PE7.26 Common Factor Analysis of Pork Quality Traits 255.00

Brandon Fields (1) brandon.fields@pic.com, Scott Newman(1), Steve Jungst (1), Andrzej Sosnicki (1)
(1)PIC North America

Abstract—The objective of this analysis was to identify factors that contribute to the common variance between carcass quality traits and objective and subjective pork quality traits. Measurements were recorded for 20 different variables using 436 pigs sired by 14 boars of predominantly Duroc genetic background, 14 boars of predominantly Hampshire genetic background, and 16 synthetic boars that were mated to sows of the same genetic line. Common Factor Analysis was used as a data reduction technique to reduce the large number of variables down to a smaller and more manageable number of factors. Three traits were eliminated from the analysis due to either a low correlation with all other traits (subjective off-flavor score) or low communality estimates (cook loss % and carcass loin depth). Six other traits, age at 125 kg, carcass backfat thickness, loin Minolta a*, shear force, purge loss, and drip loss did not meet either the + .5 or - .5 criteria as a loading factor and were eliminated from the final analysis as well. Three factors were identified that accounted for 63% of the common variation in the remaining traits. The first factor was named "pH" because the three traits associated with this factor were 24-hr pH (loading factor=.88), pH after a 10-day aging period (loading factor=.73), and subjective firmness score (loading factor=.59)]. Traits associated with lean tissue color [Minolta L* (loading factor=.83), subjective Japanese color score (loading factor=- .72) and Minolta b*(loading factor=.69)] were the second common factor that contributed to the common variance of the traits. The third factor can be categorized as intra-muscular fat with three traits that loaded high [intra-muscular fat % (loading factor=.91), loin moisture % (loading factor=-.76), and subjective marbling score (loading factor=.54)]. The complex factor analysis applied to a large number of experimental samples used in this study identified pH as the leading indicator of overall pork quality.

S. Newman, B. Fields, S.B. Jungst and A.A. Sosnicki are with PIC North America, 100 Bluegrass Commons Blvd, Suite 2200, Hendersonville, TN, 37075 USA.

Index Terms— meat quality, pH, pork, variance

I. INTRODUCTION

MEAT quality is an economically important trait to the pork processor, retailer, restaurant industry, and ultimately to the consumer. Consumers will make repeated purchases of pork products if their eating experiences are favorable in terms of flavor, tenderness, and juiciness. There are many definitions of desirable pork quality. To the processor pH, loin color, marbling and water holding capacity are traits that define quality, but to the consumer these traits are meaningless per se, but are correlated to the traits that are important to the consumer such as flavor, tenderness, or juiciness [1]. There are numerous traits that can be measured related to pork quality, but from a logistical standpoint it is not possible to measure all these traits all the time. Therefore, simplifying to two or three specific traits that account for most of the common variance among the traits is a logical approach. The objective of this trial was to determine what factors contribute most to the common variance in traits associated with pork quality using a large number of experimental samples. Factor Analysis (FA) is a multivariate-statistical technique that explores interrelationships among variables with the objective to discover if those variables can be grouped into a smaller set of underlying factors [2]. For our purposes, FA has two main purposes: (1) To explore data for patterns that may not be apparent from analyses of variance; and (2) as a data reduction technique to shrink a large number of variables into a smaller and more manageable number of factors. The underlying assumption of factor analysis is there exist a number of unobserved latent variables (or 'factors') that account for the correlations among observed variables, such that if the latent variables are held constant, the partial correlations among observed variables all become zero. In other words, the latent factors determine the values of the observed variables.

II. MATERIALS AND METHODS

Data from two trials were pooled together for this analysis. The combined data sets included 436 pigs sired by 14 boars of predominantly Duroc genetic background, 14 boars of predominantly Hampshire genetic background, and 16 synthetic boars, which were mated to sows of the same genetic line. All sire lines were represented in all replicates and the data were edited to ensure that each pig had a recorded value for each trait used in the analysis. Pigs were harvested at commercial packing facilities under normal operational conditions. Each carcass was weighed and a Fat-O-Meater was used to measure backfat thickness and loin depth. Meat quality evaluations of loins were conducted the next morning following a 22 to 24-hr refrigeration period. Bone-in loins from the left sides of the carcasses were retained for the meat quality evaluations and were boned out on-line. Ultimate pH, Minolta L*, a*, and b*, and subjective scores of Japanese color, marbling, and firmness were measured in the Longissimus dorsi at approximately the last rib.

Boneless loins were then shipped to the University of Illinois, Urbana-Champaign for further laboratory and taste panel analysis. Drip loss was evaluated using the tube method [3] while all other laboratory and sensory analysis was conducted using standard University of Illinois procedures as described by Bidner et. al. [4].

Only records with no missing values for all variables in the analysis were used (n = 436). Correlations of all variables were checked and those above .90 (too similar) or below .10 (unique factor) were removed prior to analysis. All data were required to be of simple structure, meaning that (1) at least three input variables load highly; and that (2) for each input variable that loaded highly, it has to have a maximized loading on itself and a minimized loading on the others, after rotation. Data were analyzed using the FACTOR Procedure of SAS® (SAS Inst., Cary, NC). The initial factor method used was iterated principal factor analysis using squared multiple correlations as priors and the varimax algorithm for rotation.

III. RESULTS AND DISCUSSION

Prior communality estimates for the 17 variables are shown in Table 1, along with the communalities of the variables when 20 variables were used. Variables with high communalities for the full dataset (20) still expressed high communalities for the reduced dataset.

