Genetic Improvement of Meat quality for Canadian swine industry

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Introduction

The Canadian pork industry enjoys a solid reputation world wide for superior quality and health status. Canadian pork exports have jumped to over 2 billion dollars during the recent years. Canada ranks number one among the pork exporting countries of the world. Domestically also the pork industry is recognised as a major industry sector in Agriculture, contributing to the trade surplus. This is not just a coincidence. It is the hard work and success of the Canadian swine industry that has been able to develop a pig that is fast growing, efficient and produces high quality meat. The reputation of the Canadian swine industry is mainly based on quality and the industry must strive to keep this leading edge (Pomerleau 2002).

The industry cannot afford to rest upon past success. In the years to come it will become more challenging to maintain this position. There an increased competition both domestically and abroad especially due to globalisation. The industry needs to produce a quality product and offer this product at a competitive price. Competition based on supplying large volumes of average quality product through huge commercial operations is especially difficult for relatively smaller operations in Canada. The smaller units can also reduce the stress on the environment and compete more effectively on quality than on volume. Even for the very large commercial operations a good quality product is important.

There are arguments for and against improvements in meat quality like two sides of a coin. First of all it is the quality of the product we sell. The consumers expect a good quality product: a product that looks good and tastes good. As of today, there is no direct payment for a better meat quality at the producer level. However, the trends are also changing. In many cases, the packing plants have started paying premiums for certain quality standards. In some other cases the plants do their own tests on small samples for their business decision with the suppliers. If the meat quality is below certain requirements, the suppliers run the risk of losing the business (McKeith 2003). Therefore, some would argue improvements in meat quality as the cost of doing business. The value of meat quality is also increasing due to increased processing, case ready packaging, consumer perceptions and consumer acceptability.

There is a need to monitor, maintain and improve the meat quality through genetics, through management and a combination of both. The breeders, producers and packers must continue to work together to ensure that the industry keeps supplying the quality of pork required by the domestic and international markets. This also requires an effective communication between different segments of the value chain such that breeders and producers are not only asked for the quality of pork that needs to be produced, but also receive feedback on the product they are delivering.

Meat quality requirements for different markets

At present it is not yet clear what constitutes a good quality. Different segments of the meat production chain interpret meat quality differently (McKeith, 2003). The producers mainly consider the quality in terms of rate and efficiency of growth, health and uniformity. The slaughter plants may be more interested in yield, uniformity of carcass weights, and lack of defects. There is also more interest in color and water-holding capacity. The Retailers mainly characterize the meat quality based on shelf life, cutting yields, color, trim level, and water-holding capacity. Ultimately, there is also a need to satisfy the intermediate and the end point consumer to maintain and enhance the demand for pork in comparison to other meats.

The quality requirements also vary for different markets. Good quality for the domestic market may not be good for the Japanese market. There is a need for clear definition of what is good quality. Perhaps there is no such thing as a general "good quality" so the definition of good quality can vary for different markets.

There are three major markets for Canadian pork which depend upon specific quality requirements: the domestic (54%), US (20%) and Japanese (11%) markets (Pomerleau, 2003). The following (Table 1) summarizes the input provided by retail and export specialists at a meeting held to discuss this topic.

Table 1: Meat quality requirements for different markets

Requirements	Fresh			Processing
	Japan	US	Canada	
Water retention	H	H	H	H
Marbling	H	M/H	M/H	L
Color	H	-	-	-

(H=High, L=low, M/H=medium high -=not applicable or not sure)
Source: CCSI Genetics Symposium on objectives for swine selection in Canada, Toronto, Nov. 1-2, 2000.

In general, the Canadian retailers prefer to have loins of the same size as currently but, with more marbling, and possibly better water retention. For the US markets, a series of pork quality targets have been determined by the Pork Quality Solutions Team of the National Pork Producers Council (Table 2). These targets represent minimums or ranges for quality attributes in fresh pork loin measured at 24-hours post-mortem.

