Effects of ractopamine hydrochloride on the growth performance and carcass characteristics of heavy-weight finishing pigs sent for slaughter using a three-phase marketing strategy

Journal: Translational Animal Science

Manuscript ID: TAS-2017-0053

Manuscript Type: Non ruminant nutrition

Date Submitted by the Author: 07-Aug-2017

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Key Words: Pig, carcass, growth, marketing, ractopamine
Effects of ractopamine hydrochloride on the growth performance and carcass characteristics of heavy-weight finishing pigs sent for slaughter using a three-phase marketing strategy

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ABSTRACT

A total of 2,158 crossbred pigs was used to evaluate the effects of feeding 7.4 mg/kg ractopamine hydrochloride (RAC) on the growth performance and carcass characteristics of heavy-weight finishing pigs sent to slaughter using a 3-phase marketing strategy. The study was carried out from 121.0 ± 4.28 kg to 144.5 ± 4.73 BW using a randomized complete block design (blocking factor was d of start on test) with 2 treatments (0 vs. 7.4 mg/kg RAC). Pigs were housed in a commercial wean-to-finish facility in groups of approximately 25 (44 groups/treatment), with ad libitum access to feed and water throughout the study, and pen weights of pigs were recorded at the start (d 0), and on d 7, 21, and 35 of study. Pigs were sent for slaughter according to the following marketing strategy: 1) after 7 d on RAC, the heaviest 16% of each pen was sent for slaughter (Phase 1), 2) after 21 d on RAC, the next 40% of each pen was sent for slaughter (Phase 2), and 3) after 35 d on RAC, the remaining 44% of each pen was sent for slaughter (Phase 3). Pigs were selected for slaughter by visual appraisal and shipped to a commercial facility where standard carcass measurements (HCW, LM depth, and backfat depth) were measured. Overall, feeding RAC increased (P < 0.001) ADG (18.8%) and G:F (23.7%) compared to the control, but lowered (P < 0.001) ADFI (3.3%). In addition, feeding RAC increased (P < 0.001) HCW (3.9 kg), carcass yield (0.7 percentage units), LM depth (5.0%), and predicted lean content (1.0 percentage units), and reduced backfat depth (6.3% lower) compared to controls. With each subsequent phase of marketing, the magnitude of improvements in response to feeding RAC decreased for ADG (43.1, 20.9, and -3.1% for Phase 1, 2, and 3, respectively) and G:F (37.5, 25.8, and 6.4% for Phase 1, 2, and 3, respectively); however, improvements in HCW (1.6, 4.5, and 4.2 kg for Phase 1, 2, and 3, respectively), carcass yield (0.2, 0.6, and 0.9 percentage units for Phase 1, 2, and 3, respectively), LM depth
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(2.3, 5.7, and 5.2% for Phase 1, 2, and 3, respectively), and predicted lean content (0.2, 1.0, and 1.3 percentage units for Phase 1, 2, and 3, respectively) generally increased from feeding RAC. These results suggest that while improvements in growth performance from feeding RAC will generally decline after 21 d of feeding, but improvements in carcass traits, particularly carcass yield and lean content, will continue with feeding RAC until d 35.

**Key words:** carcass, growth, marketing, ractopamine, Paylean, pigs

**INTRODUCTION**

Ractopamine hydrochloride (RAC; Paylean, Elanco Animal Health, Greenfield, IN) is a beta-agonist used during the marketing period in late-finishing pigs to improve growth performance and carcass leanness (Apple et al., 2007). Most studies evaluating RAC have been carried out in academic settings with relatively limited group sizes and numbers of pigs and ends after a fixed-time feeding duration (Armstrong et al., 2004; Puls et al., 2015). However, in a commercial setting, pigs are often sent for slaughter using a multiple-phase marketing strategy to minimize variation in HCW and lean percentage, resulting in variable days on RAC. This marketing strategy has been shown to increase the growth performance (ADG, ADFI, and G:F) of pigs remaining in the pen after the heaviest pigs are sent for slaughter (DeDecker et al., 2005; 2007; Gerlemann et al., 2013). In theory, the increase in ADFI may result in greater RAC intake and could lead to a greater response to RAC in pigs sent later in the marketing period. Conversely, it has been shown that the improvements in growth performance generally decline as RAC feeding duration increases (Dunshea et al., 1993; Williams et al., 1994; Christianson et al., 2014), but previous research has also reported that carcass improvements continue with increasing time on RAC (Armstrong et al., 2004; Christianson et al., 2014; Gerlemann et al., 2014). Slaughter weights of pigs continue to increase, reaching near record highs for the US in
2013-2014, and there is a need to determine the effects of RAC in heavy-weight pigs (>136 kg BW) managed in a commercial setting. This is the first study, to the authors’ knowledge, to evaluate effects of feeding RAC in this heavy weight of pig. Therefore, the objective of this study was to evaluate the effects of feeding 7.4 mg/kg RAC on the growth performance and carcass characteristics of heavy-weight finishing pigs sent for slaughter using a 3-phase marketing strategy.

