THE EFFECT OF HYDROGEN ION CONCENTRATION EVALUATION METHODOLOGY ON GENETIC PREDICTION WHEN ASSESSING PORK QUALITY

K.J. Stalder[1], A.M. Saxton[1], R.K. Miller[2] and R.N. Goodwin[3]

[1] University of Tennessee, Knoxville, Tennessee 37996, USA
[2] Texas A & M University, College Station, Texas 77843, USA
[3] The National Pork Board, Des Moines, Iowa 50306, USA

INTRODUCTION

The use of pH is becoming widely accepted as an indicator of pork quality. Additionally, selection programs used by seedstock suppliers are emphasizing pork quality and its indicators. Accurate evaluation of pH will allow the pork industry to increase rate of genetic improvement through the selection of animals that are more likely to improve muscle quality. Improved quality will enhance pork in the global market place.

Biologically, pH is defined as the negative log of the hydrogen ion concentration (pH= -log $[H^+]$) of an item being measured (Zubay, 1988). The use of pH has been widely accepted and used as an indicator of pork muscle quality and has been used when conducting genetic evaluations (Gibson *et al*., 1996 ; Goodwin and Burroughs, 1995) and studying various factors associated with and / or affecting pork quality (Stalder *et al*., 1998 ; Barton – Gade, 1990 ; Christian and Rothschild, 1981). Few investigations (Boutilier and Shelton, 1980) have examined the statistical differences and the effects on the inferences made when hydrogen ion concentration and pH are simultaneously evaluated. Few, if any, studies have investigated the effects of using pH or hydrogen ion concentration when estimating genetic parameters, conducting a genetic evaluation of lines or breeds, or conducting an across-herd genetic evaluation. Meat scientists and geneticists have focused on pork quality traits and their indicators in an attempt to improve the quality of commercially produced pork. One of the indicator traits receiving much attention has been pH. The pork harvesting and processing industries are concerned with identifying environmental factors that can improve the pH and other pork quality indicator traits so more of their pork products can be sold as premium products. Seedstock and pork harvesting / processing industries need to know if the breeding value estimates (selection decisions) are dependent on how hydrogen ion concentration is evaluated (directly or as pH).

PROCEDURES

The project utilized the National Barrow Show ™ Progeny Test data. This program is managed by the George A. Hormel Company of Austin, Minnesota. Complete three-generation pedigrees, and fixed and random classifications used for analyses of various traits, and pertinent muscle quality information (pH) were obtained from the National Pork Board. Existing muscle pH data was converted to its original hydrogen ion concentration. Genetic prediction and heritability estimates were estimated for pH and hydrogen ion concentration using ASREML software (Gilmour *et al*., 2001) that incorporated a sire model and the full relationship matrix of individuals. The model utilized in the analysis of pH and H^+ concentration was as follows,:

y	=	$X_1b_1 + X_2b_2 + X_3b_3 + X_4b_4 + X_5b_5 + Zu + e$, where,
y	=	vector of pH and H^+ concentration phenotypic values,
$X_{1,2,3,4,5,\text{ and }6}$	=	are incidence matrices for fixed effects related to the phenotypic values,
b_1	=	unknown vector of a fixed breed effect associated with the record in y,
b_2	=	unknown vector of a fixed herd effect associated with the record in y,
b_3	=	unknown vector of a fixed test group effect associated with the record in y,
b_4	=	unknown vector of a off-test date within a test group fixed effect associated with the record in y,
b_5	=	unknown vector of a fixed sex effect associated with the record in y,
b_6	=	unknown vector of a fixed Hal 1843™ effect associated with the record in y,
Z	=	incidence matrix for random effects related to the phenotypic performance values (pH and H^+ concentration),
u	=	unknown vector of random sire effects (using full the relationship matrix) associated with the records in y, and
e	=	vector of random residual effects.

Spearman rank correlations were calculated to evaluate breeding value estimates obtained for two traits. Differences that were obtained for individual animals and the order in which individuals are ranked were evaluated. Genetic correlations between selected objective pork quality measures, pH, and H^+ concentration were estimated.

RESULTS AND DISCUSSION

In total, data from 4,262 animals were utilized in this study. The heritability estimates for pH and H^+ concentration were 0.52 ± 0.074 and 0.62 ± 0.078, respectively. Both estimates would be considered highly heritable, however greater genetic progress would be expected if selection were based upon H^+ concentration rather than its transformed pH value when attempting to improve pork quality. The Pearson coefficient of correlation between pH and H^+ breeding values concentration was -0.92. The highly negative correlation between the two traits was expected as pH is a transformed value of H^+ concentration.

