding epitope, as less enzyme was detected in the sublingual tissue than in the submaxillary tissue despite the equal enzyme activity of the two tissues (Table 2). We obtained similar results with tissues from line JA. No immunologically reactive phytase protein was detected in other major tissues by western blotting.

## Discussion

The phytase activity present in the saliva of different transgenic founder lines of pigs differed considerably. We have attributed these differences to positional effects of the transgene insertion, a phenomenon commonly seen in transgenic mice[24, 25]. Because we have determined the transgene copy number for only two lines of transgenic pigs, we cannot relate copy number to phytase expression.

The salivary phytase activity and the tissue phytase activities of pigs within line WA differed between animals from the same litter and, furthermore, the phytase activities decreased with increasing age of the pig. Excluding sampling difficulties, the variation in salivary phytase activities may have arisen from random repeat-induced silencing[26], although we have no evidence for this. Likewise, the general decrease in phytase activities with increasing age may have been due to diminishing activity of the promoter, as found with transgenic mice (Golovan *et al*., unpublished data), or to age-dependent silencing, which at least in mice is exacerbated by high copy number[27].

These studies provide evidence that provision of salivary phytase enables essentially complete digestion of dietary phytate phosphorus, largely relieving the requirement for inorganic phosphate supplementation, and reduces fecal phosphorus output of pigs by up to 75%. Conventional pigs require approximately 2.5 kg of supplemental dicalcium phosphate for optimal growth from weaning to market weight[6]. Transgenic pigs expressing salivary phytase can apparently recover sufficient phosphorus for optimal growth from phytate present in normal feed constituents. *E. coli* phytase degrades phytate only to inositol 2-phosphate or to inositol 5-phosphate[28]. These remaining inositol phosphate products may be further digested by other intestinal phosphatases or may be absorbed and enter the intracellular pool of inositol phosphates[29]. Despite the involvement of inositol phosphates in a variety of essential intracellular signaling processes[30], we have not detected any deleterious effect of phytase expression on the health or performance of the transgenic pigs.

The reduction in fecal phosphorus of 64–67% by finisher phytase pigs not receiving the supplemental phosphate substantially exceeds the 40% reduction reported for finisher pigs fed expensive phytase supplements (2,500 U/kg feed)[31]. A plausible reason for the greater efficiency of the salivary phytase is the much larger amount of enzyme continuously present in the stomach of the transgenic pig. A pig can secrete as much as 0.5 liters of saliva during the consumption of 0.5 kg of dry feed[32]. Consequently, pigs expressing phytase in the salivary glands may deliver as much as 200,000 U of phytase to the digestive tract during the consumption of 1 kg of feed. This compares with a typical phytase supplementation to conventional pigs of 2,500 U of phytase per kg (ref. 31). Our preliminary evidence indicates that even a modest phytase-producing line expressing 2–5 U/ml may produce sufficient phytase to satisfy the dietary phosphorus requirement. Thus, the age-dependent reduction in the amount of phytase secreted in the saliva by some lines of transgenic pigs would not have an effect on phytate digestion as long as this threshold activity is exceeded.

What is the minimum concentration of fecal phosphorus that can be attained? Because most of the dietary phosphorus is used by the transgenic pigs, as documented by the true digestibility, phosphorus present in the fecal matter of transgenic phytase pigs is probably derived from endogenous sources that escape digestion and absorption[33]. Consequently, the origins of fecal phosphorus would parallel those of endogenous nitrogenous compounds present in fecal

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



matter[33]. It would therefore appear that we have attained nearly the maximum reduction in fecal phosphorus by digestion of dietary phosphorus, and that any further reduction would require a reduction of phosphorus released from endogenous metabolism.

Previous studies have shown a negligible effect of feeding microbial phytase on the total tract digestibility of dry matter[34, 35]. However, more recent trials have documented enhanced use of dry matter[31, 36]. Phytase should also abrogate the well documented anti-nutritional property of phytate, that is, the binding of essential multivalent cations, amino acids, and starch, which prevents their efficient digestion and absorption[5]. The possible benefits of phytate for the digestion of other nutrients in phytase pigs await further study.

In summary, pigs producing phytase in the saliva present a new biological approach for reducing phosphorus pollution in animal agriculture and for reducing dependence on diminishing global phosphate reserves[16, 37].