**Keywords:** carcass, growth, marketing, pig, ractopamine

**MATERIALS AND METHODS**

All experimental procedures and animal care were approved by the Elanco Animal Health Institutional Animal Care and Use Committee (EIAC-0141).

**Experimental Design and Treatments**

The study was carried out for 35 d from 121.0 ± 4.28 kg to 144.5 ± 4.73 kg BW using a randomized complete block design (blocking factor was d of start on test) with 2 treatments (0 vs. 7.4 mg/kg RAC). A total of 2,158 crossbred barrows and gilts were housed in 88 pens (44 single-sex replicates/treatment group). Ractopamine was added to the diets beginning on d 0 and remained at a constant level throughout the study period.

Pen was the experimental unit for all measurements.

**Animals and Allotment to Study**

Pigs used in the study were the progeny of PIC 337 sires × C22 dams (PIC USA, Hendersonville, TN). A total of 88 single-sex pens, each initially housing 25 pigs, were stratified over 2 blocks that were used in the experiment.

Allotment to the study was carried out within sex at approximately 152 d of age. Within sex, pigs were weighed as a group (pen weight) and formed into outcome groups of 2 pens of
similar BW, and were randomly allotted from within outcome group to treatment. Following allotment, pigs were moved to their allotted location within the facility and allowed a 15 d acclimation period prior to start of the RAC feeding period.

**Animal Housing and Management**

Prior to the start of the growth study, pigs were managed according to standard unit protocols, with *ad libitum* access to standard diets that were formulated to meet or exceed the nutrient requirements of growing pigs recommended by NRC (2012). During the study period, pigs were housed in a curtain-sided, naturally ventilated facility that had fully-slotted concrete floors. Pen dimensions provided a usable floor space of 16.25 m², which resulted in 0.65 m²/pig prior to the first group of pigs being sent for slaughter. Each pen had a 4-space single-sided dry box feeder mounted on the pen division that provided a total of 122 cm of linear feeder space (4.88 cm/pig) and a single cup water drinker.

**Diets and Feeding**

Two diets were used during the study period: 1) Control diet (0 mg/kg RAC) vs. 2) RAC diet which included 7.4 mg/kg RAC and increased lysine for the 35 d RAC feeding period (Table 1). Diets were formulated to meet or exceed the nutrient requirements of finishing pigs recommended by NRC (2012). Diet formulations and calculated composition of the diets fed during the experimental period are presented in Table 1.

Pigs had *ad libitum* access to feed and water throughout the study period.

**Marketing Strategy**

Pigs were sent for slaughter according to the following marketing strategy: 1) after 7 d on test, the heaviest 16% of each pen (i.e., 4 pigs) was sent for slaughter such that 21 pigs remained in the pen (Phase 1); 1) after 21 d on RAC, the next heaviest 40% of each pen (i.e., 10 pigs) was
sent for slaughter such that 11 pigs remained in the pen (Phase 2); and 3) after 35 d on RAC, the remaining 44% of each pen (i.e., 11 pigs) was sent for slaughter (Phase 3) (Table 2).

Adjustments were made to the number of pigs removed to account for differences in morbidity and mortality. Pigs were selected for slaughter by visual appraisal by the production site’s normal marketing personnel. At the end of each marketing phase (d 7, 21, and 35), pigs were weighed as a group, and the heaviest pigs were selected for slaughter and removed from the group, which was weighed again to achieve a start weight for the subsequent marketing phase. The pigs selected for slaughter were weighed as a group, tattooed, loaded on a conventional semi-trailer, and shipped approximately 725 km (4.5 h) to a commercial slaughter facility.

Descriptions of housing and marketing conditions are presented in Table 2.

**Growth Study Measurements**

All pigs were weighed as a group (i.e., pen basis) on d 0 (start of the RAC feeding period), and on d 7, 21, and 35 (end) of the study period. All feed additions to the feeders were recorded and feed disappearance was recorded at the time of pig BW collection and used to calculate ADFI and G:F.

**Carcass Measurements**

Pigs were unloaded and held in lairage overnight with access to water, but not feed, and were humanely slaughtered using standard procedures. Immediately after carcass dressing, HCW was recorded, and backfat and LM depth were measured using the Animal Ultrasound Services (AUS) Carcass Value Technology System (Animal Ultrasound Services Inc., Ithaca, NY). Predicted lean content was calculated using a plant-proprietary equation using these measurements.

**Statistical Analysis**
All variables were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC). The pen of pigs was the experimental unit for all measurements. The model included the fixed effects of RAC treatment and random effects of block and replicate nested within block. Sex was not included in the statistical model, but was accounted for as replicate (single-sex) was included in the random statement. Least-squares means were separated using the PDIF option of SAS with means being considered different at a \( P \leq 0.05 \).

**RESULTS AND DISCUSSION**

The analyzed RAC level of the diet was 7.5 mg/kg which was similar to the formulated level of 7.4 mg/kg.

