Interactive Effects of Ractopamine and Dietary Fat Source on Quality Characteristics of Fresh Pork Loins and Bellies

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Introduction

Soft pork fat and bellies are an economical concern to today's pork processors, resulting in carcass handling and fabrication difficulties, reduced bacon yields, unattractive products, reduced shelf-life, and discrimination by importers of U.S. pork. The increase in the incidence of soft fat in the U.S. has resulted from the adoption of leaner genetics and increased use of polyunsaturated fat sources (i.e., poultry fat, restaurant grease, etc.) as more cost effective energy sources. More importantly, it is apparent that pork fat becomes softer as carcasses become leaner.

Dietary inclusion of ractopamine hydrochloride (RAC; Elanco Animal Health, Greenfield, Ind.) in swine finishing diets has repeatedly been shown to improve growth rate and carcass lean meat yields without detrimental effects on longissimus muscle (LM) quality. Even though Jeremiah et al. (1994) and Stites et al. (1991) demonstrated that RAC did not affect fresh belly thickness or cooking properties, palatability or consumer acceptance of bacon, some pork processors are concerned about belly quality because RAC has been shown to increase polyunsaturation of pork fat (Perkins et al., 1992). Therefore, the objective of the present study was to determine the interactive effects, if any, of RAC and dietary fat source on quality characteristics of fresh pork loins and bellies.

Experimental Procedures

Crossbred barrows and gilts (n = 216) from the mating of line 348 sows to EB boars (Monsanto Choice Genetics, St. Louis, Mo.) were blocked by weight (24 pigs/block) and allotted randomly to pens within blocks (six pigs/pen). After a one-week adjustment period when all pigs were fed a common finishing diet (devoid of ractopamine), pens within blocks were assigned randomly to one of four dietary treatments arranged in a 2 x 2 factorial design, with two ractopamine (RAC) levels (0 or 10 ppm) and 5% fat from two sources (beef tallow or soy oil). For more details concerning diet composition, feeding protocols, and swine housing, please refer to Apple et al. (2004).

At completion of the finishing period, pigs were transported to a commercial pork packing plant (Bryan Foods, West Point, Miss.), and slaughtered according to industry-accepted procedures. After a standard, 24-h spray-chilling period, carcasses were fabricated, and fresh pork bellies and bone-in loins were collected, wrapped in parchment paper, boxed, and transported under refrigeration to the University of Arkansas Red Meat Research Abattoir for pork quality data collection.

Upon arrival, loins were fabricated into three 1.0-in and two 1.5-in thick loin chops. After a 30-min bloom period, two 1.0-in chops were visually evaluated for marbling (1 = devoid to 10 = abundant; NPPC, 1999) and color based on both the American (1 = pale, pinkish gray to 6 = dark purplish-red; NPPC, 1999) and Japanese (1 = pale gray to 6 = dark purple; Nakai et al., 1975) standards. Also, L*, a*, and b* values were determined from a mean of four random readings (two readings for each chop) made with a Hunter MiniScan XE using illuminate C and a 10° standard observer.

The two 1.5-in thick LM chops were used to measure drip loss according to a modified suspension procedure of Honikel et al. (1986). Additionally, a 2-g sample of LM was homogenized in 20 mL of distilled, deionized water, and the pH of the homogenate was measured with a temperature-compensating combination electrode attached to a pH/ion/FET-meter.

Subjective belly firmness was measured using the bar-suspension method by measuring the distance between belly ends when the length of the belly was suspended perpendicular (skin-side down and skin-side up) and parallel (skin-side up) to a 0.75-in diameter bar. Additionally, color (L*, a*, and b* values) of the rectus abdominus belly fat was measured, and two 2.0-in diameter cores were removed from the center of each belly to objectively measure belly firmness. Briefly, belly cores were compressed 50% their thickness

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with an Instron testing machine equipped with an 880-lb load cell and a crosshead speed of 100 mm/min.

Data were analyzed as a randomized complete block design with treatments arranged in a 2 x 2 factorial design, with individual loin or individual belly as the experimental unit. Analysis of variance was generated using the GLM procedure of SAS (SAS Inst., Inc., Cary, N.C.) with RAC level (0 vs 10 ppm), dietary fat source (beef tallow vs soy oil), and the RAC x fat source interaction included in the model as main effects. Least-squares means were computed and separated statistically using pair-wise t-tests (PDIFF option) when a significant F-test (P < 0.10) was observed.

Results and Discussion

Fresh loins. The 48-h pH of the LM was elevated (P = 0.011) in loins from pigs fed RAC (Table 1). Including 10 ppm RAC in the diet of finishing pigs resulted in loin chops receiving higher American (P = 0.010) and Japanese (P = 0.041) color scores than chops from pigs fed 0 ppm RAC. Additionally, LM chops from non-RAC-fed pigs were redder (higher $a^*$ value; $P = 0.002$) and more yellow (higher $b^*$ value; $P = 0.005$) than those from RAC-fed pigs.

