Is There a Cost Effective Way to Produce High-Quality Pork?

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Introduction: Pork Quality – The Subject

The obvious answer to the question under consideration: "Is there a cost effective way to produce high-quality pork?", is — yes; there are cost effective ways to produce desirable pork products for given market segments. This answer, although appearing simple, implies many possible scenarios that depend upon several linked factors; starting with pig genetics, through pig production, slaughter, carcass/product fabrication, and ending with the set of conditions determining fresh or further-processed product salability at the wholesales, retail, food service, or restaurant markets.

There have been numerous attempts to define both fresh meat quality and quality for further processing. These definitions range from very simple such as "quality is what the market is prepared to pay a premium for", to very functional and complex descriptions involving the four major quality categories: sensory (organoleptic or eating), nutritional, hygienic/toxicological, and technological/further processing (Table 1; Gusse, 1993; Hofmann, 1994; Honikel, 1993; Kauffman et al., 1990; Kauffman, 1996; Olsen, 1997). However, in any market, the consumer influences the perception of quality and directions of product development. Thus, the consumer determines the ultimate success of products (Bozell and Hanna, 1996; Hoen, 1996; Meisinger, 1996; Neel, 1994; Shay and Bill, 1996; Story, 1996; Young, 1996).

Pig breeding is the first link in a chain that connects the pork producer to the pork consumer. The needs of those along the pork chain are changing in response to consumer demands, resulting in clearer segmentation of the market. For instance, the cooked, ready-to-eat meat products market relies primarily on the technological meat quality attributes (water binding capacity, texture), whereas the fresh meat market relies primarily on the visual (color) and sensory (tenderness, juiciness, taste) traits (Table 1).

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Table 1. Examples of Different Quality Factors/Markets of Meat and Meat Products (after Hofmann, 1994).

Sensory Factors	Nutritional Factors	Hygienic and Toxicological Factors	Technological Factors
Color	Proteins	Microorganisms	Structure
Shape	Peptides	Toxins	Texture
pH	Amino acids	Shelf-life	Consistency
Taste	Fats	pH	Viscosity
Flavor	Vitamins	Water activity	Water content
Marbling	Minerals	Red-ox potential	Water binding
Fat composition	Digestibility	Additives	pH
Tenderness	Utilization	Residues	State of protein(s)
Juiciness	Biological value	Contaminants	State of fat

This review is not intended to be inclusive, but describes the complexity of the pork chain approaches to economically provide high quality pork products to pork chain customers and to the ultimate consumer. After a brief summary of the genetic and environmental factors affecting pork quality, examples of the industry views on the subject are provided. The final chapter contains plausible recommendations as well as a specific example of how the collaborative efforts of the pork chain can result in economically justified production of high quality pork.

Pork Quality – The Science

Pig breeders have been extremely successful at improving the efficiency of production of lean pork during the past three decades using selection programs. The basis for this improvement has been the development of increasingly sophisticated statistical methods to analyze performance test data based on the infinitesimal gene model, which assumes an infinite number of genes, each of small effect but together additively affecting quantitative traits (Cameron, 1990; McLaren et al., 1987; Knapp et al., 1997; Meuwissen and Goddard, 1996; Short et al., 1997; Skorupski et al., 1995; te Pas and Gerbens, 1996). For example, estimated annual genetic trends for PIC USA com-

[1] The HAL-1843 trademark is licensed from The Innovations Foundation, Toronto, Canada, owner of the trademark. This PCR test is performed in the U.S. under a license with Roche Molecular Systems, Inc.

mercial lines indicate that the average annual improvement in reducing costs and increasing value has been $2.38 and $2.25 per pig for the past five years for the lean and backfat market, respectively (Table 2).

Table 2. Estimated Annual Genetic Trends at Choate Genetic Nucleus Farm for Pigs Born January 1, 1992 to December 31, 1996.

