

# The Effect of the Time of Feeding Prior to Slaughter of Supplemental Magnesium Sulfate Heptahydrate on Pork Quality.

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## Introduction

Australian research has shown that including magnesium aspartate in the diet of pigs during the final five days of the finishing period before slaughter reduced the incidence of Pale, Soft, and Exudative (PSE) pork thus improving the color and water holding capacity of the pork (D-Souza et al., 1998). In a follow up study (D-Souza et al., 1999), magnesium sulfate and magnesium chloride were found to be as effective as magnesium aspartate in reducing both the incidence of PSE and muscle drip loss. However, these studies were carried out with entire males slaughtered at relatively light weights (less than 90 kilogram live weight). Research is required to validate the effect of magnesium supplementation on pork quality under US production conditions which includes castrated males and heavier slaughter conditions.

Thus, the objective of this study was to compare the effect of time feeding before slaughter of a fixed level of supplemental magnesium on pork quality.

## Materials and Methods

*Study design.* The study was carried out as a completely randomized design with four dietary treatments:

Control:	Control diet-no added magnesium sulfate heptahydrate
5 d:	Magnesium sulfate heptahydrate-fortified diet fed for 5 days pre-slaughter
3 d:	Magnesium sulfate heptahydrate-fortified diet fed for 3 days pre-slaughter
2 d:	Magnesium sulfate heptahydrate-fortified diet fed for 2 days pre-slaughter

The magnesium sulfate-fortified diet was formulated to supply 3.2 grams of magnesium per pig per day (assuming a daily feed intake of 2.72 kilograms/pig and that the magnesium content of sulfate was 9.6% as analyzed). Diet composition and calculated analysis are presented in Table 1.

*Animals.* A total of 144 pigs were used in the study which was carried out in three replicates with 36 pigs in each of replicates 1 and 2 and 72 pigs in replicate 3. The pigs used were the progeny of PIC line 326 sires mated to C22 dams (Replicates 1 and 2) and PIC line 406 sires mated to C22 dams (Replicate 3). Barrows (n = 50) and gilts (n = 94) were balanced across magnesium treatments. Prior to the start of the study, pigs were reared under standard commercial conditions. Pigs for each replication were selected one week prior to the start of the study period at approximately 105 kilograms live weight. They were allotted to treatment on the basis of sex, weight, Rendement Napole (RN) genotype, Halothane genotype and feed intake (determined in the acclimation phase).

*RN and Halothane genotype determination.* The pigs used in replicates 1 and 2 were from a population within which the RN gene was segregating. Animals used in replicate 3 were from a population within which the RN and Halothane genes were segregating. Both of these genes are known to have a major impact on pork quality and, consequently, only Halothane negative pigs were selected for replicate 3. Pigs were allotted across treatments on the basis of RN genotype for all replicates. The RN and Halothane genotypes were determined from a biopsy sample of skin, fat and muscle taken from the longissimus at approximately 40 kg live weight using spring loaded biopsy equipment (Biotech PPB-U, Nitra, Slovakia). The muscle sample was used to determine glycolytic potential which is the basis for predicting RN genotype while the skin was used to determine Halothane genotype. A frequency distribution for the glycolytic potential values for the population tested was plotted and animals were classified as having low or high glycolytic potential on the basis of this distribution. Samples with glycolytic potential greater than 200 F mol/g for replicates 1 and 2 and greater than 210 F mol/g for replicate 3 were considered to be RN carriers (RN<sup>-</sup>rn<sup>+</sup>); those with glycolytic potentials below 200 F mol/g for replicates 1 and 2 and below 210 F mol/g for replicate 3 were considered to be homozygous normal (rn<sup>+</sup>rn<sup>+</sup>) for the RN gene.

*Housing and Feeding.* Animals were housed in one of two identical buildings with 36 individual pens in each building. The environment within the building was controlled using a thermostat and fan ventilation. Pen dimensions were .91 x 1.83 meters giving a floor space allowance of 1.67 meters<sup>2</sup>/pig. Pigs were moved into the building seven days prior to the start of the study. Feed in the form of a standard pelleted finisher diet (Control diet; Table 1) was offered ad libitum prior to the start of the study from a single-space feeder and water was freely available from a nipple waterer. A restricted feeding regime was used with pigs being given 2.75 kg/pig/day throughout the trial period.