**Experimental protocol**

Construction of the PSP/APPA transgene has been described[18]. Transgenic pigs were generated by pronuclear embryo microinjection[38]. The experimental protocols involving animals were in accordance with the Guide to the Care and Use of Experimental Animals (Vol. 1, 1980) by the Canadian Council on Animal Care. Transgenic piglets were identified at 4–11 days of age by PCR analysis of DNA from blood and tail samples, and by assay of saliva for phytase activity. For further details of the extraction conditions for genomic DNA from tail biopsies and blood, PCR conditions, and primers, see the Supplemental Text in the Web Extras page of *Nature Biotechnology* Online. One unit (U) of phytase is 1 μmol phosphate released from phytate per min. Analytical methods were essentially as described before[18, 19]. Monoclonal antibodies against the purified *E. coli*-produced phytase were prepared as described before[39].

Digestion trials were done according to a 4 × 4 Latin square design as described in detail before[40]. For each trial, four 6- to 15-kg weanling pigs or 20- to 65-kg growing-finishing pigs were fed a basal diet containing soybean meal at levels of 13.6, 27.3, 40.9, and 54.6% (weight/weight) with chromic oxide as a digestibility marker (see Supplementary Tables 1 and 2 in the Web Extras page of *Nature Biotechnology* Online). The phytate phosphorus content of the soybean meal used in this study was estimated to be 53% of the total phosphorus[41].

*Note: Supplementary information can be found on the* Nature Biotechnology *website in Web Extras (http://biotech.nature.com/web_extras).*

Received 30 April 2001; Accepted 4 June 2001.

**REFERENCES**

1. Tilman, D. *et al*. Forecasting agriculturally driven global environmental changes. *Science* **292**, 281-284 (2001). | Article | PubMed | ISI |
2. Smil, V. Phosphorus in the environment: natural flows and human interferences. *Annu. Rev. Energy Environ.* **25**, 53-88 (2000). | Article | ISI |
3. American Society of Agricultural Engineers. Manure production characteristics. In *ASAE standards: Standards, engineering practices and data*. 663-665 (American Society of Agricultural Engineers, St. Joseph, MI; 1999).
4. Jongbloed, A.W. & Kemme, P.A. Effect of pelleting mixed feeds on phytase activity and the apparent absorbability of phosphorus and calcium in pigs. *Anim. Feed Sci. Technol.* **28**, 233-242 (1990). | ISI |

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete



5. Kornegay, E.T. Digestion of phosphorus and other nutrients: the role of phytases and factors influencing their activity. In *Enzymes in Farm animal nutrition*. (ed. Bedford, M.R. & Partridge, G.G.) 237-271 (CABI Publishing, Marlborough; 2001).
6. NRC. *Nutrient requirements of swine*. (National Academy Press, Washington, DC; 1998).
7. Correll, D.L. Phosphorus: a rate limiting nutrient in surface waters. *Poultry Sci.* **78**, 674-682 (1999). | ISI |
8. Jongbloed, A.W. & Lenis, N.P. Environmental concerns of animal manure. *J. Anim. Sci.* **76**, 2641-2648 (1998). | PubMed | ISI |
9. Mallin, M.A. Impacts of industrial animal production on rivers and estuaries. *American Scientist* Jan-Feb., 26-37 (2000).
10. Naqvi, S.W. *et al*. Increased marine production of $N_2O$ due to intensifying anoxia on the Indian continental shelf. *Nature* **408**, 346-349 (2000). | Article | PubMed | ISI |
11. Poulsen, H. Phosphorus utilization and excretion in pig production. *J. Environ. Qual.* **29**, 24-27 (2000). | ISI |
12. Jongbloed, A.W. & Kemme, P.A. Apparent digestible phosphorus in the feeding of pigs in relation to availability, equipment and environment. 1. Digestible phosphorus in feedstuffs from plant and animal origin. *Neth. J. Agric. Sci.* **38**, 567-575 (1990). | ISI |
13. Ridley, R.M. & Baker, H.F. Big decisions based on small numbers: lessons from BSE. *Vet. Q.* **21**, 86-92 (1999). | PubMed | ISI |
14. Ryder, S.J., Hawkins, S.A., Dawson, M. & Wells, G.A. The neuropathology of experimental bovine spongiform encephalopathy in the pig. *J. Comp. Pathol.* **122**, 131-143 (2000). | Article | PubMed | ISI |
15. Spencer, J.D., Allee, G.L. & Sauber, T. E. Phosphorus bioavailability and digestibility of normal and genetically modified low-phytate corn for pigs. *J. Anim. Sci.* **78**, 675-681 (2000). | PubMed | ISI |
16. Abelson, P.H. A potential phosphate crisis. *Science* **283**, 2015 (1999). | Article | PubMed | ISI |
17. Wodzinski, R.J. & Ullah, A.H.J. Phytase. *Adv. Appl. Microbiol.* **42**, 263-302 (1996). | PubMed | ISI |
18. Golovan, S.P., Hayes, M.A., Phillips, J.P. & Forsberg, C.W. Transgenic mice expressing bacterial phytase as a model for phosphorus pollution control. *Nature Biotechnol.* **19**, 429-433 (2001). | Article | PubMed | ISI |
19. Golovan, S., Wang, G., Zhang, J. & Forsberg, C.W. Characterization and overproduction of the *Escherichia coli appA* encoded bifunctional enzyme which exhibits both phytase and acid phosphatase activities. *Can. J. Microbiol.* **46**, 59-71 (2000). | Article | PubMed | ISI |
20. Leeson, S., Namkung, H., Cottrill, M. & Forsberg, C.W. Efficacy of a new bacterial phytase in poultry diets. *Can. J. Anim. Sci.* **80**, 527-528 (2000). | ISI |
21. Drackley, J.K. *Soy in animal nutrition*. (Federation of Animal Science Societies, Savoy, IL; 2000).
22. Ball, W.D. Cell-restricted secretory proteins as markers of cellular phenotype in salivary glands. In *Biology of the salivary glands*. (ed. Dobrosielski-Vergona, V.) 355-395 (CRC Press, Boca Raton; 1993).
23. Mirels, L., Miranda, A.J. & Ball, W.D. Characterization of the rat salivary-gland B1-immunoreactive proteins. *Biochem. J.* **330**, 437-444 (1998). | PubMed | ISI |
24. Allen, N.D. *et al*. Transgenes as probes for active chromosomal domains in mouse development. *Nature* **333**, 852-855 (1988). | PubMed | ISI |
25. Al-Shawi, R., Kinnaird, J., Burke, J. & Bishop, J.O. Expression of a foreign gene in a line of transgenic mice is modulated by a chromosomal position effect. *Mol. Cell Biol.* **10**, 1192-1198 (1990). | PubMed | ISI |
26. Garrick, D., Fiering, S., Martin, D.I.K. & Whitelaw, E. Repeat-induced gene silencing in mammals. *Nature Genet.* **18**, 56-59 (1998). | PubMed | ISI |
27. Robertson, G., Garrick, D., Wilson, M., Martin, D.I. & Whitelaw, E. Age-dependent silencing of globin transgenes in the mouse. *Nucleic Acids Res.* **24**, 1465-1471 (1996). | Article | PubMed | ISI |