Trait	Genetic Trend[a]	$ Value/pig[b]
Days to 245 lb.	-3.25	.39
Feed / gain	-.049	.68
P_2 backfat, mm	-.675	.63
Lean %	.506	.76
Total no. born / litter	.070	.55
Leg score	.055	
Teat no.	.112	
Total Value		
Lean market		2.38
Backfat market		2.25

[a] Trends in basic line EBVs weighted PIC326 x C15/C22 for days, F/G, BF, lean % and leg score; weighted C15/C22 for TNB and teat number.

[b] Assumes: $.12 cost/additional day to market; $.07/lb of feed; 198 lb. finishing gain; 245 lb. slaughter weight; 76% yield; $.50/mm decrease in backfat/100 lb. of carcass weight; $1.50/pig/1% increase in lean; $4.50/additional pig/litter; 80% pigs born sold; 2.2 litters/sow/yr.

However, evidence is accumulating from many species, including swine, that genes with relatively large effects (major genes) are important for a number of traits (Anderson et al., 1994; Rothschild, 1994). Two major genes affecting pork quality have been identified to date: the [1] HAL-1843® gene and the RN-gene,

The HAL-1843®. The halothane or stress gene is the most studied major gene affecting meat quality, and it is the first practical manipulation of a major gene in pig breeding using molecular biology tools (Fujii et al., 1991; MacLennan and Phillips, 1992; Otsu et al., 1991). Briefly, a single point mutation in the calcium release channel ryanodine receptor gene (ryrl) in recessive condition is responsible for porcine stress syndrome (PSS, malignant hyperthermia; pigs homozygous for this mutation are likely to develop the PSE (pale, soft, exudative) condition postmortem). This gene also results in, or is closely linked to, a gene(s) involved in determining muscling and leanness (for reviews see Backstrom and Kauffman, 1994; Greaser, 1986; Lister, 1987; McLaren and Schultz, 1992; Vogeli et al., 1985; Vogeli, 1992),

The detection of this mutation using the HAL-1843® test provides pig breeders with the means to precisely control the distribution of the mutation (Fujii et al., 1991; McLennan et al.,1990; Otsu et al., 1991). PIC USA has had an aggressive removal program for the HAL-1843® gene, testing over 160,000 animals in the U.S. alone since June, 1991. Since June 1996, PIC parent Camborough 22 gilts have been guaranteed free of the stress gene. In addition, the elimination of the halothane gene from all parent boars and semen products PIC market in the US will occur by the year 2000. This decision was made since the results of many studies demonstrated that the HAL-1843® gene probably accounts for about 25% to 35% of the PSE meat observed in commercial abattoirs (de Vries et al., 1994a,b; Barton-Gade, 1988; Fortin et al., 1993; Monin et al., 1986; Muray and Johnson, 1995; Pommier and Haude, 1993; Sather et al., 1990),

The RN-gene. Another major gene affecting meat quality - the RN (Redement Napole) was discovered by Naveau (1986) in two French composite pig lines. The postulated gene was shown to decrease the technological quality (the so-called "Napole yield"; processing without addition of phosphates) of the Semimembranosus muscle of the ham. Le Roy et al., (1990) reported that the RN- is a dominant gene. They showed that the difference in Napole yield between the RN- carriers and the rn+rn+ homozygotes was approximately 8%, corresponding to a difference of 5-6% in the technological yield of processed hams. For comparison, the HAL-1843® gene sensitivity induces a decrease of 2-3% in this yield (Estrade et al., 1993a,b; Sellier and Monin, 1994).

Table 3. Relationship Between Meat Quality, Backfat Thickness and Intramuscular Fat, and Heritability Values of Meat Quality Attributes (after Morel, 1995).

