HOW WE PRODUCE A UNIFORM HIGH QUALITY MARKET PIG

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INTRODUCTION

For the past thirty years the pig industry has enjoyed the luxury of a single clear message from its end-user: reduce backfat. With the grading grid as the incentive, and by a combination of genetics and nutrition, this reduction has been spectacularly successful. Lean growth rate has improved some 60% over 30 years, the accumulated improvement worth some $400 million per year in Canada. Since a kilo of lean requires over three times less energy than a kilo of fat, producers also benefited from large reductions in feed costs.

With fatness now under control the situation is changing. Meat runs the risk of falling seriously behind everything else on the supermarket shelf in quality, uniformity and above all *predictability*. The notion of quality stretches far beyond the product into responsibility for animal welfare and food safety. The industry's present dilemma arises from five factors:

- Uncertain market conditions with cyclical profitability.
- Poor communication of what constitutes good quality.
- Payment systems that no longer reflect what the market requires.
- Independent management of the different steps in the pork value chain.
- Possible effects of animal health on quality and uniformity.

This paper looks at the main components of quality, and asks how the industry must change to ensure its future competitive position.

PRODUCT REQUIREMENTS

What is Quality?

Product quality includes all the factors that describe whether the product meets the customer's expectation. This includes not only the composition of the meat and its eating and processing properties but also the size and shape of the joint (see Table 1). Thus, the weight and length of a loin is as important as the fat content and eating properties.

Uniformity

Achieving a uniform and predictable product is perhaps the greatest challenge, given the inherent biological variation of meat. As well as ensuring that a higher proportion of product meets the customer's expectation, the unpredictable nature of meat is one of its most potentially damaging properties.

Table 1. Some components of meat quality.

Fat:lean ratio
Muscle distribution
Individual joint weight, size and shape
Intramuscular fat (marbling)
Intermuscular fat
Waterholding capacity
Rate of pH (acidity) change
Muscle and fat colour
Muscle and fat firmness
Ease of slicing
PSE and DFD
Tenderness, juiciness, and flavour
Curing loss
Bacteriology

Traceability

Today the responsibility of the pig industry goes well beyond the physical form of the product. There is public accountability for food safety. As medical knowledge grows, there will be increasing responsibility for human dietary health. There will also be responsibility to defend the various claims that add value to the finished product, involving for example "high welfare, organic, barley-fed, omega-3, animal protein-free or antibiotic-free". The need for traceability arises from the following:

- Rising attention to food safety.
- Need for zoning in the event of epidemic animal disease (eg foot and mouth).
- Tracking the source of drug residues.
- Recall in the event of contamination (eg pesticides).
- Feedback to allow quality control.
- Protection against bioterrorism.
- Marketing the 'Canada Brand' worldwide.

Traceability as a key *point of difference* will be a major competitive advantage for Canada, as the country's cost advantages are eroded by US and EU subsidies.

HITTING THE MARK ON MEAT QUALITY

Breeds and Genetic Selection

The genetic options to improve quality are choice of breeds and lines, selection within breeds, and the use of individual genes. Since eating quality traits have low heritabilities and are difficult to measure in the live animal, most of the selection effort within lines has been directed to more rewarding growth and fat traits. Sib selection, which is the use of measurements on slaughtered littermates to predict genetic merit of candidate breeding herd replacements, is slow and expensive.

For some fresh meat markets, the Duroc breed has an advantage in eating quality, at least partly resulting from greater intramuscular fat. The Berkshire is favoured for fatter Japan products but is uneconomic. In spite of its added fat, the Meishan does not have the same advantage as the Duroc, and the proportion of Meishan in slaughter generation products has so far been too low to improve quality. Extremely lean types appear more susceptible to poor handling that can lead, for example, to two-tone meat.

Individual Genes

The halothane gene was probably unique in farm livestock as the mutation actually responsible for the greatest source of PSE (pale soft exudative) meat. Thanks to the DNA test developed at Toronto and Guelph, the gene should now be largely eliminated from nucleus lines. Some residual testing will be needed to check that the mutation does not recur. Third Wave AgBio of Madison Wisconsin has developed a bulk halothane test that shows whether the gene is present in a single test on many pooled samples. This opens the door to cost-effective testing on the meat itself.

