51st International Congress of Meat Science and Technology
August 7-12, 2005 – Baltimore, Maryland USA

Production Systems and Meat Quality

PRACTICAL USE OF AN ECONOMIC INDEX FOR SIMULTANEOUS GENETIC IMPROVEMENT OF LIVE PERFORMANCE, CARCASS AND MEAT QUALITY OF THE MODERN PIG

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Key Words: Pig Genetics, Meat Quality

Introduction

For decades, selection of boars and gilts within lines and selection between lines (crossbreeding) has been the standard procedure for genetically improving traits of economic importance to the pork industry. For producers, production traits such as growth rate, feed conversion, and carcass lean are of great economic importance. Traits of economic importance for packers include carcass lean, and primal, sub-primal, and processing yields. In recent years, as packers have moved from selling "commodity pork" to branded pork products, meat quality has become more economically important (Allen, 1995; Sosnicki et al., 2003). Tenderness, juiciness, flavor, and other organoleptic traits are paramount to the consumer and must also be considered when setting up selection objectives as the ultimate goal for the industry is to produce products that the consumers want at a price they will pay (Miller, 2003; Sosnicki et al., 2003). Although different segments of the industry rely on differing economic criteria, a genetic improvement program must include those traits with the greatest economic importance to the overall pork chain.

Without the ability to directly measure meat quality in live animals, only progeny testing or measuring meat quality in full- or half-siblings has been available to calculate estimated breeding values (EBVs) for meat quality traits. Larzul et al. (1999) demonstrated that glycolytic potential measured *in vivo* was a viable option to predict meat quality, but recent guidelines and standards for animal welfare discourage live animal biopsies. Modern practices that reduce the difficulty of including progeny, full-sibling and half-sibling data allows for traits such as pH to now be more readily incorporated into a genetic improvement program. The wide-ranging effects of ultimate pH on pork quality and the relative ease of collecting the phenotypic data make this an ideal trait for selection purposes. Ultimate pH has been shown to be genetically and phenotypically correlated with many economically important criteria such as color, water holding capacity, and sensory quality (Huff-Lonergan, et al., 2002; 2003). More specifically, a higher ultimate pH is associated with better water holding capacity, translating into lower drip or purge losses during storage, and a higher yield when processing (Eikelenboom et al., 1995). Although continuing to increase pH may have a positive effect on water holding capacity and processing characteristics, flavor of fresh pork and shelf life may be compromised when ultimate pH exceeds 6.1 (Bidner et al. 2004; Klont et al. 2002). Therefore, genetic companies wishing to improve meat quality must keep the pH level within an upper threshold to both maximize the benefits of darker color and improved WHC while minimizing effects of potential off-flavor and decreased shelf life. Moreover, focusing selection strictly on one area of performance such as meat quality while disregarding potential negative effects on growth or carcass quality could actually create a negative trend for the overall economic performance of the animal. Huff-Lonergan et al. (1998) showed the converse of this to be true where selection emphasis placed strictly on lean growth efficiency while ignoring meat quality traits resulted in lower pH and higher drip loss than in the randomly selected control line.

Until recently, molecular genetics and marker assisted selection (MAS) has provided little contribution to the standard animal breeding program, but this is rapidly changing as more genetic markers and genes are discovered. These techniques allow the animal breeder to more readily exploit the diversity of the current population (Beuzen, et al. 2000). In addition to basic evaluation programs and quantitative selection approaches, PIC has included major genes and markers into the breeding program in order to increase the rate of genetic improvement for traits of economic importance to the pork industry. PIC products sold in North America are guaranteed free of the Hal-1843® mutation and the RN- gene. Additionally, favorable alleles of the PRKAG3 mutation are included in the selection process due to the demonstrated positive effects on glycolytic potential and resultant meat quality traits (Ciobanu, et al., 2001; Fields, et al., 2002; Oliver et al., 2003; Sosnicki et al., 2003). Furthermore, there are several additional meat quality markers in the advanced validation phase that will soon be available for inclusion in the PIC breeding program (Knap, et al., 2002).