Table 2: Targets for meat quality traits specified by National Pork Producers Council (US)

Attribute	Target	Comment
a) Color	3.0 to 5.0	utilizing a 6-point scale
b) pH	5.6 to 5.9	
c) Tenderness	<7 lb. (3.2 KG)	utilizing WBS at 7 days
d) Flavour	robust pork flavour	(no off-flavours)
e) Intramuscular Fat ("Marbling")	2 to 4%	
f) Drip Loss	not to exceed 2.5%	

Source: NPPC Pork Quality Solutions Team: Pork Quality Targets http://www.nppc.org/facts/targets.html

The Japanese market generally seeks bigger loins with more marbling, colour and water retention. There are further differences: for example, at the domestic level, marbling is desirable for fresh loins, but less for processed products. It is said for the Japanese that good taste consist of tenderness, juiciness and good flavour (Makise, 2002). The highly marbled pork is very expensive. In fact the other factors, tenderness, juiciness and good flavour are highly associated with marbling. In these specialised markets there is also some risk of changing market demands in future as it has happened over the past years.

There are some variations in the quality requirements from one market to the other but in general, the consumers expect healthy meat with no pathogens or residues, lean pork with a high belly and ham quality and superior meat quality consisting of good colour, good marbling and minimum drip loss.

Producing quality pork for different markets

Meat quality is affected by a number of factors including genetics and management. A combination of good genetics at the nucleus level and good management practices at the producer level as shown in the following chart are required for producing high quality pork. Pre-slaughter is especially important and practices such as careful selection of pigs, stocking densities, climatic conditions, length of feed withdrawal, length of rest at the abattoir, etc. can reduces losses from production herds to packing plants (Murray, 2000). In some cases it might be enough to sort the pigs according the market requirements. For example, the females may be used for markets that demand larger loins and barrows for the markets where the loin size is not very important. This may be useful to satisfy small quantities for specific markets. However, when large volumes are required for target markets it is necessary to have the appropriate genetics and then use the management practices that allows the production of large volumes of the desired type of product.

Genetics	**Recommended breed cross(es).**
+	Specific selection scheme, monitoring.
	?
Management (producer level)	**Specific management conditions** (health, production system, traceability). **Specific diet** (energy, protein content)
+	**Specific slaughter weight** (may differ for each sex). **Pre-slaughter handling.**
	?
Management (slaughter level)	**Slaughtering methods.** **Sorting** (different markets)

Relative economic values of meat quality traits

The economic values for each of the traits included in the profit function and selection indices would require more extensive work. This will require critical evaluation of cost factors to the Canadian producers and returns based on the market conditions. It should be possible to derive a set of general economic values to be used in the national indices and tools to compute customized economic values based on the current production levels in commercial herds and returns from target markets.

At present, the results of the consumer preference study (*Pork and the U.S. Consumer Conference*) can be used as a reference to provide an indication of the economic value of marginal changes in meat quality traits (Table 3). The economic values have been converted to Canadian Dollars and then divided by the standard deviation for the trait to put all values in the same units of measure. Therefore, the relative economic value is calculated by setting one trait as the basis by which all comparisons will be made. In this example Intra-muscular fat is set as the base trait and therefore has a relative economic value of $1.00. The relative economic values indicate how much additional profit can be earned by making an improvement of one standard deviation in one trait versus another trait. Relative economic values also indicate what profit is possible by genetic selection for each trait.

Table 3: Economic values for meat quality traits

Trait	Unit	Standard deviation (SD)	Economic value (Can $)	Economic value/SD (Can $)	Relative economic value*
pH	Unit	.25	53.65	13.41	0.50
Drip loss	%	1.35	-1.30	1.76	0.07
Intra-muscular fat	%	1.00	26.98	26.98	1.00
Tenderness	Kg	1.10	-7.94	8.73	0.32

*Considering Intra-muscular fat as a basis ($1.00)
Source: Todd See, Kelly Zering and O.W. Robison, Economic Value of Pork Quality Traits, North Carolina State University http://mark.asci.ncsu.edu/nsif/95proc/evnsif.htm

The above economic values suggest that marbling or intra-muscular fat has the highest economic value per unit standard deviation, followed by pH, Tenderness and drip loss. The above study did not include meat colour. This is not very important for the domestic or US markets but can have significant economic value for Japanese markets.

The above values may differ when applied to the Canadian situation especially depending upon the components of the cost and profit calculations. However, it may be safe to assume that the relative significance of the traits may not be very different. It is also important to compare the relative significance of the traits in terms of the expected response to selection rather than the economic values themselves.