There is much interest in finding other genes that might be used to improve quality, but so far with only modest success. The new science of *functional genomics* is now building on gene maps to measure the level of expression of individual genes. It can show which genes are expressed in certain environmental conditions. For example, it will identify the genes that are expressed only when animals are stressed and lead to poor meat quality. The understanding of genetic pathways could therefore equally lead to husbandry rather than genetic solutions.

Nutrition

Through fatness and rate of growth, nutrition can clearly impact meat quality. Genetically lean pigs obtain a higher proportion of the fatty acids needed for tissue deposition from the diet. Hence their body fat contains a higher proportion of unsaturated vegetable fats, and may be softer. Fat firmness can be affected by changing the fatty acid content of the diet.

In future pig nutrition could offer a means to improve the healthiness of the meat to the consumer. Examples might be minerals and vitamins, choline as a brain neurotransmitter, CLA (conjugated linoleic acid) in cancer prevention, and cholesterol control agents.

Transport and Handling

Good treatment from farm to slaughter is critical for good quality. This includes loading, the truck environment, length of journey, unloading, mixing, resting time, temperature in holding pens, ventilation, the race to the point of stunning, stunning itself, and slaughter. Quiet handling at all stages is essential. Procedures through the plant need to be optimized and standardized. For example, one of the main variables affecting quality in the plant is the cooling rate.

IN SEARCH OF UNIFORMITY

Genetics

The ultimate solution to genetic uniformity might be cloning, which would produce individuals that are largely genetically identical. By cloning the best individuals from nucleus herds, clones could be genetically superior to the mean of the nucleus. However, the notion that this would give 'peas in a pod' uniformity is a myth. With a heritability of only 30%, some 70% of the variation in most eating quality traits is non-genetic and would remain after cloning. Additionally, non-surgical introduction of frozen embryos on commercial farms would be needed to deliver cloning, and these are not yet feasible in practice.

At present the best option to improve genetic uniformity would be to select terminal sires for AI (artificial insemination) into a very narrow band of predicted genetic merit. AI allows very few sires that can be very similar in genetic merit. The dam-line GP sires of parent females can similarly be selected into a narrow range.

Production and Health

Assuming a uniform feed and environment, one of the greatest causes of variation will be differences in feed intake. Common causes of a reduction in intake are poor pig health, overstocking, and high ambient temperatures.

With females 10% leaner than barrows, one of the greatest sources of product variation is the sex difference. Split sex feeding ensures the nutrient requirements of both sexes are met, but it does not remove the difference in performance. The solution would be to produce only one sex. Semen sexing by staining sperm and then physical sorting by laser (flow cytometry) is possible but prohibitively slow, with little prospect of speeding up. The hope is to devise sex specific antibodies that could destroy the unwanted gender of sperm by simple addition to the ejaculate at the point of collection.

Reward System

One of the fundamental causes of poor uniformity has been that the payment system for carcases has not reflected what the processor really wants. For example, a grading grid that simply rewards low backfat gives no information or incentive to control other aspects of carcass and meat quality. Thus, there may be a large range in ham shapes and joint distribution at the same fatness. Some genotypes for example containing the halothane gene may be lean at the expense of muscle quality that may tend towards PSE.

Uniformity is not a realistic goal until the requirements of the market are translated into clear parameters for quality that the producer can use as targets. This requires an understanding of the needs of the customer and how to measure real value. The industry must question whether weight and fatness are a sufficient description of value in 2003.

Vertical Coordination

Much of the loss in uniformity and value to the pig industry has arisen from poor communication among the steps in the pork value chain. Sharing information and working together can increase the recovery of value by 20-30%. As an example, changing the feed to improve meat quality would add cost for the producer, but would increase profit for the processor. In many cases at present this added value would be taken by the processor at the expense of the producer. In a vertically coordinated system such as Maple Leaf, the added value can be shared equally.

Vertical integration in the form of common ownership of multiple stages of the pork value chain is not essential. What is needed is coordinated action to maximize overall value. The opportunity then exists for differentiated products with added value. Production can also be partitioned to accommodate the requirements of different markets. Vertical coordination also gives a unique opportunity for high levels of traceability.

