

Effect of the Halothane and Rendement Napole Genes on Carcass and Meat Quality Characteristics of Pigs.

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Introduction

Meat quality is affected by a number of factors such as environment, nutrition and genetics. The Halothane and RN genes impact animal performance, carcass composition and pork quality. The Halothane gene offers producers a rapid way of producing lean, heavily muscled market hogs that will receive higher packer premiums. However, Halothane reactor and carrier animals have poorer meat quality and processing characteristics, when compared to Halothane negative pigs. The meat quality problems associated with the Halothane gene result from a high incidence of the pale, soft, exudative (PSE) condition. Animals that carry the dominant allele of the Rendement Napole gene (RN⁻) have been found to produce paler meat with reduced water holding capacity and processing yields. However, RN⁻ carriers have also been found to have higher carcass lean meat percentages and lower shear force values, indicating more tender meat. Thus, both the Halothane and RN genes independently have both negative and positive effects on carcass and meat quality and because of their different modes of action may have a greater combined effect on meat quality. However, there have been no studies that have characterized the impact of both genes in combination. Thus, the objective of this study was to determine the effects of and potential interactions between the Halothane and Rendement Napole genes on carcass and meat quality characteristics in pigs.

Materials and Methods

Animals for this study were bred and reared at the Moorman Swine Farm at the University of Illinois. Semen from Halothane carrier Hampshire sires (n = 9) was obtained from three boar studs and used to artificially inseminate dams (10 dams/sire) that were homozygous normal at both the Halothane and RN loci (NN/rn⁺rn⁺).

Biopsy sampling, Halothane genotyping and glycolytic potential determination. At approximately 40 kg live weight, a total of 200 pigs had a sample of longissimus removed using spring loaded biopsy equipment. The skin was trimmed from the sample and was used for the determination of Halothane genotype, using the method outlined by Fujii et al. (1991). Glycolytic potential on the longissimus sample was determined by enzymatic assay. Metabolite concentrations for glucose, glucose-6-phosphate, glycogen and lactate were determined. Glycolytic potential was calculated using the formula described by Monin and Sellier (1985): Glycolytic potential (umoles/g wet tissue) = 2([glycogen] + [glucose-6-phosphate] + [glucose]) + [lactate].

A frequency distribution for the glycolytic potential values for the population was plotted and animals were classified as having low or high glycolytic potential on the basis of this distribution.

Animals: Boars that sired litters with both a bimodal distribution for glycolytic potential and with both Halothane carrier and normal pigs were considered to be heterozygous for the RN and Halothane genotypes (Nn/RN rn⁺). Four of the original nine boars were found to be heterozygous at both loci and

only progeny from these sires and litters with at least eight pigs were used in this study. Animals were classified into four genotypes on the basis of the results of the Halothane test and the glycolytic potential values: 1) Halothane and RN normal (NN/rn^+rn^+) ($n = 31$); 2) Halothane carrier and RN normal (Nn/rn^+rn^+) ($n = 27$); 3) Halothane normal and RN carrier (NN/RN^-rn^+) ($n = 30$); and 4) Halothane carrier and RN carrier (Nn/RN^-rn^+) ($n = 23$).

Trial design. Four genotypes and two sexes were evaluated in a 4×2 factorial arrangement with a total of 111 animals being used. At 120 kg live weight, animals were taken off feed and transported to a commercial slaughter facility which was located approximately 150 miles from the farm. Animals were weighed before loading and mixed in one group during transport and in the lairage. At the slaughter plant, pigs were held for approximately 16 h prior to slaughter without food but with access to water. Slaughter and carcass dressing was carried out using standard commercial procedures.

Carcass and meat quality evaluation. At 24-h postmortem, cold carcass weight was recorded, and standard carcass measurements were obtained from the left side of each carcass. Longissimus pH was measured at 45 min and 24-h postmortem. Subjective scores for longissimus color, firmness, and marbling were taken on the cut surface of the loin at the tenth rib using the procedures described by NPPC (1991) using 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. Two loin chops (2.5 cm thick) were cut from the longissimus immediately posterior to the 10th rib with one chop being used to determine drip loss and the other for chemical analysis. A section of the loin 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 4EC, cut into 2.5 cm thick chops, and frozen (-20EC).

