

The Carcass and Meat Quality Characteristics of Two Lines of Pig Reared under Two Differing Environmental Conditions

D. N. Hamilton*, M. Ellis*¹, B. F. Wolter*, F. K. McKeith*, and E. R. Wilson[†]

* Department of Animal Sciences, University of Illinois, Urbana, IL
and [†] Pig Improvement Company, Franklin, KY

Introduction

There has been limited research carried out on the effects of environmental factors such as group size and crowding on carcass and meat quality characteristics in pigs. A number of studies investigating the effects of rearing environment on carcass and meat quality traits have compared outdoor versus indoor rearing systems and have shown variable results. Pigs reared outdoors have been reported to have darker meat color and no difference in ultimate pH when compared to confinement reared pigs (Wariss et al., 1983). Enfalt et al. (1996) showed that pigs reared in confinement had higher ultimate pH and marbling and lower drip loss than pigs reared outdoors. Other studies have shown no effect of rearing environment on these traits (van der Wal et al., 1993).

The animal's rearing environment will dictate the level to which it will express its genetic potential. An important consideration in choice of the genotype to use in any particular situation is the potential for genotype x environment interactions for the important traits. Commercially, genotype x environment interactions are important because they will dictate the optimum genetic line for use in a particular environment. Several studies have shown that genotype x rearing environment interactions occur in swine populations (Bidanel and Ducos, 1996; Merks, 1989). However, most studies have focused on growth performance and the objective of this study was to investigate the interaction between sire line and environment for carcass and meat quality characteristics in pigs.

Materials and Methods

Experimental Design and Treatments. This study compared three treatments with two replicates over time. The treatments were: sire line (line A vs line B, [Pig Improvement Company, U.S.A., Franklin, KY]), environment (spacious vs crowded), and sex (barrows vs gilts). The protocol for this study was approved by the University of Illinois Laboratory Animal Care Committee.

Animals and Management Line A was Pietrain-based and line B was a synthetic containing Large White, Landrace, Duroc and Pietrain. Sires from line A (n = 7) and line B (n = 8) were mated to PIC Camborough 22 dams. All lines used in this study had been tested as free of the detrimental alleles of both the Halothane and RN genes.

Two replicates of 242 pigs each were put on test at an average of approximately 40 kg live weight. The study was conducted in a mechanically ventilated building at the University of Illinois Swine Research Center which had part-solid, part-slotted floors. The spacious

environment consisted of small groups (4 pigs) with a more than adequate floor space allowance (0.93 m²/pig for the entire grow-finish period). Pigs in the crowded environment were in larger groups (12 pigs) with a reduced floor space allowance [(0.37 and 0.56 m²/pig for the grower (40 to 80 kg) and finisher (80 to 120 kg) phases, respectively)]. At a mean pen weight of 80 kg, the crowded environment pens were enlarged by widening the existing pen, keeping a constant ratio of solid to slotted floor. Pigs were given ad libitum access to feed from a two-hole feeder and were fed on a three-phase dietary program; diets were based on corn and soybean meal.

When the mean pen weight reached 120 kg, two individuals were selected at random from each pen to be slaughtered for carcass and meat quality evaluation. Pigs remained in their test groups until they were transported from the farm to the Meat Science Laboratory at the University of Illinois on the afternoon prior to slaughter, where they were held overnight for approximately 16 h prior to slaughter. Animals were mixed with those from other groups during transport and in the lairage where they were held without food but with access to water.

Slaughter and Carcass Evaluation. Pigs (n = 128) were weighed immediately before slaughter. The carcass was split down the midline, the head was removed, and hot carcass weight was recorded. Carcasses were placed in a chiller (4°C) approximately 1-h postmortem where they were held overnight. At 24-h postmortem, cold carcass weight was recorded, and carcass measurements were obtained from the left side of each carcass.

Meat Quality Measurements. At 45-min post mortem, muscle pH was measured on a longissimus sample (approximately 3 g) taken at the level of the 10th rib. At 24-h post mortem, subjective scores for longissimus color, firmness, and marbling were taken on the cut surface of the longissimus at the tenth rib using the procedures described by NPPC (1991) based on five point scales (1 = pale, soft, and devoid of marbling; 5 = dark, firm, and moderately abundant or greater marbling). Minolta color (L*, a*, and b* values) was measured on the cut surface of the loin section at the 10th rib. A loin chops (2.5 cm thick) were cut from the longissimus immediately posterior to the 10th rib. One chop was used to determine drip loss and the other for ultimate pH. A 10-cm section of the longissimus was taken immediately anterior to the last rib for shear force and cooking loss evaluation. The section was vacuum packaged, aged for 7 d at 4°C, then frozen (-20°C).

Shear Force and Cooking Loss. A chop was removed from the frozen loin section for Warner-Bratzler shear force determination thawed for 24 h at 4°C, and cooked to an internal temperature of 70°C. The chops were weighed before and after cooking to determine cooking loss. Shear force was measured on three cores from each chop.