The same finisher diet formulation used in the acclimation period was used for all treatments during the trial period (Table 1). Magnesium sulfate heptahydrate was used as the magnesium source. The magnesium-supplemented diet was substituted for the control diet on days 1, 3 and 4 of the trial period for the five-, three-, and two-day treatments, respectively. Pigs on the control treatment were fed the control diet for the entire trial period; pigs on the five-day treatment were fed the magnesium diet on days 1 to 5 of the trial period; pigs on the three-day treatment were fed the control diet on days 1 and 2 and the magnesium diet on days 3 to 5 of the trial period; pigs on the two-day treatment were fed the control diet for days 1 to 3 and the magnesium diet on days 4 and 5 of the trial period. The pigs on the magnesium sulfate heptahydrate-fortified diets were offered the experimental diet at 6:00 am on the day they started their respective treatment. During the experimental period, feed additions and refusals were measured on a daily basis. All pigs on test were weighed at the start of each feeding period (days 1, 3, and 4) and at end of the experimental period immediately prior to transport for slaughter. All pigs were health checked and fecal consistency scores were taken (1 = normal; 2 = slight looseness; 3 = moderate looseness; 4 = significant scouring) on a daily basis. General comments concerning pig behavior were also recorded throughout the trial period.

*Slaughter and carcass evaluation.* Slaughter was performed at a commercial packing facility with animals being transported to the plant on the morning of the final day of the experimental period. Pre-slaughter handling was standardized and reflected commercial conditions. Pigs were mixed and loaded onto a livestock trailer at 6:00 am, and transported directly to the packing facility. Slaughter took place on the same day as soon as possible after arrival at the plant. Pigs for all replicates were taken to the kill floor approximately 15 minutes after arrival in order to minimize the time in lairage. Hot carcass weights and carcass Fat-o-Meater measurements were collected on the slaughter line.

Following overnight chill, carcass measurements were taken, including carcass length (measured from the cranial tip of the aitch bone to the cranial edge of the first rib adjacent to the thoracic vertebra), midline fat measurements (opposite the first rib, last rib, and last lumbar vertebra), 10<sup>th</sup> rib fat depth (measured at one-half the distance from the midline) and loin eye area at the 10<sup>th</sup> rib.

At 24-h postmortem the loin from the left side of each carcass was removed and transported to the University of Illinois Meat Science Laboratory for meat quality assessment. Subjective color, firmness, and marbling were evaluated on the cut surface of the longissimus at the 10<sup>th</sup> rib using the procedures of NPPC (1991), based on five point scales (1 = pale, soft and devoid of marbling; 5 = dark, firm, and moderately abundant or greater marbling). Hunter color (L\*, a\*, and b\*) was also measured on the cut surface of the loin section at the 10<sup>th</sup> rib using a Hunter LabScan Spectrocolorimeter. Two loin chops were cut from the longissimus immediately posterior to the 10<sup>th</sup> rib and trimmed of epimysium and external fat. One chop was weighed, placed in a Whirl-pak bag, suspended in a cooler (4EC) for 48 hours, reweighed, and drip loss was recorded.

A 5-gram sample was removed from the second chop, homogenized in 15 milliliters of distilled water, and the pH measured. The remainder of the chop was homogenized, placed in a Whirl-pak bag, and frozen (-20EC) for subsequent proximate analysis. The remaining loin sections (anterior and posterior to the 10<sup>th</sup> rib) were weighed, vacuum packaged, and stored in a cooler (4EC) for six days, reweighed and purge loss calculated.

## **Results and Discussion**

The results relating to the diet composition, growth performance, carcass characteristics, and meat quality for all animals used in the study are presented in Table 1, 2, 3 and 4, respectively. Generally speaking, the treatment effects were similar across the replicates and, therefore, only the combined results for all replicates will be discussed in this report.

*Magnesium Treatment Effects.* Diets were analyzed in duplicate for crude protein, lysine, calcium, phosphorus, and magnesium. Both diets were similar in crude protein, lysine, calcium and phosphorus. Analyzed magnesium levels in the control and magnesium sulfate-supplemented diets were .12% and .24%, respectively (Table 1). This equates to a daily magnesium intake of 3.3 and 6.6 g for pigs on the control and magnesium-sulphate supplemented diets, respectively.

No differences were found between magnesium treatments for growth performance (Table 2) or carcass characteristics (Table 3). Barrows had heavier hot carcass weights, and were fatter at the 10<sup>th</sup> rib and last lumbar vertebrae than gilts, results that are in line with most other studies.