**Growth Performance**

Pigs fed RAC were heavier \((P = 0.001)\) at the end of each marketing phase and for overall end weight \((P = 0.001)\) compared to controls (Table 3). For the overall 35 d feeding period, feeding RAC increased \((P = 0.001)\) ADG (18.8%) and G:F (23.7%), and lowered \((P = 0.001)\) ADFI (3.3% lower) compared to controls (Table 3). Generally speaking, the improvements in growth performance from feeding 7.4 mg/kg RAC observed in the current study are slightly greater than those observed in previous research. Christianson et al. (2014) reported a 20% improvement compared to controls in overall growth rate and feed efficiency in pigs fed 7.4 mg/kg RAC for 35 d; however, Gerlemann et al. (2014) reported smaller improvements of only 10.9% and 12.9% in ADG and G:F in RAC-fed pigs, respectively, compared to controls. Christianson et al. (2014) reported no difference in overall ADFI between RAC-fed pigs and controls whereas Gerlemann et al. (2014) reported 2.7% lower ADFI for RAC-fed pigs, results similar to the current study (3.3% lower; \( P < 0.001 \); Table 3).
During Phase 1 (d 0 to d 7), feeding RAC increased \( P = 0.001 \) ADG and G:F, but had no effect \( P = 0.78 \) on ADFI compared to the control. During Phase 2 (d 7 to d 21), pigs fed RAC had greater \( P = 0.001 \) ADG and G:F, and lower \( P = 0.001 \) ADFI compared to the control. Finally, during Phase 3 (d 21 to d 35), feeding RAC had no effect \( P > 0.05 \) on ADG, but lowered \( P = 0.001 \) ADFI, which resulted in increased \( P < 0.05 \) G:F compared to the control (Table 3).

Improvements over controls from feeding RAC with respect to ADG were greatest in Phase 1 (d 0 to d 7) and gradually declined with increasing time on RAC (43.1% greater, 20.9% greater, and 3.1% lower for Phases 1, 2, and 3, respectively). Interestingly, feeding RAC longer than 21 d (through Phase 3) resulted in similar \( P = 0.19 \) ADG as the control (Table 3).

Compared to the controls, feeding RAC lowered ADFI, and this reduction increased with increasing time on RAC (0.3% lower, 2.9% lower, and 6.7% lower for Phases 1, 2, and 3 respectively). Similarly, the magnitude of improvements in G:F from feeding RAC declined with increasing time on RAC (37.5, 25.8, and 6.4% greater for Phases 1, 2, and 3, respectively).

The study was designed as a fixed-time study, where pigs were removed from pens and sent for slaughter on specific d (7, 21, and 35) during the RAC feeding period. As such, the growth performance of pigs during each phase of the marketing strategy is confounded with the start and end weight of the respective phase, as RAC-fed pigs were heavier than the controls at each marketing phase. Nonetheless, feeding RAC improved the growth rate and feed efficiency of pigs compared to the controls up to the end of Phase 2, similar to the results of Armstrong et al. (2004) which demonstrated that the greatest response to RAC was measured within the first 6 d on feed, and generally speaking, the improvements in RAC declined after 20 d on feed. There is relatively limited published research utilizing a similar study duration and design in a
commercial production setting as the current study. Gerlemann et al. (2014) used a similar marketing strategy (16, 18, and 66% of pigs sent for slaughter on d 7, 21, and 35 of RAC feeding, respectively) and reported gradual reductions in ADG (18.2, 13.0, and 1.9% for Phases 1, 2, and 3, respectively) and G:F (16.7, 21.2, and 6.9% for Phases 1, 2, and 3, respectively) as the RAC-feeding duration increased. Similarly, Christianson et al. (2014) reported continual reductions for the improvement in growth rate (30.0, 17.7, and 10.8% for Phases 1, 2, and 3, respectively) and feed efficiency (30.3, 18.9, and 8.8% for Phases 1, 2, and 3, respectively) when 26, 31, and 43% of the pen was sent for slaughter on d 7, 21, and 35, respectively. In contrast to the current study, Hinson et al. (2012a) reported increases in growth rate and feed efficiency with increasing RAC feeding durations. In the current study, feeding RAC reduced ADFI and this reduction increased with time on RAC, which contributed to the greater feed efficiency as time on RAC increased. However, this has not been observed in other studies of similar study design (Hinson et al., 2012a; Christianson et al., 2014; Gerlemann et al., 2014). Collectively, these results, along with others, suggest that, while RAC consistently improves overall growth rate and feed efficiency, the greatest improvement is observed soon after RAC implementation, and may decline after 21 d of feeding.