Curing of Hams. The trimmed boneless ham from the left side of half of the carcasses chosen at random from the first replicate (n=64) was frozen for subsequent curing yield evaluation. After all hams were collected they were thawed at 4°C for 72 h and green weights were recorded. Hams were injected to 125% of their weight with a commercial cure solution to result in a finished product that contained sodium chloride, 2.0%; sodium tripolyphosphate, 0.5%; sodium

erythorbate, 550 ppm; sodium nitrite, 150 ppm, and a pumped weight was recorded. The hams were tumbled at 25 mm Hg vacuum for 4 h, weighed, placed into fibrous casing, then cooked and smoked in a smoke house. Hams were cooled in a chiller at 4°C for 12 h, the cooked chilled weights were recorded, and curing yields were calculated.

Results and Discussion

Effect of Sire Line. There was no difference between the lines for fat depths (Table 1); however, line A progeny had greater ($P < 0.05$) loin eye depth and loin eye area than line B. These findings are similar to those of others who have compared purebred Pietrain or lines base on the Pietrain to other breeds or lines (Howard and Smith, 1977). Line B had higher ($P < 0.05$) 45 min and 24 h pH ($P < 0.05$) values than line A (Table 2). Furthermore, line B was superior for a number of pork quality characteristics measured on the longissimus such as subjective color, firmness, and marbling, and Minolta L* and b* (Table 2). A number of other studies have shown inferior pork quality attributes for Pietrains compared to other breeds (Howard and Smith, 1977; Oliver et al., 1993). A genotype x environment interaction was observed for drip loss ($P < 0.05$, Table 2); line B pigs had a lower drip loss (2.23% units) in the crowded environment than the spacious environment, whereas line A animals showed no difference in drip loss between the two environments (Table 2). However, there was no significant ($P > 0.10$) interaction between genotype, and rearing environment for other indices of PSE such as 45 min pH, color, firmness and Minolta L* values (Table 5). Sire line had no effect on ham pumping characteristics (Table 3).

Effect of Rearing Environment. There were no differences ($P > 0.05$) in fat or muscle measurements taken on the carcass between pigs reared in the two environments (Table 1). Other studies have also reported no difference in fat depths for pigs reared at different floor-space allowances (Brumm and NCR-89, 1996; Edmonds et al., 1998). In the present study, pigs that were housed in the crowded environment did have lower ($P < 0.05$) Minolta L* values, indicating darker muscle color (Table 2); however, there was no difference between the rearing environments for other pork quality traits. Furthermore, there was no difference ($P > 0.05$) in ham pumping characteristics between animals reared in the spacious and crowded environments (Table 3). Enfalt et al. (1996) found a lower ultimate pH, higher drip loss, increased shear force values and reduced intramuscular fat for outdoor compared to indoor reared pigs. However, Jones et al. (1994) and van der Wal et al. (1993) compared pigs from outdoor and indoor production systems and found no differences in longissimus L* scores.

Effect of Sex. Gilts had heavier hot carcass weights, higher dressing percentages and a lower fat depth at the 10th rib and a larger loin eye area compared to barrows (Table 1), results that are similar to other studies at this center (Ellis et al., 1996; Cisneros et al., 1996). Subjective color, firmness, and marbling scores on the longissimus were higher ($P < 0.05$) for barrows, indicating that they had darker, firmer muscle with more visible marbling compared to gilts (Table 2). There were no differences between the sexes for any other pork quality traits. Gilts had heavier ($P < 0.05$) green ham weights than barrows; however, no other differences between the sexes were observed for ham pumping characteristics (Table 3). Leach et al. (1996) also reported that

gilts had heavier trimmed boneless ham weights when compared to barrows. Other studies have generally found little difference in muscle quality between barrows and gilts (Barton-Gade, 1987, Ellis et al., 1996).

Conclusions

1. The substantial differences among the sire lines and the limited impact of rearing environment observed in this study suggest that producers should be more concerned about choice of genetic line than about group size and floor space allowance in terms of carcass and meat quality.
2. With the exception of the genotype x environment interaction for drip loss it would appear that there is a limited number of genotype x environment interactions for carcass and pork quality traits which reduces the concern about choosing genotypes for specific environments in these respects.

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Table 1. Least square means for the effects of sire line, environment and sex on slaughter and carcass measurements.