Treatment and sex means for fresh meat quality measurements are presented in Table 4. No interactions between magnesium treatment and sex were detected for any of the meat quality measurements. There were no treatment differences for ultimate pH, marbling scores, Hunter a\* and b\* values, and purge loss. Pigs on the three-day supplementation treatment had lower subjective color scores, indicating paler meat, compared to the other treatments which were similar in this respect. Subjective firmness scores were lower for pigs on the control and three-day treatments indicating softer muscle compared to the other two treatments.

Relative to controls, feeding the magnesium-supplemented diets for five and two days prior to slaughter resulted in a decrease in Hunter L\* values. In addition, drip loss was reduced for all of the periods of magnesium supplementation compared to the control treatment (Table 4).

*Rendement Napole Gene Effects.* Generally speaking, the effects of the RN gene found in this study were similar to those observed in most other research carried out at this and other centers. There was no effect of the gene on growth performance (Table 2). Backfat thickness at the last lumbar vertebra and tenth rib was lower for RN carriers (RN<sup>+</sup>m<sup>+</sup>) than for homozygous recessive animals (m<sup>+</sup>m<sup>+</sup>; Table 3). In addition, RN carriers had lower ultimate pH and increased purge and drip loss compared to homozygous recessive pigs (Table 4). Most other studies have shown that the dominant allele of the RN gene (RN<sup>-</sup>) is associated with a lower muscle pH and reduced water holding capacity.

There were no statistically significant interactions between magnesium treatment and RN genotype for any of the variables measured in this study (Tables 2, 3 and 4) suggesting that the improvements in pork quality resulting from supplementary magnesium would be similar across the range of RN genotypes currently found in the US industry.

*General observations.* As a consequence of the restricted feeding regime that was used in this study, all pigs consumed the majority of their daily feed allowance in the morning, resulting in an average time off feed prior to slaughter of approximately 18 to 24 hours. No differences between the treatments were observed in the general health of the animals and the fecal consistency was considered normal for all animals throughout the study period.

#### *Conclusions.*

1. The results of this study suggest that the feeding of a fixed level of magnesium (3.3 g/pig/day) to finishing pigs for periods of up to five days prior to slaughter has no effect on animal health, fecal consistency, growth performance or carcass characteristics.
2. Feeding supplemental magnesium sulfate heptahydrate for periods of two, three, and five days resulted in a reduction in drip loss; objective muscle reflectance (Hunter L\*) was reduced for the five- and two-day treatments only.
3. Despite these improvements in color and water holding capacity, purge loss, as measured in this study, was not influenced by magnesium supplementation, a result that requires further investigation.

4. The lack of a statistical interaction between magnesium treatment and RN genotype suggests that the improvement in pork quality resulting from the supplemental magnesium treatment would be similar for all RN genotypes. The RN gene has only been observed in the Hampshire breed where the incidence of the dominant allele is generally high in US populations. This study suggests that any beneficial effect of magnesium supplementation will be independent of the RN gene status of the population in which it is used.

5. Overall, these results support the hypothesis that feeding supplemental magnesium (at a level of 3.3 g/pig/day) for periods between two and five days prior to slaughter can improve pork color and drip loss. However, further studies are required to establish the optimum combination of level of supplementation and time of feeding to improve these quality attributes.

### **References**

D-Souza, D. N., R. D. Warner, B. J. Leury, and F. R. Dunshea. 1998. The effect of dietary magnesium aspartate supplementation on pork quality. *Journal of Animal Science* 76:104.

D-Souza, D. N., R. D. Warner, F. R. Dunshea, and B. J. Leury. 1999. Comparison of different dietary magnesium supplements on pork quality. *Meat Science* 51:221.

*Table 1. Percentage composition<sup>a</sup> and calculated analysis of experimental finisher diets.*

	Control Diet		Magnesium Sulfate Diet	
<u>Ingredient</u>				
Corn	81.12		79.65	
Soybean meal (dehulled)	15.70		15.95	
Fat	1.00		1.00	
Limestone	0.85		0.85	
Di-calcium phosphate	0.80		0.80	
Trace mineral salt <sup>b</sup>	0.30		0.30	
Vitamin mix <sup>c</sup>	0.10		0.10	
L-Lysine HCl	0.13		0.13	
Magnesium sulfate heptahydrate	-		1.22	
<u>Composition</u>	<u>Calculated</u>	<u>Analyzed</u>	<u>Calculated</u>	<u>Analyzed</u>
Crude protein, %	14.55	13.75	14.55	14.38
Lysine, %	.787	.83	.791	.89
Calcium, %	.55	.56	.55	.55
Phosphorous, %	.21 <sup>d</sup>	.52 <sup>e</sup>	.21 <sup>d</sup>	.52 <sup>e</sup>
Magnesium, %	-	.12 <sup>f</sup>	-	.24 <sup>f</sup>
ME, kcal/kg	3,346	-	3,305	-

<sup>a</sup> As-fed basis.