	Color	IMF	WHC	Tenderness	pH_u	C18:2
h^2	0.30	0.50	0.20	0.30	0.20	0.55
Range	0.10/0.60	0.25/0.85	0.05/0.65	0.20/0.40	0.10/0.40	0.40/0.70
r_gADG	-0.15 (U)	0.40	0.00	—	-0.15 (U)	-0.20 (F)
Range	-0.50/0.15	0.15/0.60	-0.80/0.50	—	-0.40/0.50	-0.40/0.0
r_gBF	0.20 (F)	0.20	0.20 (F)	0.20 (F)	0.15 (F)	-0.70 (F)
Range	-0.20/0.60	-0.20/0.60	-0.20/0.80	-0.20/0.40	-0.40/0.50	-0.50/-0.90
r_gLean	-0.25 (U)	-0.20	-0.35 (U)	-0.20 (U)	-0.10 (U)	0.60 (U)
Range	-0.60/0.20	-0.50/0.40	-0.80/0.25	-0.60/0.20	-0.70/0.35	0.40/0.80
r_gIMF	-0.20 (U)	—	-0.05 (U)	0.25 (F)	0.0	-0.30 (F)
Range	-0.10/0.35	—		0.20/0.30	-0.20/0.40	

Note: Heritability values (h^2) for meat color (color), intramuscular far (IMF), water holding capacity (WHC), tenderness, pH ultimate (pH_u) and linoleic acid (C18:2), and their genetic correlation (r_g) with average daily gain (ADG), backfat thickness (BF), lean percentage (Lean), and intramuscular fat (IMF). F = Favorable, U = Unfavorable.

There is good evidence that the RN- gene primarily acts by increasing the glycogen content of the "white" (fast-glycolytic) fiber and muscle types. Also, there is a relationship between the sarcoplasmic accumulation of glycogen in the "white" fibers and a high muscle glycolytic potential resulting in low ultimate pH, partial protein denaturation, and consequently a low Napole yield (Fernandez, 1992; Milan et al.,1995; Miller, 1998; Sellier and Monin, 1994).

PIC has recently developed a DNA-probe that enables the direct removal of the RN- gene effect. The new genetic test, PICporc™, has been extensively validated in four countries with PIC animals, However, although the test works well to quickly reduce the incidence of the gene, its complete control requires a DNA probe that detects the causative mutation (de Vries at al., 1997; 1998).

Genetic (line/breed) effects on pork quality. It is well accepted that there is considerable variation between and within lines for carcass composition traits such as backfat thickness and percent lean. However, only moderate variation exists for some meat quality traits like tenderness, drip loss, intramuscular fat content, and color; but less opportunity exists to improve eating quality attributes such as flavor, texture or juiciness via line selection or substitution (Table 3; for additional reviews see Barton-Gade, 1986, 1987, 1988; Cameron, 1990; Cameron et al., 1990; Hovenier et al., 1993a,b; Hermesch, 1995; de Vries and Van der Wal., 1992; de Vries et al., 1994 a,b; 1995; Ellis et al., 1990; Morrel, 1995; McLaren and Schultz, 1992; Purchas et al., 1990; Sellier,1987, 1988; Sellier and Monin, 1994; Touraille et al., 1989; Webb, 1993; Wood et al., 1995). Thus, although most aspects of pork quality have only a small-to-moderate genetic component, genetic improvement via selection can be realized.

Environmental factors affecting pork quality. Numerous on farm, transport, and slaughter plant handling factors influence meat quality including the incidence of PSE, RSE (red, soft, exudative), and DFD (dark, firm, dry) meat. These factors account for a much higher proportion of the variation in meat quality than do the genetic factors (for reviews see Backstrom and Kauffman, 1994; CAMBAC, 1995; Barton-Gade, 1986; de Vries et al., 1994a,b, 1995; Ellis and McKeith, 1995; Grandin, 1993; Jones et al., 1994; Murray and Johnson, 1995; Pommier and Houde, 1993; Sather et al., 1990; Tarrant, 1993; Warriss, 1985; 1994; Warriss et al., 1995,1998). As a result, process control programs minimizing the adverse affects of environmental conditions on pork quality need to be implemented. For instance, PIC developed Pork Quality Blueprint meant as a guideline to developing pork quality assurance programs (Table 4). The blueprint objective was to identify a combination of practices to achieve a real and substantial improvement in pork quality.

