RESEARCHREPORT

PORK QUALITY

Title: The impact of Halothane genotype, pre-slaughter handling, and season on body temperature and its relationship with subsequent meat quality. **NPB- #97-1875**

Investigator: M. Ellis M.B.

Institution: Department of Animal Sciences, University of Illinois, Urbana 61801

Co-Investigators: England, K.L. Enright, F.K. McKeith, and R.W. Johnson

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Abstract

The study was carried out to compare the impact of Halothane genotype [negative (NN) vs. carrier (Nn) vs. reactor (nn)], pre-slaughter handling procedures (high vs. low stress) and season (summer vs. winter) on body and muscle temperatures and pork quality. Sixty-five purebred Duroc pigs (approximately 110kg live weight) were surgically implanted with VHF transmitters one week prior to slaughter to monitor body temperature. The study was replicated in both the summer and winter to investigate the effect of season. Body temperatures were monitored from the time that the animals left the farm, through the slaughter process. The pH and temperature of the *Longissimus* and *Semimembranosus* were measured from slaughter through 24 hours post mortem. Meat quality attributes were evaluated at 24 hours post mortem.

Halothane genotype effects on body temperature were relatively small. Animals exposed to high compared to low pre-slaughter stress had higher body temperatures (between +0.5 to 1.7^{o}C) from arrival at the slaughter facility through to evisceration when the measurements were terminated.

Halothane Reactors had the lowest pH values in the *Longissimus* and *Semimembranosus* muscles from 45 minutes to 24 hours post mortem. Post mortem muscle pH values for Carrier and Negative animals were generally similar. The effect of pre-slaughter stress on muscle pH decline differed between the *Longissimus* and *Semimembranosus*. There was no consistent effect of season on muscle pH decline.

Halothane Negative pigs had the highest *Longissiumus* temperature from one hour post mortem onwards and the highest *Semimembranosus* temperature from 4 to 12 hours post mortem. High pre-slaughter stress increased the temperature in the

Longissimus and *Semimembranosus* from 45 minutes to 6 and 4 hours post mortem, respectively. There was little effect of season on post mortem muscle temperature change.

Halothane reactors produced poorer meat quality, in terms of color and drip loss, than Negative pigs, with Carriers tending to be intermediate for pork quality attributes. High stress prior to slaughter increased the ultimate pH in the *Longissimus* and *Semimembranosus* but had limited effect on muscle color and drip loss. Pigs slaughtered in the winter generally produced poorer pork quality than those slaughtered in the summer with a lower ultimate pH and increased *Semimembranosus* drip loss.

Overall, Halothane Reactors produced the poorest meat quality largely as a result of a rapid decline in muscle pH in the early post mortem period rather than from any increase in body or muscle temperature. Exposing pigs to high pre-slaughter stress increased body temperatures at slaughter and muscle temperatures in the early post mortem period. However, the high stress treatment had an inconsistent effect on muscle pH decline and pork quality. Pigs slaughtered in the winter produced poorer quality meat than those slaughtered in the summer, an effect which appears independent of any association between season and either body and muscle temperatures or post mortem muscle pH changes. In this study, the link between changes in body temperature and post mortem muscle temperature changes and pork quality has not been clearly established and additional research is required to further understand these relationships.

Introduction

Pale, soft, and exudative (PSE) pork is a major problem that has an economic impact on all sectors of the swine industry (NPPC Pork Chain Quality Audit, 1994). This condition is produced by a rapid drop in pH in conjunction with high muscle temperatures immediately post mortem. This results in reduced water holding capacity and pale muscle color and associated reductions in both processing yields and the acceptability of pork products to consumers. Previous work has shown that holding carcasses at an elevated temperature for prolonged periods post mortem can produce the PSE condition in Halothane negative animals (McCaw et al., 1996). In addition, research has been conducted to show that increases in pre-slaughter body temperature will increase post mortem muscle metabolism (Klont and Lambooy, 1995). Consequently, the animal's body temperature at slaughter could have an impact on how quickly a carcass chills. It is, therefore, possible that elevated body temperatures at slaughter could also be associated with an increased incidence of PSE. However, little research has been done to establish the relationship between pre-slaughter body temperature and the incidence of PSE pork. Two factors that could impact body temperatures at slaughter are the stress susceptibility of the animals and the pre-slaughter handling regimen. This study was carried out to investigate the effects of Halothane genotype and high compared to low pre-slaughter stress on body and muscle temperatures and on the incidence of the PSE condition.

Klont, R.E. and E. Lambooy. 1995. Influence of pre-slaughter muscle temperature on muscle metabolism and meat quality in anaesthetized pigs of different Halothane genotypes. J.Anim.Sci. 73: 96-107.

McCaw, J., M. Ellis, M.S. Brewer, and F.K. McKeith. 1996. Post mortem incubation effects on pork quality. J.Anim.Sci. 75: 1547-1552.

Objectives

The objectives of this study were to:

1. Establish the effect of Halothane genotype, season, and pre-slaughter handling on pre-slaughter body temperature and on post mortem muscle temperature and pH changes.
2. Characterize the relationship between pre-slaughter body temperature and subsequent meat quality.

Materials and Methods

A total of sixty-five purebred Duroc barrows and gilts (approximately 110kg) were used in this study. The animals were produced from the mating of Halothane carrier (Nn) sires and dams which resulted in all three Halothane genotypes (i.e. Negative [NN], Carrier [Nn], and Reactor [nn]) being produced in the same litter. Halothane genotype was established using a DNA test carried out on a blood sample from each animal using the procedures outlined by Fuji et al. (1991).

Prior to the start of the study, pigs were housed in a finishing facility at the University of Illinois Moorman Swine Farm and subjected to standard management.

Animals were surgically implanted with VHF frequency transmitters (Mini-Mitter Co., Sunriver, OR) one week prior to harvest. The frequency of the signal from the transmitter is directly proportional to body temperature and frequency readings are converted into body temperature readings using previously established conversion equations. Transmitters were calibrated prior to implantation. Prior to surgery, pigs were given a general anesthetic and the transmitters were sutured to the linea alba between the superficial inguinal lymph nodes. An antibiotic with zero withdrawal time was administered daily for four days post surgery.

Two pre-slaughter handling treatments were designed to produce high and low stress. Animals were allocated across pre-slaughter stress treatments on the basis of Halothane genotype and sex. The Low Stress treatment consisted of careful handling of the animals during loading, transport, and prior to slaughter. Animals on this treatment were transported from the farm to the Meat Science Laboratory at the University of Illinois on the afternoon of the day prior to slaughter and were held in lairage for approximately 16 hours, with access to water but not food. Animals on the Low Stress treatment were slaughtered first before the High Stress treatment animals were delivered to the Meat Science Laboratory to insure no other animals were present to induce unnecessary stress. Animals on the high stress treatment remained at the farm until the morning of slaughter and were killed as soon as possible after arrival at the Meat Science Laboratory. An electric prod was used once on each animal prior to loading, during loading, during transport, during unloading, and in the final drive to stunning. In addition, animals on the High Stress treatment that were held in lairage awaiting slaughter were prodded every 10 minutes to maintain an elevated stress level.

The study was carried out in two season, namely the summer (July and August), and the winter (February). Slaughter was carried out on three occasions in the summer replicate and on two occasions in the winter replicate.

Body temperatures were measured on days two and one prior to slaughter, on the morning of harvest, prior to loading, after loading, on arrival at the slaughter facility, prior to stunning, post exsanguination, on removal from the scald tank, post singeing, and prior to evisceration. Frequency readings were converted to temperature values using established conversion equations.

Following slaughter, *Longissimus* and *Semimembranosus* temperatures were taken at .25, .33, .5, .67, .75, 1, 2, 3, 4, 6, 12, and 24 hours post mortem with a digital thermometer (Koch Supplies, Kansas City, MO). In addition, *Longissimus* and *Semimembranosus* pH was measured at .75, 1, 1.5, 2, 3, 4, 5, 6, 12, and 24 hours post mortem with an SFK pH Star probe (SFK Technologies, Cedar Rapids, IA).

Twenty-four hours post mortem, linear carcass measurements were obtained. The following traits were evaluated on the *Longissimus*: drip loss (measured over a 24 hour period), Minolta L*, a*, and b* values (taken at the D65/10^{o} settings), subjective color, firmness, and marbling (NPPC, 1991). Ultimate pH was measured on the *Longissimus* and *Semimembranosus* by homogenizing a 0.5 g sample of muscle in distilled water and taking the measurement with a pH meter (Model 720A, Orion Research, Boston, MA). *Semimembranosus* colorimeter values were obtained at three locations along the longitudinal midline of the inside surface of the muscle. The anterior reading was measured approximately four centimeters from the aitch bone, the middle reading was taken in the center of the muscle, and the posterior reading was measured approximately four centimeters from the posterior end of the muscle. After obtaining color measurements, the *Semimembranosus* was placed on its inside surface, and two perpendicular slices (2.54 cm thick) were removed. The first slice was used to face the muscle for subsequent sampling. The second slice was cut in half transversely and drip loss was measured on both the inside portion (closest to the femur), and the outside portion (closest to the external surface) by suspending the samples in a chiller for 24 hours.

Statistical analysis of the meat quality data was carried out using the PROC GLM procedure of SAS with the model used including the effects of season, Halothane genotype, and pre-slaughter handling procedure as main effects. Repeated measures analysis was used for the muscle temperature and pH data taken over time and the curves for temperature and pH changes by treatment were developed using regression analysis.

Fuji, D., K. Otsu, F. Zorgato, S. DeLeone, V.K. Khana, J.E. Weiler, D.H. MacLennan. 1991. Identification of a mutation in porcine ryanodine receptor associated with malignant hyperthermia. Sci. 253: 448-451.

Results

Carcass and meat quality.

The effects of Halothane genotype, pre-slaughter handling, and season on carcass traits, meat quality, and Minolta color values are presented in Tables 1, 2, and 3, respectively.

Halothane genotype effects: The impact of genotype on carcass characteristics was relatively limited (Table 1). Negative animals had higher leaf fat weights than Carriers and Reactors and Carrier carcasses had lower tenth rib fat depth than the other two genotypes. However, the differences between Halothane genotypes for other backfat thickness measurements were not statistically significant. Reactors had larger loin eye areas than Negative and Carrier carcasses (Table 1).

Genotype had a significant impact on meat quality characteristics (Table 2). Reactors had the lowest subjective color, firmness, and marbling scores as well as the lowest ultimate *Longissimus* pH values and the highest drip loss compared to the other two genotypes. Carriers compared to Negative animals had lower subjective marbling scores and higher *Longissimus* drip loss; however, there was no difference between these two genotypes for *Semimembranosus* drip loss (Table 2). In addition, there was no difference between the three genotypes for S*emimembranosus* ultimate pH.

Minolta L* values were consistently higher for Reactors compared to the Negative and Carrier animals which were generally similar (Table 3).

Pre-slaughter management effects: Pre-slaughter management had no impact on linear carcass measures (Table 1); however, the High Stress treatment significantly reduced subjective firmness and marbling scores (Table 2). Both *Longissimus* and S*emimembranosus* ultimate pH values were increased (by .13 and .27 pH units, respectively) by the High Stress treatment (Table 2); however, drip loss was not statistically different between the pre-slaughter stress treatments (Table 2). There was no effect of pre-slaughter stress treatment on Minolta L* or a* values; however, b* values were lower for the anterior and middle positions on the S*emimembranosus* (Table 3).

Season effects: Season differences were apparent for carcass characteristics with leaf fat weight and tenth rib fat depth being lower for animals slaughtered in the winter replicate (Table 1). Animals slaughtered in the winter had lower subjective color, firmness, and marbling scores, a lower ultimate pH in the *Longissimus* and the S*emimembranosus*, and increased drip loss in the inside section of the S*emimembranosus* compared to animals slaughtered in the summer (Table 2). In addition, Minolta L*, a* and b* values were generally higher for pigs slaughtered in the winter compared to the summer (Table 3). Thus, in this study pigs slaughtered in the winter generally had poorer fresh pork quality compared to those that were slaughtered in the summer which is the reverse of what would have been predicted based on other research. The most likely explanation of this difference is that it reflects the samples of animals used in the two seasons rather than indicating a true seasonal effect.

Body temperature and muscle temperature and pH changes.

Least squares means for the effects of Halothane genotype, pre-slaughter stress and season of slaughter on body temperature changes from the farm through to evisceration are presented in Table 4 with the regression curves for the two-way treatment interaction subclasses being illustrated in Figures 1,2, and 3, respectively. The regression equations for body temperature against time for the treatment interaction subclasses are presented in Appendix A (Tables A1, A2, and A3, respectively) with the predicted means, based on these regression equations, being given in Appendix B (Tables B1, B2, and B3, respectively).

Least squares means for the effects of Halothane genotype, pre-slaughter stress and season of slaughter on post mortem *Longissimus* pH decline are presented in Table 5 with the regression curves for the two-way treatment interaction subclasses being illustrated in Figures 4, 5, and 6, respectively. The regression equations for *Longissimus* pH against time for the treatment interaction subclasses are presented in Appendix A (Tables A4, A5, and A6, respectively) with the predicted means, based on these regression equations, being given in Appendix B (Tables B4, B5, and B6, respectively).

Least squares means for the effects of Halothane genotype, pre-slaughter stress and season of slaughter on post mortem *Semimembranosus* pH decline are presented in Table 6 with the regression curves for the two-way treatment interaction subclasses being illustrated in Figures 7, 8, and 9, respectively. The regression equations for *Semimembranosus* pH against time for the treatment interaction subclasses are presented in Appendix A (Tables A7, A8, and A9, respectively) with the predicted means, based on these regression equations, being given in Appendix B (Tables B7, B8, and B9, respectively).

Least squares means for the effects of Halothane genotype, pre-slaughter stress and season of slaughter on post mortem *Longissimus* temperature decline are presented in Table 7 with the regression curves for the two-way treatment interaction subclasses being illustrated in Figures 10, 11, and 12, respectively. The regression equations for *Longissimus* temperature against time for the treatment interaction subclasses are presented in Appendix A (Tables A10, A11, and A12, respectively) with the predicted means, based on these regression equations, being given in Appendix B (Tables B10, B11, and B12, respectively).

Least squares means for the effects of Halothane genotype, pre-slaughter stress and season of slaughter on post mortem *Semimembranosus* temperature decline are presented in Table 8 with the regression curves for the two-way treatment interaction subclasses being illustrated in Figures 13, 14, and 15, respectively. The regression equations for *Semimembranosus* temperature against time for the treatment interaction subclasses are presented in Appendix A (Tables A13, A14, and A15, respectively) with the predicted means, based on these regression equations, being given in Appendix B (Tables B13, B14, and B15, respectively).

Halothane genotype effects: Reactors had a lower temperature than the other two genotypes on the morning of slaughter, and after scalding, de-hairing, and singeing (Table 4), however, the genotype differences were relatively small and there was no difference in body temperature between Carrier and Negative animals (Table 4).

