Pigs, Food and Technology:  
The Next 40 Years

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Introduction

The pig industry has an outstanding record of success in improving efficiency and lean yield. At the same time the industry has faced major challenges in commodity prices, exchange rates, finance, and disease. In future, the industry must be prepared to deal with continuing uncertainty. There will be much greater emphasis on meeting the needs of the consumer for health and wholesomeness. Success will depend on matching new emerging technologies to new business goals in tune with a changing society. This paper looks at some of the likely developments in technology, and asks what strategy the industry should adopt going forward.

Food and the Consumer

Consumer eating habits and attitudes towards food will continue to change. Traditional meat and two vegetables family meals are disappearing. Already more than half of all households have only one or two people, and a quarter of all meals are eaten on the go as snacks. The proportion of old people is set to increase, along with ethnic diversity. The digital age means that consumers will be much more informed on issues such as global warming and animal welfare.

With these changes has come the realization that food will be the first line of defence in averting huge healthcare costs in the future. Today 35% of Canadians are overweight and 24% are obese. One in 16 Canadians have been diagnosed with diabetes. Recent studies have implicated processed meat as a major cause of cancer and cardiovascular disease (WCRF, 2007; Micha et al., 2010). Although these meta-analyses based on published data
are highly questionable (Alexander et al., 2010), they paint a negative picture with consumers. Confidence in food safety needs to be recovered following the recent spate of recalls, including the Maple Leaf Foods listeriosis outbreak of 2008.

- **Pigs and Society**

Pig production and processing will be very vulnerable to a negative public perception. On sustainability, the industry consumes water and produces effluent along with greenhouse gases. Hauling animal feed and pigs uses energy. Animal protein is much more heavy on natural resources than plant protein, and in future crops can probably be genetically modified to deliver all the essential nutrients without any animals. GM crops are far less open to ethical debate than animals.

Livestock have been implicated in creating antibiotic resistance, for example with Salmonella or MRSA. Alternatives to antibiotics and strategies to eliminate food pathogens are badly needed. Pigs were the automatic culprit for the reassortment event that led to the 2009 “Swine Flu” H1N1 outbreak. Animal welfare issues such as castration, sow stalls and farrowing crates remain open to legislation based on emotion rather than science. The slaughter process itself is equally open to adverse publicity. The good news is that every one of these potentially negative aspects of pig production presents an opportunity for emerging technologies to provide a solution.

- **Emerging Technologies**

It is hard to imagine the advances in technology that will occur over the next forty years. The last forty saw molecular genetics and genome mapping, personal computers, the internet, cell phones, GPS, cheap air travel, and breakthrough drug discovery. The following are some of the areas where transformational technologies are either likely, or are badly needed.

**Animal Genetics**

With the new sciences of proteomics, metabolomics and regulomics, animal genetics will shift from using genes as serendipitous markers to a full understanding of gene function. Genetic improvement will be much more heavily based on DNA testing targeted towards function. DNA testing will be much cheaper, and eventually hand-held and on-the-spot. Genetic manipulation and cloning will be accessible technologies, and affordable markers will be available to identify and regulate GM or cloned meat. We
must assume that both GM and cloning will be permitted as soon as the science is available to show that they are safe.

**Personalized Medicine**

Nutrigenomics is the science of tailoring food to genotype (El Sohemy, 2009). It uses knowledge of the genotype of an individual person or pig to optimize the choice of food. People who are liable to elevated cholesterol or blood pressure can then select their diet accordingly. This is likely to receive a great deal of attention, some initially based on tenuous associations. Eventually this could be a golden opportunity to tailor the fatty acid or amino acid profiles of pork, creating a synergy between the human and porcine genomes. The industry will need to be proactive on nutrigenomics, because there is clearly a threat that meat could again be dubbed generically as “bad for you”.

**Designer Bacteria**

2010 saw the announcement of the first “designer bacteria” produced entirely from man-made DNA (Gibson et al., 2010). From a genomics-based understanding of the exact nutrient requirements of pigs or people, designer bacteria could synthesize ideal proteins or fats. Most exciting, designer carbohydrates could be made using carbon dioxide drawn from the atmosphere. This could be one answer to global warming, removing greenhouse gases, providing a novel source of either feed or biofuels, and removing the need to haul cereals long distances. Designer bacteria might also be harnessed to attack pathogens and reduce greenhouse gas emissions from effluent.

**Synthetic Meat**

The spectre of artificial meat, either by culturing muscle or designer DNA, has been on the horizon for some years. Already attempts at pilot scale production have been partially successful (Langelaan et al., 2010). On a large enough scale it might be competitive on cost. The main claims would be that it is environmentally friendly, very healthy for the consumer in terms of ideal fat and protein, free from food pathogens, and possibly even aseptic. The counter-claim would be that real meat is natural, wholesome and full of trace vitamins and minerals. It would then be essential to remove any stigmas associated with welfare, safety, and sustainability of animal production.