Breeding for pork quality: quantitative and molecular genetics. Despite inherent difficulties described above, some breeding organizations consider including pork quality traits in their breeding schemes (Anonymous, 1997a,b; McMahan, 1997; Olsen, 1997; Petersen et al., 1996). The main goal of the PIC "Breeding for Meat Quality" program is to further accelerate the genetic improvement in lean quality by including the two most important quality traits – meat ultimate pH and color — in Estimated Breeding Values (EBVs) for selection decisions (for reviews regarding the importance of ultimate pH and color in pork quality see Eikelenboom et al., 1995,1996; NPPC, 1997). This is being achieved through measuring these traits on relatives of selected animals from Genetic Nucleus farms. Through pedigrees, breeding values for meat quality are estimated using BLUP (Best Linear Unbiased Prediction). Two specialized PIC sire lines are already being selected with emphasis on meat quality.

Research is conducted in several scientific centers around the world to discover new molecular markers for meat quality (for reviews see Boichard et al., 1988; de Vries et al., 1988; Meuwissen and Goddard, 1996; Sellier, 1992; te Pas and Visscher, 1994). This new "molecular breeding" approach offers great potential to further enhance pork quality attributes via genetic selection.

Breeding for pork quality: muscle biology. When the rate of lean muscle growth in pigs is increased using improvements in genetics, nutrition, and management, what happens to the pig? To answer this question, research is conducted to fully understand the relationship between intrinsic structural and metabolic properties of skeletal muscles; i.e., the relative number and size of different muscle fiber types (myosin isoforms), oxidative versus glycolytic potential, etc., and meat color, water holding capacity, tenderness or taste (Bjurstrom et al., 1995; Boyd and Sosnicki, 1997; Gerrard, Purdue University, personal communication; Karlsson, 1993; Larzul et al., 1997; Ruusunen et al., 1996; Sosnicki,1987a,b). New knowledge of the relationship between several "stress-borne" blood enzymes (i.e., creatine kinase) or "stress hormones" (i.e., cortisol) and meat quality, as well meat quality information based on needle-biopsy samples taken from live pigs, are also promising in developing predictive methods for evaluation of meat quality in live animals (Cameron et al., 1997; Cheah and Cheah, 1993, 1994; Cheah et al., 1997; Doize et al., 1992; Jensen et al., 1995; Petersen et al., 1996; Shaw et al., 1995; von Lengerken et al., 1994; von Presuhn et al., 1997; Warnants et al., 1993; Watchko et al., 1996; Weiler et al., 1995). Thus, better understanding of basic animal physiology and muscle biology may enable breeders to include muscle growth/structure and physiological stress-response traits in future selection indexes.

Pork Quality – Industry Views on its Value and Cost?

There is a basic production cycle that exists in all pig farms regardless of their function. At each point on the

Table 4. PIC USA Pork Quality Blueprint – Summary of Recommendations

Production

Feeding/Growth

- Supplementing pig diets with up to 200 mg vitamin E/kg during the last 30 days before slaughter may have a positive effect on meat quality (color and drip loss).
- Pigs fed at high levels, close to *ad libitum*, produce more tender meat than those that have been restrict fed.
- Raising the dietary concentration of unsaturated fatty acids (i.e. oleic acid) to a high level may result in their increased concentration in muscle tissue and subsequently more tender meat. However, such feeding may adversely affect fat quality.
- Fast lean tissue growth rate and meat tenderness are positively correlated and, therefore, using fast-growing pig genotypes is recommended.
- Correlation between meat (loin) tenderness and marbling is low.
- Pork flavor intensity is positively correlated with high levels of saturated fatty acids in muscle tissue and negatively correlated with high levels of unsaturated fatty acids. Feeding higher levels of unsaturated fatty acids to pigs may benefit the health of the consumer, but it may also detrimental to meat flavor and taste.
- Pigs left in dark, quiet rooms are more easily startled than pigs in well lighted pens with exposure to some human noise. Daily inspection of hogs by walking among them will help reduce stress of loading.
- All pigs ought to be allowed to leave their pens into the passageways at least twice in the 15-17 week finishing period. This will also reduce stress of loading.