Several researchers have demonstrated that including RAC in swine finishing diets has no appreciable effect on pork quality traits. Stoller et al. (2003) reported that $L^*$ values were not affected by RAC inclusion in swine diets, and Uttaro et al. (1993) demonstrated that pork from pigs fed diets devoid of RAC was redder and more yellow than pork from RAC-fed pigs. Conversely, Watkins et al. (1990) found that pork color was actually improved over controls when 10 to 20 ppm RAC was included in the finishing diet.

Interestingly, the LM of pigs fed diets containing RAC and beef tallow received higher ($P < 0.05$) marbling scores than all other treatment combinations (RAC x dietary fat source; $P = 0.040$; Figure 1). Uttaro et al. (1993) reported that intramuscular fat content was reduced by the addition of RAC in the diet, whereas several other researchers have observed no effect of RAC on marbling scores (Stoller et al., 2003). However, results of the present study align closely to results of Watkins et al. (1990), who reported that the LM from RAC-fed pigs received higher marbling scores than pork from control pigs.

Ultimate (48-h) pH tended to be higher ($P = 0.089$) in the LM of pigs fed soy oil than beef tallow, and chops from pigs fed soy oil received higher ($P = 0.048$) American color scores (Table 1). Additionally, LM chops from pigs fed soy oil tended to be darker (lower $L^*$ value; $P = 0.064$) than chops from tallow-fed pigs; however, dietary fat source did not affect drip loss percentage ($P = 0.761$), Japanese color scores ($P = 0.189$) or $a^*$ ($P = 0.679$) or $b^*$ ($P = 0.105$) values. In general, results of the present study are in agreement with those of Engel et al. (2001), who failed to observe an effect of dietary fat source on color, marbling, and water-holding capacity of fresh loin chops. However, Miller et al. (1990) reported that feeding canola oil to finishing pigs resulted in softer loins with significantly less marbling.

Fresh pork bellies. Belly thickness was not affected by RAC ($P = 0.116$) or dietary fat source ($P = 0.372$; Table 2). Even though there was a tendency for bellies from RAC-fed pigs to be softer ($P = 0.068$) when suspended skin-side down, belly firmness was not affected by RAC when measured skin-side up ($P = 0.583$) or lengthwise ($P = 0.476$). Moreover, compression values were similar ($P = 0.608$) between bellies from pigs fed 0 or 10 ppm RAC. On the other hand, subjective measures of belly firmness were greater ($P < 0.003$) for bellies from pigs fed beef tallow than soy oil. In support of the subjective firmness measures, bellies from tallow-fed pigs required over 20 lb more force to compress 50% their thickness than bellies from soy oil-fed pigs.

Neither RAC nor dietary fat source affected $L^*$ ($P = 0.573$ and 0.364, respectively), $a^*$ ($P = 0.114$ and 0.607, respectively), and $b^*$ ($P = 0.801$ and 0.471, respectively) values of the rectus abdominus (Table 2). Moreover, there was no effect of RAC on $L^*$ ($P = 0.755$), $a^*$ ($P = 0.768$), and $b^*$ ($P = 0.956$) values for belly fat. However, bellies from pigs fed beef tallow were lighter (higher $L^*$ values; $P = 0.036$) and redder (higher $a^*$ values; $P = 0.023$) than bellies from pigs fed soy oil; yellowness ($b^*$) values were similar ($P = 0.334$) between bellies from soy oil and tallow fed pigs.

Results are consistent with previous research showing that RAC did not affect fresh belly thickness or firmness (Stites et al., 1991). Miller et al. (1990) found that feeding unsaturated fats resulted in softer bellies, which were unacceptable for bacon production. However, when comparing poultry fat (a more polyunsaturated fat source) and choice white grease (a more saturated fat source) in swine diets, Engel et al. (2001) reported that dietary fat source did not affect bar-suspension belly firmness, belly compression values, or $L^*$, $a^*$, and $b^*$ values of belly lean and fat.

Implications

Results of the present study indicate that quality characteristics (i.e., marbling and visually-evaluated color) of fresh pork loins may actually be improved by feeding 10 ppm ractopamine, whereas dietary fat source had little to no effect on pork loin quality. Conversely, ractopamine did not alter belly firmness; however, feeding swine diets with 5% soy oil caused fresh bellies to become considerably softer, which may render bellies unacceptable for bacon production.

Acknowledgments

The authors wish to express their appreciation to Elanco Animal Health, a division of Eli Lilly and Company, for financial support of this experiment, and Darling International for donation of beef tallow. Additionally, the authors gratefully acknowledge the assistance of Jerry Stephenson and the staff at the University of Arkansas Red Meat Research Abattoir for assistance in loin and belly quality data collection.

