

Effects of Iron Supplementation Level in Diets of Growing-Finishing Swine.

II. Pork Quality Traits During Retail Display

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Story in Brief

Bone-in pork loins (n = 80) from pigs fed diets devoid of iron (negative control), 100 ppm iron (Fe) from ferrous sulfate (positive control), or the positive control diets supplemented with an additional 50, 100, or 150 ppm Fe from Availa-Fe were used to determine the effect of dietary Fe concentration on pork quality during 7 d of retail display. Briefly, loin chops were cut, placed on foam trays, overwrapped with an oxygen-permeable PVC film, and placed under 1600 lx of warm white light in chest-type display cases for 7 d. Loin chops from pigs fed diets supplemented with 50 Fe from Availa-Fe had less (P < 0.05) moisture loss during retail display than chops from pigs fed either the negative or positive control diets and diets supplemented with 150 ppm Fe. Even though L* values were similar among dietary treatments during the first 4 d of retail display, chops from pigs fed diets supplemented with 50 ppm Fe were darker (lower L* values) than chops from pigs fed the negative control diet (dietary treatment x display day interaction; P = 0.03). Neither b* values nor estimated oxymyoglobin content (630/580 nm) were affected (P > 0.10) by dietary Fe level; however, chops from pigs fed the negative control and 100 ppm Fe from Availa-Fe diets tended to be a more (P < 0.10) vivid, redder (P < 0.10) color than chops from pigs fed diets supplemented with 50 ppm Fe. Although there was a dietary treatment x display day interaction (P = 0.002) for 2-thiobarbituric acid reactive substances (TBARS) values, values were quite small, implying that dietary inclusion of Availa-Fe had no appreciable effects on the development of oxidative rancidity. Results from the present study indicate that supplementing the diets of growing-finishing swine with 100 ppm Fe from Availa-Fe may enhance pork color, without negatively impacting oxidative rancidity, during retail display.

Introduction

Myoglobin is the primary pigment in meat; however, other heme proteins, such as hemoglobin and cytochrome C, also contribute to meat color. Myoglobin content of muscle varies greatly between muscles and species, and has been shown to increase with increasing age and elevation. Supplementing swine diets with iron (Fe) has been shown to increase muscle concentrations of heme (Yu et al., 2000) and non-heme (Miller et al., 1994b) Fe. The response of increasing muscle Fe content on meat color, however, may be source dependent. For example, elevating dietary Fe content with an inorganic source resulted in detrimental effects on visual color of pork (O'Sullivan et al., 2002); whereas, feeding increased levels of a more bioavailable, organic source (Availa-Fe; Zinpro Corp., Eden Prairie, MN) of Fe increased the redness of pigskin (Yu et al., 2000) and longissimus muscle (unpublished data), and reduced the percentage of pale, soft and exudative pork (unpublished data).

Miller et al. (1994a; b) reported that supplementing swine diets with ferrous sulfate resulted in increased rancidity in cooked ground pork and pork chops stored for up to 12 weeks; however, dietary Fe did not affect lipid oxidation in raw, whole-muscle pork. Additionally, O'Sullivan et al. (2002) reported that supplementing swine diets with 3,000 mg/kg of ferrous sulfate resulted in greater oxidation of oxymyoglobin (bright red color) to metmyoglobin (brown color), adversely impacting visual color scores of pork from pigs fed the Fe-supplemented diet. However, there is no available information concerning the effects of supplementing swine diets with an organic-source of Fe (Availa-Fe) on the shelf-life of pork. Therefore, the objectives of this experiment were to test the effect of Availa-Fe supplementation level on pork quality characteristics of the longissimus muscle during 7 days of retail display.

Experimental Procedures

Bone-in pork loins (n = 80) were randomly selected from pigs fed either: corn-soybean meal-wheat middlings starter, grower, and finisher diets devoid of supplemental Fe in the vitamin-mineral premix (negative control; NC); corn-soybean meal-wheat middlings starter, grower and finisher diets with an inorganic Fe-source in the vitamin-mineral premix (positive control; PC); or the PC starter, grower and finisher diets supplemented with 50, 100, or 150 ppm Fe from Availa-Fe. Description of pigs, diets and feeding protocols, rearing conditions, and harvest are presented in detail in the companion article (Apple et al., 2003).