To better understand the impact of selection based upon pH or H^+ concentration, a Spearman Rank coefficient of correlation was calculated. While relatively strong, the -0.85 rank correlation indicates that some difference in raking among individuals is likely to occur when they are ranked based on their pH or H^+ concentration breeding values. To show how a selection program attempting to improve pork quality could be impacted by selecting on pH or H^+ concentration, an example of truncation selection on the two traits is shown in Figure 1. Loss in H^+ selection differential by selecting on pH instead of H^+ ranges from 5% to 13%

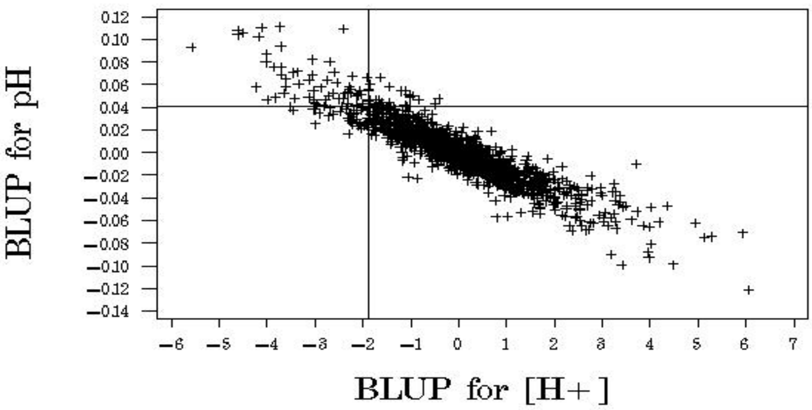
depending upon selection intensity utilized. This is a consequence of not selecting individuals in the lower left quadrant of the graph, instead choosing those in the upper right. The graph (Figure 1) shows 5% selection intensity. Additionally, the companion table associated with Figure 1 shows the loss in H^+ in selection differential by selection on pH instead of H+ at the top 1, 5 and 25 percent truncation levels. It should be noted that selection differential loss increases as selection intensity increases.

Differences in the genetic correlations between various pork quality indicators, pH and H^+ concentration were examined (Table 1). Relative differences in the magnitude of the genetic correlation between various objective pork quality traits and pH or H^+ concentration were negligible. The absolute value of the genetic correlations between various pork quality traits and pH or H^+ concentration ranged from 0.00 to 0.62.

The H^+ concentration heritability was greater than that for pH and the genetic correlations between the two values and other pork quality indicator traits are nearly identical. Differences in the fixed effect results from the pH and H^+ concentration would likely impact decisions that swine breeders and meat processors who are concerned about pork quality. These two facts indicate that H^+ concentration rather than pH is the more appropriate trait breeders and processors should focus on when attempting to improve pork quality.

Table 1. Genetic correlations between hydrogen ion concentration, pH and indicators of pork quality from the National Barrow Show ™ Progeny Test

Trait	pH	Hydrogen ion Concentration
H^+ concentration	-0.9676 ± 0.0124	
Minolta L*	-0.5425 ± 0.0818	0.5088 ± 0.0803
Lipid	-0.0021 ± 0.1075	0.0068 ± 0.1015
Instron™	-0.1257 ± 0.1275	0.1235 ± 0.1222
Hunter	-0.6262 ± 0.0958	0.6241 ± 0.0925



	H+ Selection Differential			
Selection Intensity	Select on pH	Select on H+	Selection Differential	Selection Differential Loss, %
25%	-0.78	-0.82	-0.04	4.8
5%	-1.80	-1.93	-0.13	6.7
1%	-2.53	-2.91	-0.38	13.1

Figure 1. Example truncation selection for pH and Hydrogen ion concentration based on top 5 percent breeding values

REFERENCES

Barton – Gade, P. A. (1990) Proc. 4th.*WCGALP* **XV :** 511-520.
Boutilier, R. G. and Shelton, G. (1980) *J. Exp. Biol.* **84 :** :335-339.
Christian, L. L. and Rothschild, M.F. (1981) Publication AS-528-F. Iowa State University Cooperative Extension Service, Ames.
Gibson, J. P, Aker, C.A. and Ball, R.O. (1996) Proceedings of the Ontario Pork Carcass Appraisal Project Symposium. Ontario Swine Improvement Inc. Guelph, Ontario, Canada.
Gilmour, A. R, Cullis, B.R., Welharn, S.J. and Thompson, R. (2001) ASREML Reference Manual. NSW Agriculture, Orange, 2800, Australia.
Goodwin, R. N. and Burroughs, S. (1995) Genetic Evaluation: National Pork Producers Council Terminal Line Program Results. National Pork Board, Des Moines, IA.
Stalder, K. J., Maya, J., Christian, L.L., Moeller, S.J. and Prusa, K.J. (1998) *J. Anim. Sci.* **76**:2435-2443.
Zubay, G. (1988) Biochemistry 2nd Ed. MacMillian Publishing Company, New York, NY.