Feed Withdrawal Time

- A total feed withdrawal time (from farm to stick) should be kept between 12-18 hours.
- Taking pigs off feed overnight would save the producer approximately $2.40/head in total costs if the pigs were sold on a grade and yield basis.
- Feed withdrawal prior to transport may decrease the incidence of gut spillage which is important from a food safety point of view.
- Feed withdrawal may decrease the incidence of dead on arrival (DOA's), and improve meat color and water-holding capacity.

Transport

- Allow no more than a 20 degree angle on the loading chute.
- Move pigs in small, manageable groups.
- Commingling of hogs from different pens should be minimized during loading and unloading.
- Approximately 0.6m^2 per 115 kg hog should be allowed on trailers.
- Electric prods should not be used for handling pigs at any time.

Pre-Slaughter Handling

- Allow no more than a 20 degree angle on the unloading chute.
- Minimize the time trucks stand waiting for unloading to reduce heat-associated stress in summer.
- Shower pigs upon unloading at the processing plant (weather permitting).
- Holding pens should allow adequate movement with access to fresh water; frequent showering in summer will help to prevent hog overheating.
- Allow a 2-5 hours of rest before slaughter.
- Electrical prods should not be used during movement of pigs from pens to restrainers.
- Move animals from holding pens to restrainers in small manageable groups; eliminate sharp curves and minimize loud noises and bright lights.
- Reduce the time pigs spend in the final restrainer to a minimum.
- Eliminate single-file systems of moving hogs to restrainer.

Stunning And Sticking

- Electrical stunning system should deliver 1.25-1.5 Amps within the first 1-2 seconds; stunning should not exceed 5 seconds.
- Constant amperage systems should be used to insure consistent stunning.
- Sticking of the animal should be done within 5-10 seconds after the end of stun.
- A minimum of 5 minutes should be allowed for bleeding before the dehairing process.
- Implementing horizontal bleeding to minimize post-mortem body convulsions is recommended.
- Water temperature in scalding tank should be 65°C.
- Scalding time should not exceed 6 minutes.

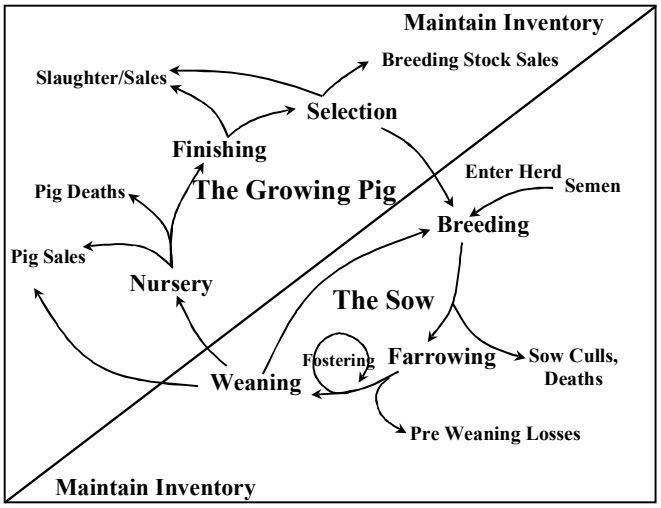
Carcass Chilling

- To improve meat color and minimize drip loss, the chilling process should start as soon as possible post mortem; skinning is recommended over scalding when possible.
- Very rapid chilling (i.e. internal muscle temperature below 30°C) will reduce the incidence and severity of PSE.
- The internal muscle temperature should be no lower than 10°C within 3 hours after slaughter to prevent the so-called "old-shortening" and associated high drip loss.
- The internal muscle temperature should be between 4-8°C at 24 hours post mortem.

Meat Packaging And Storage

- The use of modified atmosphere packaging (70% O_2 and 30% CO_2) dramatically improves meat color shelf life stability.
- Vacuum packaging (i.e. "case-ready" products) increases shelf-life of fresh meats.
- Pork loins should be aged approximately 5-8 days prior to marketing to achieve an optimum tenderness.