Reactors had the lowest values for *Longissimus* pH (Table 5) and *Semimembranosus* pH (Table 6) at each time of measurement from 45 minutes to 24 hours post mortem. Halothane Carrier and Negative animals generally had similar *Longissimus* and *Semimembranosus* pH values at each time of measurement (Tables 5 and 6, respectively).

Longissimus temperature did not differ between genotypes for the first hour post mortem (Table 7). Subsequently, Carriers and Reactors tended to have lower temperatures than Negative animals. Genotype had limited effects on *Semimembranosus* temperature (Table 8), with the only statistically significant differences being at four, six, and twelve hours post mortem, where temperatures were lower for Carriers compared to the other two genotypes (Table 8).

Pre-slaughter management effects: Body temperature was not impacted by stress level until the pigs arrived at the slaughter facility (Table 4). From that point through to evisceration, the High Stress treatment produced a higher body temperature than the Low Stress treatment (Table 4).

Animals exposed to High Stress pre-slaughter had lower *Longissimus* pH values from 45 minutes to 3 hours post mortem; subsequently *Longissimus* pH values were similar for the two pre-slaughter stress treatments (Table 5). In contrast, pre-slaughter stress had no impact on *Semimembranosus* pH values up to 3 hours post mortem (Table 6); subsequently, pigs on the High Stress treatment had a higher pH than those on the Low Stress treatment (Table 6).

The High Stress treatment resulted in increased *Longissimus* (Table 7) and *Semimembranosus* (Table 8) temperature through to six and four hours post mortem, respectively, after which time muscle temperatures were similar for the two pre-slaughter management treatments.

Season effects: Differences for body temperature between the Summer and Winter replicates were relatively small (Table 4). Longissimus pH was lower for the Winter treatment between 1.5 and 5 hours post mortem (Table 5). *Semimebranosus* pH values were higher for pigs slaughtered in the summer at 1.5, 2, and 5 hors post mortem, however, the differences between the seasons at other times were small (Table 6).

The temperature of the *Longissimus* (Table 7) and *Semimembranosus* (Table 8) were relatively similar for summer and winter group through to approximately 6 hours post mortem; subsequently, pigs slaughtered in the winter had lower muscle temperatures than those slaughtered in the summer (Tables 7 and 8).

Treatment interactions

Body temperature:

The body temperature curves for the two-way interaction subclasses are illustrated in Figures 1, 2, and 3. The High Stress treatment resulted in an increase in body temperature for all three Halothane genotypes (Figure 1). For pigs on the Low Stress treatment, Carriers had consistently higher body temperatures than the other two genotypes (Figure 1).

For the season by pre-slaughter management subclasses (Figure 2), the High Stress treatment produced an increase in body temperature prior to and immediately after slaughter in both the winter and summer. However, within pre-slaughter management treatment, body temperatures were generally lower in the summer than the winter (Figure 2).

Body temperatures were lower for Reactors slaughtered in the summer than for the other Halothane genotype x season treatment combinations, which had generally similar body temperature curves (Figure 3).

Longissimus pH:

The *Longissimus* pH decline curves for the two-way interaction subclasses are illustrated in Figure 4, 5, and 6. The shape of the curves were generally similar for Negative animals exposed to high and low stress and for Carriers on the Low Stress treatment (Figure 4). The other three genotype by pre-slaughter treatment combinations had much lower pH values in the early post mortem period and, consequently, reached ultimate pH earlier and had flatter decline curves (Figure 4).

Differences in the pH decline curves between the High and Low Stress treatments in the summer were relatively small (Figure 5). The curves for the winter were generally lower than those for the summer and the High Stress treatment produced consistently lower *Longissimus* pH values than the Low Stress treatment in the winter (Figure 5).

Reactors had lower *Longissimus* pH during the first 6 hours post mortem than the other two genotypes in both the winter and the summer and reached their ultimate pH very early post slaughter (Figure 6). Negative and Carrier animals slaughtered in the summer had higher *Longissimus* pH than those slaughtered in the winter in the first 6 hours post mortem (Figure 6).

Semimembranosus pH:

Semimembranosus pH decline curves for the the two-way interaction subclasses are illustrated in Figure 7, 8, and 9. Halothane reactors on both the low and high stress treatments reached their ultimate pH by 45 minutes post mortem and had lower pH values early post mortem than the other genotype x pre-slaughter management treatment subclasses (Figure 7). Negative pigs on the High Stress treatment had higher pH values at all times of measurement than Negative animals on the Low Stress treatment with Carrier animals tending to be intermediate (Figure 7).

The *Semimembranosus* pH decline curves for pigs on the High Stress treatment killed in either the summer or winter were similar and higher than those for pigs on the Low Stress treatment (Figure 8)

Reactor pigs killed in either the summer or the winter reached their ultimate pH early post mortem and had very flat decline curves (Figure 9). Carrier and Negative pigs slaughtered in the summer generally had the highest *Semimembranosus* pH with Carrier pigs slaughtered in the winter having the lowest pH values after 2 hours post slaughter of all of the genotype x season subclasses (Figure 9).

Longissimus temperature: The temperature decline curves for the *Longissimus* for the two-way interaction subclasses are presented in Figures 10, 11, and 12. The curves for the Halothane genotype x pre-slaughter management (Figure 10) and the season x pre-slaughter management subclasses (Figure 11) were relatively similar. Reactor and Negative animals on the Low Stress treatment tended to have higher *Longissimus* temperatures over the first 24 hours post mortem than the other Halothane genotype x season subclasses (Figure 12).

Semimembranosus temperature:

The temperature curves for the *Semimembranosus* for the two-way interaction subclasses are presented in Figures 13, 14, and 15. The temperature of the *Semimembranosus* was lower for Carriers slaughtered in both the winter and the summer compared to the other genotype x season combinations over most of the 24 hour period after slaughter (Figure 13). Pigs on the Low Stress treatment slaughtered in the summer had the lowest *Semimembranosus* temperature over the first 24 hours compared to the other season x pre-slaughter stress subclasses (Figure 15). Carriers slaughtered in both summer and winter had the lowest *Semimembranosus* pH of all of the Halothane genotype x season combination (Figure 15).

Table 1. Least square means for the effects of Halothane genotype, pre-slaughter management, and season on carcass characteristics.

Trait	Genotype				Pre-slaughter management			Season		
	Normal (NN)	Carrier (Nn)	Reactor (Nn)	Ave SEM	Low Stress	High Stress	Ave SEM	Summer	Winter	Ave SEM
Number of animals	24	28	13		32	33		37	28	
Final live weight, kg	113.8	107.9	113.1	2.50	113.9	109.3	2.08	114.3	109.0	2.08
Hot carcass weight, kg	86.6	82.2	88.5	2.03	87.8	83.7	3.73	87.7	83.8	1.69
Cold carcass weight, kg	84.5	79.9	85.8	2.00	85.4	81.5	1.66	85.5	81.4	1.66
Leaf fat weight, kg	$.93^{a}$	$.76^{b}$	$.74^{b}$	.058	.82	.82	.048	$.95^{a}$	$.67^{b}$	.047
Length, cm	82.6	83.7	80.0	2.22	81.9	82.3	1.85	81.4	82.8	1.85
Midline fat depth measurements, cm										
First rib	3.87	3.51	3.59	.136	3.78	3.53	.113	3.64	3.67	.113
Last rib	2.40	2.08	2.22	.114	2.34	2.12	.095	2.31	2.16	.095
Last lumbar	1.56	1.37	1.41	.090	1.54	1.36	.075	1.54	1.36	.075
Tenth rib measurements, cm										
Fat depth	1.98^{a}	1.57^{b}	1.84^{a}	.102	1.98^{a}	1.61^{b}	.048	2.00^{a}	1.60^{b}	.085
Loin eye depth	5.89	5.96	6.22	.136	6.04	6.00	.113	5.92	6.12	.113
Loin eye area, cm^2	40.89^{b}	40.25^{b}	44.12^{a}	.982	42.12	41.41	.821	41.21	42.25	.820

^{a,b,c} Means in the same row within grouped effect with differing superscripts are significantly different (P<.05).

Table 2. Least square means for the effects of Halothane genotype, pre-slaughter management, and season on meat quality characteristics.

Trait	Halothane genotype				Pre-slaughter management			Season		
	Normal (NN)	Carrier (Nn)	Reactor (nn)	Ave SEM	Low Stress	High Stress	Ave SEM	Summer	Winter	Ave SEM
Visual scores										
Subjective color [d]	2.76[a]	2.37[a]	1.45[b]	.185	2.32	2.06	.154	2.39[a]	2.12[b]	.154
Subjective firmness [d]	2.62[a]	2.22[a]	1.41[b]	.189	2.35[a]	1.82[b]	.157	2.35[a]	1.81[b]	.157
Subjective marbling [d]	2.78[a]	2.32[b]	1.60[c]	.188	2.46[a]	2.01[b]	.156	2.63[a]	1.84[a]	.156
Drip loss[e]										
Longissimus	4.31[c]	5.68[b]	7.56[a]	.510	5.28	6.42	.425	5.56	6.14	.424
Semimembranosus										
Inside	3.76[b]	3.71[b]	5.47[a]	.438	4.57	4.05	.365	2.22[b]	3.86[a]	.364
Outside	2.18[b]	2.19[b]	4.76[a]	.459	3.30	2.79	.382	3.77	4.84	.381
Ultimate pH[f]										
Longissimus	5.58[a]	5.54[a]	5.42[b]	.033	5.45[b]	5.58[a]	.028	5.58[a]	5.44[b]	.028
Semimembranosus	5.70	5.66	5.60	.039	5.52[b]	5.79[a]	.033	5.70[a]	5.61[b]	.032

[a,b,c] Means in the same row within grouped effect with differing superscripts are significantly different. (P<.05).
[d] Subjective score from 1= extremely pale, soft and devoid of marbling to 5= extremely dark, firm and abundant marbling.
[e] Drip loss measured over twenty-four hour period.
[f] Measured on muscle sample homogenized in distilled water using a pH meter (Model 720A, Orion Research, Boston, MA).

Table 3. Least square means for the effects of Halothane genotype, pre-slaughter management, and season on Minolta color values.

Trait	Genotype				Pre-slaughter management			Season		
	Normal (NN)	Carrier (Nn)	Reactor (nn)	Ave SEM	Low Stress	High Stress	Ave SEM	Summer	Winter	Ave SEM
Minolta L* values										
Longissimus	49.34[b]	49.01[b]	55.53[a]	.882	50.80	51.78	.735	49.51[a]	53.07[b]	.733
Semimembranosus										
Anterior	48.68[b]	49.91[b]	54.81[a]	1.04	52.28	49.98	.863	49.94[a]	52.32[b]	.861
Middle	53.05[b]	53.74[ab]	56.41[a]	1.05	54.68	54.11	.872	52.27[a]	56.64[b]	.871
Posterior	43.35[b]	45.47[b]	49.53[a]	.886	46.14	46.09	.738	45.38	46.86	.736
Minolta a* values										
Longissimus	7.47[a]	7.98[a]	10.08[b]	.353	8.24	8.78	.294	6.00[a]	11.01[b]	.293
Semimembranosus										
Anterior	9.05	8.57	10.11	.438	9.55	8.94	.365	7.30[a]	11.18[b]	.364
Middle	9.02	10.47	10.05	.651	10.45	9.24	.543	7.60[a]	12.10[b]	.541
Posterior	10.37[b]	9.14[a]	10.95[b]	.476	10.52	9.79	.396	8.15[a]	12.16[b]	.395
Minolta b* values										
Longissimus	8.83[a]	8.79[a]	12.53[b]	.534	9.76	10.34	.445	8.56[a]	11.54[b]	.443
Semimembranosus										
Anterior	9.24[a]	9.19[a]	11.89[b]	.529	10.79[b]	9.42[a]	.441	9.18[a]	11.03[b]	.440
Middle	10.55[a]	11.21[ab]	12.41[b]	.511	12.04[b]	10.73[a]	.426	10.64[a]	12.16[b]	.425
Posterior	8.12[a]	7.69[a]	9.79[b]	.500	8.73	8.33	.416	7.62[a]	9.44[b]	.415

[a,b] Means in the same row within grouped effect with differing superscripts are significantly different (P<.05).

Table 4. Least square means for the effects of Halothane genotype, pre-slaughter management, and season on body temperature.

Time	Halothane genotype				Pre-slaughter management			Season		
	Normal (NN)	Carrier (Nn)	Reactor (nn)	Ave SEM	Low Stress	High Stress	Ave SEM	Summer	Winter	Ave SEM
Two days prior to harvest	37.8	38.0	37.7	.26	37.9	37.8	.21	38.2[a]	37.3[b]	.21
One day prior to harvest	38.2	38.4	38.1	.26	38.2	38.2	.21	37.8[a]	38.6[b]	.21
Morning of harvest	38.5[a]	38.3[ab]	37.9[b]	.26	38.2	38.3	.21	38.1	38.4	.21
Prior to loading	38.3	38.3	38.1	.26	38.2	38.2	.21	37.8[a]	38.6[b]	.21
After loading	38.3	38.4	38.3	.26	38.2	38.5	.21	38.1	38.5	.21
On arrival at the slaughter facility	38.9	38.8	38.8	.27	38.6[a]	39.1[b]	.21	38.8	38.8	.21
Prior to stunning	39.1	39.1	38.7	.26	38.4[a]	39.6[b]	.21	38.9	39.2	.21
Post exsanguination	39.5	39.4	39.0	.26	38.6[a]	40.0[b]	.21	39.1	39.5	.21
Post scalding	39.6[a]	39.5[ab]	39.0[b]	.26	38.7[a]	40.1[b]	.21	39.3	39.5	.21
Post dehairer	39.9[a]	39.7[a]	39.0[b]	.26	38.7[a]	40.4[b]	.21	39.4[a]	39.9[b]	.22
Post singe	40.4[a]	40.5[a]	39.4[b]	.27	39.3[a]	40.9[b]	.21	40.0	40.3	.22
Prior to evisceration	39.9	40.1	39.5	.27	39.3[a]	40.4[b]	.21	39.9	39.7	.22

[a,b] Means in the same row within grouped effect with differing superscripts are significantly different. (P<.05).

Table 5. Least square means for the effects of Halothane genotype, pre-slaughter management, and season for *Longissimus* pH.