Twenty-four hours after harvest, pork loins were collected during fabrication at a commercial pork packing plant (Bryan Foods, Inc., West Point, MS). Loins were wrapped in parchment paper, boxed, and shipped back to the University of Arkansas Red-Meat Abattoir under refrigeration. At approximately 48 h postmortem, each loin was processed into four, 1-in thick loin chops, cut perpendicular to the length of the loin. Chops (4 chops/loin) were weighed, placed on foam trays, over-wrapped with an oxygen-permeable PVC film, and allotted randomly to 0, 1, 4, or 7 days of retail display (chest display cases with an average temperature of 34°F, and under 1,600 lx of warm, white light). On each day of display, L* (a measure of darkness to lightness; a larger number indicates a lighter color), a* (a measure of redness; a larger number indicates a redder color), and b* (a measure of yellowness; a larger number indicates a more yellow color) values were determined from a mean of three random readings made with a Hunter MiniScan XE (model 45/0-L; Hunter Associates Laboratory, Reston, VA) using illuminant C. Additionally, the hue angle (a measure of the distance, in degrees, from the true red axis) was calculated as: $\tan^{-1}(b^*/a^*)$; whereas, chroma (a measure of the total color, or vividness of color) was cal-

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culated as: $(a^2 + b^2)^{1/2}$. The ratio of reflectance measured at 630 nm to 580 nm was used to estimate oxymyoglobin concentration of chops during retail display.

After color data collection on each day of retail display, chops were removed from the packaging material, re-weighed, and the difference between chop weights was divided by the initial (day-0) weight to calculate moisture loss percentage. Also, approximately 2 g of pulverized longissimus muscle were used to measure 2-thiobarbituric acid reactive substances (TBARS; a measure of lipid oxidation) according to the procedures of Witte et al. (1970). Values for TBARS are reported as mg of malonaldehyde/kg of muscle.

Data were analyzed as a repeated measures design using the mixed-model procedure of SAS (SAS Inst., Inc., Cary, NC) with loin as the experimental unit. Fixed effects included in the model were dietary treatment, display day, and the treatment x display day interaction, and block and the block x pen x loin x treatment were included in the model as random effects. Least squares means were generated for the main effects and the two-way interaction, and separated statistically by pairwise t-test (PDIFF option of SAS) when $P \leq 0.10$.

Results and Discussion

The effect of Fe supplementation level on pork quality characteristics of loin chops during retail display is presented in Table 1. Loin chops from pigs fed diets supplemented with 50 ppm Fe from Availa-Fe had less ($P < 0.05$) moisture loss during retail display than chops from pigs fed either the negative or positive control diets and the positive control diet supplemented with 150 ppm Fe. These results conflict with those of O'Sullivan et al. (2002), who failed to note a difference in drip loss percentage of chops from pigs fed diets supplemented with Fe, vitamin E, or Fe and vitamin E.

Lightness (L^*) values were similar among dietary treatments on d-0, 1, and 4 of retail display; however, on d-7, chops from pigs fed 50 ppm Fe from Availa-Fe were darker (lower L^* values) than chops from pigs fed the negative control diet (dietary treatment x display day interaction; $P = 0.03$; Fig. 1). Even though dietary treatments did not ($P > 0.10$) affect yellowness (b^*) or estimated oxymyoglobin content (630/580 nm), chops from pigs fed the negative control diets and diets supplemented with 100 ppm Fe tended to have a more vivid (higher chroma values; $P < 0.10$), redder (higher a^* values; $P < 0.10$) color than chops from pigs consuming diets supplemented with 50 ppm Fe (Table 1).

There was a treatment x display day interaction ($P = 0.07$) for hue angle, indicating that loin chops from pigs fed diets supplemented with 100 ppm Fe were redder (lower hue angles) than chops from pigs fed the positive control diets or diets supplemented with 50 ppm Fe on d-0 of retail display (Fig. 2). Hue angles were similar among dietary treatments on d-1 of retail display; however, loin chops from pigs fed diets supplemented with 50 ppm Fe had higher hue angles than chops from pigs fed the negative control diet on d-4 of display, and remained higher on d-7 of display than pork from pigs fed either the negative or positive control diets and diets supplemented with 150 ppm Fe. Interestingly, the hue angle values of chops from pigs fed 100 ppm Fe from Availa-Fe were numerically lower at each time during retail display.

Recent, unpublished information indicated that subjective and objective measures of color of the loin muscle were improved by supplementing swine diets with Fe from Availa-Fe (I. Lecaros, personal communication). O'Sullivan et al. (2002), on the other hand, reported that pork from pigs fed diets supplemented with Fe became less red and more brown in color after 5 d of retail display whereas chops from vitamin E-supplemented pigs was less red and less

brown on d-5 of display compared to values collected on d-1. The authors concluded that supplementing swine diets with Fe lead to increased pigment oxidation from oxymyoglobin (bright red pigment) to metmyoglobin (brown pigment).