Six Sigma

At Maple Leaf vertical coordination has allowed the adoption of Six Sigma at all levels of the value chain. Pioneered by Motorola and GE, and widely used in the aviation industry, Six Sigma is a formal analytical approach to the control of unwanted variation in meeting customer requirements. It provides a disciplined framework for describing customer needs, analysis of the production process, and quality control by continuous measurement. It also provides for the design of experiments on the farm or in the plant to investigate unknown causes of variation.

TRACEABILITY

Methods of Tracking

The ultimate objective will be to track every piece of meat from plate to farm through each step in the production, slaughter, processing and distribution chain. Some of the possible methods might include ear tags, tattoos, bar codes, “smart” trays and gambrels, creation of specific antibodies, molecular bar codes, and quantum dots.

Live animal tracking from birth to slaughter is very possible using ear tags and tattoos. Tracking through the slaughter and processing plants at modern line speeds with so many different steps and routes will be extremely expensive. For a high-speed plant the capital cost could be $10-20 million with development costs of a further $4 million. Tracking the packaged product through distribution and retail will be much cheaper since codes can be printed on the wrapper. If necessary, consumer access could be provided through product codes and a website.

DNA Tracking from Meat to Farm

In an evolution of forensic genetic fingerprinting, DNA tracking can link meat back to the farm of origin, by-passing the expensive step of tracking through the plant. The attraction of DNA typing is that it requires no capital investment. DNA typing is very accurate, and relatively free of the human error from hand-labeling systems. It can therefore be used to audit and verify other tracking systems. It works on cooked as well as fresh material.

In December 2002, Maple Leaf placed a contract with Pyxis Genomics Inc. to identify a "DNA panel" that can track from meat back to the mother of the slaughter pig. The mother's identity indicates the farm and date of birth of the progeny. Live animal tracking then links to the nursery and finisher barns, the truck, and the slaughter plant. Since boars are used across farms by AI, tracking to the terminal sire would not identify the farm of origin.

How DNA Tracking Works

Tracking will use naturally occurring base changes in the DNA code known as single nucleotide polymorphisms or "snips" (SNPs). It is expected that 200 to 300 SNP's will be needed to discriminate between mothers that are full sisters on different farms. All replacement breeding females will be DNA typed at first farrowing and their genotype for the panel entered into a database. When meat is DNA typed, it can then be cross-matched to the mother using the database.

The cost of DNA typing is currently around $70 per female, or $1-2 per slaughter pig. Within three years, the cost of high speed SNP typing is expected to drop to around $6 per female, or 10 cents per slaughter pig. Large economies of scale are expected since the DNA results on the mother are not required until five months after the birth of her first litter. At first, tests on meat will have a turnaround of some 48 hours, but this will be greatly reduced as DNA testing becomes available in kits that can be used on-site.

The Maple Leaf DNA panel is expected to be ready in the autumn of 2003. During 2004, it will be introduced for the 93 000 sows in Maple Leaf's own Elite Swine, and for other producers supplying Maple Leaf plants.

ACTION POINTS FOR THE INDUSTRY

So what immediate action could the industry take today to ensure a uniform high quality product? Here are some suggestions.

- Understand customer requirements and set clear targets for performance.

- Introduce a clear payment system that measures quality and rewards value for meat that falls within the desired range.

- Vertically coordinate the steps in the value chain. Take action that will maximize aggregated profits from the whole value chain. Be prepared to communicate and share costs and rewards.

- Introduce traceability as a means of identifying the causes of poor quality. Be seen to be responsible and accountable to the consumer.

- Work to improve pig health as a major source of potential advance in quality and uniformity.

- Adopt uniform genotypes in terms of choice of lines, and selection of AI sires within lines.

- Operate split sex feeding to optimize nutrition for barrows and gilts.

- Standardize husbandry and stress-free handling practices, without overstocking and extremes of temperature.

Longer term, perhaps the greatest step forward would be production of a single sex of slaughter animal. Research on cost-effective methods of semen sexing should therefore be encouraged. Better methods are required to measure and reward quality on-line at the slaughter plant. For genetic selection at nucleus level, methods are also required to measure meat quality in the live breeding animal.

It is clear that a move to the next level of quality and uniformity is well within the grasp of the industry. This will be manifest to importers of pork products from Canada as higher quality, coupled with traceability that underwrites both food safety and value-added propositions. Public and private sector research should work together down the route that will give a competitive advantage in quality, safety and added value.