Although the effect of marketing strategy was not directly evaluated in the current study, ADG and ADFI of pigs was generally lowest in Phase 1, when floor space and feeder space were most restrictive (Table 3). After Phase 1, ADG and ADFI were greater in both control and RAC-fed pigs during Phase 2, with the ADG of controls being 20.0% greater in Phase 2 compared to Phase 1. Interestingly, the removal of 16% of pigs from the RAC-fed pens on d 7 did not produce a substantial response in subsequent growth rate during phase 2 (d 7 to d 21). Whether it was due to remaining floor space still being restrictive or due to maximal growth rates already
being achieved remains unclear. Growth performance in Phase 3 was generally similar to that of Phase 2, suggesting that the additional removal of 10 pigs on d 21, and resulting increase in floor and feeder space, did not further improve growth performance of the remaining pigs in the pen, which is generally in agreement with previous research evaluating effects of removing pigs from a pen on subsequent growth performance of remaining pigs (DeDecker et al., 2005; 2007; Gerlemann et al., 2013).

**Carcass Characteristics**

Pigs fed RAC were heavier ($P < 0.001$) at the end of Phase 2 and 3 and for overall end weight (Table 4). Overall, feeding RAC increased ($P < 0.001$) HCW (3.9 kg), which falls within the range reported in previous research (Apple et al., 2007; Puls et al., 2015). In addition, carcass yield (0.7 percentage units), LM depth (4.98%), and predicted lean content (1.0 percentage units) were all increased from feeding RAC, results similar to other studies (Hinson et al., 2012b; Christianson et al., 2014; Gerlemann et al., 2014) whereas backfat depth was reduced ($P < 0.001$; 6.3% lower) compared to controls.

Improvements over controls in carcass yield (0.20, 0.60, and 0.90 percentage units for Phase 1, 2, and 3, respectively) and predicted lean content (0.2, 1.0, and 1.3 percentage units greater for Phase 1, 2, and 3, respectively) from feeding RAC increased with increasing time on RAC. This is likely driven by the sharp reduction in backfat in RAC-fed pigs compared to the control (2.4% greater, 4.0% lower, and 10.4% lower for Phase 1, 2, and 3, respectively).

In the current study, improvements in carcass traits associated with feeding RAC increased with increasing time on feed, which concurs with the results of Hinson et al. (2012a), who reported greater improvements compared to controls for HCW, carcass yield, LM depth, and lean content, as well as decreased backfat depth as RAC feeding duration increased.
Additionally, Gerlemann et al. (2014) reported improvements in carcass yield of 0.1, 0.9, and 1.1 percentage units for pigs slaughtered after 7, 21, and 35 d of RAC feeding, respectively.

Similarly, Christianson et al. (2014) reported a 0.1 percentage unit lower, 0.7 percentage unit greater, and 0.7 percentage unit greater carcass yield for RAC-fed pigs sent for slaughter on d 7, 21, and 35, respectively, compared to controls. Similar to the current study, these authors reported greater reductions in backfat depth, but greater LM depth, and an increase in predicted lean content as RAC feeding duration increased (Gerlemann et al., 2014; Christianson et al., 2014). The results of this study, along with other previous research, suggest that even in heavy-weight finishing pigs, RAC-induced responses on carcass traits relative to those of controls-fed pigs continue to increase with greater RAC feeding durations.

CONCLUSIONS

These results validate the consistent response observed from feeding RAC on increased growth performance, carcass yield, and carcass leanness. Moreover, these results also suggest that with increasing time on RAC, growth rate and feed efficiency will decrease, but improvements in carcass yield and leanness will continue to increase with longer feeding periods in heavy weight (144 kg) pigs.

LITERATURE CITED


# TABLES AND FIGURES

## Table 1. Dietary composition, as-fed basis

<table>
<thead>
<tr>
<th>Item</th>
<th>Ractopamine inclusion level, mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td><strong>Ingredient, %</strong></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>82.94</td>
</tr>
<tr>
<td>Soybean meal 48%</td>
<td>13.00</td>
</tr>
<tr>
<td>Choice white grease</td>
<td>2.00</td>
</tr>
<tr>
<td>Monocalcium</td>
<td>0.50</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.85</td>
</tr>
<tr>
<td>Salt</td>
<td>0.40</td>
</tr>
<tr>
<td>L-Lysine</td>
<td>0.17</td>
</tr>
<tr>
<td>L-Threonine</td>
<td>0.01</td>
</tr>
<tr>
<td>Alimet</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin premix with phytase</td>
<td>0.03</td>
</tr>
<tr>
<td>Mineral premix</td>
<td>0.10</td>
</tr>
<tr>
<td>Ractopamine hydrochloride</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