Although TBARS values were quite small, chops from pigs fed 150 ppm Fe from Availa-Fe had higher TBARS values than chops from all other dietary treatments after one day of retail display; however, on d-4 of display, TBARS values were lower in chops from pigs fed diets supplemented with 150 ppm Fe than chops from pigs fed the negative control diets or diets supplemented with 100 ppm Fe (dietary treatment x display day interaction; $P = 0.002$; Fig. 3). On d-0 and 7 of display, the degree of oxidative rancidity was similar among the dietary treatments. Increasing dietary Fe content of finishing pigs was shown to increase lipid oxidation in cooked ground pork and pork loin chops stored for up to 12 weeks (Miller et al., 1994a, b); however, dietary Fe did not affect TBARS of fresh, uncooked, whole-muscle pork (Miller et al., 1994a), which is consistent with results from the present study.

Implications

Results from the present study indicate that pork color may be enhanced during retail display by supplementing swine diets with 100 ppm iron from Availa-Fe. Moreover, dietary inclusion of Availa-Fe had no effect on the development of oxidative rancidity. Even though more research is need to thoroughly investigate the effects of dietary iron on pork quality, the supplementation of swine diets with iron may be an effective way of improving pork color during retail display.

Literature Cited

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Table 1. Effects of iron-supplementation level on pork quality characteristics during retail display.

| Item | Negative control | Positive control | Supplemental iron, ppm | | | SEM |
|------------------------------|--------------------|---------------------|------------------------|--------------------|---------------------|-------|
| | | | 50 | 100 | 150 | |
| Moisture loss, % | 3.10 ^g | 3.01 ^g | 2.47 ^f | 2.77 ^{fg} | 3.26 ^g | 0.190 |
| Lightness (L*) ^a | 50.72 | 50.55 | 50.32 | 50.42 | 50.16 | 0.526 |
| Redness (a*) ^a | 10.05 ⁱ | 9.64 ^{hi} | 9.27 ^h | 10.21 ⁱ | 9.78 ^{hi} | 0.230 |
| Yellowness (b*) ^a | 16.04 | 15.88 | 15.57 | 16.04 | 15.80 | 0.185 |
| Hue angle ^b | 58.18 | 58.93 | 59.59 | 57.75 | 58.45 | 0.530 |
| Chroma ^c | 18.97 ⁱ | 18.61 ^{hi} | 18.17 ^h | 19.05 ⁱ | 18.63 ^{hi} | 0.240 |
| 630/580 nm ^d | 2.68 | 2.69 | 2.55 | 2.61 | 2.72 | 0.106 |
| TBARS, mg/kg ^e | 0.13 | 0.14 | 0.13 | 0.14 | 0.15 | 0.008 |

^a L* = measure of darkness to lightness (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 yellow color).

^b Hue angle represents the change from the true red axis (larger number indicates a shift from red to yellow).

^c Chroma represents the total color of the sample (larger number indicates a more vivid color).

^d 630/580 nm is an estimate of the quantity of oxymyoglobin (larger number indicates more oxymyoglobin).

^e TBARS are representative of lipid oxidation (larger number indicates greater oxidative rancidity).

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

^{h,i} Within a row, least-squares means lacking a common superscript letter differ (P < 0.10).

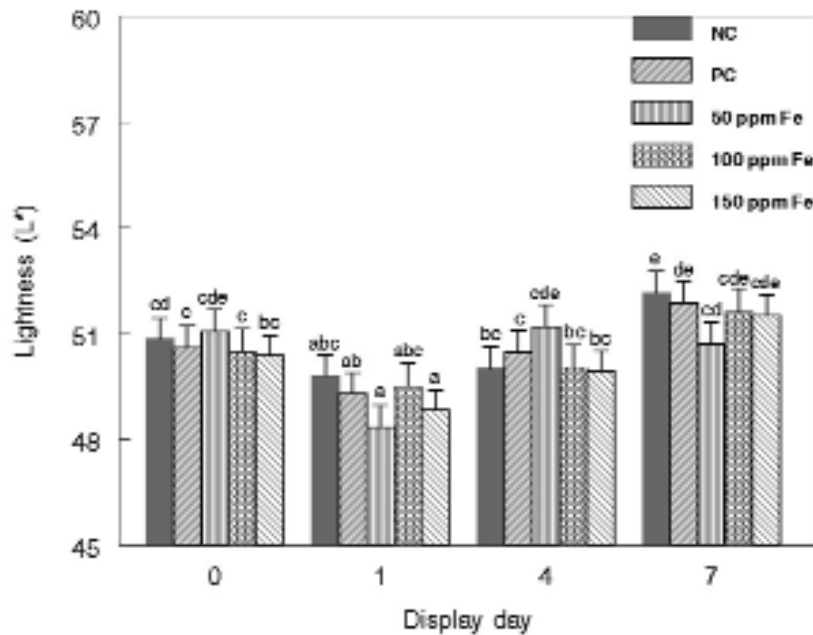


Fig. 1. Effect of dietary iron level on the lightness (L*) value of pork loin chops during seven days of retail display (dietary treatment x display day; P = 0.03). A larger L* value indicates a lighter color. Within a display day, bars lacking a common letter differ (P < 0.05).