<sup>b</sup> Each kilogram of mix contained the following: Se, 85.7 mg; I, 100 mg; Cu, 2.3 g; Mn, 5.7 g; Fe, 25.7 g; Zn, 28.6 g; NaCl, 855 g.

<sup>c</sup> Each kilogram of mix contained the following: vitamin A, 3,000,000 IU; vitamin D3, 330,000 IU; vitamin E, 44,000 IU; vitamin K, 2.2 g; vitamin B12, 17.9 mg; riboflavin, 4.4 mg; d-pantothenic acid, 12.1 g; niacin, 16.5 g; choline chloride, 165 g; and roughage products to 1 kg.

<sup>d</sup> Expressed as % of available phosphorus.

<sup>e</sup> Expressed as % of total phosphorus.

<sup>f</sup> % magnesium determined using an Inductively Coupled Plasma (ICP) spectrometry assay.



Table 2. Least square means of growth performance for replicates 1,2 and 3 (barrows and gilts n = 139).

VARIABLE	Dietary Treatment <sup>a</sup>				Ave SE	P Value	Sex		Ave SE	P Value	RN Genotype			
	Control	5 day	3 day	2 day			Barrows	Gilts			m <sup>+</sup> m <sup>-</sup>	RN <sup>+</sup> m <sup>-</sup>	Ave SE	P Value
Start weight <sup>b</sup> , kg	122.7	121.3	122.1	119.4	1.53	.42	122.0	120.7	1.13	.44	123.0 <sup>f</sup>	119.7 <sup>e</sup>	1.12	.03
End weight <sup>c</sup> , kg	124.9	123.8	125.2	122.2	1.43	.41	124.2	123.9	1.05	.86	125.3	122.7	1.04	.07
Average daily gain <sup>d</sup> , kg	.465	.504	.629	.578	.0945	.61	.433 <sup>e</sup>	.655 <sup>f</sup>	.0696	.03	.474	.614	.0690	.14
Average daily feed intake, kg	2.72	2.75	2.75	2.75	.010	.07	2.74	2.75	.007	.40	2.75	2.74	.007	.13

<sup>a</sup> Dietary treatment: Control = standard finisher diet fed 5 days before slaughter.

5 Day = magnesium diet fed 5 days before slaughter.

3 Day = magnesium diet fed 3 days before slaughter.

2 Day = magnesium diet fed 2 days before slaughter.

<sup>b</sup> Start of trial period (Day 1).

<sup>c</sup> End of trial period (Day 6 before shipping).

<sup>d</sup> Calculated using start and end weights from trial period.

<sup>ef</sup> Means with common superscript do not differ (P>.05).

Table 3. Least square means of carcass traits for replicates 1,2 and 3 (barrows and gilts, n = 139).

VARIABLE	Dietary Treatment <sup>a</sup>				Ave SE	P Value	Sex		Ave SE	P Value	RN Genotype			
	Control	5 day	3 day	2 day			Barrows	Gilts			m <sup>+</sup> m <sup>+</sup>	RN <sup>-</sup> m <sup>+</sup>	Ave SE	P Value
Slaughter weight, kg	126.4	124.3	125.1	124.0	1.37	.60	126.8 <sup>d</sup>	123.1 <sup>c</sup>	1.01	.02	126.7 <sup>d</sup>	123.2 <sup>e</sup>	1.00	.01
Hot carcass weight, kg	93.8	94.0	94.2	92.5	1.29	.74	96.1 <sup>d</sup>	91.2 <sup>c</sup>	.97	.00	94.9	92.4	.96	.06
Dressing percent	74.2	74.9	74.7	74.5	.58	.80	75.0	74.2	.44	.25	74.8	74.4	.43	.43
Carcass length, cm	85.5	84.2	83.8	84.5	.54	.16	84.3	84.7	.40	.45	84.5	84.4	.40	.83
First rib backfat, cm	4.14	3.87	4.12	4.09	.185	.71	4.16	3.96	.139	.35	4.16	3.96	.139	.40
Last rib backfat, cm	2.83	2.90	2.87	2.69	.136	.65	2.92	2.72	.102	.20	2.89	2.76	.100	.35
Last lumbar backfat, cm	2.01	2.16	1.99	2.27	.123	.26	2.23	1.98	.091	.06	2.23 <sup>d</sup>	1.98 <sup>e</sup>	.090	.04
10 <sup>th</sup> rib backfat, cm	2.22	2.48	2.17	2.21	.127	.30	2.45 <sup>d</sup>	2.09 <sup>e</sup>	.095	.01	2.43 <sup>d</sup>	2.11 <sup>e</sup>	.094	.01
Loin eye area, cm <sup>2</sup>	40.76	40.96	42.99	41.04	.886	.22	40.70	42.17	.654	.13	41.09	41.78	.648	.44
Carcass muscle score <sup>b</sup>	2.1	2.1	2.3	2.2	.09	.26	2.2	2.2	.06	.88	2.2	2.2	.06	.78