When considering a multi-trait, “desired gains” approach to a breeding program it is necessary to verify the approach is both commercially feasible and biologically effective. The purpose of the research presented in this paper is to evaluate the effectiveness and demonstrate that the combination of quantitative selection and marker assisted selection is a viable tool for simultaneous improvement of carcass and meat quality performance in the modern commercial animal.

Objectives

The objective of this paper is to demonstrate the effectiveness of selection of boars based on an economic index to improve growth, feed conversion, carcass leanness, and loin and ham pH of their progeny.

Methodology

Twenty-eight PIC 280M boars of a predominantly Duroc background from a commercial Gene Transfer Center (GTC) were ranked and bi-directionally selected based on their commercial sales index (High genetic merit = High index and Low genetic merit = Low index). Estimated breeding values used to calculate the economic index for each boar came from the PIC Global Best Linear Unbiased Prediction (BLUP) that included the effects of the boar’s PRKAG3 genotype in addition to performance data. The mean sales index for the "High" indexing boars was 105.1 and 89.4 for the "Low" indexing boars.

Three one-week breeding periods at a commercial farm were set up in March, April, and May 2004. During each breeding period approximately 140 PIC C22 sows were single-sire mated using semen from the selected boars. Prior to cross-fostering, pigs were double-tagged with duplicate numbered colored ear tags. Boar and sow ear tag numbers and farrowing date were recorded for each pig.

Pigs were approximately 10 weeks of age when weighed on-test. Each pig was individually weighed at the start of the growing – finishing period and allotted to one of 50 pens within a room in the finisher by gender and according to whether its sire was a "High" or "Low" sales index boar. Ten pigs were allotted to each pen. Feed consumption was recorded on a pen basis.

All pigs were individually weighed off-test at a target weight of 125 kg and a unique tattoo number was applied to each pig's shoulder so identification could be maintained at the packing plant. The pigs were harvested at a commercial packing facility that harvests approximately 10,000 pigs per day. Pigs were electrically stunned and placed into a standard holding cooler (~3°C) for 24 hours. A Fat-O-Meat'er (SFK Technologies, Denmark) was used to measure backfat thickness, loin depth, and lean percentage. Hot carcass weight was recorded for all carcasses. For each of the three replicates of pigs produced for the trial, the pigs were harvested on three separate days. Approximately 160 to 170 pigs were harvested on each day.

Loin and ham pH measurements were taken approximately 22 hours post-mortem in the cooler utilizing an MPI "pistol grip" pH meter fitted with a Mettler-Toledo glass tipped probe (Meat Probes, Inc., Topeka, Kansas). Loin pH was measured in the *longissimus dorsi* at approximately the last rib while ham pH measurements were taken in the *semimembranosus* by inserting the probe approximately 2.5 cm caudal of the aitch bone to a depth of approximately 5 cm.

SAS PROC GLM (SAS Institute, Inc., Cary, NC) was used to complete the statistical analyses. Sources of variation accounted for in the analyses for all traits included breeding group, gender of the pig, and the linear regression of the progeny's phenotype for each trait on its sire's sales index. For average daily gain and feed conversion, a linear covariate for on-test weight was also included in the statistical model. A linear covariate for age at harvest was included in the statistical model in the analysis of carcass lean percentage. For loin and ham pH, fixed effects for harvest date nested within breeding group was included in the statistical models to account for day-to-day variation. Response graphs were developed showing the changes in each trait as the sales index of the boars increased from 70 to 136 index points (Figure 1).

Results & Discussion

Table 1 presents the estimates of the regression of the progeny's performance on its sire's sales index for each trait. For loin pH, the coefficient of .001 indicates that pH will increase .01 units for every 10-point increase in the sales index ($P < .001$). Likewise, ham pH increased .007 units for every 10-point increase in the sales index ($P < .05$). Selection of boars based on the sales index resulted in a .017 improvement in feed conversion and a

.126 % increase in carcass leanness for every 10-point increase in the sales index ($P < .01$ and $P < .001$, respectively).