Calculated analysis

<table>
<thead>
<tr>
<th></th>
<th>0</th>
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</tr>
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<tbody>
<tr>
<td>ME, Mcal/kg</td>
<td>3.44</td>
<td>3.43</td>
</tr>
<tr>
<td>CP, %</td>
<td>13.22</td>
<td>16.98</td>
</tr>
<tr>
<td>Total Lys, %</td>
<td>0.74</td>
<td>1.06</td>
</tr>
<tr>
<td>SID(^5) Lys, %</td>
<td>0.65</td>
<td>0.95</td>
</tr>
<tr>
<td>Total P, %</td>
<td>0.43</td>
<td>0.50</td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.16</td>
<td>0.20</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.46</td>
<td>0.50</td>
</tr>
<tr>
<td>g SID lysine / Mcal ME</td>
<td>1.89</td>
<td>2.77</td>
</tr>
<tr>
<td>SID Met:Lys</td>
<td>31.64</td>
<td>30.47</td>
</tr>
<tr>
<td>SID Met+Cys:Lys</td>
<td>65.37</td>
<td>58.20</td>
</tr>
<tr>
<td>SID Thr:Lys</td>
<td>64.27</td>
<td>68.20</td>
</tr>
<tr>
<td>SID Trp:Lys</td>
<td>18.09</td>
<td>17.58</td>
</tr>
<tr>
<td>SID Ile:Lys</td>
<td>69.37</td>
<td>63.79</td>
</tr>
<tr>
<td>SID Val:Lys</td>
<td>83.05</td>
<td>72.92</td>
</tr>
</tbody>
</table>

1. L-Met precursor HMTBA, an 88% aqueous solution of 2-hydrox-4-(methylthio) botanic acid (Novus International Inc., St. Louis, MO).
2. Provided per kg of final diet: vitamin A, 6,600 IU; vitamin D\(_3\), 704 IU; vitamin E, 26 IU; riboflavin, 4.9 mg; menadione, 2.6 mg; vitamin B\(_{12}\), 0.02 mg; D-pantothenic acid, 16.5 mg; and niacin, 29.7 mg.
3. Provided per kg of final diet: 66 mg iron, 66 mg zinc, 19.8 mg manganese, 66 mg copper, 14 mg iodine, and 0.12 mg selenium.
4. Provided either 0 or 7.4 mg of ractopamine hydrochloride (Paylean; Elanco Animal Health, Greenfield, IN) per kg of diet.
5. SID = Standardized ileal digestible.
Table 2. Summary of housing conditions and marketing strategy of pigs fed ractopamine hydrochloride (RAC)\textsuperscript{1} and sent for slaughter in a 3-phase marketing strategy

<table>
<thead>
<tr>
<th>Item</th>
<th>Housing conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 (d 0 to 7)</td>
<td></td>
</tr>
<tr>
<td>No. pigs/pen on d 0</td>
<td>25</td>
</tr>
<tr>
<td>Days on RAC</td>
<td>7</td>
</tr>
<tr>
<td>Feeder space, cm/pig</td>
<td>4.88</td>
</tr>
<tr>
<td>Floor space, m\textsuperscript{2}/pig</td>
<td>0.65</td>
</tr>
<tr>
<td>Approximate % of pigs sent for slaughter/pen</td>
<td>16</td>
</tr>
<tr>
<td>No. pigs remaining/pen on d 7</td>
<td>21</td>
</tr>
<tr>
<td>Phase 2 (d 7 to 21)</td>
<td></td>
</tr>
<tr>
<td>No. pigs/pen on d 7</td>
<td>21</td>
</tr>
<tr>
<td>Days on RAC</td>
<td>14</td>
</tr>
<tr>
<td>Feeder space, cm/pig</td>
<td>5.81</td>
</tr>
<tr>
<td>Floor space, m\textsuperscript{2}/pig</td>
<td>0.77</td>
</tr>
<tr>
<td>Approximate % of pigs sent for slaughter/pen</td>
<td>40</td>
</tr>
<tr>
<td>No. pigs remaining/pen on d 21</td>
<td>11</td>
</tr>
<tr>
<td>Phase 3 (d 21 to 35)</td>
<td></td>
</tr>
<tr>
<td>No. pigs/pen on d 21</td>
<td>11</td>
</tr>
<tr>
<td>Days on RAC</td>
<td>14</td>
</tr>
<tr>
<td>Feeder space, cm/pig</td>
<td>11.09</td>
</tr>
<tr>
<td>Floor space, m\textsuperscript{2}/pig</td>
<td>1.48</td>
</tr>
<tr>
<td>Approximate % of pigs sent for slaughter/pen</td>
<td>44</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Trade name: Paylean, Elanco Animal Health, Greenfield, IN
Table 3. Effects of ractopamine hydrochloride (RAC)\(^1\) on the growth performance of heavy-weight finishing pigs sent for slaughter using a 3-phase marketing strategy