Figure 1. The Production Cycle: Biological and Financial Events



Revenue: Sales number weight and value;
Variable Costs: Feed amount and value, breeding stock and semen, veterinary and medicine, supplies, utilities, labor and benefits, transport;
Fixed Costs: depreciation, finance, service, taxes.

production cycle, events happen in a logical sequence (Figure 1). Product (breed/line) decisions, along with production cycle management, are the foundation of any live-production system. Possible trade-offs among sow life-time prolificacy, feed conversion efficiency (cost of weight gain), carcass yield, back-fat thickness, loin muscle depth, and boneless loin and ham yield; and pork quality attributes such as color, water holding capacity, tenderness, and taste need to be continuously evaluated (Melton et al., 1979; 1994; Skorupski et al., 1995),

Quality aberrations as PSE or RSE pork, discoloration or purge, are associated only with a very few muscles in the carcass: Longissimus dorsi and Gluteus medius in the loin, and Biceps femoris, Semimembranosus, Semitendinosus, Gluteus medius, and (sometimes) Quadriceps femoris in the ham, Although these muscles account for approximately 16% of the carcass weight, they represent approximately 35% of the carcass market value (Gusse, 1993; Kauffman, 1996; Kauffman and Sosnicki, 1996).

The quality issue becomes more complicated when one attempts to measure it at different segments of the pork industry. For instance, one can ask the following questions: What is the cost of 5% purge? (for the producer? for the packer/integrator?, for the processor?, for the retail/food service market? for the consumer?); How does 5% PSE pork incidence translate into the value loss for different segments of the pork chain? How does the "target" pork color translate into the economic profit/loss? (for export? for the domestic niche or commodity market?). It is obvious that different segments of the industry will have different answers depending on their business segment. A few examples follow.

There are two main areas of concern of the packer/integrator and wholesales/retail market related to purge loss from the loin.

First: "weight loss" (shrinkage); i.e., a retailer purchased 100 lbs. of product containing 5% of purge in the vacuum bag. As a result, the retailer sold only 95 lb of the "usable" product, so the total loss is accounted for the value of 5 lb of this particular product.

Second: "value loss" in the supply chain; for example, if a boneless loin is worth $3.50/lb to the packer, but $4.50/lb to the retailer, the actual value loss for each 1% purge can be considered as either $0.035/lb, or $0.045/lb. However, one may generally assume that fresh product containing high purge will be sold at a discount due to its unattractive appearance.

Similar reasoning can be applied to discolored and/or non-uniformly colored products — there may be a lost opportunity to sell the product for a higher margin. Color-based selection for export or niche domestic market may serve as an example.

Let's assume: (1) boneless loins scoring <2.0 according to the Japanese color scale will be rejected (too pale); (2) group "A" of 1,000 loins had a passing rate of 90% versus group "B" of 1,000 loins having a passing rate of 70%; (3) the price difference between the rejected (commodity market) and accepted loins is $2.50 per loin; (or $0.25/lb). If 2,000 loins were ordered for export, the margin loss would be $250 (or 100 rejected loins) for group "A", and $750 (or 300 rejected loins) for group "B".

However, we must remember that the loin color could be measured objectively or subjectively, on the sirloin end or blade-end of the loin, or on the loin surface, and the color variation within the loin may be as large as variation between loins (Lundstrom and Malmfars, 1985).

The economic value of PSE and/or purge loss in fresh and processed hams is even more complex. First, if the incidence of PSE in fresh bone-in hams in a given population of pigs is 5%, and only 8% of boneless ham muscles (relative to carcass weight) is affected, the final value loss can be quite small. Second, in a multi-muscle ham product not all the PSE-prone muscles may exhibit PSE, nor to the same extent, and there may be PSE-variation within a single muscle. Third, one may accept that purge related to PSE meat by itself is not a yield loss factor because it can be added back and incorporated into the product, and there are enough "binders" to help hold purge as well as added water. However, there may be problems with PSE in the finished cooked product; i.e., poor sliceability and unattractive appearance.