Trait	Time Post-mortem, h									
	.75	1	1.5	2	3	4	5	6	12	24
<u>Halothane Genotype</u>										
Normal (NN)	6.20[a]	6.16[a]	6.03[a]	6.01[a]	5.94[a]	5.85[a]	5.83[a]	5.80[a]	5.75[a]	5.70[ab]
Carrier (Nn)	6.17[a]	6.05[a]	5.97[a]	5.93[a]	5.90[a]	5.87[a]	5.79[ab]	5.81[a]	5.76[a]	5.76[a]
Reactor (nn)	5.72[b]	5.64[b]	5.59[b]	5.59[b]	5.60[b]	5.61[b]	5.61[b]	5.62[b]	5.63[b]	5.62[b]
Average SEM	.046	.046	.046	.046	.046	.046	.046	.046	.046	.046
<u>Pre-slaughter management</u>										
Low stress	6.15[a]	6.05[a]	5.97[a]	5.95[a]	5.88[a]	5.82	5.75	5.75	5.71	5.67
High stress	5.91[b]	5.84[b]	5.76[b]	5.75[b]	5.75[b]	5.74	5.73	5.74	5.71	5.71
Average SEM	.037	.037	.037	.037	.037	.037	.037	.037	.037	.037
<u>Season</u>										
Summer	6.07	6.00	5.96[a]	5.93[a]	5.89[a]	5.84[a]	5.79[a]	5.78	5.72	5.70
Winter	6.04	5.95	5.79[b]	5.77[b]	5.73[b]	5.71[b]	5.68[b]	5.69	5.67	5.65
Average SEM	.038	.037	.037	.037	.037	.037	.037	.037	.037	.037

[a,b] Means in the same column within grouped effects with different superscripts are significantly different. ($P<.05$).
SEM = standard error of the mean

Table 6. Least square means for the effects of Halothane genotype, pre-slaughter management, and season for *Semimembranosus* pH.

Trait	Time Post-mortem, h									
	.75	1	1.5	2	3	4	5	6	12	24
<u>Halothane Genotype</u>										
Normal (NN)	6.10[a]	6.05[a]	5.98[a]	5.94[a]	5.90[a]	5.88[a]	5.87[a]	5.84	5.79[a]	5.79[a]
Carrier (Nn)	6.17[a]	6.01[a]	6.04[a]	6.00[a]	5.93[a]	5.86[a]	5.84[a]	5.82[ab]	5.74[ab]	5.75[ab]
Reactor (nn)	5.70[b]	5.68[b]	5.65[b]	5.68[b]	5.66[b]	5.71[b]	5.63[b]	5.70[b]	5.68[a]	5.67[a]
Average SEM	.052	.052	.052	.052	.052	.052	.052	.052	.052	.052
<u>Pre slaughter management</u>										
Low stress	6.00	5.89	5.89	5.86	5.80	5.77[b]	5.74[b]	5.70[b]	5.63[b]	5.62[b]
High stress	5.98	5.93	5.89	5.89	5.86	5.87[a]	5.83[a]	5.87[a]	5.83[a]	5.85[a]
Average SEM	.042	.042	.042	.042	.042	.042	.042	.042	.042	.042
<u>Season</u>										
Summer	6.00	5.94	5.97[a]	5.93[a]	5.87	5.83	5.82[a]	5.79	5.73	5.74
Winter	6.05	5.91	5.83[b]	5.83[b]	5.79	5.79	5.73[b]	5.75	5.71	5.70
Average SEM	.043	.042	.042	.042	.042	.042	.042	.042	.042	.042

Table 7. Least square means for the effects of Halothane genotype, pre-slaughter management, and season for *Longissimus* temperature.

Trait	Time Post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
Halothane Genotype											
Normal (NN)	41.3	41.2	41.2	41.3	40.9	41.2[a]	31.9[a]	17.3[a]	11.2[a]	3.2[a]	1.5[ab]
Carrier (Nn)	41.1	41.3	41.3	41.3	40.7	40.2[b]	29.5[c]	15.9[b]	9.6[b]	2.7[b]	1.3[b]
Reactor (nn)	41.2	41.4	41.3	41.4	40.7	39.1[b]	30.4[b]	15.6[b]	10.4[ab]	3.1[ab]	1.6[a]
Average SEM	.44	.44	.44	.44	.44	.44	.44	.44	.44	.44	.44
Pre-slaughter management											
Low stress	40.5[b]	40.5[b]	40.5[b]	40.6[b]	40.2[b]	39.0[b]	30.1[b]	15.5[b]	10.0[b]	3.0	1.4
High stress	41.8[a]	42.1[a]	42.0[a]	42.1[a]	41.4[a]	40.7[a]	31.2[a]	17.0[a]	10.8[a]	2.9	1.5
Average SEM	.36	.36	.36	.36	.36	.36	.36	.36	.36	.36	.36
Season											
Summer	41.1	41.3	41.3	41.3	41.0	39.7	30.2[b]	16.6	10.9[a]	3.7[a]	2.2[a]
Winter	41.3	41.3	41.3	41.3	40.6	40.4	31.2[a]	16.1	9.7[b]	1.9[b]	.5[b]
Average SEM	.36	.36	.36	.36	.36	.36	.36	.36	.36	.36	.36

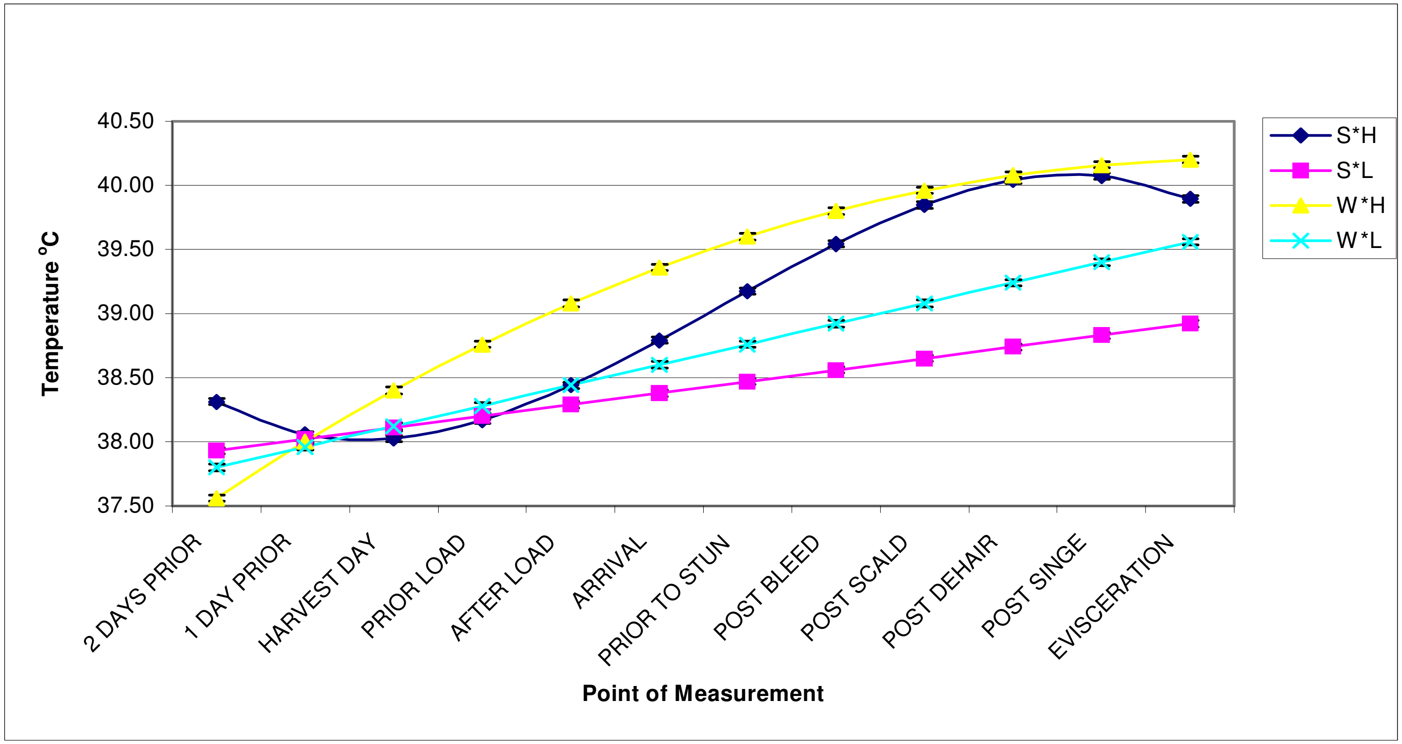
[a,b,c] Means in the same column within grouped effects with different superscripts are significantly different. (P<.05).

Table 8. Least square means for the effects of Halothane genotype, pre-slaughter management, and season for *Semimembranosus* temperature.

Trait	Time Post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
Halothane Genotype											
Normal (NN)	41.3	41.8	41.9	41.8	41.5	41.9	40.7	33.1^{a}	25.0^{a}	10.2^{a}	3.8
Carrier (Nn)	41.2	41.5	41.5	41.7	41.6	41.9	40.1	31.8^{b}	23.1^{b}	9.2^{b}	3.4
Reactor (nn)	41.3	41.1	42.0	42.0	42.0	42.1	40.5	32.3^{ab}	24.4^{ab}	10.0^{a}	3.8
Average SEM	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Pre-slaughter management											
Low stress	40.6^{b}	40.9^{b}	41.1^{b}	41.1^{b}	40.9^{b}	41.2^{b}	39.8^{b}	32.0^{b}	23.9	9.8	3.1^{b}
High stress	41.9^{a}	42.0^{a}	42.5^{a}	42.6^{a}	42.6^{a}	42.7^{a}	41.1^{a}	32.9^{a}	24.5	9.8	4.5^{a}
Average SEM	.33	.33	.33	.33	.33	.33	.33	.33	.33	.33	.33
Season											
Summer	41.0	41.3	41.6	41.7	41.6	41.9	40.2	32.5	24.8^{a}	10.7^{a}	4.8^{a}
Winter	41.7	41.9	42.1	42.1	41.9	42.1	40.8	32.4	23.3^{b}	8.5^{b}	2.3^{b}
Average SEM	.33	.33	.33	.33	.33	.33	.33	.33	.33	.33	.33

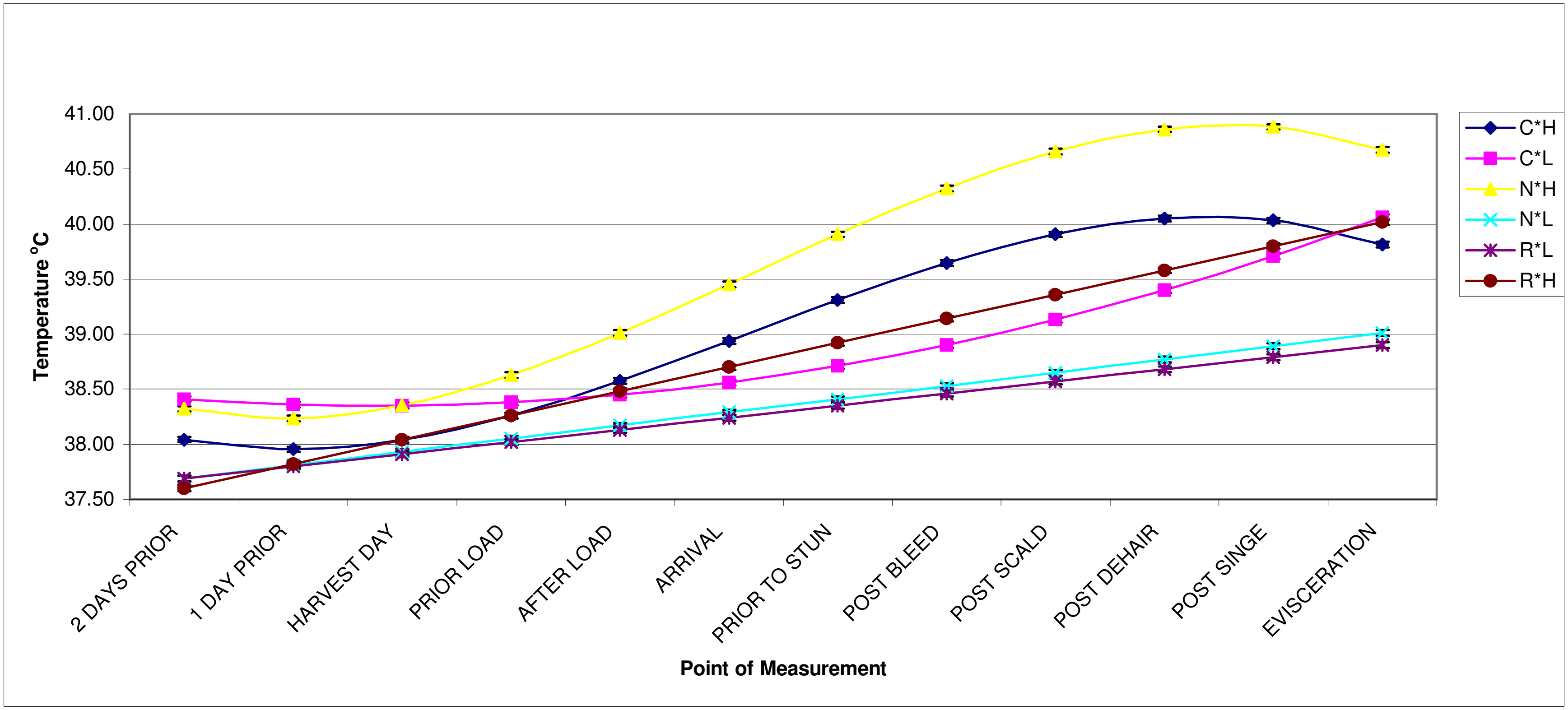
[a,b,c] Means in the same column within a grouped trait with different superscripts are significantly different. (P<.05).