<table>
<thead>
<tr>
<th>Item</th>
<th>0</th>
<th>7.4</th>
<th>SEM</th>
<th>P-value</th>
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<tbody>
<tr>
<td>No. of pens</td>
<td>44</td>
<td>44</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phase 1 (d 0 to d 7)(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. pigs/pen</td>
<td>25</td>
<td>25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 0 (start)</td>
<td>121.0</td>
<td>121.0</td>
<td>0.72</td>
<td>0.98</td>
</tr>
<tr>
<td>d 7</td>
<td>126.2</td>
<td>128.3</td>
<td>1.52</td>
<td>0.001</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.72</td>
<td>1.03</td>
<td>0.104</td>
<td>0.001</td>
</tr>
<tr>
<td>ADFI, kg</td>
<td>2.87</td>
<td>2.86</td>
<td>0.056</td>
<td>0.78</td>
</tr>
<tr>
<td>G:F</td>
<td>0.261</td>
<td>0.359</td>
<td>0.0361</td>
<td>0.001</td>
</tr>
<tr>
<td>Phase 2 (d 7 to d 21)(^3)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. pigs/pen</td>
<td>21</td>
<td>21</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 7</td>
<td>124.2</td>
<td>126.2</td>
<td>1.66</td>
<td>0.001</td>
</tr>
<tr>
<td>d 21</td>
<td>136.2</td>
<td>140.8</td>
<td>1.23</td>
<td>0.001</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.86</td>
<td>1.04</td>
<td>0.033</td>
<td>0.001</td>
</tr>
<tr>
<td>ADFI, kg</td>
<td>3.06</td>
<td>2.97</td>
<td>0.051</td>
<td>0.001</td>
</tr>
<tr>
<td>G:F</td>
<td>0.279</td>
<td>0.351</td>
<td>0.0075</td>
<td>0.001</td>
</tr>
<tr>
<td>Phase 3 (d 21 to d 35)(^4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. pigs/pen</td>
<td>11</td>
<td>11</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 21</td>
<td>130.6</td>
<td>135.0</td>
<td>1.05</td>
<td>0.001</td>
</tr>
<tr>
<td>d 35 (end)</td>
<td>144.4</td>
<td>148.2</td>
<td>1.04</td>
<td>0.001</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.97</td>
<td>0.94</td>
<td>0.013</td>
<td>0.19</td>
</tr>
<tr>
<td>ADFI, kg</td>
<td>3.26</td>
<td>3.04</td>
<td>0.036</td>
<td>0.001</td>
</tr>
<tr>
<td>G:F</td>
<td>0.296</td>
<td>0.315</td>
<td>0.0057</td>
<td>0.01</td>
</tr>
<tr>
<td>Overall (d 0 to d 35)(^5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 0 (start)</td>
<td>121.0</td>
<td>121.0</td>
<td>0.72</td>
<td>0.98</td>
</tr>
<tr>
<td>d 35 (end)</td>
<td>142.6</td>
<td>146.5</td>
<td>1.18</td>
<td>0.001</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>0.85</td>
<td>1.01</td>
<td>0.019</td>
<td>0.001</td>
</tr>
<tr>
<td>ADFI, kg</td>
<td>3.06</td>
<td>2.96</td>
<td>0.015</td>
<td>0.001</td>
</tr>
<tr>
<td>G:F</td>
<td>0.278</td>
<td>0.344</td>
<td>0.0067</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\(^1\)Trade name: Paylean, Elanco Animal Health, Greenfield, IN
\(^2\)Heaviest ~16% of pigs sent for slaughter on d 7.
\(^3\)Next heaviest 40% of pigs sent for slaughter on d 21.
\(^4\)Final 44% of pigs sent for slaughter on d 35.
\(^5\)Weighted average of growth performance for the entire 35 d feeding period.
Table 4. Effects of ractopamine hydrochloride (RAC)\(^1\) on the carcass characteristics of heavy-weight finishing pigs sent for slaughter using a 3-phase marketing strategy