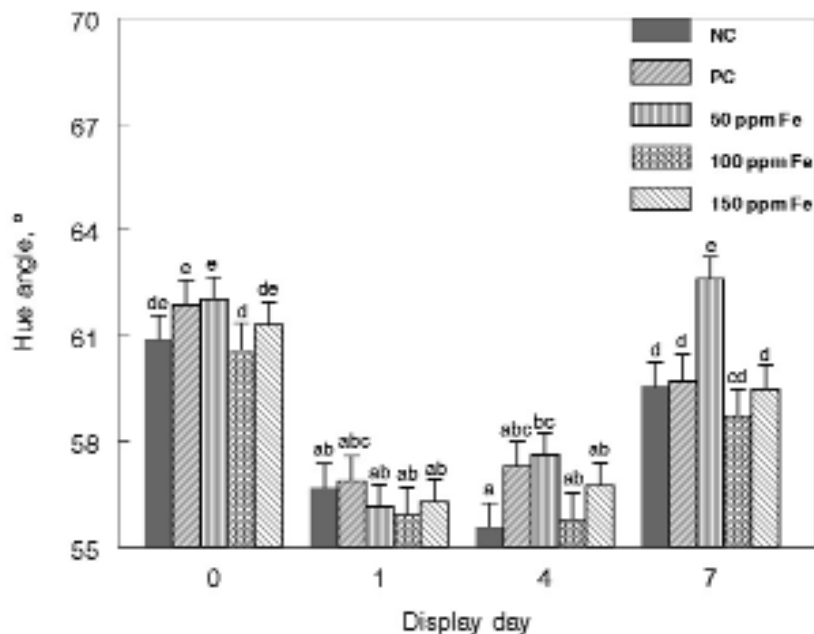


Fig. 2. Effect of dietary iron level on the hue angle of pork loin chops during seven days of retail display (dietary treatment x display day; $P = 0.07$). A larger hue angle indicates a greater distance from the true red axis (less red, more yellow). Within a display day, bars lacking a common letter differ ($P < 0.05$).

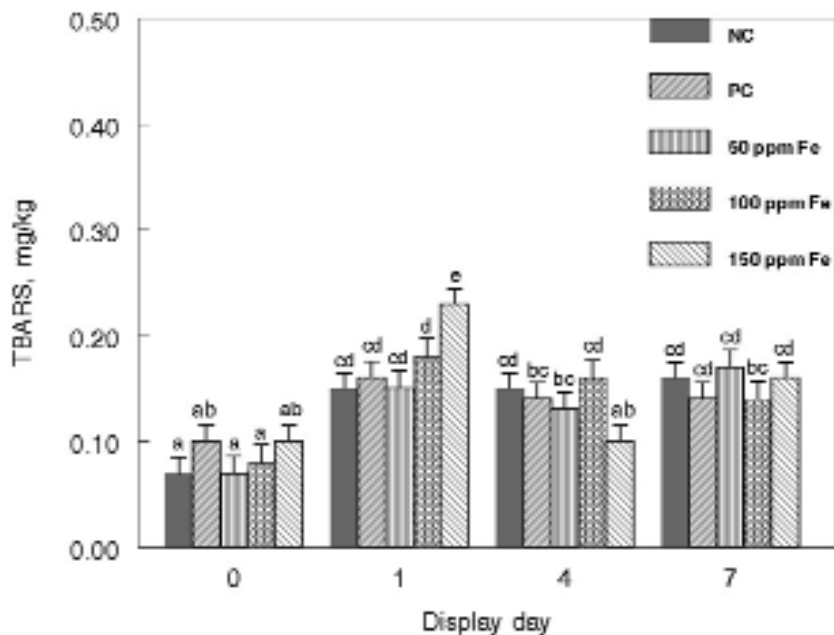


Fig. 3. Effect of dietary iron level on 2-thiobarbituric acid reactive substances (TBARS) values of pork loin chops during seven days of retail display (dietary treatment x display day; $P = 0.002$). Within a display day, bars lacking a common letter differ ($P < 0.05$).