Variable	Sire line			Environment			Sex			G × E ^f
	Line A	Line B	Av. SE	Spacious	Crowded	Av. SE	Barrows	Gilts	Av. SE	P value
Slaughter weight, kg	115.4 ^a	118.0 ^b	0.76	117.0	116.5	0.77	116.7	116.8	0.78	0.74
Hot carcass weight, kg ^e	-	-	0.39	-	-	-	90.6 ^a	91.5 ^b	0.33	0.02
Spacious Env.	91.3 ^d	89.8 ^c								
Crowded Env.	91.7 ^d	91.4 ^d								
Dressing percentage ^e	-	-		-	-	-	77.6 ^a	78.4 ^b	0.29	0.03
Spacious Env.	78.2 ^d	77.0 ^c	0.34							
Crowded Env.	78.6 ^d	78.3 ^d								
Carcass length, cm ^e	82.5	82.8	0.43	82.7	82.6	0.43	82.7	82.6	0.42	0.11
Tenth rib	20.2	21.7	0.72	20.8	21.0	0.70	22.5 ^b	19.3 ^a	0.70	0.98
Loin eye depth, cm ^e	6.87 ^b	6.66 ^a	0.072	6.68	6.86	0.070	6.60 ^a	6.93 ^b	0.071	0.87
Loin eye area, cm ^{2e}	47.9 ^b	44.9 ^a	0.74	45.4	47.4	0.73	44.2 ^a	48.6 ^b	0.73	0.30

^{ab} Means in the same row with differing superscripts differ, $P \leq 0.05$.

^{cd} Interaction means with differing superscripts differ, $P \leq 0.05$.

^e Measurements corrected to a slaughter weight of 116.7 kg using covariance analysis.

^f Genotype by environment interaction.

Table 2. Least square means for the effects of sire line, environment and sex on pork quality characteristics measured on the longissimus.

Variable	Sire line			Environment			Sex			G × E ^f
	Line A	Line B	Av. SE	Spacious	Crowded	Av. SE	Barrows	Gilts	Av. SE	P value
45 min. pH	6.19 ^a	6.37 ^b	0.062	6.29	6.27	0.062	6.19	6.37	0.062	0.22
24 hr. pH	5.43 ^a	5.48 ^b	0.018	5.45	5.45	0.017	5.46	5.44	0.017	0.22
Color ^e	2.0 ^a	2.5 ^b	0.11	2.1	2.4	0.11	2.5 ^b	2.0 ^a	0.11	0.31
Firmness ^e	2.0 ^a	2.4 ^b	0.12	2.2	2.2	0.12	2.4 ^b	2.0 ^a	0.11	0.98
Marbling ^e	1.9 ^a	2.3 ^b	0.13	2.1	2.2	0.12	2.5 ^b	1.7 ^a	0.12	0.83
Minolta L [*]	49.37 ^b	47.42 ^a	0.647	49.61 ^b	47.17 ^a	0.643	48.10	48.69	0.627	0.39
Minolta a [*]	6.04	5.76	0.725	5.56	6.24	0.726	5.95	5.85	0.720	0.34
Minolta b [*]	8.36 ^b	7.54 ^a	0.378	8.09	7.81	0.381	7.92	7.99	0.373	0.51
Drip loss, %							5.87	6.83	0.434	0.04
Spacious env.	6.96 ^d	6.69 ^d	0.616							
Crowded env.	7.29 ^d	4.46 ^c								
Cooking loss, %	23.22	23.04	0.669	23.26	23.00	0.666	23.04	23.22	0.647	0.08
Warner Bratzler shear, kg	4.76	4.96	0.234	4.77	4.96	0.242	4.80	4.93	0.234	0.89

^{ab} Means in the same row with differing superscripts differ, $P \leq 0.05$.

^{cd} Interaction means with differing superscripts differ, $P \leq 0.05$.

^e Subjective color, firmness, and marbling scores where 1 =pale, soft and devoid of marbling and 5=dark, firm and moderately abundant marbling.

^f Genotype by environment interaction.

Table 3. Least square means for the effects of sire line, environment, and sex on ham curing characteristics.

Variable	Sire line			Environment			Sex		G × E ⁱ	
	Line A	Line B	Av. SE	Spacious	Crowded	Av. SE	Barrows	Gilts	Av. SE	P value
Green weight, kg	-	-		10.5	10.6	0.38	10.1 ^a	11.0 ^b	0.38	0.02
Spacious env.	11.0 ^d	9.9 ^c	0.43							
Crowded env.	10.5 ^{gc}	10.8 ^d								
Pumped weight ^e , kg	13.3	13.2	0.06	13.2	13.2	0.06	13.2	13.2	0.06	0.70
Pump percentage ^{ef}	25.2 ^b	24.0 ^a	0.54	24.4	24.8	0.54	24.5	24.6	0.54	0.89
Cooked weight ^{ch} , kg	11.8	11.9	0.02	11.9	11.9	0.02	11.9	11.9	0.02	0.83
Yield ^{egh} , %	111.5	111.6	0.16	111.6	111.5	0.16	111.5	111.7	0.16	0.34

^{ab} Means within a row with differing superscripts differ significantly, $P < 0.05$.

^{cd} Interaction means with differing superscripts differ, $P \leq 0.05$.

^e All measurements corrected to a green ham weight of 10.6 kg using covariance analysis.

^f Pump percentage = ((pumped weight - green weight)/green weight) x 100.

^g Yield = (cooked weight/green weight) x 100.

^h Cooked weight and yield are corrected to a pump percentage of 24.6 using covariance analysis.

ⁱ Genotype by environment interaction.