Figures 1 through 4 graphically represent the incremental change in progeny performance as the sires' sales index increases. All responses are linear in nature. As greater selection intensity is placed on a genetic line (ie. selecting only the top 20% of boars in the herd), improvements can be made more rapidly and the resultant change will have a greater economic impact to the industry.

Conclusions

The research clearly shows that a simultaneous improvement of pig live performance, carcass, and meat quality is both commercially feasible and biologically effective. By using index selection, unfavorable genetic correlations between production, carcass and meat quality traits can be overcome. Ultimately, products that improve profitability for all segments of the pork chain can be brought to the marketplace in a timelier manner.

References

Allen, P., (1995). Carcass classification and composition – methods of accurately predicting commercial yield. Conference Proceedings: International Developments in Process Efficiency and Quality in the Meat Industry (pp 33–45). 16–17 November 1995, Dublin, Ireland.

Beuzen, N.D., Stear, M.J., Chang, K.C., (2000). Molecular markers and their use in animal breeding. The Veterinary Journal, 160:42–52.

Bidner, B., Ellis, M, Brewer, M.S., Campion, D., Wilson, E.R., McKeith, F.K., (2004). Effect of Ultimate pH on the Quality Characteristics of Pork. Journal of Muscle Foods, 15:139–154.

Ciobanu, D., Bastiaansen, J., Malek, M., Helm, J., Woollard, J., Plastow, G., Rothschild, M., (2001). Evidence for new alleles in the protein kinase adenosine monophosphate-activated γ3-subunit gene associated with low glycogen content in pig skeletal muscle and improved meat quality. Genetics, 159:1151–1162.

Eikelenboom, G., Van der Wal, P.G., De Vries, A.G., (1995). The significance of ultimate pH for pork quality. In Proceedings of 41st International Congress of Meat Science and Technology (pp 654–655)., 20–25 August 1995, San Antonio, Texas, USA.

Fields, B., Klont, R.E., Jungst, S.B., Wilson, E.R., Plastow, G.S., Sosnicki, A.A. (2002). New DNA marker affecting muscle glycogen content: practical implications for pork quality. In Proceedings of 48th International Congress of Meat Science and Technology (pp 620–621)., 25–30 August 2002. Rome, Italy.

Huff-Lonergan, E., Melody, J., Klont, R., Sosnicki, A.A., (2003). Pork Quality: Current and Future Needs of Industry and Academia. In Proceedings of the 56th Annual Reciprocal Meat Conference (pp 23–29)., 15–18 June 2003, University of Missouri.

Huff-Lonergan, E., Baas, T.J., Malek, M., Dekkers, J.C.M., Prusa, K., Rothschild, M.F., (2002). Correlations among selected pork quality traits. Journal of Animal Science, 80:2–10.

Huff-Lonergan, E., Kuhlers, D.L, Lonergan, S.M., Jungst, S.B., (1998). Characterization of pork quality in response to five generations of selection for lean growth efficiency. Journal of Animal Science, 76(Supplement 1):151. (Abstract).

Klont, R.E., Davidson, P.M., Fields, B., Know, B.L., Van Laack, R.L.J.M., Sosnicki, A.A., (2002). Relationship between ultimate pH, shelf life, and drip loss of pork loins. In Proceedings of the 48th International Congress of Meat Science and Technology (pp 932–933). 25–30 August 2002. Rome, Italy.

Knap, P.W., Sosnicki, A.A., Klont, R.E. and Lacoste, A., (2002). Simultaneous Improvement of Meat Quality and Growth and Carcass Traits in Pigs. In Proceedings of the 7th World Congress on Genetics Applied to Livestock Production 31 (pp.339–346). INRA, Castanet-Tolosan, France.

