

Effects of Supplemental Manganese Source on the Pork Quality During Seven Days of Retail Display

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Story in Brief

Loins from 168 crossbred pigs were used to test the effects of supplemental manganese (Mn) on pork quality during 7 d of retail display. Loins were from pigs assigned randomly to one of six dietary treatments arranged in a 2 x 3 factorial design with Mn present (+Mn) or absent (-Mn) in the basal diet and 0 or 350 ppm of supplemental Mn from either Mn sulfate (MnSO₄) or AvailaMn-80 (AvMn). Bone-in loins were collected during fabrication and shipped to Oklahoma State University for quality data collection. Loins were cut into longissimus muscle (LM) chops and placed in a modified atmosphere package (80% O₂:20% CO₂) for 7 d of retail display. Chops from pigs fed diets supplemented with MnSO₄ received higher (P < 0.05) lean color scores, were redder, and more vivid than chops from pigs fed diets supplemented with AvMn. Moreover, chops from pigs fed basal diets +Mn and supplemental MnSO₄ received higher (P < 0.05) color scores than all other treatment combinations, and were darker (P < 0.05) than chops from pigs fed the basal diet -Mn or the basal +Mn and supplemented with AvMn. Discoloration was reduced over the last 3 d of retail display by inclusion of Mn in the basal diets and supplemented with MnSO₄. Results suggest that supplementing 350 ppm Mn from MnSO₄ to swine diets formulated to meet maintenance Mn requirements improves pork color and reduces discoloration during retail display.

Introduction

Manganese (Mn) is a divalent, transition metal cation that functions as a co-factor of several enzymes crucial for carbohydrate, lipid and protein metabolism; however, the dietary requirements for Mn in swine diets are quite low and not well established, and, until recently, little was known about the effects of supplemental Mn on pork carcass composition or quality. In the first of two studies, Roberts et al. (2002) found that including 350 ppm Mn from AvailaMn (a Mn amino acid complex) in diets of growing-finishing swine improved pork color. However, when lower dietary Mn inclusion levels (0 to 320 ppm) from AvailaMn were included in swine diets, Apple et al. (2003) noted no beneficial effects on pork quality during retail display.

In both previous studies, Mn was removed from the vitamin-mineral premix included in the basal diets. Therefore, the objectives of this study were to determine the effect of supplementing two different basal diets (diets devoid of Mn vs diets formulated to meet Mn maintenance requirements) with 0 or 350 ppm Mn from either Mn sulfate (MnSO₄) or AvailaMn (AvMn) on pork quality of growing-finishing swine.

Experimental Procedures

Crossbred barrows and gilts (n = 168) from the mating of line 348 sows to EB boars (Monsanto Choice Genetics, St. Louis, Mo.) were blocked by weight and randomly allotted within blocks to pens (six pigs/pen in blocks 1, 2, 5, and 6, whereas there were only four pigs/pen in blocks 3 and 4) at an average weight of 48.8 lb. Within blocks, pens were assigned randomly to one of six dietary treatments arranged in a 2 x 3 factorial design: 1) negative control starter, grower, and finisher diets devoid of Mn in the basal diet; 2) the negative

control diets supplemented with 350 ppm Mn from manganese sulfate (MnSO₄); 3) negative control diets supplemented with 350 ppm Mn from AvailaMn-80 (a Mn amino acid complex; Zinpro Corp., Eden Prairie, Minn.); 4) positive control starter, grower, and finisher diets with Mn included in the basal diet; 5) positive control diets supplemented with 350 ppm Mn from MnSO₄; or 6) positive control diets supplemented with 350 ppm Mn from AvailaMn-80 (AvMn). For more details concerning feeding regimen, diet composition, and pig housing refer to Apple et al. (2004).

When the lightest block of pigs averaged 250 lb, all pigs were transported to a commercial pork packing plant (Bryan Foods, Inc., West Point, Miss.), and slaughtered according to industry-accepted procedures. After a 24-h spray-chilling period, carcasses were fabricated, and right-side, bone-in pork loins were collected, paper-wrapped, boxed, and transported to the Oklahoma State University Meat Laboratory (Stillwater, Okla.) for pork quality data collection.