Selection for meat quality

The economically important traits have moderate to high heritability (Table 4) so that they would respond better to selection and genetic improvement, even compared to traits of growth (h^2 =30%) and sow productivity (h^2 =11%).

Effective selection and genetic improvement for these traits will require estimation of breeding values, development of selection indices and methods to customise the selection objectives depending upon the market requirements. Therefore genetic evaluations are being developed using data from test stations and breeding herds have started to collect the information the next important step is to start collecting the information from production herds and packing plants to evaluate and make effective use of this information for achieving the ultimate results required by the consumers.

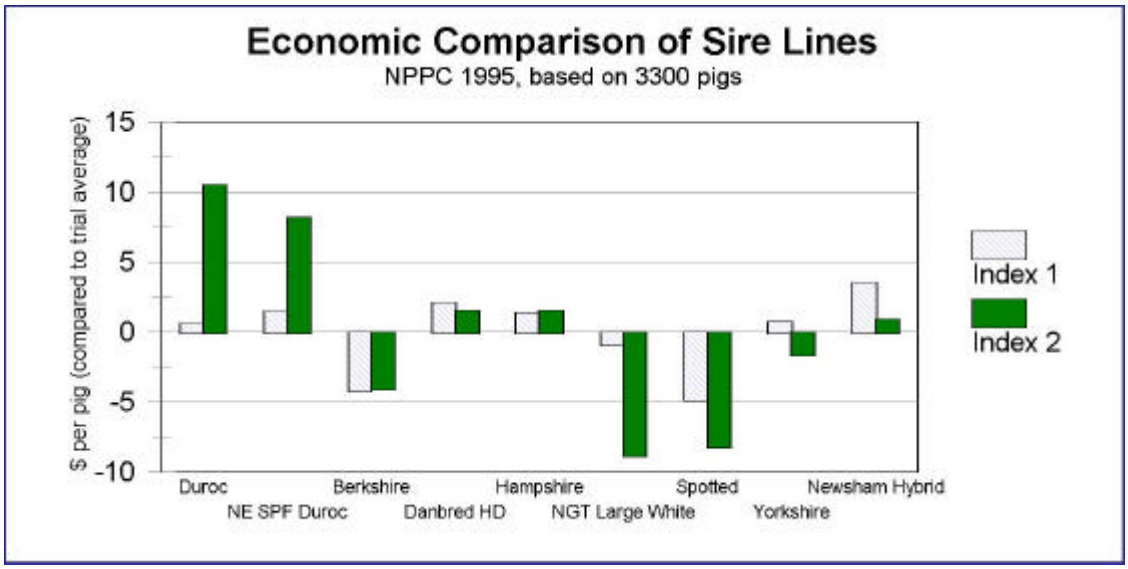
Table 4: Impact of genetics on meat quality traits

Trait	Heritability (%)
Meat color	28
Intramuscular fat	50
Ultimate pH	21
Drip loss	16
Structure score	30
Maximum shearforce	26

Source: Sellier (1998)

Genetic choices available to producers

The breeds used in Canada and especially the Duroc have a high meat quality (CCSI, 2000). The Duroc has outperformed every other breed or breed cross for meat quality, even compared to other commercial hybrids as shown in the following chart. Durocs were also among top in the (OPCAP) trial (1990-1994) (Gibson et al., 1996) and recent trails at the test station in Deschambault, Quebec (Chesnais, 2002).



Index 1: growth rate and lean yield and feed conversion
Index 2: Traits in Index 1 + Meat quality
Source: National Pork Producers Council

In general the different terminal lines can be rated as follows: (Table 5)

Table 5: Selection of terminal sire lines

	Water	Marbling	Colour	Growth	Yield	Feed efficiency
Duroc	**H**	**H**	**H**	H	M	M
Yorkshire	**M**	**M**	**M**	H	M	M
Pietrain	**L**	**L**	**L**	L	H	M

H: High, M = Medium, L = Low

Major genes and molecular markers

Selection using major genes and molecular markers is most effective compared to conventional quantitative selection methods for traits that are either difficult or expensive to measure or for those that are measured after the death when the individual is no longer available for breeding. Meat quality traits fall under this category and the search for candidate genes and molecular markers have also shown some promising results.