Figure 2. Body temperature curves for season x pre-slaughter management subclasses[a]



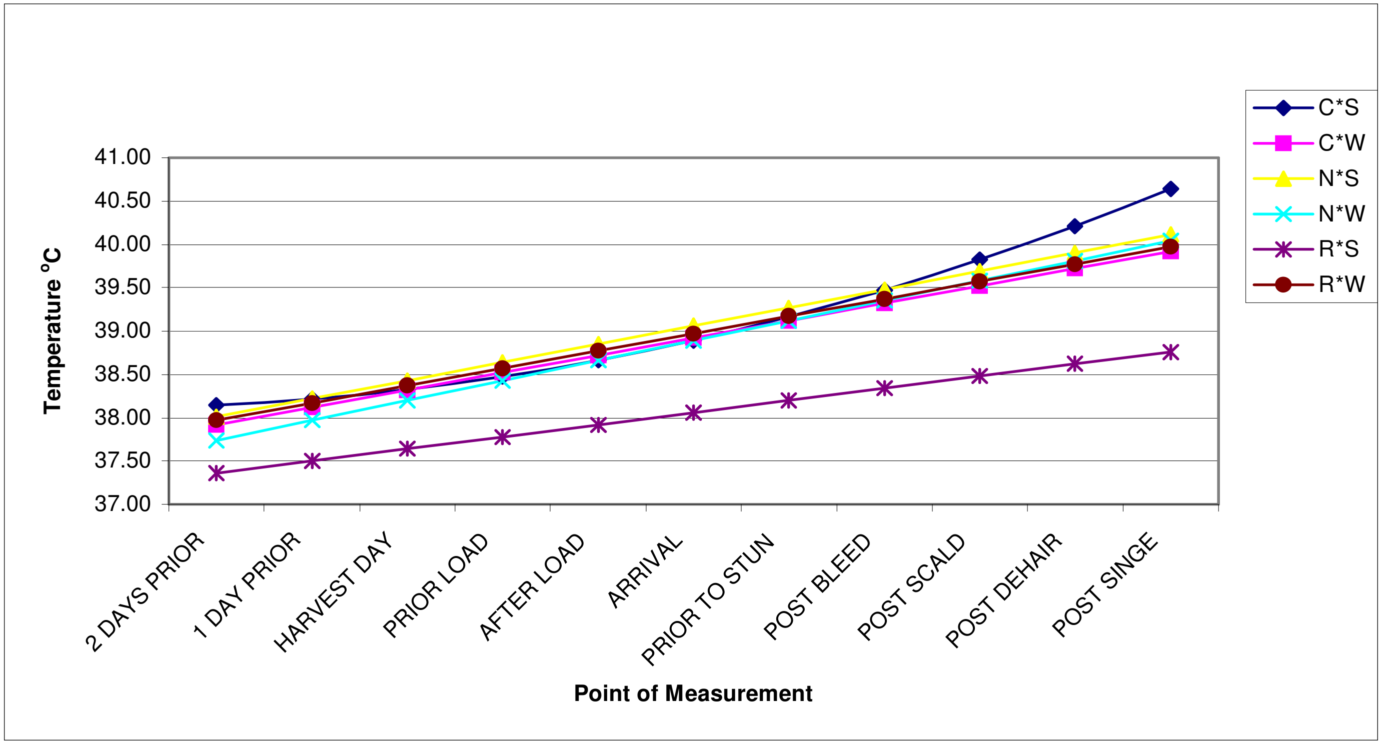
[a] Season: S = Summer, W = Winter; Pre-slaughter management: L = low stress, H = high stress

Figure 1. Body temperature curves for Halothane genotype x pre-slaughter management subclasses[a]



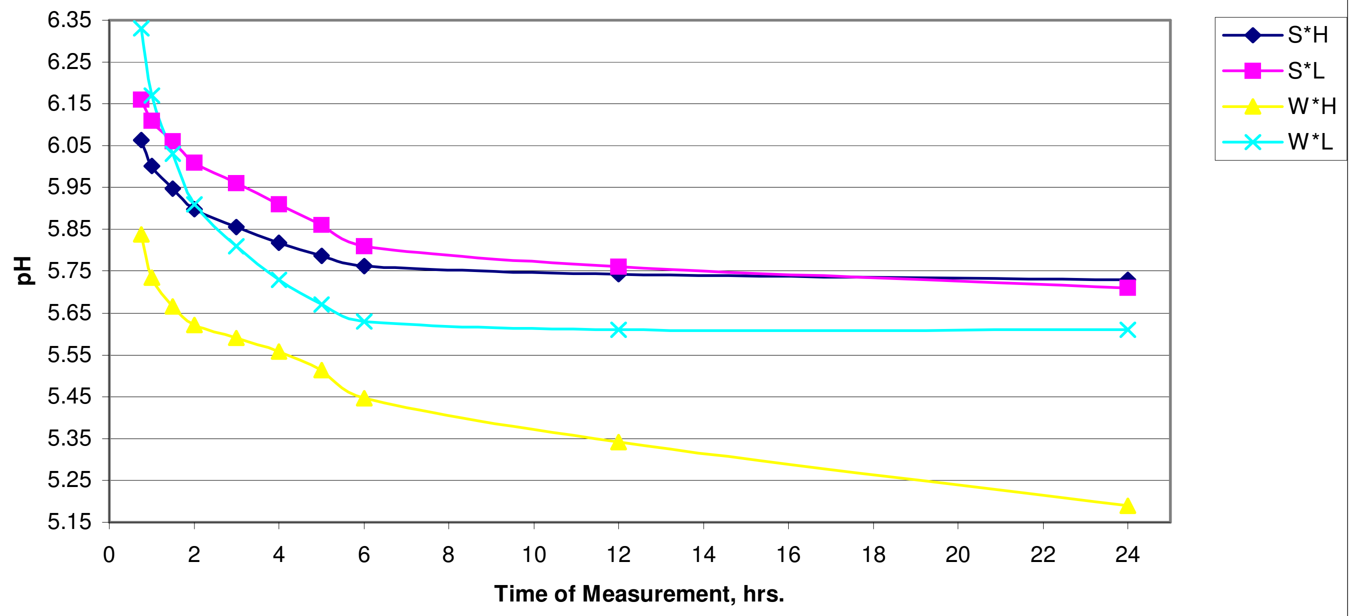
[a] Halothane genotype: C = carrier, N = normal, R = reactor; Pre-slaughter management:, L = low stress, H = high stress

Figure 3. Body temperature curves for Halothane genotype x season subclasses[a]



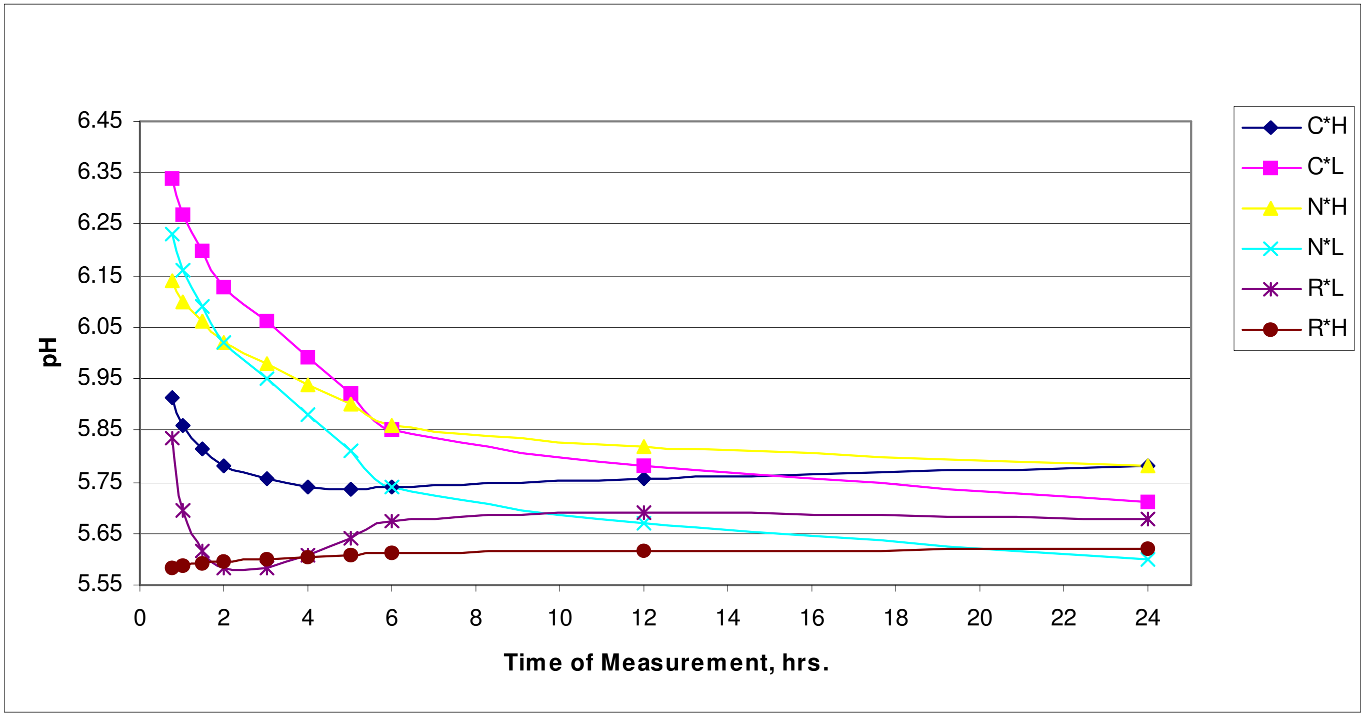
[a]Halothane genotype: C = carrier, N = normal, R = reactor; Season: S = summer, W = winter

Figure 5. *Longissimus* pH curves for season x pre-slaughter management subclasses[a]



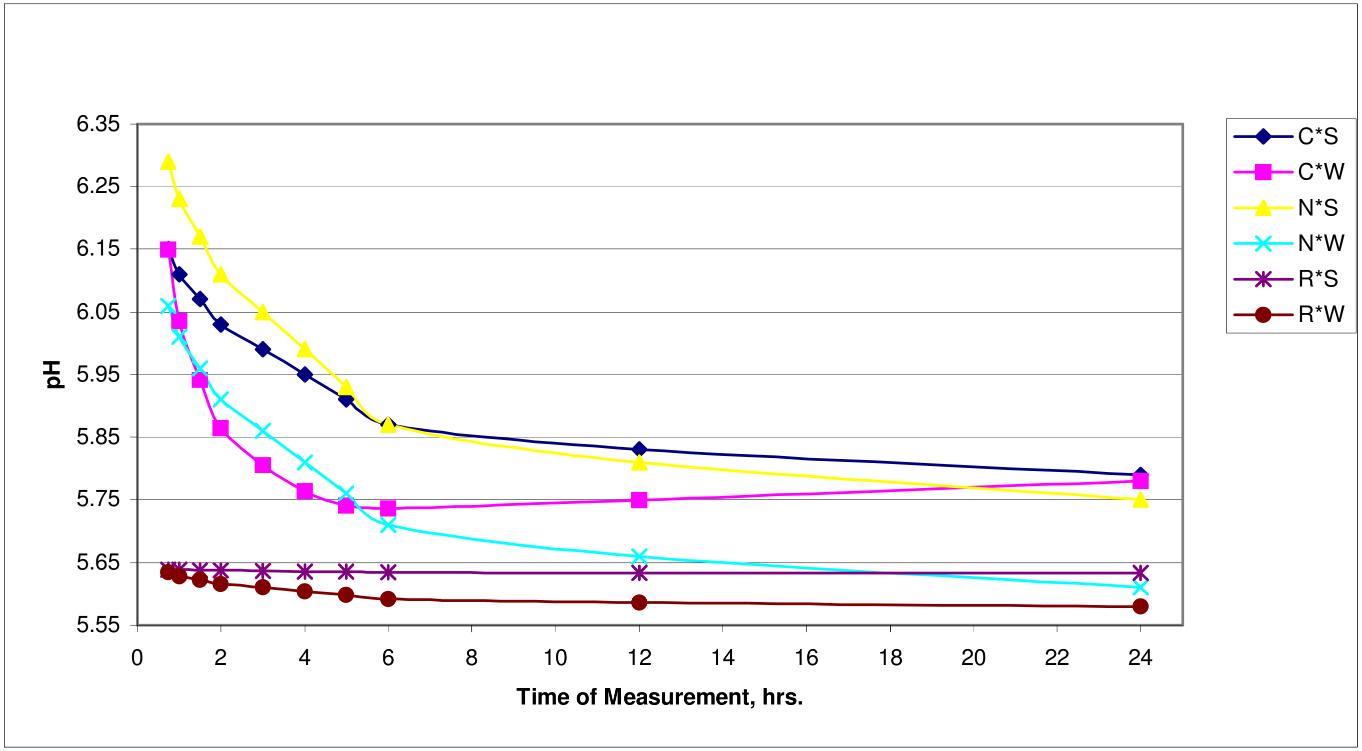
[a]Season: S = summer, W = winter; Pre-slaughter management: L = Low Stress, H = High Stress

Figure 4. *Longissimus* pH curves for Halothane genotype x pre-slaughter management subclasses[a]



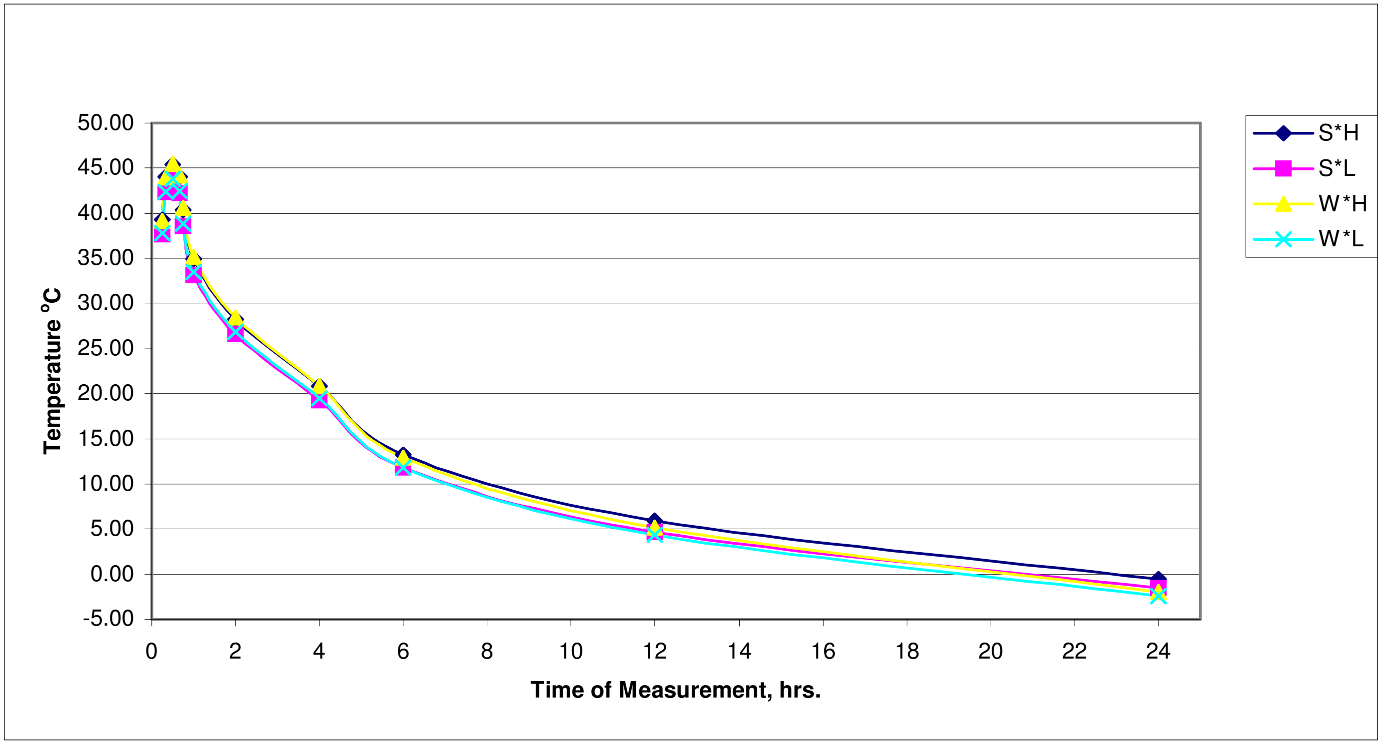
[a]Halothane genotype: C = carrier, N = normal, R = reactor; Pre-slaughter management: L = Low Stress, H = High stress

Figure 6. *Longissimus* pH curves for Halothane genotype x season subclasses[a]