Upon arrival, the blade and sirloin ends of each loin were removed, and the remaining center-cut portion of each loin was processed into 1-in thick longissimus muscle (LM) chops, weighed, and allowed to bloom for 15 min. Visual appraisal of color, firmness, and discoloration was evaluated by a five-person trained and experienced panel. Then, chops were packaged in a modified atmosphere (80% O₂:20% CO₂) and displayed in coffin-display cases under constant light (1,600 lx) at 34°F for 7 d. On each day of retail display, chops were visually evaluated for lean color (1 = pale pinkish gray to 6 = dark purplish red; NPPC, 1999), discoloration (1 = total (100%) discoloration to 8 = no (0%) discoloration), and firmness (1 = very soft/very watery to 5 = very firm/very dry; NPPC, 1991) by the trained, experienced panel. Additionally, on d 0 and 7 of display, L*, a*, and b* values were determined from a mean of four readings made with a Minolta Chromameter (Minolta Corp., Ramsey, N.J.) using D65 illuminant. The saturation index, or chroma (C*), was calculated as $C^* = (a^{*2} + b^{*2})^{1/2}$, and is a measure of the total color, or vividness of the color, of the LM.

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On d 0 and 7, thiobarbituric acid reactive substances (TBARS) were analyzed on duplicate samples according to the modified procedure of Witte et al. (1970) to measure the amount of oxidative rancidity. Furthermore, on d 7 of display, chops were removed from their packages and weighed, and the difference between the d 0 and d 7 weights was used to calculate moisture loss percentage.

Data were analyzed as a randomized complete block design with treatments arranged in a 2 x 3 factorial design. Analysis of variance was generated using the mixed model procedure of SAS (SAS Inst., Inc., Cary, N.C.) with individual loin as the experimental unit for pork quality data analyses. Dietary treatment, display day, and the treatment x display day were the fixed effects included in the repeated measures model for pork quality measures. Least squares means were computed, and statistically separated by the PDIF option of SAS when $P < 0.05$. Additionally, preplanned contrasts were used to make specific comparisons between the positive and negative control diets, Mn sources (MnSO_4 vs AvMn), and presence or absence of Mn in the basal diet.

Results and Discussion

The main effects of dietary and supplemental Mn on pork quality traits are presented in Table 1. The LM from pigs fed diets supplemented with 350 ppm Mn from MnSO_4 received higher ($P = 0.022$) color scores than chops from pigs consuming diets supplemented with AvMn. Specifically, chops from pigs fed Mn in the basal diet and supplemented with MnSO_4 had higher ($P < 0.05$) color scores than all other treatment combinations. The LM of pigs consuming diets with Mn in the basal diet and supplemented with MnSO_4 was also darker (lower L^* values; $P < 0.05$) than the LM from pigs fed the unsupplemented (NC and PC) diets, as well as from pigs fed basal diets containing Mn and supplemented with AvMn. Additionally, chops of pigs fed MnSO_4 were redder (larger a^* values; $P = 0.022$) and more vivid ($P = 0.037$) than those of pigs fed AvMn. Neither firmness scores nor b^* values were ($P > 0.10$) altered by either dietary or supplemental Mn.

There was a dietary treatment x display day interaction ($P = 0.038$) on discoloration scores (Figure 1). Discoloration scores were similar ($P > 0.10$) during the first 4 d of retail display. However, on d 5 and d 6 of retail display, chops from pigs fed basal diets including Mn and supplemented with MnSO_4 were less ($P < 0.05$) discolored than chops from pigs fed basal diets devoid of Mn or basal diets with Mn and supplemented with AvMn. Furthermore, chops from pigs fed Mn-diets supplemented with AvMn were more ($P < 0.05$) discolored on d 6 of display than chops from pigs fed diets lacking Mn and supplemented with either MnSO_4 or AvMn, as well as pigs fed basal diets including Mn. By d 7, chops from the pigs fed diets containing Mn and supplemented with MnSO_4 were still the least ($P < 0.05$) discolored, whereas chops from pigs fed the basal diet with Mn and supplemented with AvMn were discolored the most ($P < 0.05$), to the point of total consumer discrimination.