<table>
<thead>
<tr>
<th>Item</th>
<th>RAC inclusion level, mg/kg</th>
<th>0</th>
<th>7.4</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of pens</td>
<td></td>
<td>44</td>
<td>44</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phase 1 (d 0 to d 7)(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. pigs sent for slaughter on d 7</td>
<td></td>
<td>4</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slaughter live weight, kg</td>
<td></td>
<td>139.2</td>
<td>140.8</td>
<td>0.96</td>
<td>0.15</td>
</tr>
<tr>
<td>HCW, kg</td>
<td></td>
<td>104.4</td>
<td>106.0</td>
<td>0.58</td>
<td>0.08</td>
</tr>
<tr>
<td>Carcass yield, %</td>
<td></td>
<td>75.1</td>
<td>75.3</td>
<td>0.13</td>
<td>0.28</td>
</tr>
<tr>
<td>Backfat depth, mm(^3)</td>
<td></td>
<td>16.4</td>
<td>16.8</td>
<td>0.30</td>
<td>0.46</td>
</tr>
<tr>
<td>LM depth, mm(^3)</td>
<td></td>
<td>74.8</td>
<td>76.5</td>
<td>0.67</td>
<td>0.01</td>
</tr>
<tr>
<td>Predicted lean content, %</td>
<td></td>
<td>56.7</td>
<td>56.9</td>
<td>0.16</td>
<td>0.31</td>
</tr>
<tr>
<td>Phase 2 (d 7 to d 21)(^4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. pigs sent for slaughter on d 21</td>
<td></td>
<td>10</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slaughter live weight, kg</td>
<td></td>
<td>142.5</td>
<td>147.2</td>
<td>1.48</td>
<td>0.001</td>
</tr>
<tr>
<td>HCW, kg</td>
<td></td>
<td>107.7</td>
<td>112.2</td>
<td>1.20</td>
<td>0.001</td>
</tr>
<tr>
<td>Carcass yield, %</td>
<td></td>
<td>75.6</td>
<td>76.2</td>
<td>0.08</td>
<td>0.001</td>
</tr>
<tr>
<td>Backfat depth, mm(^3)</td>
<td></td>
<td>16.4</td>
<td>15.8</td>
<td>0.11</td>
<td>0.01</td>
</tr>
<tr>
<td>LM depth, mm(^3)</td>
<td></td>
<td>74.8</td>
<td>79.1</td>
<td>0.69</td>
<td>0.001</td>
</tr>
<tr>
<td>Predicted lean content, %</td>
<td></td>
<td>56.5</td>
<td>57.5</td>
<td>0.21</td>
<td>0.001</td>
</tr>
<tr>
<td>Phase 3 (d 21 to d 35)(^5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. pigs sent for slaughter on d 35</td>
<td></td>
<td>11</td>
<td>11</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slaughter live weight, kg</td>
<td></td>
<td>144.4</td>
<td>148.2</td>
<td>1.04</td>
<td>0.001</td>
</tr>
<tr>
<td>HCW, kg</td>
<td></td>
<td>108.9</td>
<td>113.1</td>
<td>0.50</td>
<td>0.001</td>
</tr>
<tr>
<td>Carcass yield, %</td>
<td></td>
<td>75.4</td>
<td>76.3</td>
<td>0.25</td>
<td>0.002</td>
</tr>
<tr>
<td>Backfat depth, mm(^3)</td>
<td></td>
<td>19.3</td>
<td>17.3</td>
<td>0.24</td>
<td>0.001</td>
</tr>
<tr>
<td>LM depth, mm(^3)</td>
<td></td>
<td>73.7</td>
<td>77.5</td>
<td>0.27</td>
<td>0.001</td>
</tr>
<tr>
<td>Predicted lean content, %</td>
<td></td>
<td>55.7</td>
<td>57.0</td>
<td>0.14</td>
<td>0.001</td>
</tr>
<tr>
<td>Overall (d 0 to d 35)(^6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slaughter live weight, kg</td>
<td></td>
<td>142.9</td>
<td>146.8</td>
<td>1.20</td>
<td>0.001</td>
</tr>
<tr>
<td>HCW, kg</td>
<td></td>
<td>107.8</td>
<td>111.7</td>
<td>0.78</td>
<td>0.001</td>
</tr>
<tr>
<td>Carcass yield, %</td>
<td></td>
<td>75.4</td>
<td>76.1</td>
<td>0.12</td>
<td>0.001</td>
</tr>
<tr>
<td>Backfat depth, mm(^3)</td>
<td></td>
<td>17.7</td>
<td>16.6</td>
<td>0.10</td>
<td>0.001</td>
</tr>
<tr>
<td>LM depth, mm(^3)</td>
<td></td>
<td>74.3</td>
<td>78.0</td>
<td>0.34</td>
<td>0.001</td>
</tr>
<tr>
<td>Predicted lean content, %</td>
<td></td>
<td>56.2</td>
<td>57.2</td>
<td>0.07</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\(^1\)Trade name: Paylean, Elanco Animal Health, Greenfield, IN

\(^2\)Heaviest ~16% of pigs sent for slaughter on d 7.

\(^3\)Backfat depth and LM depth measured using Animal Ultrasound Services Carcass Value Technology System (Animal Ultrasound Services Inc., Ithaca, NY).

\(^4\)Next heaviest 40% of pigs sent for slaughter on d 21.

\(^5\)Final 44% of pigs sent for slaughter on d 35.

\(^6\)Weighted average of carcass characteristics for the entire 35 d feeding period.
**Reviewer 1.**

Although it may not appear like it based on the number of specific comments, I really liked this manuscript and found the results interesting (especially considering the emerging information on multi-phase marketing of finishing pigs). There are times that the authors are a bit repetitive and verbose, but they report their results accurately (short, sweet, and to the point is greatly appreciated) and I can’t see why it might not be published after the revision process.