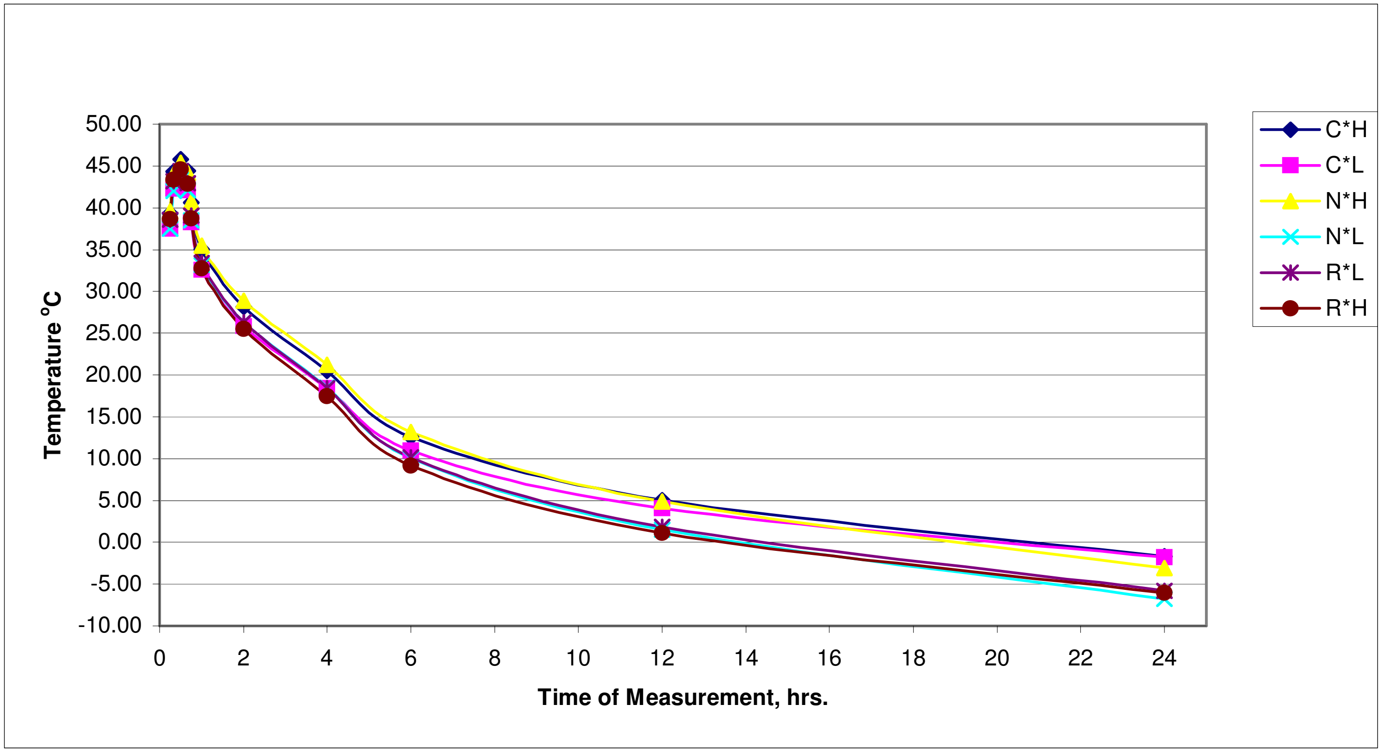
[a]Halothane genotype: C = carrier, N = normal, R = reactor; Season: S = summer, W = winter

Figure 11. *Longissimus* temperature curves for season x pre-slaughter management subclasses[a]



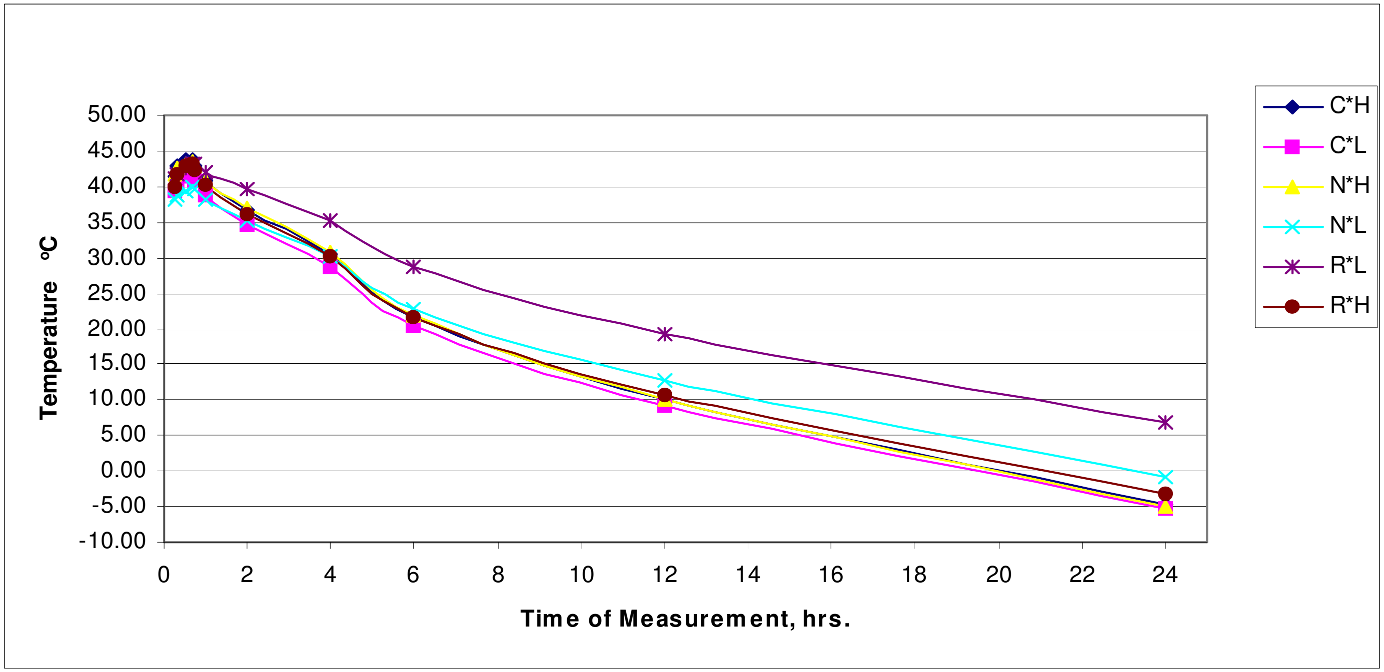
[a]Season: S = summer, W = winter; Pre-slaughter mangement: L = low stress, H = high stress

Figure 10. *Longissimus t*emperature curves for Halothane genotype x pre-slaughter management subclasses[a]



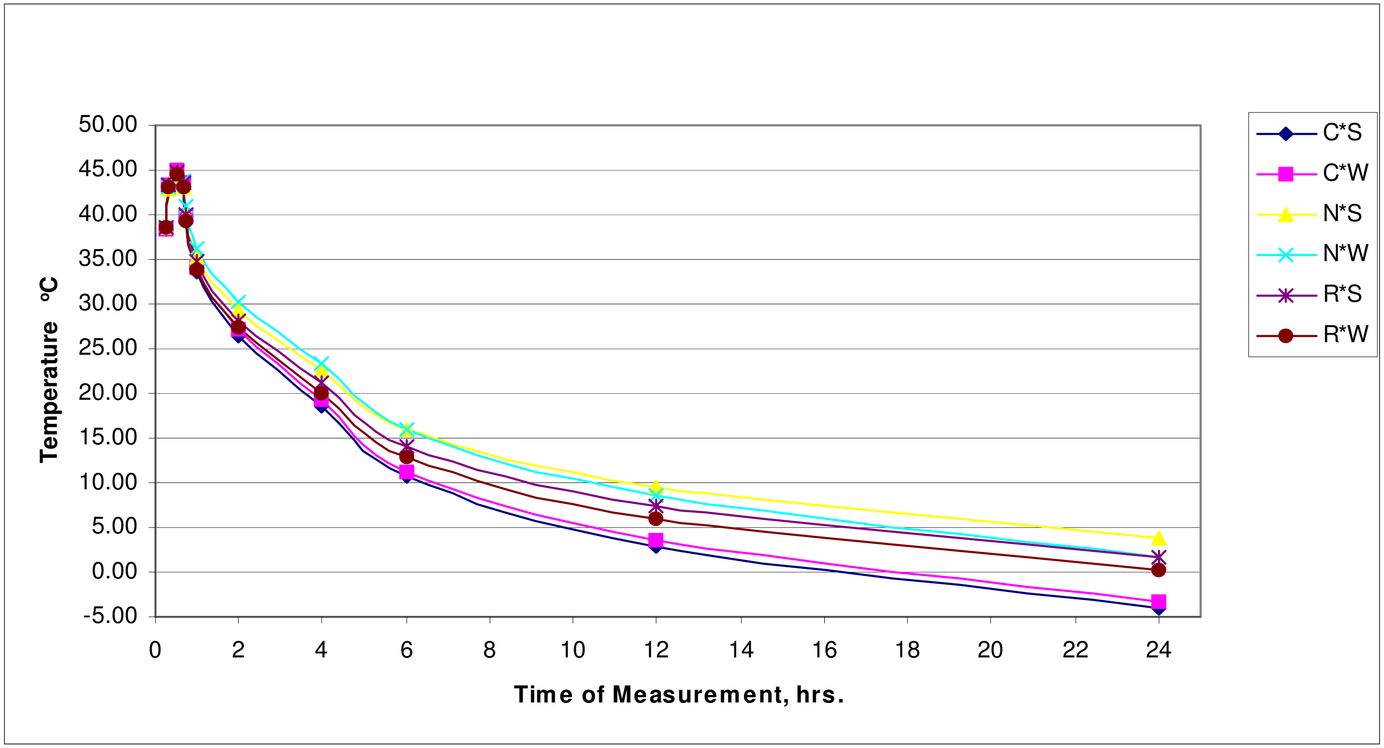
[a]Halothane genotype: C = carrier, N = normal, R = reactor; Pre-slaughter management: L = low stress, H = high stress

Figure 12. *Longissimus t*emperature curves for Halothane genotype x season subclasses[a]



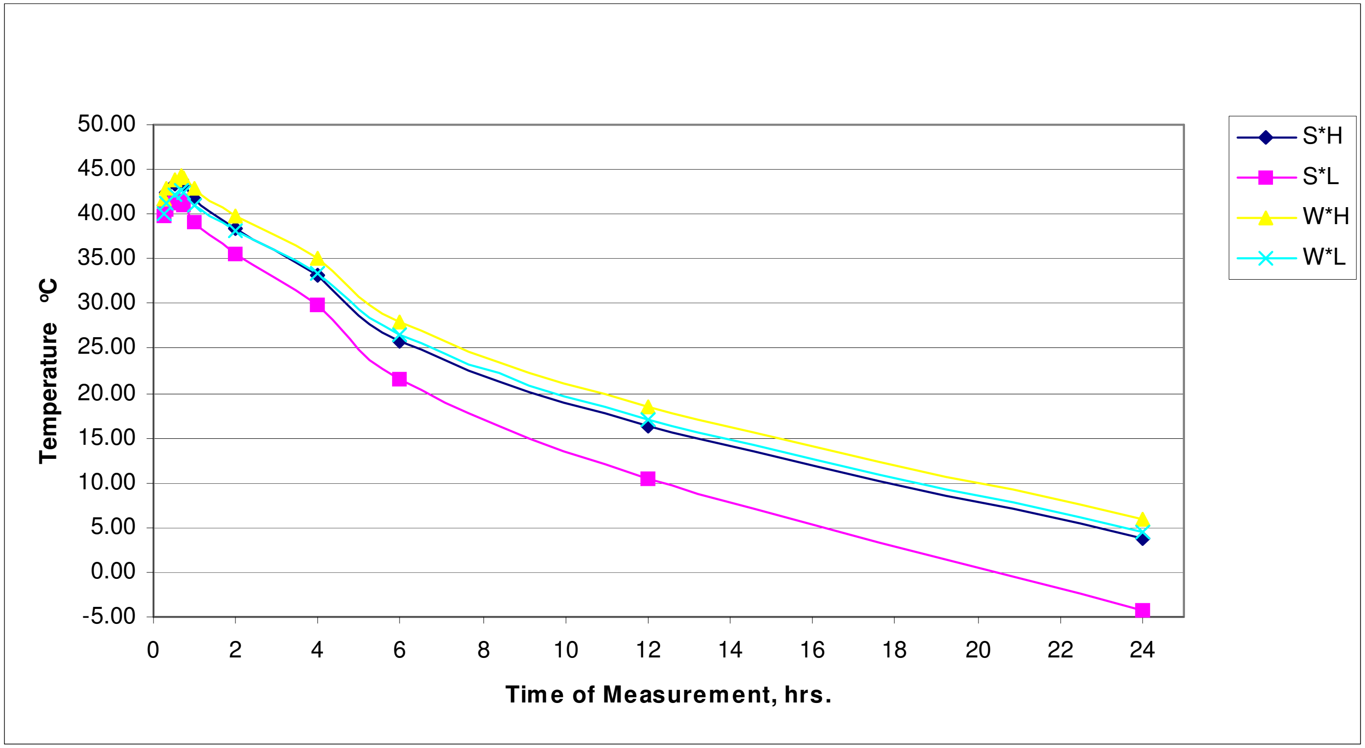
[a]Halothane genotype: C = carrier, N = normal, R = reactor; Season: S = summer, W = winter

Figure 13. *Semimembranosus t*emperature curves for Halothane genotype x pre-slaughter management subclasses[a]