Roberts et al. (2002) reported that loin chops from pigs fed diets containing 350 ppm Mn from AvMn received higher American and Japanese color scores than pigs fed diets devoid of Mn or diets containing 350 ppm Mn from MnSO_4 , as well as diets containing 700 ppm Mn from either AvMn or MnSO_4 . Furthermore, these authors indicated that including 350 ppm Mn from AvMn tended to produce darker (lower L^* values) and less yellow (lower b^* values) LM chops. On the other hand, lower dietary inclusion levels (0 to 320 ppm) of Mn from AvMn did not affect subjective and objective color measures, nor was the amount of discoloration during retail display

affected by dietary Mn level (Apple et al., 2003).

Moisture loss over the 7 d of retail display was not ($P > 0.27$) altered by either dietary or supplemental Mn (Table 1). However, chops from pigs fed basal diets devoid of Mn had lower ($P = 0.045$) TBARS values than chops of pigs fed basal diets with Mn.

Manganese is a co-factor of superoxide dismutase, a free-radical scavenging enzyme that catalyzes superoxide anion radicals into hydrogen peroxide and water. Ellis et al. (1971) found inhibited lipid oxidation when pork lard was treated with low levels of Mn chloride; however, when methyl linoleate (a lipid model) was treated with very high levels of Mn, lipid oxidation actually increased (Tjho and Karel, 1969). Moreover, Roberts et al. (2002) noted that TBARS values for pork of pigs fed 350 ppm Mn from MnSO_4 were lower than pork from pigs fed control diets or supplemented with 700 ppm Mn from MnSO_4 or AvMn. It is important to note that TBARS values of chops in the present study were considerably lower than 1.0 mg/g, which is the threshold where humans detect rancidity; therefore, the statistical difference among the dietary treatments may not be detected by either trained evaluators or consumers.

Implications

Results of the present study indicate that pork color can be improved by supplementing swine diets with 350 ppm of manganese from manganese sulfate above maintenance requirements. More importantly, supplementing basal diets containing manganese with 350 ppm of manganese from manganese sulfate effectively delayed pork discoloration during retail display.

Acknowledgments

The authors wish to express their appreciation to the Zinpro Corporation (Eden Prairie, Minn., USA) for donation of Availa®Mn-80 and financial support of this project. Additionally, the authors gratefully acknowledge the assistance of Keith Richardson and the employees at Bryan Foods (West Point, Miss., USA) for their hospitality and assistance with pig slaughter, carcass fabrication, and pork loin procurement. Finally, the authors wish to thank Jennifer Leach, Juan Jimenez, Abby Keener, Wendy White, and Angela Collins for assistance in loin fabrication and data collection

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Table 1. Effect of manganese (Mn) in the basal diet and Mn supplementation on pork quality during retail display.

Item	Basal diet without Mn ^a (-Mn)			Basal diet with Mn ^a (+Mn)			P-value ^b		
	NC	MnSO ₄	350 ppm	PC	MnSO ₄	350 ppm	PC vs NC	MnSO ₄ vs AvMn	+Mn vs -Mn
	3.2 ^y	3.2 ^y	3.2 ^y	3.1 ^y	3.4 ^x	3.1 ^y	0.209	0.022	0.939
Lean color score ^c	3.2 ^y	3.2 ^y	3.2 ^y	3.1 ^y	3.4 ^x	3.1 ^y	0.06	0.022	0.939
Firmness score ^d	4.7	4.8	4.7	4.8	4.9	4.8	0.07	0.097	0.182
Lightness (L*) ^e	50.27 ^x	49.41 ^{xy}	49.01 ^{xy}	50.08 ^x	48.25 ^y	50.36 ^x	0.585	0.118	0.997
Redness (a*) ^e	7.47	7.71	7.46	7.57	8.07	7.25	0.234	0.022	0.638
Yellowness (b*) ^e	12.01	11.89	11.78	11.83	11.81	11.59	0.167	0.327	0.283
Chroma ^f	14.21	14.27	14.04	14.14	114.37	13.76	0.197	0.037	0.605
Moisture loss, %	7.76	6.15	6.08	6.34	5.75	6.52	0.993	0.698	0.537
TBARS, mg/g ^g	0.41	0.37	0.29	0.36	0.33	0.49	0.045	0.389	0.045

^aNC = negative control (basal diet devoid of Mn); MnSO₄ = manganese sulfate; PC = positive control; and AvMn = AvailaMn-80.