Larzul, C., LeRoy, P., Gogue, J., Talmant, A., Jacquet, B., Lefaucheur, L., Ecolan, P., Sellier, P., Monin, G., (1999). Selection for reduced muscle glycolytic otential in Large White pigs. II. Correlated responses in meat quality and muscle compositional traits. Genetics Selection Evolution. 31:61–76.

Miller, R.K., (2003). Assessing consumer attitudes toward meat and meat products. In Proceedings of 49th International Congress of Meat Science and Technology (pp 67–73)., 31 August – 6 September, 2003. Campinas, Brazil.

Oliver, M.A., Gil, M., Gispert, M., Hortós, M., Carrión, D.C., Font i Furnols, M., Mormede, P., Cairns, M., Maltin, C., Klont, R., Sosnicki, A.A., Plastow, G.S., (2003). Quality pork genes: variation in phenotypic traits for functional genomic analysis of meat quality for economical production of high quality meat. In Proceedings of 49th International Congress of Meat Science and Technology (pp 47–48)., 31 August – 6 September, 2003. Campinas, Brazil.

Sosnicki, A.A., Pommier, S., Klont, R., Newman, S., Plastow, G.S., (2003). Best-cost production of high quality pork: bridging the gap between pig genetics, muscle biology/meat science and consumer trends. In Proceedings of Manitoba Pork Seminar. 29–31 January, 2003

Tables and Figures

Table 1. Estimates of the regression of progeny performance on its sire's sales index

Trait	Regression coefficient	Probability
Loin pH	.0010 ± .0003	P < .001
Ham pH	.0007 ± .0003	P < .05
Lean Percentage, %	.0126 ± .004	P < .01
Average Daily Gain, g/day	.078 ± .146	P < .60
Feed Efficiency, feed, kg:gain, kg	-.0017 ± .0005	P < .001

Figure 1.