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 4EC, and cooked to an internal temperature of 70EC. The chops were weighed before and after cooking to determine cooking loss. Shear force was measured on three cores from each chop.

Results

Cluster analysis indicated that the breakpoint between the two parts of the bimodal distribution for loin glycolytic potential was at 225 $\mu\text{mol/g}$. Animals ($n = 55$) with glycolytic potential greater than 225 $\mu\text{mol/g}$ were considered to be carriers of the RN^- allele (RN^-rn^+), while pigs ($n = 56$) with glycolytic potential less than 225 $\mu\text{mol/g}$ were considered to be homozygous normal (rn^+rn^+).

RN gene effects. No differences were found between RN carrier ($_ _ / RN^-rn^+$) and normal ($_ _ / rn^+rn^+$) animals for carcass measurements (Table 1). Few studies have reported the effects of the RN gene on carcass characteristics and the results of these are conflicting, with some showing a reduced backfat thickness and increased carcass lean content for pigs with the dominant allele (LeRoy et al., 1996) and others showing no effect of the RN gene (Enfalt et al., 1997a; Enfalt et al., 1997b). In the current study, pigs carrying the RN^- allele ($_ _ / RN^-rn^+$) had significantly lower ultimate pH, higher longissimus L^* and b^*

values, and greater drip loss and cooking loss than homozygous recessive animals (nn/rn^+rn^+ ; Table 2).

Halothane gene effects. No difference ($P > .05$) was observed for dressing percentage between Halothane carrier and normal genotypes (Table 1). Halothane carrier ($Nn/_ _$) animals had significantly shorter carcasses than Halothane normal ($NN/_ _$) animals. Backfat thickness measurements did not differ among the Halothane genotypes. Halothane carrier pigs had lower longissimus ultimate pH compared to normal animals ($NN/_ _$) (Table 2) which is consistent with other studies in the literature (Jones et al., 1994; Leach et al., 1996). In contrast, Pommier et al. (1998) and Tam et al. (1998) found no significant differences in ultimate pH between Halothane genotypes. Halothane carriers ($Nn/_ _$), in comparison to homozygous normal animals ($NN/_ _$), had higher L^* , b^* and drip loss values (Table 2), indicating paler meat with less water-holding capacity.

RN and Halothane interaction effects. There were no significant RN H Halothane interactions for any of the carcass measurements. However, the interaction between RN and Halothane genotype was significant for subjective color, firmness and marbling scores (Table 2), suggesting that the effects of the two genes were not additive for these traits. Pigs that were normal for both genes (NN/rn^+rn^+) had higher values for subjective color, firmness and marbling (Table 2), indicating darker, firmer muscle compared to the other three genotypes, which were similar in these respects. Thus, the detrimental alleles of the two genes, either singly or in combination, resulted in similar subjective longissimus color, firmness and marbling. In contrast, the Halothane by RN gene interaction was not significant for ultimate pH, Minolta L^* values, or drip loss (Table 2) suggesting that effects of the genes were additive for these traits and that animals that were carriers of both detrimental alleles produced the meat with the lowest ultimate pH, the lightest color, and the greatest drip loss of all of the genotypes evaluated. There was a RN H Halothane interaction ($P < .05$) for shear force (Table 2) with pigs that were homozygous normal at both loci (NN/rn^+rn^+) having the highest values suggesting tougher meat compared to the three genotypes, which were similar in this respect.

Sex effects. There were no differences between the sexes for carcass weight, dressing percentages or carcass length (Table 1). Gilts had less backfat at the 10th rib, and last lumbar vertebra and greater loin eye depth and area compared to barrows. These results are similar to most other studies (Ellis et al., 1996; Leach et al., 1996). Gilts had lower subjective marbling scores than barrows (Table 2). Minolta b^* values were higher for barrows (Table 2); however, there were no differences between the sexes for any other meat quality traits. Other studies have generally found little difference in muscle quality between barrows and gilts (Barton-Gade, 1987; Leach et al., 1996).