<sup>a</sup> Dietary treatment: Control = standard finisher diet fed 5 days before slaughter

5 Day = magnesium diet fed 5 days before slaughter

3 Day = magnesium diet fed 3 days before slaughter

2 Day = magnesium diet fed 2 days before slaughter

<sup>b</sup> Carcass muscle score: 1=thin to 3=thick

<sup>cd</sup> Means with common superscript within the same row do not differ (P>.05).

Table 4. Least square means of fresh meat quality traits in the longissimus for replicates 1,2 and 3 (barrows and gilts, n = 139).

VARIABLE	Dietary Treatment <sup>a</sup>				Ave SE	P Value	Sex		Ave SE	P Value	RN Genotype			
	Control	5 day	3 day	2 day			Barrows	Gilts			m <sup>+</sup> m <sup>+</sup>	RN <sup>-</sup> m <sup>+</sup>	Ave SE	P Value
Ultimate pH	5.38	5.43	5.40	5.42	.023	.33	5.41	5.40	.017	.76	5.45 <sup>d</sup>	5.36 <sup>c</sup>	.017	.00
Color <sup>b</sup>	2.65 <sup>c d</sup>	2.81 <sup>d</sup>	2.39 <sup>c</sup>	2.76 <sup>d</sup>	.112	.02	2.66	2.64	.082	.90	2.70	2.60	.08	.39
Firmness <sup>b</sup>	2.02 <sup>c</sup>	2.42 <sup>d</sup>	2.20 <sup>c d</sup>	2.58 <sup>d</sup>	.124	.01	2.23	2.38	.091	.25	2.37	2.25	.091	.33
Marbling <sup>b</sup>	2.18	2.19	2.09	1.99	.155	.76	2.22	1.99	.114	.18	2.11	2.11	.113	.97
Hunter L*	55.7 <sup>d</sup>	53.9 <sup>c d</sup>	55.5 <sup>d</sup>	52.8 <sup>c</sup>	.738	.02	54.8	54.2	.54	.46	54.1	54.9	.54	.26
Hunter a*	7.4	7.3	7.3	7.7	.22	.51	7.4	7.4	.16	.85	7.4	7.4	.16	.70
Hunter b*	15.3	14.9	15.1	15.0	.22	.69	15.2	15.0	.16	.33	15.1	15.1	.16	.91
Drip loss, %	8.98 <sup>d</sup>	7.41 <sup>c</sup>	7.89 <sup>c d</sup>	7.29 <sup>c</sup>	.447	.04	7.86	7.93	.329	.89	7.43 <sup>c</sup>	8.35 <sup>d</sup>	.327	.04
Purge loss, %	2.12	2.01	2.25	2.03	.131	.51	2.04	2.16	.096	.40	1.91 <sup>c</sup>	2.28 <sup>d</sup>	.096	.01

<sup>a</sup> Dietary treatment: Control = standard finisher diet fed 5 days before slaughter

5 Day = magnesium diet fed 5 days before slaughter

3 Day = magnesium diet fed 3 days before slaughter

2 Day = magnesium diet fed 2 days before slaughter

<sup>b</sup> Subjective score: 1 = extremely pale, soft, and devoid of marbling to 5 = extremely dark, firm, and abundant marbling

<sup>c d</sup> Means with common superscript within the same row do not differ (P>.05)