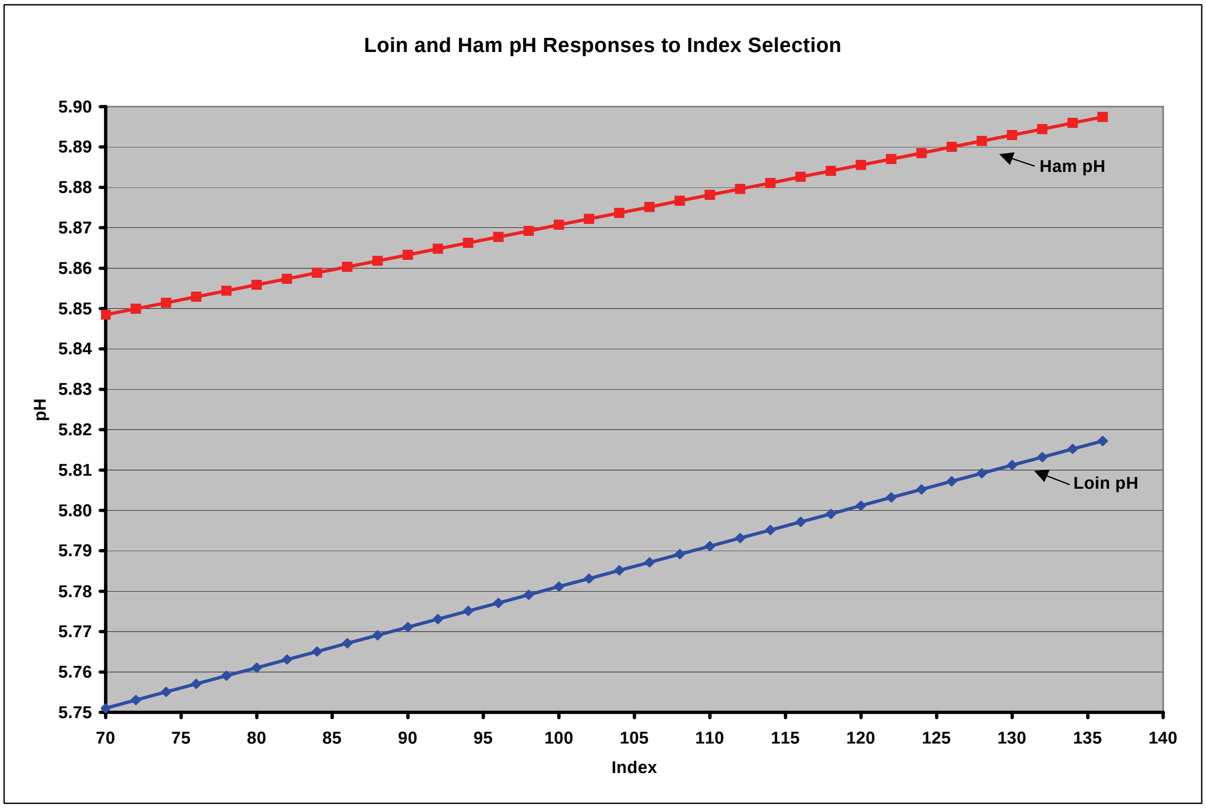

Figure 2.