**Food Safety**

As recent recalls have shown, ready-to-eat meat is highly vulnerable to contamination between cooking and packaging. Very harmful bacteria such as Listeria monocytogenes are ubiquitous in the environment, so elimination
from livestock would not be the answer. The solution would be some form of post-packaging kill step once the container is sealed. The obvious technology would be irradiation, but at present there is large consumer resistance. Neither ultra-high pressure nor lactate-diacectate treatment completely eliminate bacteria. Some plants are now moving to pharmaceutical style sterile rooms for packaging. Robotics could also reduce the need for human contact.

Nanotechnology

The European Commission recently proposed a definition for nanoparticles as ranging from 1 nm to 100 nm. Though some way off, the promise is that nanotechnology can facilitate delivery of micronutrients and drug therapies. In the food industry it might be applied to delivering functional foods, improving taste, controlling pathogens to extend shelf life, and biodegradable packaging. Nanostructures can be designed to have specific physical properties. One example would be a fat substitute made from an air-filled protein emulsion micro-structure that has all the sensory properties of fat without the high energy content (Tchuenbou-Magaia et al., 2009). At present there is great uncertainty about the safety of very small nanoparticles that might pass through cell walls.

Quantum Biology

At some point it is likely that wet chemistry and microbiology will be superseded by quantum mechanics. DNA sequences will be recognized by their energy signature which will be read by electromagnetic waves. Such a technology might allow “instant” genotyping and genomic selection of newborn piglets. Another application might be realtime scanning for diseases either for individual animals or a whole pen or barn. One can imagine a further step of destroying the pathogens by transmitting a counter-wave that disrupts DNA or RNA. For the processor, this could offer on-line scanning for pathogens, and possibly sorting of carcasses based on their nutritional properties.

- Strategies for the Future

Again it is impossible to predict which technologies will prevail, along with the economic and social conditions that might evolve over the next forty years. The strategy must be to closely monitor emerging technologies and trends, and to be prepared to respond accordingly. Here are some key elements of a successful approach to the future.
Understand the Consumer

The first step is to understand how the consumer is thinking, and be prepared to meet any concerns head-on. Big picture, the industry needs to provide great-tasting and safe food that is healthy, easy to prepare, and with the proviso that it is good for the environment, and good for animal welfare. Industry must be flexible in meeting the new needs of society. For example, how could pork play a role in the diet of old people who are deficient in protein and have difficulty preparing food or swallowing? Some form of ready-to-eat or ready-to-cook soft miniature sausages, pies or sandwiches would be ideal. Equally, a desire for all-natural or antibiotic-free presents an opportunity to improve the image of meat.

Communicate

Industry must be proactive in winning public confidence. The message that pork is nutritious and safe must be loud and clear. The media must be given firm guidance on emergencies like the 2009 H1N1 “swine flu” outbreak. If genetic modification is approved in livestock, the public will need clear information on the position that the pork industry is taking. Consumers need to hear that producers care about animal welfare. The pork industry may require a stronger brand identity: “We trust the pork industry because they tell us what they are doing to make better food for our family and they are in control”.

Innovate

Easy to say and much more difficult to bring to life, innovation requires a change of mindset and a freedom to generate ideas. Innovation is not just about technology. It is simply a new way of doing things such as finding a new market in the aging population. Blackberry (RIM) and iPod (Apple) are leaders in technical innovation. What made them successful was that they filled an identified need, and they continue to delight the customer. Maple Leaf Foods spent four years developing a highly innovative SNP and web-based DNA traceability system for pork, but it was never used due to the effect of exchange rates on exports. “Open innovation” lowers the financial risk by trawling existing knowhow and solutions from outside the industry, and a number of companies now provide this service.

Science Base

The industry needs a strong base of fundamental science to protect its competitive position. For this it will be important to communicate research priorities to government and academia. High on the list of priorities must be more basic understanding of bacteria and viruses, since they pose a huge
threat to both livestock and people. Other priorities include alternative feedstuffs from biofuels, objective measures of welfare, meat quality and taste, human health attributes, immune function, waste disposal, and genetic modification. It seems likely that at some point the question of slaughter conditions will need to be addressed.

**Research Funding**

To maintain its competitive edge, the industry will surely need to return to the vexed question of how research is funded. The “valley of death” for publicly-funded emerging technologies that fail to cross the funding gap to near-market development needs to be overcome. Far too much of top scientists’ time is spent on applications for short-term funding. Long-term core funding is needed to focus on widely agreed objectives that benefit the industry, the consumer, and, where healthcare is concerned, the public purse.

**Conclusions**

For the foreseeable future the industry will need to deal with major uncertainty. There will be a shift towards technologies that will improve public health and the environment and boost public confidence. A further challenge will be to capture the added value of these technologies in higher profits that can drive research and innovation. A single strong point of contact is needed with the consumer, government and academia. With all the recent focus on short-term survival, some effort now needs to be directed to a longer-term strategy to compete with alternative sources of protein and to understand and manage consumer attitudes towards pork.

**References**


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