Conclusions

1. Gilts have significantly less backfat and greater loin eye area when compared to barrows with no difference in meat quality measurements.
2. This study suggest that the RN and Halothane genes have little or no effect on carcass leanness or dressing percent. However, other studies have reported slight advantages in these carcass

measurements for RN and Halothane animals.

3. The RN and Halothane genes independently have negative effects on muscle color and water-holding capacity. The lack of any interaction between the two genes for longissimus ultimate pH, objective color, and drip loss suggest that these genes in combination may have a greater effect on pork quality.

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Table 1. Least square means for RN and Halothane genotypes and sex for slaughter and carcass measurements

Variable	RN genotype		Halothane genotype		Sex		AVG SE	Level of Significance ^a			
	— _/_m ⁺ m ⁺	—/_RN _/_m ⁺	NN/_/_	Nn/_/_	Barrows	Gilts		RN	Hal	Sex	RN H Hal
	Slaughter weight, kg	119.2	118.2	118.8	118.6	121.7		115.7	3.10	NS	NS
Cold carcass weight, kg	87.2	86.9	87.4	86.7	87.5	86.6	1.14	NS	NS	NS	NS
Dressing percentage	73.8	73.6	74.1	73.4	74.1	73.3	1.12	NS	NS	NS	NS
Carcass length, cm	82.3	82.2	82.7	81.8	82.3	82.2	.44	NS	*	NS	NS
Backfat depth, mm											
Tenth rib	23.5	22.6	23.0	23.1	26.0	20.2	1.16	NS	NS	***	NS
Loin eye area, cm ²	43.7	43.3	42.6	44.5	41.5	45.5	1.36	NS	NS	***	NS

^a NS, *, **, *** = not significant, P < .05, P < .01, P < .001, respectively.

Table 2. Least square means for RN and Halothane genotypes and sex for meat quality measurements taken on the longissimus

Variable	RN genotype		Halothane genotype		Sex		AVG SE	Level of Significance ^e			
	__/_rn ⁺ m ⁺	__/_RN ⁺ m ⁺	NN/__	Nn/__	Barrows	Gilts		RN	Hal	Sex	RN H Hal
Ultimate pH	5.50	5.26	5.45	5.32	5.37	5.39	.044	***	***	NS	NS
Color ^d					2.12	2.01	.149	*	*	NS	**
NN/__	2.60 ^b	1.85 ^a					.181				
Nn/__	1.88 ^a	1.95 ^a					.192				
Firmness ^d					2.18	2.09	.149	NS	*	NS	*
NN/__	2.53 ^b	2.10 ^a					.182				
Nn/__	2.03 ^a	1.89 ^a					.182				
Marbling ^d					1.80	1.52	.124	NS	*	*	**
NN/__	2.11 ^b	1.53 ^a					.153				
Nn/__	1.44 ^a	1.55 ^a					.152				
Minolta L [*]	50.29	54.50	50.69	54.10	53.42	51.38	1.350	***	***	NS	NS
Minolta a [*]	8.75	8.71	8.76	8.71	9.00	8.47	1.230	NS	NS	NS	NS

Minolta b [*]	7.28	9.13	7.51	8.90	8.72	7.69	1.061	***	***	NS	NS
Drip loss, %	4.67	7.02	5.11	6.59	6.08	5.62	.892	***	**	NS	NS
Cooking Loss, %	23.99	26.26	24.61	25.65	24.46	25.80	.770	**	NS	NS	NS
Warner Bratzler Shear, kg					3.83	4.09	.121	*	NS	NS	*
NN/_ _	2.11 ^b	1.53 ^a					.172				
Nn/_ _	1.44 ^a	1.55 ^a					.171				

^{ab} Means with differing superscripts for a RN and Halothane interaction differ ($P < .05$).

^c NS, *, **, *** = not significant, $P < .05$, $P < .01$, $P < .001$, respectively.

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