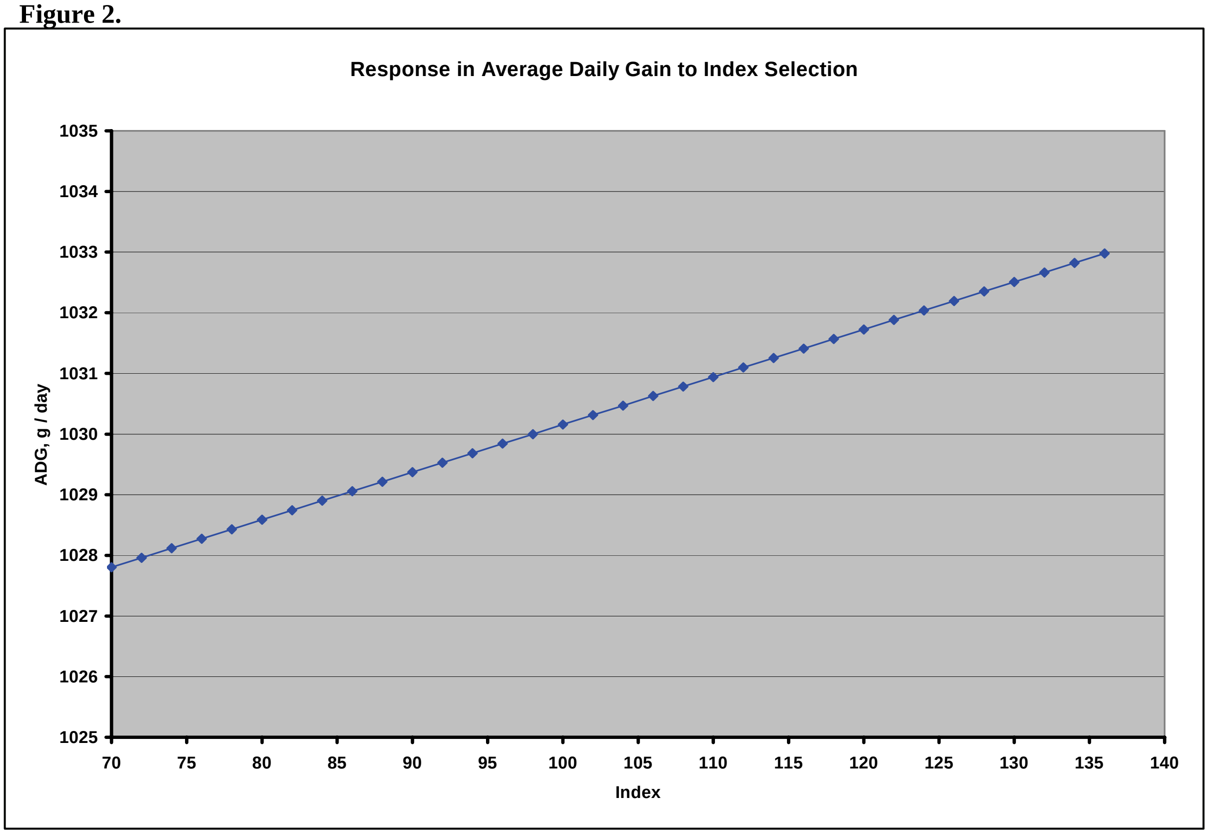

Figure 3.

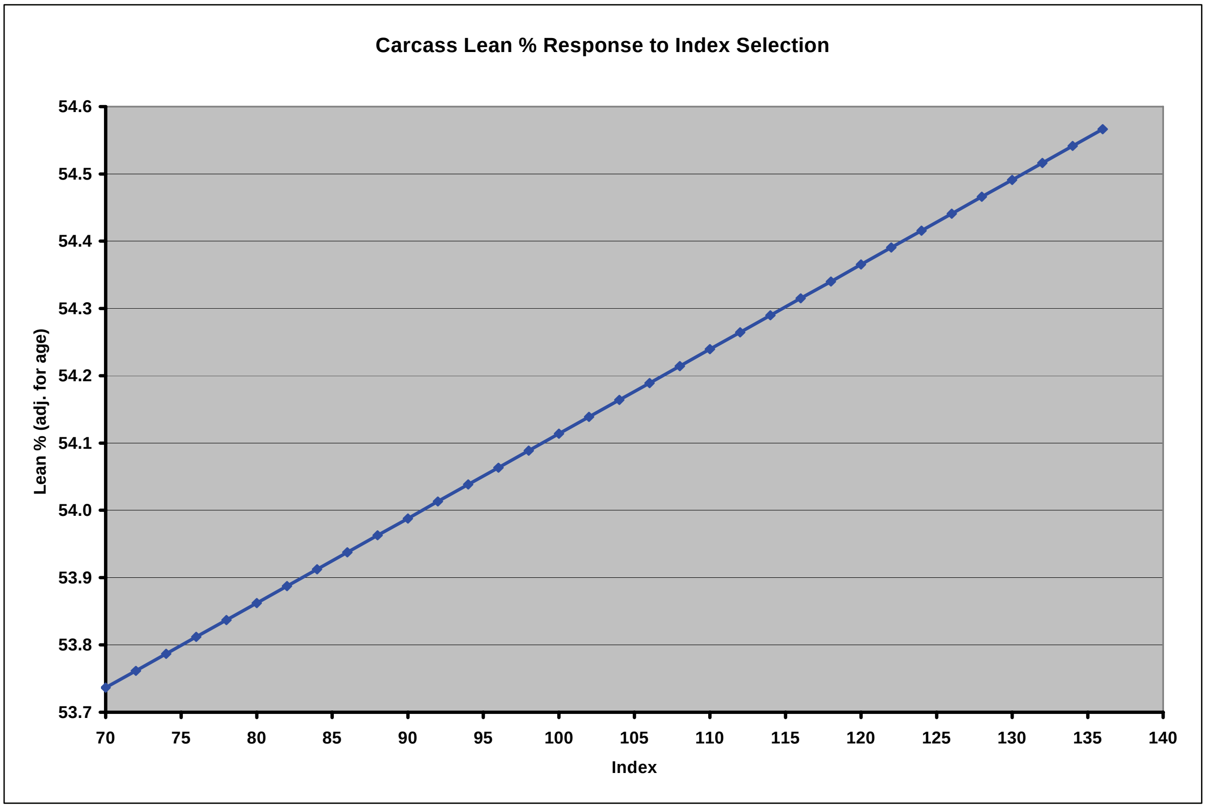

Figure 4.