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete Documents



28. Greiner, R., Carlsson, N. & Alminger, M.L. Stereospecificity of myo-inositol hexakisphosphate dephosphorylation by a phytate-degrading enzyme of *Escherchia coli*. *J. Biotechnol.* **84**, 53-62 (2000). | Article | ISI |
29. Sakamoto, K., Vucenik, I. & Shamsuddin, A.M. [$^3$H]Phytic acid (inositol hexaphosphate) is absorbed and distributed to various tissues in rats. *J. Nutr.* **123**, 713-720 (1993). | PubMed | ISI |
30. Chi, T.H. & Crabtree, G.R. Inositol phosphates in the nucleus. *Science* **287**, 1937-1939 (2000). | Article | PubMed | ISI |
31. Zhang, Z.B., Kornegay, E.T., Radcliffe, J.S., Wilson, J.H. & Veit, H. P. Comparison of phytase from genetically engineered *Aspergillus* and canola in weanling pig diets. *J. Anim. Sci.* **78**, 2868-2878 (2000). | PubMed | ISI |
32. Corring, T. Endogenous secretions in the pig. In *Current concepts of digestion and absorption in pigs*. (eds. Low, A.G. & Partridge, I.G.) 136-150 (National Institute for Research in Dairying, Reading; 1980).
33. Souffrant, W.B. Endogenous nitrogen losses during digestion in pigs. In *Digestive physiology in pigs*. (eds. Verstegen, M.W.A., Huisman, J. & den Hartog, L.A.) 147-166 (Pudoc, Wageningen; 1991).
34. Simons, P.C.M. *et al*. Improvement of phosphorus availability by microbial phytase in broilers and pigs. *Brit. J. Nutr.* **64**, 525-540 (1990). | ISI |
35. Ketaren, P.P., Batterham, E.S., Dettmann, E.B. & Farrell, D.J. Phosphorus studies in pigs. 3. Effect of phytase supplementation on the digestibility and availability of phosphorus in soya-bean meal for grower pigs. *Br. J. Nutr.* **70**, 289-311 (1993). | PubMed | ISI |
36. Mroz, Z., Jongbloed, A.W. & Kemme, P.A. Apparent digestibility and retention of nutrients bound to phytate complexes as influenced by microbial phytase and feeding regimen in pigs. *J. Anim. Sci.* **72**, 126-132 (1994). | PubMed | ISI |
37. Driver, J., Lijmbach, D. & Steen, I. Why recover phosphorus for recycling and how? *Environmental Technol.* **20**, 651-662 (2001).
38. Wall, R.J., Pursel, V.G., Hammer, R.E. & Brinster, R.L. Development of porcine ova that were centrifuged to permit visualization of pronuclei and nuclei. *Biol. Reprod.* **32**, 645-651 (1985). | PubMed | ISI |
39. Lam, S.J. & Mutharia, L.M. Antigen-antibody reactions. In *Methods for general and molecular bacteriology*. (eds. Gerhardt, P., Murray, R.G.E., Wood, W.A. & Krieg, N.R.) 104-132 (American Society for Microbiology, Washington; 1994).
40. Fan, M.Z. *et al*. Novel methodology allows simultaneous measurement of true phosphorus digestibility and the gastrointestinal endogenous phosphorus outputs in studies with pigs. *J. Nutr.* **131**, (2001).
41. Eeckhout, W. & De Paepe, M. Total phosphorus, phytate-phosphorus and phytase activity in plant feedstuffs. *Anim. Feed Sci. Technol.* **47**, 19-29 (1994). | ISI |
42. Fan, M.Z. & Sauer, W.C. Determination of true ileal amino acid digestibility in feedstuffs for pigs with the linear relationships between distal ileal outputs and dietary inputs of amino acids. *J. Sci. Food Agric.* **73**, 189-199 (1997). | Article | ISI |