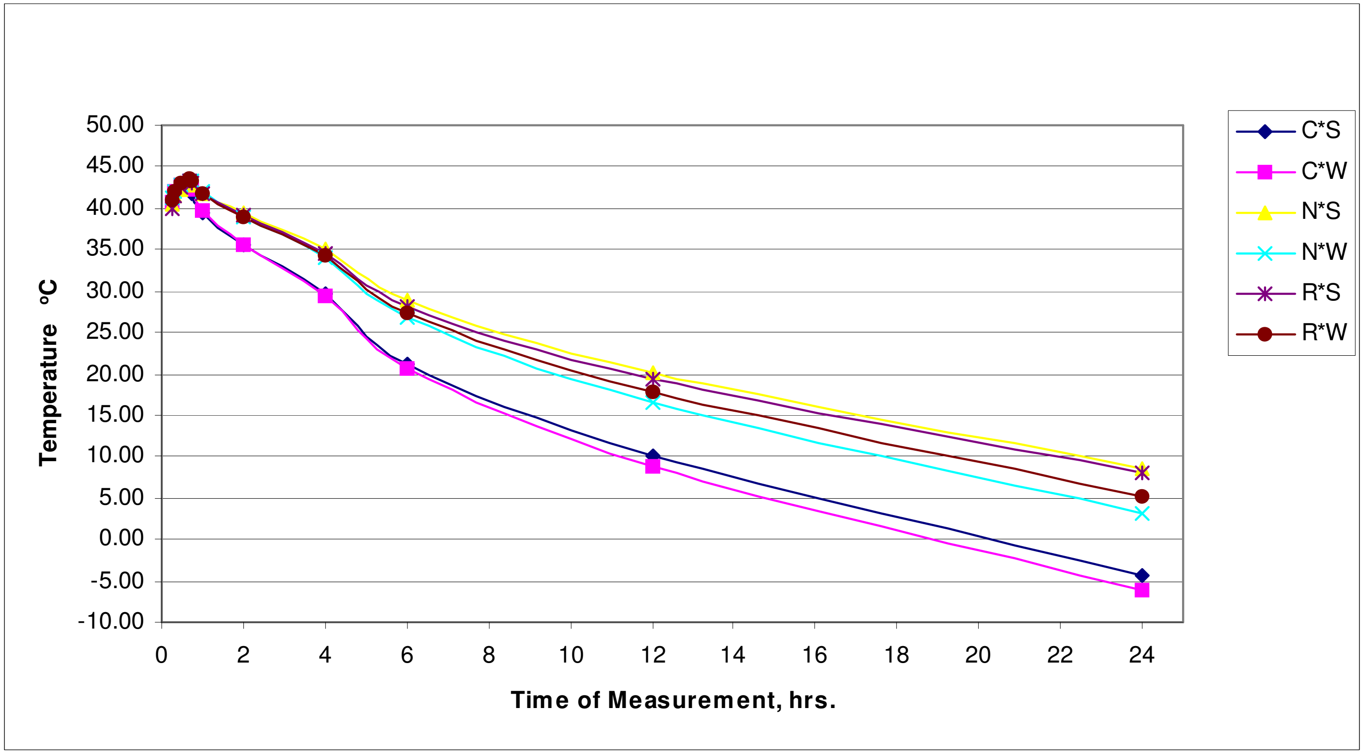
[a]C = Carrier, N = Normal, R = Reactor, L = Low Stress, H = High Stress

Figure 14. *Semimembranosus* temperature curves for season x pre-slaughter management subclasses[a]



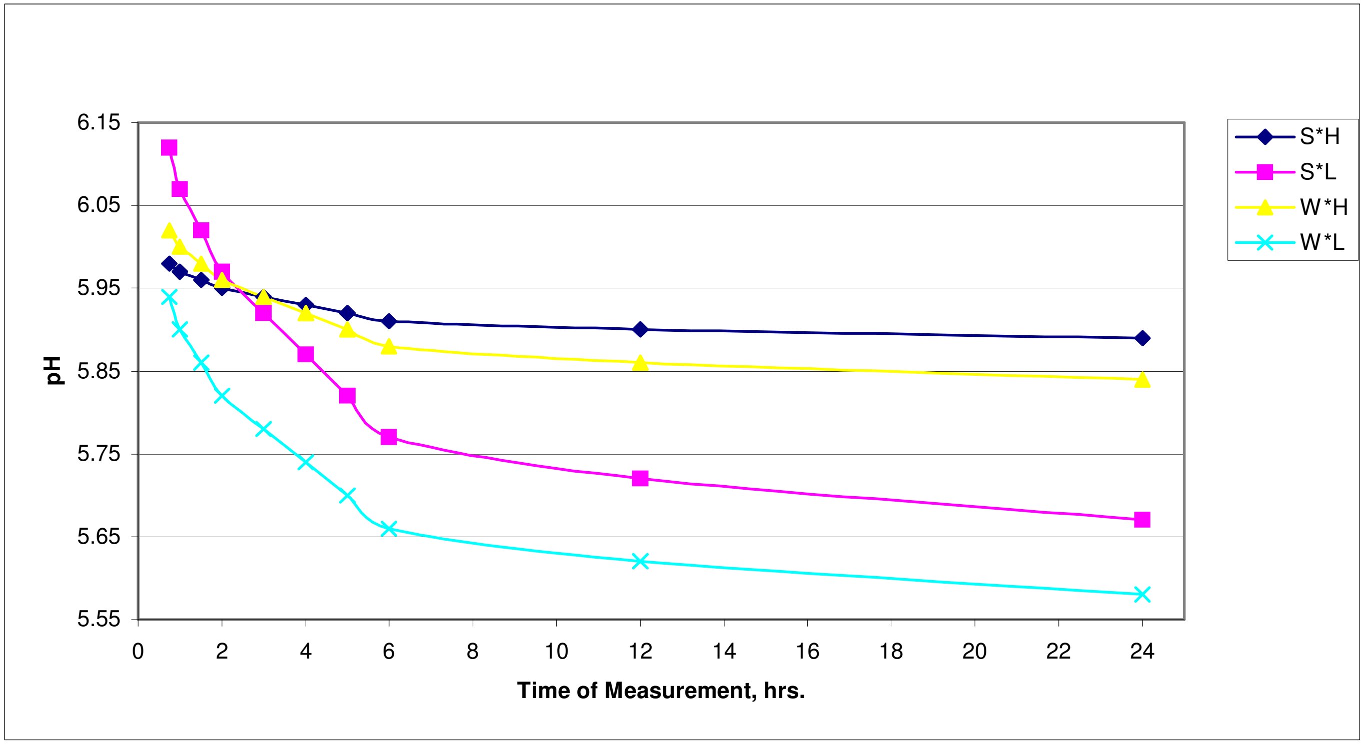
[a]Season: S = summer, W = winter; Pre-slaughter management: L = low stress, H = high stress

Figure 15. *Semimembranosus t*emperature curves for Halothane genotype x season subclasses[a]



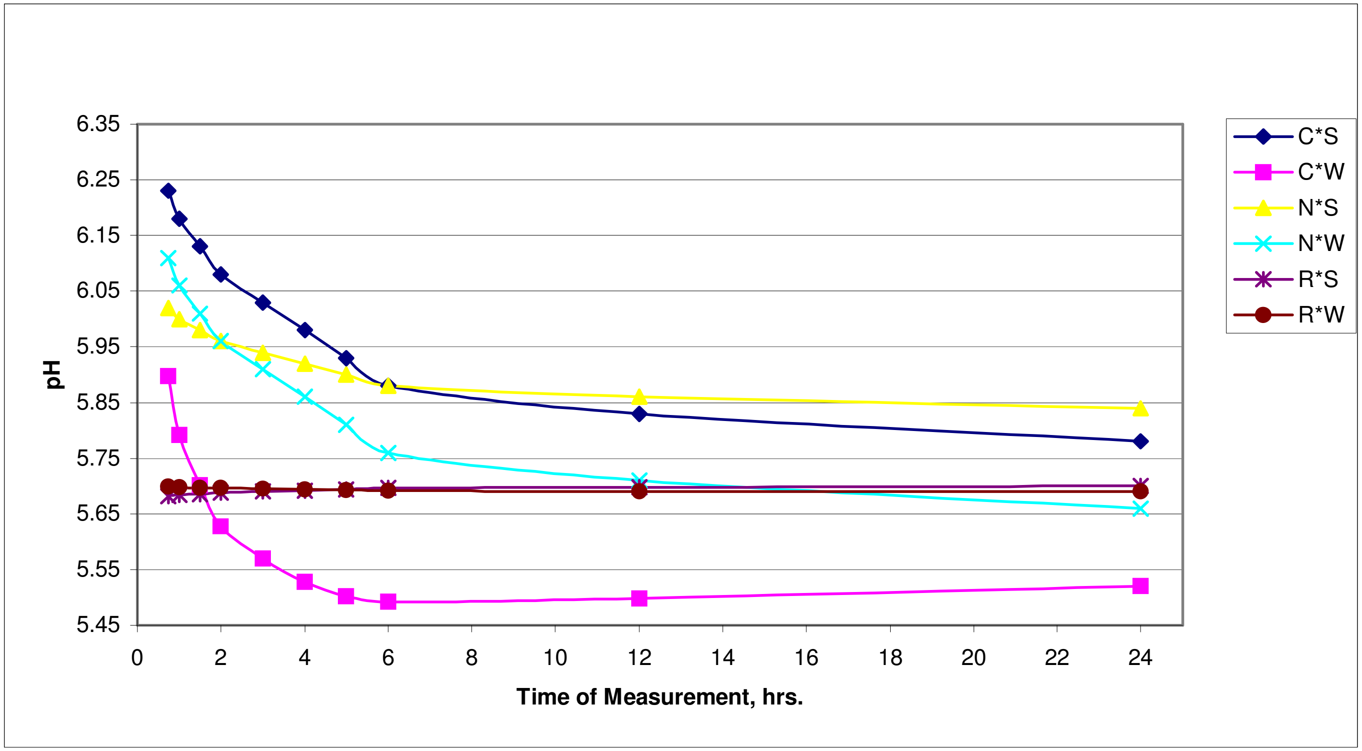
[a]Halothane genotype: C = carrier, N = normal, R = reactor; Season: S = summer, W = winter

Figure 8. *Semimembranosus* pH curves for season x pre-slaughter management subclasses[a]



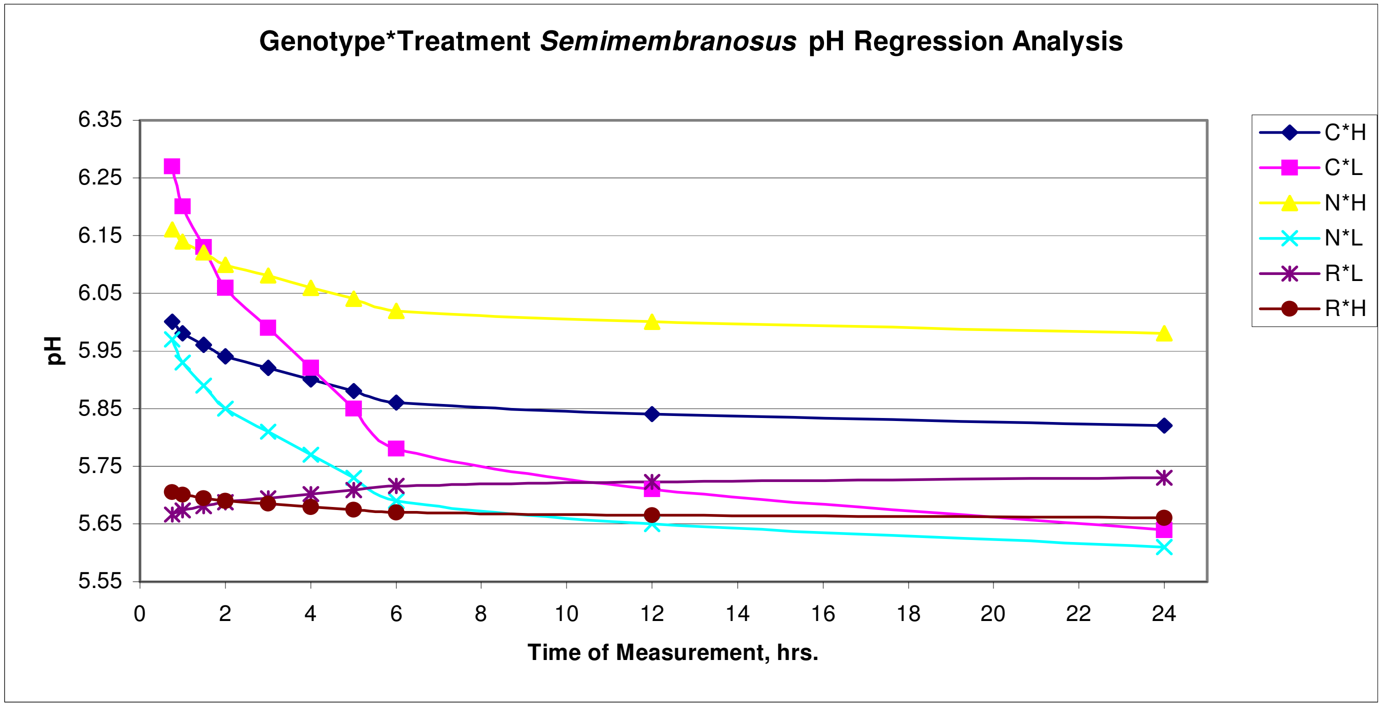
[a]Season: S = summer, W = winter; Pre-slaughter management: L = low stress, H = high stress

Figure 9. *Semimembranosus* pH curves for Halothane genotype x season subclasses[a]



[a]Halothane genotype: C = carrier, N = normal, R = reactor; Season: S = summer, W = winter

Figure 7. *Semimembranosus* pH curves for Halothane genotype x pre-slaughter management subclasses[a]



[a]Halothane genotype: C = carrier, N = normal, R = reactor; Pre-slaughter management: L = low stress, H = high stress

APPENDIX A

Table Al. Regression of body temperature against time for Halothane genotype x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxH	$y = 38.85 - .43t + .13t^2 - .007t^3$	.0126	.003	.52
CxL	$y = 38.5 - .11t + .02t^2$	.0074	.017	.22
NxH	$y = 38.66 - .48t + .15t^2 - .008t^3$	.0190	.003	.43
NxL	$y = 37.57 + .12t$	.0001	.024	.18
RxL	$y = 37.59 + .11t$	.0663	.059	.05
RxH	$y = 37.38 + .22t$	.0001	.046	.22

[a] C = Carrier, N = Normal, R = Reactor, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A2. Regression of body temperature against time for season x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
SxH	$y = 38.84 - .68t+ .16t^2 - .008t^3$	.0153	.003	.39
SxL	$y = 37.84 + .09t$	.0011	.026	.05
WxH	$y = 37.68 + .04t +.07t^2 - .004t^3$	.0156	.008	.44
WxL	$y = 37.64 + .16t$	.0001	.019	.31

[a] S = Summer, W = Winter, H = High Stress, L = Low Stress.
[b] t= time in hours

Table A3. Regression of body temperature against time for Halothane genotype x season subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxS	$y = 38.12 + .009t + .016t^2$	.0317	.008	.34
CxW	$y = 37.71 + .20t$	.0001	.027	.31
NxS	$y = 37.80 + .21t$	.0001	.039	.17
NxW	$y = 37.51 + .23t$	.0001	.026	.37
RxS	$y = 37.20 + .14t$	.0174	.060	.07
RxW	$y = 37.77 + .20t$	.0001	.035	.31

[a] C = Carrier, N = Normal, R = Reactor, S = Summer, W = Winter.
[b] t= time in hours

Table A4. Regression of *Longissimus* pH against time for Halothane genotype x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxH	$y = 5.99 - .07t + .005t^2$	.0203	.002	.10
CxL	$y = 6.41 - .07t$	.0001	.008	.38
NxH	$y = 6.18 - .04t$	.0001	.007	.25
NxL	$y = 6.31 - .07t$	.0001	.008	.37
RxL	$y = 6.04 - .25t + .04t^2 - .002t^3$	.0307	.001	.25
RxH	$y = 5.58 + .004t$	.3834	.004	.01

[a] C = Carrier, N = Normal, R = Reactor, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A5. Regression of *Longissimus* pH against time for season x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
SxH	$y = 6.06 - .03t$	.0001	.006	.13
SxL	$y = 6.21 - .05t$	.0001	.007	.21
WxH	$y = 5.99 - .18t + .03t^2 - .002t^3$	.0312	.001	.10
WxL	$y = 6.51 - .19t + .01t^2$	.0027	.003	.37