^bSignificance of orthogonal contrasts for: positive control (PC) vs. negative control (NC); manganese sulfate (MnSO₄) vs. AvailaMn-80 (AvMn); and basal diets containing Mn (+Mn) vs. basal diets absent of Mn (-Mn).

^c1 = pale pinkish gray to 6 = dark purplish red (NPPC, 1999).

^d1 = very soft/very wet to 5 = very firm/very dry (NPPC, 1991).

^eL* = measure of lightness to darkness (larger number indicates a lighter color); a* = measure of redness (larger number indicates a more intense red color); and b* = measure of yellowness (larger number indicates a more intense yellow color).

^fChroma is a measure of total, or vividness of, color (larger number indicates a more vivid color).

^gTBARS = thiobarbituric acid reactive substances are representative of lipid oxidation (larger number indicates greater oxidative rancidity).

^{x,y}Within a row, least squares means lacking a common superscript letter differ (P < 0.05).

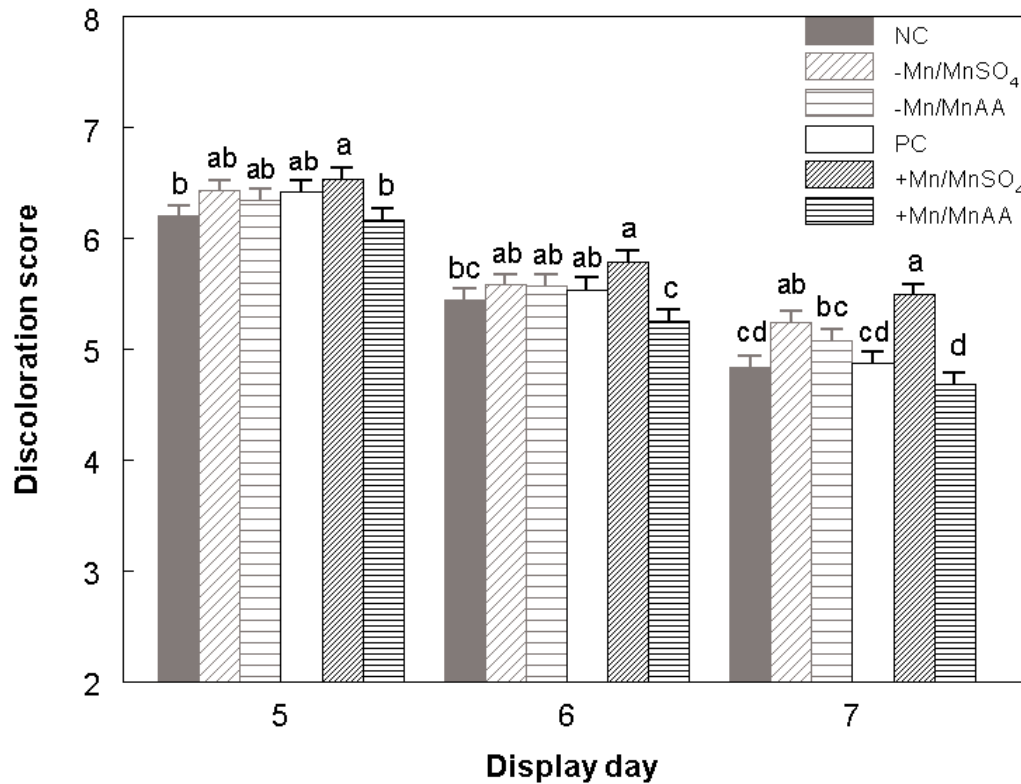


Fig. 1. Interactive effect of dietary and supplemental manganese (Mn) on longissimus muscle chop discoloration scores (1 = total (100%) discoloration to 8 = no (0%) discoloration) during 7 d of retail display (treatment x display day; P = 0.038). Within a display day, bars lacking a common letter differ (P < 0.05). Treatment abbreviations include: -Mn = no Mn included in the basal diet; +Mn = basal diet included Mn; NC = negative control diets; PC = positive control diets; MnSO₄ = manganese sulfate; and AvMn = AvailaMn-80 (a Mn amino acid complex).