## ACKNOWLEDGMENTS

*We thank the staff at Arkell Swine Research and T. Archbold in the Department of Animal and Poultry Science for their assistance. This research was supported by funding from Ontario Pork, Ontario Ministry of Agriculture, Food, and Rural Affairs, Food Systems Biotechnology Centre (University of Guelph), and the Natural Sciences and Engineering Research Council of Canada to C.W.F. and J.P.P.*

Click Here & Upgrade
Expanded Features
Unlimited Pages
PDF Complete


**ONTARIO FARMER Tuesday, January 1, 2002**
**Letters**
**The Enviropig will reach the meat counter, but when?**

**Dear editor:**
In the December 4th issue Tom Van Dusen asked where does the Enviropig fit in' to help the pork producer satisfy the proposed Nutrient Management Act, and still remain profitable?

To provide a refresher, manure from pigs and poultry is enriched in phosphorus, the major pollutant in areas of pork and poultry production. The Enviropig is designed to secrete in its saliva the enzyme phytase. This endows the pigs with the capability to utilize practically all of the phosphorus present in cereal grains.

This has two primary benefits: there is no need to add either supplemental phosphate or phytase enzyme to the diet, and second, the phosphorus content of the manure will be reduced by 60 to 80 per cent, which will allow manure to be spread on land at the same or greater rate than before and still meet stringent nutrient management requirements. Trials are in progress to determine whether the Enviropig manure has less odour.

Initial testing has documented that the transgenic phytase pigs are as healthy and grow as rapidly as other pigs. If the transgenic pigs appear healthy, why are they not in the food chain? Because of strict Canadian legislation including the Canadian Environmental Protection Act, the Novel Foods Act and the Health of Animals Act, which we fully support, and will necessitate extensive studies to document that the pigs have no deleterious effect on the environment, that they are healthy, and produce safe pork over an extended period of time.

Has industry shown interest in the Enviropig? Despite the tide of interest from the press, government and individuals throughout the world, no major player has come forward to sponsor the last hurdle for the Enviropig. However, we have had discussions with several swine breeders in Canada and with scientists in China who are keen to import the Enviropig.

There are good reasons for this wait and see attitude; first, there is the matter of cost, taking the first transgenic pig through the regulator process will be expensive and uncharted course, and second, the Enviropig is a GMO, and at least one major player in the pork industry is concerned that being associated with research and development on genetically modified pigs may leave the impression that their breeding stock is genetically modified, a factor which could have financial consequences.

When can we expect industry to take the Enviropig flag and run with it? The worst-case scenario is that the pork industry will not embrace the Enviropig until nutrient legislation is pressing the financial bottom line such that the continued profitability supersedes the concern over the GMO issue.

A factor that has been discounted is the flexibility of consumers when it comes to price shopping. Knowing that the pigs had been thoroughly tested, and if enviro-pork is a few cents cheaper than conventional pork, many consumers will go for the cheaper product. Some may even buy it because the Enviropig leaves a significantly smaller footprint in the environment.

The bottom line is yes the Enviropig is "hogtied in red tape'", however, be patient, its time will come, perhaps sooner than we expect.

**Cecil W. Forsberg, Professor,**
**Department of Microbiology, U. of Guelph**