The sum of all prior communality estimates, constituted 49.88% of the total variance present among all 17 variables. The rotated factor pattern is displayed in Table 2. Factor loadings greater than + .50 or less than - .50 are displayed in bold type to facilitate the identification of high-loading variables.

The rotation was successful from the perspective of delineating more meaning from the factors. For example, Factor 1 is dominated by two measures of pH (pH24-hours and 10-day pH) and subjective loin firmness. Factor 2 is dominated by variables associated with color (Minolta L*, Minolta b*, and subjective Japanese color), while Factor 3 is dominated by fatness (subjective marbling score, intramuscular fat percentage, and chemical moisture percentage). Factor 4 had only one variable (Minolta a*) load high while only two variables (subjective taste panel juiciness and tenderness) loaded high on Factor 5 (although it is interesting to note that both of those variables are associated with taste panel tests).

Based on the requirement of having a simple structure the last two factors were dropped from further analyses. It was also observed that six other variables (Minolta a*, drip loss, package purge, shear force, backfat, and age at 125 kg) did not load highly on any factors.

Therefore, analysis was limited to three factors and only included those nine remaining variables that loaded highly on them. The final rotated factor pattern is displayed in Table 3. The total variance for this model was 5.69, or an average of 0.63. While the total variance is not as great as the previous models (with more variables), the average variability accounted for by each factor is larger. Three factors were determined to contribute to the common variance among the nine remaining traits. The first factor was pH with three traits [24-hr pH (.88), pH after a 10-day aging period (.73), and subjective loin firmness score (.59)].

Traits associated with lean tissue color [Minolta L* (.83), subjective loin color score (- .72) and Minolta b*(.69)] was the second common factor that contributed to the common variance of the traits. The third factor can be categorized as intra-muscular fat or marbling with three traits that loaded high [intra-muscular fat % (.91), loin moisture % (- .76), and subjective loin marbling score (.54)].

IV. CONCLUSION

Common Factor Analysis is a step-wise multivariate approach to analyzing correlated traits. The first factor in this analysis, pH, is the most important factor because it accounts for the largest amount of the common variation in the meat quality traits. Each subsequent factor is less important because it accounts for a smaller amount of the total variation in the meat quality traits. A loin pH measurement is the trait of first choice to determine if a loin has acceptable meat quality because it accounts for the most variation and because of the ease of taking the measurement in the cooler without having to fabricate the carcass into the primal cuts.

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Table 1. Comparison of communalities from two different analyses

	20 variables	**17 variables**
Loin ultimate pH	0.694	0.691
10-day pH	0.586	0.580
Loin Minolta L*	0.761	0.760
Loin Minolta a*	0.724	0.723
Loin Minolta b*	0.766	0.764
Loin subjective color score	0.627	0.622
Loin subjective marbling score	0.403	0.391
Loin subjective firmness score	0.577	0.563
Drip loss percentage	0.353	0.313
Purge loss percentage	0.265	0.255
Shear force	0.306	0.285
Loin moisture percentage	0.590	0.584
Intra-muscular fat percentage	0.626	0.616
Subjective juiciness score	0.409	0.407
Subjective tenderness score	0.438	0.431
Carcass backfat thickness	0.310	0.282
Age at 125 kg	0.291	0.209

Table 2. Rotated factor pattern

	Factor1	Factor2	Factor3	Factor4	Factor5	Communality
Loin pH24-hours	**0.84**	-0.23	0.01	-0.19	0.05	0.80
Loin pH10-day	**0.82**	-0.11	0.00	0.12	0.07	0.70
Loin Minolta L*	-0.11	**0.90**	0.09	-0.19	-0.12	0.88
Loin Minolta a*	-0.36	-0.06	0.10	**0.88**	0.10	0.92
Loin Minolta b*	-0.25	**0.69**	0.13	0.36	0.01	0.68
Loin subjective color score	0.39	**-0.69**	0.03	-0.02	0.03	0.62
Loin subjective marbling score	0.26	-0.07	**0.56**	-0.10	0.00	0.39
Loin subjective firmness score	**0.58**	-0.38	0.13	-0.22	-0.07	0.55
Drip loss percentage	-0.39	0.06	-0.04	0.25	-0.16	0.24
Purge percentage	-0.41	0.14	0.13	0.15	-0.11	0.24
Shear force	-0.02	0.05	-0.08	0.47	-0.10	0.24
Moisture percentage	0.26	-0.04	**-0.76**	0.04	0.04	0.66
Intra-muscular fat percentage	-0.01	0.11	**0.87**	-0.06	0.07	0.78
Subjective juiciness score	0.08	-0.04	0.04	-0.03	**0.72**	0.52
Subjective tenderness score	0.14	-0.01	0.06	-0.15	**0.76**	0.62
Carcass backfat thickness	0.00	0.05	0.43	0.12	0.19	0.24
Age at 125 kg	0.00	0.01	-0.04	-0.02	-0.27	0.08

Table 3. Rotated factor pattern for final nine-variable model

	Factor1	Factor2	Factor3	Communality
Loin pH24-hours	**0.88**	-0.25	-0.01	0.83
Loin pH10-day	**0.73**	-0.15	-0.04	0.55
Loin Minolta L*	-0.08	**0.83**	0.09	0.71
Loin Minolta b*	-0.24	**0.69**	0.08	0.55
Loin subjective color score	0.38	**-0.72**	0.02	0.66
Loin subjective marbling score	0.30	-0.06	**0.54**	0.39
Loin subjective firmness score	**0.59**	-0.40	0.13	0.53
Moisture percentage	0.23	-0.07	**-0.76**	0.63
Intra-muscular fat percentage	0.03	0.13	**0.91**	0.84