[a] S = Summer, W = Winter, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A6. Regression of *Longissimus* pH against time for Halothane genotype x season subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxS	$y = 6.19 - .04t$	.0001	.007	.19
CxW	$y = 6.28 - .14t + .009t^2$	.0097	.003	.23
NxS	$y = 6.35 - .06t$	.0001	.006	.45
	$y = 6.11 - .05t$	.0001	.008	.25

NxW				
RxS	y = 5.64 - .0007t	.8259	.003	.001
RxW	y = 5.64 - .006t	.4112	.007	.01

[a] C = Carrier, N = Normal, R = Reactor, S = Summer, W = Winter.
[b] t = time in hours

Table A7. Regression of *Semimembranosus* pH against time for Halothane genotype x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxH	y = 6.02 - .02t	.0016	.006	.07
CxL	y = 6.34 - .07t	.0001	.008	.37
NxH	y = 6.18 - .02t	.0063	.009	.06
NxL	y = 6.01 - .04t	.0001	.008	.19
RxL	y = 5.66 + .007t	.3836	.008	.01
RxH	y = 5.71 - .005t	.5021	.008	.007

[a] C = Carrier, N = Normal, R = Reactor, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A8. Regression of *Semimembranosus* pH against time for season x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
SxH	y = 5.99 - .01t	.0953	.007	.02
SxL	y = 6.17 - .05t	.0001	.008	.17
WxH	y = 6.04 - .02t	.0003	.006	.08
WxL	y = 5.98 - .04t	.0001	.007	.24

[a] S = Summer, W = Winter, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A9. Regression of *Semimembranosus* pH against time for Halothane genotype x season subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxS	y = 6.28 - .05t	.0001	.007	.28
CxW	$y = 6.22 - .13t + .008t^2$	.0011	.002	.30
NxS	y = 6.04 - .02t	.0222	.01	.04

NxW	y = 6.16 - .05t	.0001	.008	.22
RxS	y = 5.68 + .002t	.7927	.007	.001
RxW	y = 5.70 - .001t	.8781	.009	.0004

[a] C = Carrier, N = Normal, R = Reactor, S = Summer, W = Winter.
[b] t = time in hours

Table A10. Regressional *Longissimus* temperature against time for Halothane genotype x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxH	$y = 30.31 + 11.17t - 2.27t^2 + .09t^3$	.0001	.012	.95
CxL	$y = 28.64 + 11.04t - 2.30t^2 + .10^3$	.0001	.012	.95
NxH	$y = 31.59 + 9.83t - 1.95t^2 + .07t^3$	.0001	.013	.95
NxL	$y = 29.52 + 9.90t - 1.98t^2 + .07t^3$	.0001	.014	.94
RxL	$y = 30.26 + 10.36t - 2.12t^2 + .08t^3$	.0001	.019	.95
RxH	$y = 29.90 + 10.92t - 2.28t^2 + .09t^3$	.0001	.018	.95

[a] C = Carrier, N = Normal, R = Reactor, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A11. Regression of *Longissimus* temperature against time for season x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
SxH	$y = 30.81 + 10.61t - 2.17t^2 + .09t^3$	.0001	.011	.95
SxL	$y = 29.17 + 10.55t - 2.17t^2 + .09t^3$	.0001	.010	.95
WxH	$y = 30.55 + 10.66t - 2.14t^2 + .08t^3$	.0001	.012	.95
WxL	$y = 29.42 + 10.39t - 2.11t^2 + .08t^3$	.0001	.014	.94

[a] S = Summer, W = Winter, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A12. Regression of *Longissimus* temperature against time for Halothane genotype x season subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxS	$y = 29.51 + 11.04t - 2.29t^2 + .09t^3$	.0001	.011	.95
CxW	$y = 29.43 + 11.21t - 2.28t^2 + .09t^3$	.0001	.015	.95
NxS	$y = 30.53 + 9.89t - 2.00t^2 + .08t^3$	.0001	.012	.95
NxW	$y = 30.61 + 9.80t - 1.92\ t^2 + .07t^3$	.0001	.016	.94

RxS	$y = 30.03 + 10.73t - 2.21t^2 + .09t^3$	.0001	.017	.95
RxW	$y = 30.11 + 10.59t - 2.20t^2 + .09t^3$	.0001	.019	.95

[a] C = Carrier, N = Normal, R = Reactor, S = Summer, W = Winter.
[b] t = time in hours

Table A13. Regression of *Semimembranosus* temperature against time for Halothane genotype x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxH	$y = 40.34 + 1.08t + .19t^2 - .06t^3$	.0001	.009	.96
CxL	$y = 38.46 + .87t + .22t^2 - .06t^3$	.0001	.010	.95
NxH	$y = 41.03 + .32t + .36t^2 - .07t^3$	.0001	.010	.96
NxL	$y = 39.98 - .33t + .48t^2 - .07t^3$	.0001	.008	.97
RxL	$y = 40.00 - .47t + .53t^2 - .07t^3$	.0001	.012	.97
RxH	$y = 38.07 + 1.96t + .03t^2 - .05t^3$	.0014	.014	.96

[a] C = Carrier, N = Normal, R = Reactor, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A14. Regression of *Semimembranosus* temperature against time for season x pre-slaughter management subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
SxH	$y = 39.43 + 1.38t + .13t^2 - .05t^3$	.0001	.008	.96
SxL	$y = 39.60 - .03t + .41t^2 - .07t^3$	.0001	.007	.97
WxH	$y = 40.91 + .55t + .32t^2 - .06t^3$	.0001	.010	.96
WxL	$y = 39.36 + .46t + .33t^2 - .06t^3$	.0001	.011	.95

[a] S = Summer, W = Winter, H = High Stress, L = Low Stress.
[b] t = time in hours

Table A15. Regression of *Semimembranosus t*emperature against time for Halothane genotype x season subclasses.

Interaction[a]	Equation[b]	P Value	SE	R^2
CxS	$y = 39.40 + .86t + .22t^2 - .06t^3$	.0001	.008	.96
CxW	$y = 39.40 + 1.15t + .18t^2 - .06t^3$	.0001	.014	.94

NxS	$y = 40.14 + .10t + .39t^2 - .06t^3$	.0001	.010	.96
NxW	$y = 40.95 - .14t + .47t^2 - .07t^3$	.0001	.011	.96
RxS	$y = 38.66 + 1.18t + .19t^2 - .05t^3$	.0001	.014	.96
RxW	$y = 40.31 + .44t + .33t^2 - .06t^3$	.0001	.013	.97

[a] C = Carrier, N = Normal, R = Reactor, S = Summer, W = Winter.
[b] t = time in hours

APPENDIX B

Table B1. Predicted means[1] for the Halothane genotype x pre-slaughter management interaction for body temperature.

Time	Halothane genotype x pre-slaughter management subclasses[g]					
	C*L	C*H	R*L	R*H	N*L	N*H
Two days prior to harvest	38.41[e]	38.04[c]	37.69[b]	37.60[a]	37.69[b]	38.32[d]
One day prior to harvest	38.36[d]	37.95[b]	37.80[a]	37.82[a]	37.81[a]	38.24[c]
Morning of harvest	38.35[c]	38.04[b]	37.91[a]	38.04[b]	37.93[a]	38.35[c]
Prior to loading	38.38[c]	38.26[b]	38.02[a]	38.26[b]	38.05[a]	38.63[d]
After loading	38.45[b]	38.58[c]	38.13[a]	38.48[b]	38.17[a]	39.01[d]
On arrival at the slaughter facility	38.56[b]	38.94[d]	38.24[a]	38.70[c]	38.29[a]	39.45[e]
Prior to stunning	38.71[c]	39.31[e]	38.35[a]	38.92[d]	38.41[b]	39.91[f]
Post exsanguination	38.90[c]	39.65[e]	38.46[a]	39.14[d]	38.53[b]	40.32[f]
Post scalding	39.13[c]	39.91[e]	38.57[a]	39.36[d]	38.65[b]	40.66[f]
Post dehairer	39.40[c]	40.05[e]	38.68[a]	39.58[d]	38.77[b]	40.86[f]
Post singe	39.71[c]	40.03[e]	38.79[a]	39.80[d]	38.89[b]	40.88[f]
Prior to evisceration	40.06[d]	39.81[c]	38.90[a]	40.02[d]	39.01[b]	40.68[e]

[1]Means predicted from regression equations presented in Table A1.
[a,b,c,d,e,f] Means in the same row with differing superscripts are significantly different (P<.05).
[g] Halothane Genotype: C = Nn, N = NN, R = nn; Pre-slaughter management: L=low stress, H=high stress

Table B2. Predicted means[1] for the season x pre-slaughter management interaction for body temperature.

	Season x pre-slaughter management subclasses[e]			
Time	W*H	W*L	S*H	S*L
Two days prior to harvest	37.56[a]	37.80[b]	38.31[d]	37.93[c]
One day prior to harvest	38.00[ab]	37.96[a]	38.06[c]	38.02[bc]
Morning of harvest	38.40[c]	38.12[b]	38.02[a]	38.11[b]
Prior to loading	38.76[c]	38.28[b]	38.17[a]	38.20[a]
After loading	39.08[c]	38.44[b]	38.44[b]	38.29[a]
On arrival at the slaughter facility	39.36[d]	38.60[b]	38.79[c]	38.38[a]
Prior to stunning	39.60[d]	38.76[b]	39.18[c]	38.47[a]
Post exsanguination	39.80[d]	38.92[b]	39.54[c]	38.56[a]
Post scalding	39.96[d]	39.08[b]	39.85[c]	38.65[a]
Post dehairer	40.08[c]	39.24[b]	40.04[c]	38.74[a]
Post singe	40.16[d]	39.40[b]	40.07[c]	38.83[a]
Prior to evisceration	40.20[d]	39.56[b]	39.90[c]	38.92[a]

[1] Means predicted from regression equations presented in Table A2.
[a,b,c,d] Means in the same row with differing superscripts are significantly different. (P<.05).
[e] Season: S=summer, W=winter; Pre-slaughter management: L=low stress, H=high stress

Table B3. Predicted means[1] for the Halothane genotype x season interaction for body temperature.

Time	Halothane genotype x season subclasses[f]					
	C*S	C*W	R*S	R*W	N*S	N*W
Two days prior to harvest	38.15[e]	37.92[c]	37.36[a]	37.97[c]	38.01[d]	37.74[b]
One day prior to harvest	38.22[d]	38.12[c]	37.50[a]	38.17[cd]	38.22[d]	37.97[b]
Morning of harvest	38.33[c]	38.32[c]	37.64[a]	38.37[c]	38.43[d]	38.20[b]
Prior to loading	38.48[bc]	38.52[cd]	37.78[a]	38.57[d]	38.64[e]	38.43[b]
After loading	38.67[bc]	38.72[cd]	37.92[a]	38.77[d]	38.85[e]	38.66[b]
On arrival at the slaughter facility	38.89[b]	38.92[bc]	38.06[a]	38.97[c]	39.06[d]	38.89[b]
Prior to stunning	39.16[b]	39.12[b]	38.20[a]	39.17[b]	39.27[c]	39.12[b]
Post exsanguination	39.47[c]	39.32[b]	38.34[a]	39.37[b]	39.48[c]	39.35[b]
Post scalding	39.82[e]	39.52[b]	38.48[a]	39.57[bc]	39.69[d]	39.58[c]
Post dehairer	40.21[e]	39.72[b]	38.62[a]	39.77[bc]	39.90[d]	39.81[c]
Post singe	40.64[e]	39.92[b]	38.76[a]	39.97[b]	40.11[d]	40.04[c]
Prior to evisceration	41.11[d]	40.12[b]	38.90[a]	40.17[b]	40.32[c]	40.27[c]

For more information contact:
National Pork Board, P.O. Box 9114, Des Moines, Iowa USA
800-456-7675, **Fax:** 515-223-2646, **E-Mail:** porkboard@porkboard.org, **Web:** http://www.porkboard.org/

[1] Means predicted from regression equations presented in Table A3.
[a,b,c,d,e] Means in the same row with differing superscripts are significantly different. (P<.05).
[f]Halothane genotype: C=Nn, R=nn, N=NN; Season: summer, w=winter

Table B4. Predicted means[1] for the Halothane genotype x pre-slaughter management interaction for *Longissimus* pH.

Genotype x management subclass [g]	Time post-mortem, h									
	.75	1	1.5	2	3	4	5	6	12	24
N x H	6.14^{d}	6.10^{d}	6.06^{d}	6.02^{d}	5.98^{d}	5.94^{d}	5.90^{e}	5.86^{d}	5.82^{f}	5.78^{e}
N x L	6.23^{e}	6.16^{e}	6.09^{e}	6.02^{d}	5.95^{c}	5.88^{c}	5.81^{d}	5.74^{c}	5.67^{b}	5.60^{a}
C x H	5.92^{c}	5.86^{c}	5.82^{c}	5.78^{c}	5.76^{b}	5.74^{b}	5.74^{c}	5.74^{c}	5.76^{d}	5.78^{e}
C x L	6.34^{f}	6.27^{f}	6.20^{f}	6.13^{e}	6.06^{e}	5.99^{e}	5.92^{f}	5.85^{d}	5.78^{e}	5.71^{d}
R x H	5.58^{a}	5.59^{a}	5.59^{a}	5.60^{b}	5.60^{a}	5.60^{a}	5.61^{a}	5.61^{a}	5.62^{a}	5.62^{b}
R x L	5.83^{b}	5.70^{b}	5.62^{b}	5.58^{a}	5.59^{a}	5.61^{a}	5.64^{b}	5.67^{b}	5.69^{c}	5.68^{c}

[1] Means predicted from regression equations presented in Table A4.
[a,b,c,d,e,f] Means in the same column with differing superscripts are significantly different. (P<.05).
[g] Halothane genotype: C=Nn, N=NN, R=nn; Pre-slaughter management: L=low stress, H=high stress

Table B5. Predicted means[1] for the season x pre-slaughter management interaction for *Longissimus* pH.

Season x management subclass[e]	Time post-mortem, h									
	.75	1	1.5	2	3	4	5	6	12	24
S*H	6.06[b]	6.00[b]	5.95[b]	5.90[b]	5.86[c]	5.82[c]	5.79[c]	5.76[c]	5.74[c]	5.73[d]
S*L	6.16[c]	6.11[c]	6.06[d]	6.01[c]	5.96[d]	5.91[d]	5.86[d]	5.81[d]	5.76[d]	5.71[c]
W*H	5.84[a]	5.73[a]	5.67[a]	5.62[a]	5.59[a]	5.56[a]	5.51[a]	5.45[a]	5.34[a]	5.19[a]
W*L	6.33[d]	6.17[d]	6.03[c]	5.91[b]	5.81[b]	5.73[b]	5.67[b]	5.63[b]	5.61[b]	5.61[b]

[1] Means predicted from regression equations presented in Table A5.
[a,b,c,d] Means in the same column with differing superscripts are significantly different. (P<.05).
[e] Season: S=summer, W=winter; Pre-slaughter management: L= low stress, H= high stress

Table B6. Predicted means[1] for the Halothane genotype x season interaction for *Longissimus* pH.