The ultimate question, however, is: "how does the consumer perceive the aberrations in pork quality"? Based on several market trend reviews and consumer surveys, there is no doubt that the consumer's buying intent depends on the product gross appearance; i.e. packaging, color, uniformity, purge, external and internal fat, etc., (Story, 1996; Young, 1996). In addition, more crucial test on the product quality is performed at home — the eating experience. Thus, tenderness, juiciness, taste, and aroma, appear to be as or even more important than meat appearance in assuring repetitive product purchase by the consumer (Bozell and Hanna, 1996; Meisinger, 1996).

Pork Quality – Pork Chain Solutions

So what should the pork industry do to guarantee that pork is not only lean, but that this lean has a fresh appearing reddish-pinkish color, is high in water holding capacity, and is consistently tender and juicy? To compete with other animal proteins in domestic and global markets, producers must deliver quality pork at least cost (Tubbs, 1997). In order to achieve this,

1) breeding companies need to fully understand the economic value of these quality attributes to optimally select for least cost of high quality pork;
2) guidelines should be established and implemented to insure acceptable on-farm production management and welfare procedures at all times;
3) pork processing companies should implement statistical process control procedures for pre-slaughter handling and post-slaughter processing to minimize quality variation;
4) procedures should be put in place to electronically identify and evaluate individual groups of pigs slaughtered for carcass weight, leanness, and quality; this information should be included in quality assurance reports to continually monitor quality variations so that the appropriate steps can be made to further improve breeding stock, production, and processing environment.
5) the total value paid for market pigs should reflect accurate value differentials (as dictated by supply-demand forces) between desirable and undesirable pork quantity and quality.

The information presented in Table 5 may serve as an example of how the collaborative efforts of the pig breeding company, the producer or integrator, the processor or retail market can result in economically poised production of high quality pork. The table presents relative difference in performance traits between the progeny of sire line A, B, and C, and the standard performance of a control sire line. The performance of the control and specialized sire-line pigs are continuously validated at several production, slaughter, and carcass/meat processing environments. When the value is applied to each of the traits, the economic trade-offs between the farm costs and the market value of carcass and meat quality attributes can be predicted. Such a comprehensive approach enables commercial production pork of the desired quality for specific segments of the pork chain.

Summary

To achieve high quality pork products, contributions at all stages of the pork chain must be focused on efficiently producing the ultimate consumer goods. These goods must then be delivered through the supply chain to satisfied consumers according to the best quality control and Hazard Analysis Critical Control Point (HACCP) practices.

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Table 5. Product Evaluation Summary – Relative Differences in Performance Between Progeny of Line A,B,C, and Sire-line Standard.

Sire Line	PSY	TDG, g/d	FC	Carcass Yield, %	Carcass Lean %	Loin Carcass BF, mm	Depth, mm	Loin Minolta L*	pHu	Acceptability % Loin
A	0	.01	-.13	.10	-1.6	2.1	-1.7	-2.25	.18	8.3
A—$	0	$	$	$	$	$	$	$	$	$
B	0	-.08	0.07	1.13	-0.7	.9	2.1	-1.33	.18	6.1
B—$	0	$	$	$	$	$	$	$	$	$
C	0	-.02	-.02	.5	-.6	.8	-.9	-1.5	.13	9.0
C—$	0	$	$	$	$	$	$	$	$	$

PSY = Pigs/Sow/Year**; TDG** = Test Daily Gain; **FC** = Feed Conversion Ratio; **Carcass BF** = Carcass Backfat Thickness**; Loin Depth** = Fat-o-Meter Based Loin Muscle Depth; **Loin Minolta L*** = Loin Minolta Lightness; **pH_u** = Loin ultimate pH measured 24-hour post-mortem; **Acceptability** = Percentage of Loins with Minolta L* less than 50; Minolta L* >50 Represents a Cut-off Criterion Between Acceptable and Unacceptable Color; i.e., Loins Scoring L*>50 Would be Rejected as Being too Pale.

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