A classical example is the Halothane gene. The negative effect of this gene and its role in producing the undesirable pale soft exudative (PSE) pork is well documented. The testing for this gene is widely prevalent in Canada and has resulted in favourable results. However, this gene is not completely eradicated in Canadian populations. The results from selection at the nucleus level are now becoming apparent in commercial stocks but more screening is necessary at the commercial and packing plant levels.

Another such gene is the RN gene or the Acid meat gene. (Rendement Napole). The test for this gene was developed in France by Naveu, Pommeret and Lechaux (1985). Therefore the gene is called Rendement Napole or the RN gene. It is a dominant mutation known to be associated with the Hampshire breed. This gene is responsible for increased glycogen production after slaughter, increased drip loss, and increased cooling loss. All these effects together result in red soft exudative (RSE) pork and are estimated to cost about $14 Canadian per pig (Table 6).

Table 6: The effect of RN gene on meat quality traits: Normal (rn+) vs. carriers (RN-)

Trait	Effect
Higher glycolytic potential	+ 75 %
Lower pH	- 5.5 %
Higher drip loss	+ 90 %
Higher L value (color)	+ 8.5 %

Source: Geriépy et. al. (1999), FRDC

A study was conducted in 2001 to determine the frequency of this gene in major Canadian breeds. The intention was to test where it counts the most. A.I. sires at the peak of the breeding pyramids were tested that would transmit the gene for several generations from nucleus to multipliers herds and then to commercial herds.

The participating organizations were: Food Research and Development Centre (FRDC), Canadian Centre for Swine Improvement (CCSI), National Institute of Agriculture Research in France (Institut National de la Recherche Agronome, INRA), nine AI. centres across Canada and three Hampshire breeders from Ontario. The results of the tests are given in Table 7.

Table 7: Frequency of RN gene in major Canadian breeds

Breed	m+/m+ (free)	RN - /m+ (single carrier)	RN - /RN - (double carrier)
Hampshire	19 (21%)	31 (35%)	39 (44%)
Duroc	116	0	0
Yorkshire	110	0	0
Landrace	79	0	0

Source: Houde et al. (2002)

The results suggest that A.I. sires of the three major breeds were 100% free from the gene mutation. There were no double or single carriers. The Hampshire of course had the RN gene, confirming that the technique gave positive results if the gene was present. This is a well known fact. It is also observed in other studies that the gene is present in synthetic lines that have some proportion of Hampshire blood.

These genes (Halothane and RN) are mainly responsible for negative effects on meat quality. They are mainly used for screening of the commercial populations and independent culling in the nucleus populations. This also involves some loss of response in other traits such as growth and efficiency. The major Canadian breeds are rather free from the RN gene and the frequency of the Halothane gene is also reducing due to extensive testing at the nucleus level. Having reduced these problems, there is still a large variation for meat quality that can be addressed through selection on some other candidate genes that have positive effects. Examples of such genes are: Heart Fatty Acid binding protein gene (HFABP) for increasing intra muscular fat without increasing backfat, Melanocortin-4 receptor (MC4R) for backfat, growth and feed intake, Calpastatin (CAST) gene for tenderness, Fructooligosaccharide (FOS) gene for proportion of white fibres in the muscle, etc. There is a need to investigate the usefulness of these genes for the Canadian swine industry and develop specific methods and guidelines for their use in genetic improvement programs.

Concluding remarks

Meat quality is important for the reputation and future competitiveness of the Canadian swine industry. Canadian pork today has a very good meat quality. However, there is a need to maintain and possibly improve it to a level that large volumes of high quality pork are readily available to meet the market needs.

The quality of pork is determined by a number of factors such as pre-slaughter handling, management or production level and genetics. All these factors are important and need due attention. Genetics is not the only factor determining the pork quality but it is an important one. Genetic improvements are permanent and are cost effective. They have a long lasting effect on the outcomes from the various segments of the value chain. The relatively higher heritability of meat quality traits offers greater opportunities for genetic improvement even compared to traits of growth and sow productivity that have already shown very positive results.

Genetic improvement in meat quality is possible through the joint efforts of all major segments of pork production. It can not be the sole responsibility of breeders only. The entire industry has to work together to have a common strategic approach. This should include defining key requirements for meat quality for different markets, defining clear targets, proper guidelines for standard measures of meat quality assessment, genetics evaluation and selection as well as monitoring and demonstrating to our customers the value of our products. The goals are achievable. It is time for the industry to act now with one voice.

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