Genotype x season subclass[g]	Time post-mortem, h									
	.75	1	1.5	2	3	4	5	6	12	24
N x S	6.29[d]	6.23[e]	6.17[f]	6.11[f]	6.05[f]	5.99[f]	5.93[f]	5.87[e]	5.81[e]	5.75[d]
N x W	6.06[b]	6.01[b]	5.96[d]	5.91[d]	5.86[d]	5.81[d]	5.76[d]	5.71[c]	5.66[c]	5.61[b]
C x S	6.15[c]	6.11[d]	6.07[e]	6.03[e]	5.99[e]	5.95[e]	5.91[e]	5.87[e]	5.83[f]	5.79[e]
C x W	6.15[c]	6.04[c]	5.94[c]	5.86[c]	5.81[c]	5.76[c]	5.74[c]	5.74[d]	5.75[d]	5.78[e]
R x S	5.64[a]	5.64[a]	5.64[b]	5.64[b]	5.64[b]	5.64[b]	5.64[b]	5.63[b]	5.63[b]	5.63[c]
R x W	5.63[a]	5.63[a]	5.62[a]	5.62[a]	5.61[a]	5.60[a]	5.60[a]	5.59[a]	5.59[a]	5.58[a]

[1] Means predicted from regression equations presented in Table A6.
[a,b,c,d,e,f] Means in the same column with differing superscripts are significantly different. (P<.05).
[g] Halothane genotype: C=carrier, N=normal, R=reactor; Season: S=summer, W=winter

Table B7. Predicted means[1] for the Halothane genotype x pre-slaughter management interaction for *Semimembranosus* pH.

	Time post-mortem, h

Genotype x management subclass[g]	.75	1	1.5	2	3	4	5	6	12	24
N x H	6.16[e]	6.14[e]	6.12[e]	6.10[e]	6.08[f]	6.06[f]	6.04[f]	6.02[f]	6.00[e]	5.98[f]
N x L	5.97[c]	5.93[c]	5.89[c]	5.85[b]	5.81[c]	5.77[c]	5.73[c]	5.69[b]	5.65[a]	5.61[a]
C x H	6.00[d]	5.98[d]	5.96[d]	5.94[c]	5.92[d]	5.90[d]	5.88[e]	5.86[e]	5.84[d]	5.82[e]
C x L	6.27[f]	6.20[f]	6.13[e]	6.06[d]	5.99[e]	5.92[e]	5.85[d]	5.78[d]	5.71[c]	5.64[b]
R x H	5.71[b]	5.70[b]	5.70[b]	5.69[a]	5.69[a]	5.68[a]	5.68[a]	5.67[a]	5.67[b]	5.66[c]
R x L	5.67[a]	5.67[a]	5.68[a]	5.69[a]	5.70[b]	5.70[b]	5.71[b]	5.72[c]	5.72[c]	5.73[d]

[1] Means predicted from regression equations presented in Table A7.
[a,b,c,d,e,f] Means in the same column with differing superscripts are significantly different. (P<.05).
[g] Halothane genotype: N=normal, C=carrier, R=reactor; Pre-slaughter management: L=low stress; H= high stress

Table B8. Predicted means[1] for the season x pre-slaughter management interaction for *Semimembranosus* pH.

Season x management subclass[e]	Time post-mortem, h									
	.75	1	1.5	2	3	4	5	6	12	24
S*H	5.98[b]	5.97[b]	5.96[b]	5.95[b]	5.94[c]	5.93[c]	5.92[d]	5.91[d]	5.90[d]	5.89[d]

S*L	6.12[d]	6.07[d]	6.02[d]	5.97[c]	5.92[b]	5.87[b]	5.82[b]	5.77[b]	5.72[b]	5.67[b]
W*H	6.02[c]	6.00[c]	5.98[c]	5.96[bc]	5.94[c]	5.92[c]	5.90[c]	5.88[c]	5.86[c]	5.84[c]
W*L	5.94[a]	5.90[a]	5.86[a]	5.82[a]	5.78[a]	5.74[a]	5.70[a]	5.66[a]	5.62[a]	5.58[a]

[1] Means predicted from regression equations presented in Table A8.
[a,b,c,d] Means in the same column with different superscripts are significantly different. (P<.05).
[e] Season: S = summer, W = winter; Pre-slaughter management: L=low stress; H=high stress

Table B9. Predicted means[1] for the Halothane genotype x season interaction for *Semimembranosus* pH.

Genotype x season subclass[g]	Time post-mortem, h									
	.75	1	1.5	2	3	4	5	6	12	24
N x S	6.02[d]	6.00[d]	5.98[b]	5.96[c]	5.94[d]	5.92[d]	5.90[d]	5.88[d]	5.86[e]	5.84[e]
N x W	6.11[e]	6.06[e]	6.01[c]	5.96[c]	5.91[c]	5.86[c]	5.81[c]	5.76[c]	5.71[c]	5.66[b]
C x S	6.23[f]	6.18[f]	6.13[d]	6.08[d]	6.03[e]	5.98[e]	5.93[e]	5.88[d]	5.83[d]	5.78[d]
C x W	5.90[c]	5.79[c]	5.70[a]	5.63[a]	5.57[a]	5.53[a]	5.50[a]	5.49[a]	5.50[a]	5.52[a]
	5.68[a]	5.68[a]	5.69[a]	5.69[b]	5.69[b]	5.69[b]	5.69[b]	5.70[b]	5.70[bc]	5.70[c]

R x S										
R x W	5.70[b]	5.70[b]	5.70[a]	5.70[b]	5.70[b]	5.69[b]	5.69[b]	5.69[b]	5.69[b]	5.69[c]

[1] Means predicted from regression equations presented in Table A9.
[a,b,c,d,e,f] Means in the same column with different superscripts are significantly different. (P<.05).
[g] Halothane genotype: N=normal, C=carrier, R=reactor; Season: S=summer, W=winter

Table B10. Predicted means for the Halothane genotype x pre-slaughter handling interaction for *Longissimus* temperature.

Genotype x management subclass[g]	Time post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
N x H	39.54[f]	44.01[e]	45.42[e]	44.19[d]	40.74[f]	35.49[f]	28.86[f]	21.27[e]	13.14[e]	4.89[e]	-3.06[d]
N x L	37.52[b]	42.00[a]	43.38[a]	42.08[a]	38.52[b]	33.12[c]	26.30[c]	18.48[c]	10.08[b]	1.52[b]	-6.78[a]
C x H	39.30[e]	44.29[f]	45.82[f]	44.43[e]	40.66[e]	35.05[e]	28.14[e]	20.47[d]	12.58[d]	5.01[f]	-1.70[f]
C x L	37.48[a]	42.28[b]	43.63[b]	42.08[a]	38.22[a]	32.60[a]	25.81[b]	18.40[b]	10.96[c]	4.04[d]	-1.77[e]
R x H	38.63[d]	43.34[d]	44.57[d]	42.86[b]	38.75[c]	32.78[b]	25.49[a]	17.42[a]	9.11[a]	1.10[a]	-6.07[b]
R x L	38.58[c]	43.14[c]	44.42[c]	42.90[c]	39.06[d]	33.38[d]	26.34[d]	18.42[b]	10.10[b]	1.86[c]	-5.82[c]

[1] Means predicted from regression equations presented in Table A10.
[a,b,c,d,e,f] Means in the same column with different superscripts are significantly different. (P<.05).
[g] Halothane genotype: N=normal, C=carrier, R=reactor; Pre-slaughter management: L=low stress, H=high stress

Table B11. Predicted means[1] for the season x pre-slaughter management interaction for *Longissimus* temperature.

Season x management subclass[e]	Time post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
S x H	39.34[d]	44.04[d]	45.43[c]	44.03[c]	40.36[c]	34.93[c]	28.25[c]	20.84[c]	13.22[d]	5.91[d]	-0.58[d]
S x L	37.64[a]	42.29[a]	43.64[a]	42.22[a]	38.55[a]	33.14[a]	26.53[a]	19.23[a]	11.77[a]	4.67[b]	-1.55[c]
W x H	39.15[c]	43.97[c]	45.48[d]	44.20[d]	40.60[d]	35.18[d]	28.44[d]	20.85[c]	12.93[c]	5.15[c]	-1.99[b]
W x L	37.78[b]	42.42[b]	43.81[b]	42.47[b]	38.87[b]	33.51[b]	26.89[b]	19.48[b]	11.80[b]	4.32[a]	-2.46[a]

[1] Means predicted from regression equations presented in Table A11.
[a,b,c,d] Means in the same column with different superscripts are significantly different. (P<.05).
[e] Season: S = summer, W=winter; Pre-slaughter management: L=low stress, H=high stress

Table B12. Predicted means[1] for the Halothane genotype x season interaction for *Longissimus* temperature.

Genotype x season subclass[g]	Time post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
N x S	38.50[c]	42.95[a]	44.36[a]	43.21[c]	39.98[e]	35.15[e]	29.20[d]	22.61[e]	15.86[e]	9.43[f]	3.80[f]
N x W	38.58[d]	43.17[b]	44.80[d]	43.89[f]	40.86[f]	36.13[f]	30.12[e]	23.25[f]	15.94[f]	8.61[e]	1.68[e]
C x S	38.37[a]	43.23[c]	44.63[c]	43.11[b]	39.21[a]	33.47[a]	26.43[a]	18.63[a]	10.61[a]	2.91[a]	-3.93[a]
C x W	38.45[b]	43.45[e]	44.97[f]	43.55[e]	39.73[c]	34.05[c]	27.05[b]	19.27[b]	11.25[b]	3.53[b]	-3.35[b]
R x S	38.65[e]	43.41[d]	44.85[e]	43.51[d]	39.93[d]	34.65[d]	28.21[c]	21.15[d]	14.01[d]	7.33[d]	1.65[d]
R x W	38.59[d]	43.21[c]	44.51[b]	43.03[a]	39.31[b]	33.89[b]	27.31[b]	20.11[c]	12.83[c]	6.01[c]	0.19[c]

[1] Means predicted from regression equations presented in Table A12.
[a,b,c,d,e,f] Means in the same column with different superscripts are significantly different. (P<.05).
[g] Halothane genotype: N=normal, C=carrier, R=reactor; Season: S=summer, W=winter

Table B13. Predicted means[1] for the Halothane genotype x pre-slaughter management interaction for *Semimembranosus* temperature.

Genotype x management subclass[g]	Time post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
N x H	41.64[f]	42.55[e]	43.34[e]	43.59[e]	42.88[d]	40.79[e]	36.90[e]	30.79[e]	22.04[c]	10.23[c]	-5.06[b]
N x L	38.06[a]	38.68[a]	39.42[a]	39.86[a]	39.58[a]	38.16[a]	35.18[b]	30.22[c]	22.86[d]	12.68[e]	-0.74[e]
C x H	41.55[e]	42.78[f]	43.67[f]	43.86[f]	42.99[e]	40.70[d]	36.63[d]	30.42[d]	21.71[b]	10.14[b]	-4.65[c]
C x L	39.49[b]	40.60[b]	41.43[b]	41.62[b]	40.81[b]	38.64[b]	34.75[a]	28.78[a]	20.37[a]	9.16[a]	-5.21[a]
R x H	40.01[c]	41.71[d]	42.87[d]	43.19[d]	42.37[c]	40.11[c]	36.11[c]	30.07[b]	21.69[b]	10.67[d]	-3.29[d]
R x L	40.99[d]	41.62[c]	42.47[c]	43.12[c]	43.15[f]	42.14[f]	39.67[f]	35.32[f]	28.67[e]	19.30[f]	6.79[f]

[1] Means predicted from regression equations presented in Table A13.
[a,b,c,d,e,f] Means in the same column with different superscripts are significantly different. (P<.05).
[g] Halothane genotype: N=normal, C=carrier, R=reactor; Pre-slaughter management: L=low stress, H=high stress

Table B14. Predicted means[1] for the season x pre-slaughter management Interaction for *Semimembranosus* temperature.

Season x management subclass[e]	Time post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
S x H	40.89[c]	42.31[c]	43.39[c]	43.83[c]	43.33[c]	41.59[c]	38.31[c]	33.19[b]	25.93[b]	16.23[b]	3.79[b]
S x L	39.91[a]	40.62[a]	41.31[a]	41.56[a]	40.95[a]	39.06[a]	35.47[a]	29.76[a]	21.51[a]	10.30[a]	-4.29[a]
W x H	41.72[d]	42.81[d]	43.82[d]	44.39[d]	44.16[d]	42.77[d]	39.86[d]	35.07[d]	28.04[d]	18.41[d]	5.82[d]
W x L	40.09[b]	41.12[b]	42.09[b]	42.64[b]	42.41[b]	41.04[b]	38.17[b]	33.44[c]	26.49[c]	16.96[c]	4.49[c]

[1] Means predicted from regression equations presented in Table A14.
[a,b,c,d] Means in the same column with different superscripts are significantly different. (P<.05).
[e] Season: S=summer, W = winter; Pre-slaughter management: L=low stress, H=high stress

Table B15. Predicted means[1] for the Halothane genotype x season interaction for *Semimembranosus* temperature.

Genotype x season subclass[g]	Time post-mortem, h										
	.25	.33	.5	.67	.75	1	2	4	6	12	24
N x S	40.57[c]	41.42[b]	42.33[a]	42.94[b]	42.89[c]	41.82[d]	39.37[e]	35.18[f]	28.89[f]	20.14[f]	8.57[f]
N x W	41.21[f]	41.99[e]	42.87[c]	43.43[e]	43.25[e]	41.91[f]	38.99[c]	34.07[c]	26.73[c]	16.55[c]	3.11[c]
C x S	40.42[b]	41.52[c]	42.34[a]	42.52[a]	41.70[a]	39.52[a]	35.62[a]	29.64[b]	21.22[b]	10.00[b]	-4.38[b]
C x W	40.67[d]	41.94[d]	42.85[c]	43.04[c]	42.15[b]	39.82[b]	35.69[b]	29.40[a]	20.59[a]	8.90[a]	-6.03[a]
R x S	39.98[a]	41.38[a]	42.56[b]	43.22[d]	43.06[d]	41.78[c]	39.08[d]	34.66[e]	28.22[e]	19.46[e]	8.08[e]
R x W	41.01[e]	42.02[f]	42.97[d]	43.50[f]	43.25[e]	41.86[e]	38.97[c]	34.22[d]	27.25[d]	17.70[d]	5.21[d]

[1] Means predicted from regression equations presented in Table A15.
[a,b,c,d,e,f] Means in the same column with different superscripts are significantly different. (P<.05).
[g] Halothane genotype: N=normal, C=carrier, R=reactor; Season: S=summer, W=winter

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