Literature Cited

Table 1. Main effects of ractopamine and dietary fat source on fresh loin (longissimus muscle; LM) quality.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Ractopamine 0 ppm</th>
<th>Ractopamine 10 ppm</th>
<th>P-value</th>
<th>Fat source Soy oil</th>
<th>Fat source Tallow</th>
<th>P-value</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>48-h pH</td>
<td>5.81</td>
<td>5.87</td>
<td>0.011</td>
<td>5.86</td>
<td>5.82</td>
<td>0.089</td>
<td>0.018</td>
</tr>
<tr>
<td>Drip loss, %</td>
<td>2.69</td>
<td>2.50</td>
<td>0.384</td>
<td>2.56</td>
<td>2.63</td>
<td>0.761</td>
<td>0.160</td>
</tr>
<tr>
<td>American colora</td>
<td>3.3</td>
<td>3.6</td>
<td>0.010</td>
<td>3.6</td>
<td>3.4</td>
<td>0.048</td>
<td>0.07</td>
</tr>
<tr>
<td>Japanese colorb</td>
<td>3.0</td>
<td>3.3</td>
<td>0.041</td>
<td>3.2</td>
<td>3.1</td>
<td>0.189</td>
<td>0.07</td>
</tr>
<tr>
<td>Lightness (L*)c</td>
<td>53.40</td>
<td>52.68</td>
<td>0.200</td>
<td>52.52</td>
<td>53.56</td>
<td>0.064</td>
<td>0.403</td>
</tr>
<tr>
<td>Redness (a*)c</td>
<td>6.64</td>
<td>6.04</td>
<td>0.002</td>
<td>66.30</td>
<td>6.38</td>
<td>0.679</td>
<td>0.136</td>
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<tr>
<td>Yellowness (b*)c</td>
<td>13.90</td>
<td>13.32</td>
<td>0.005</td>
<td>13.44</td>
<td>13.77</td>
<td>0.105</td>
<td>0.146</td>
</tr>
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</table>

a 1 = pale pinkish gray to 6 = dark purplish red (NPPC, 1999).
b 1 = pale gray to 6 = dark purple (Nakai et al., 1975).
c L* = 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).

Table 2. Main effects of ractopamine and dietary fat source on fresh pork belly quality.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Ractopamine 0 ppm</th>
<th>Ractopamine 10 ppm</th>
<th>P-value</th>
<th>Fat source Soy oil</th>
<th>Fat source Tallow</th>
<th>P-value</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness, in</td>
<td>1.02</td>
<td>1.05</td>
<td>0.116</td>
<td>1.04</td>
<td>1.02</td>
<td>0.374</td>
<td>0.015</td>
</tr>
<tr>
<td>Firmness, ina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin-side down</td>
<td>5.73</td>
<td>4.93</td>
<td>0.068</td>
<td>4.59</td>
<td>6.06</td>
<td>0.001</td>
<td>0.311</td>
</tr>
<tr>
<td>Skin-side up</td>
<td>7.67</td>
<td>7.44</td>
<td>0.583</td>
<td>6.92</td>
<td>8.19</td>
<td>0.003</td>
<td>0.294</td>
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<tr>
<td>Parallel</td>
<td>7.14</td>
<td>6.86</td>
<td>0.476</td>
<td>6.31</td>
<td>7.68</td>
<td>&lt;0.001</td>
<td>0.257</td>
</tr>
<tr>
<td>Average</td>
<td>6.85</td>
<td>6.39</td>
<td>0.211</td>
<td>5.94</td>
<td>7.29</td>
<td>&lt;0.001</td>
<td>0.243</td>
</tr>
<tr>
<td>Compression, lb</td>
<td>107.2</td>
<td>102.9</td>
<td>0.608</td>
<td>94.6</td>
<td>115.4</td>
<td>0.013</td>
<td>5.84</td>
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<td>Lean color</td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Lightness (L*)b</td>
<td>45.11</td>
<td>44.87</td>
<td>0.573</td>
<td>44.80</td>
<td>45.18</td>
<td>0.364</td>
<td>0.310</td>
</tr>
<tr>
<td>Redness (a*)b</td>
<td>12.58</td>
<td>12.20</td>
<td>0.114</td>
<td>12.33</td>
<td>12.45</td>
<td>0.607</td>
<td>0.174</td>
</tr>
<tr>
<td>Yellowness (b*)b</td>
<td>12.52</td>
<td>12.59</td>
<td>0.801</td>
<td>12.45</td>
<td>12.65</td>
<td>0.471</td>
<td>0.198</td>
</tr>
<tr>
<td>Fat color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightness (L*)b</td>
<td>80.71</td>
<td>80.78</td>
<td>0.755</td>
<td>80.53</td>
<td>80.96</td>
<td>0.036</td>
<td>0.150</td>
</tr>
<tr>
<td>Redness (a*)b</td>
<td>3.58</td>
<td>3.54</td>
<td>0.768</td>
<td>3.40</td>
<td>3.72</td>
<td>0.023</td>
<td>0.100</td>
</tr>
<tr>
<td>Yellowness (b*)b</td>
<td>12.40</td>
<td>12.41</td>
<td>0.956</td>
<td>12.49</td>
<td>12.49</td>
<td>0.334</td>
<td>0.131</td>
</tr>
</tbody>
</table>

a Bar-suspension method that measures the distance between belly ends when bellies are suspended across a 0.75-in diameter bar (larger number indicates a firmer belly).
b L* = 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).

Fig. 1. Interactive effect of ractopamine (RAC) and dietary fat source (P = 0.040) on marbling scores (1 = devoid to 10 = abundant; NPPC, 1999) of fresh loins. Bars lacking a common superscript letter differ (P < 0.05).