Line(s) Comment / Suggestion
26 “A total of 2,158 crossbred pigs was used to evaluate the effects of feeding ractopamine …”
   Changed in line 26
28 “… pigs sent to slaughter using a 3-phase …”
   Changed in line 28
28-30 “Pigs were blocked by feeding trial start date, and pens of pigs (25/pen) were assigned randomly to receive 0 or 7.4 mg/kg RAC (44 pens/treatment) during the last finishing phase from 121.0 ± 4.28 to 144.5 ± 4.73 kg BW.”
   In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes. This is similar to how the authors have presented the experimental design in other manuscripts previously.
30-34 “Pigs were housed in a commercial wean-to-finish facility, with ad libitum access to feed and water throughout the study, and pen weights of pigs were recorded at the start (d 0), as well as on d 7, 21, and 35 of the feeding trial.”
   Changed line 30-33.
35-37 “… sent to slaughter according to a 3-phase marketing strategy: 1) after 7 d on RAC, the visually heaviest 16% of each pen were sent to slaughter (Phase 1); 2) after 21 d on RAC, the visually heaviest 44% of the remaining 21 pigs/pen was sent to slaughter (Phase 2); and 3) at the end of the 35-d RAC-feeding trial, the remaining 44% (11 pigs/pen) were sent to slaughter (Phase 3).”
   Changed in lines 34-37.
37-40 “Pigs were shipped to a commercial pork packing plant, and HCW, LM depth, and 10th rib fat depth were recorded during the humane slaughter process.”
   Changed lines 37-38.
40-41 “Overall, feeding 7.4 mg/kg of RAC increased … (23.7%), but depressed (P < 0.05) ADFI (3.3%), compared to control-fed pigs.”
   In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.
41 “Moreover, feeding RAC …”
   Added in some wording to line 40 and 43.
42 et al. I don’t see the need to report P-values more than thousandths (i.e., $P < 0.001$ instead of $P < 0.0001$)
Changed to 3 decimal places throughout the manuscript including in the tables.

43 “… (1.0 percentage units), while reducing ($P < 0.001$) 10th rib fat depth (6.3% lower).”
Changed lowered to reduced in line 42.

44 “… of marketing, the magnitude of improvements in response to feeding RAC decreased …”
Changed line 43-44.

50 “… generally increased by feeding 7.4 mg/kg RAC. These results suggest that improvements in …”
Changed line 49.

51 “… 21 d of feeding, but improvements in carcass traits, particularly …”
Changed line 51.

52 “… content, will continue with feeding RAC up to d 35.”
Changed line 52.

56 “… immediately prior to, or during, the marketing …”
Changed line 56.

60 et al. Please replace “harvest” with “slaughter”
Changed throughout the manuscript including in the tables.

61 Replace “carcass weights” with “HCW”
Changed in line 61.

63-64 “… performance of pigs remaining in the pen after the heaviest pigs were sent to slaughter (DeDecker …)”
Changed in line 63.

65 et al. Please replace “animals” with “pigs”
Changed throughout the manuscript.

66-67 “Conversely, it has been shown that the improvements in growth performance generally decline with increasing time fed RAC diets (Dunshea …)”
Changed lines 66-67.

70 “Slaughter weights”
Changed in line 70.
71 “… increase, and there is a need to determine …”
Changed in line 70.

72 “… commercial setting; therefore, the objective …”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

74 “… pigs sent to slaughter using a …”
Changed in line 75.

80-86 Please consider deleting this section (I have suggested how to incorporate this information in the following paragraph(s))
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes. In addition, the subheadings have been used in several of our past submissions and for this reason we have not made these changes.

88-92 “Crossbred barrows and gilts (n = 2,158), progeny of PIC 337 sires mated to C22 dams (PIC USA, Hendersonville, TN) were blocked by start date of feeding trial, and, within both blocks, pigs were assigned to gender-specific pens (25 pigs/pen) at approximately 152 d of age (107.4 ± 4.64 kg).”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

92-94 Please consider deleting this sentence
This sentence describes the allotment procedure and we wish to leave the sentence in the manuscript.

94-95 “Following pen allocation, pigs were moved to their allotted location within the wean-to-finish facility and, after a 15-d acclimation period, pens were assigned to late-finishing diets formulated without RAC (control) or with 7.4 mg/kg RAC (along with increased dietary lysine content) during the 35-d feeding trial (Table 1) from 121.0 ± 4.28 to 144.5 ± 4.73 kg BW.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

98 “… protocols, with ad libitum access to standard diets formulated to meet, or exceed, the nutrient …”
Changed in line 99.

99-100 “… of growing and early-finishing pigs (NRC, 2012). During the feeding trial, pigs were housed …”
Changed in line 100.

100-101 “… curtain-sided, naturally ventilated facility on fully-slatted concrete floors.”
Changed in line 101.
101-102 “Each 16.25m² pen provided 0.65 m²/pig of usable floor space prior to the first marketing group of pigs being sent to slaughter.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

104 “… water drinker for ad libitum access to feed and water.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

105-111 Please consider deleting this section.
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes. Furthermore, as the study included dietary treatments, we believe this paragraph (Line 107-112) is both valid and necessary. We have not made these changes.

113-115 Please consider moving this paragraph to L128
Moved to line 127-131.

113-114 “… a group (pen basis) on d 0 … period), as well as on d 7, 21, and 35 (end) of the feeding trial to calculated ADG.”
Changed in line 128-129.

114-115 “Additionally, feed disappearance was recorded at the time of pig BW collection and used to calculate ADFI and G:F.”
Changed in line 130-131.

117-120 “Pigs were sent to slaughter according to a 3-phase marketing strategy: Phase 1 = after 7 d on test, the heaviest 16% of each pen (4 pigs) were sent to slaughter and 21 pigs remained in the pen; Phase 2 = after 21 d on test, the next heaviest 40% of each pen (10 pigs) were sent to slaughter and 11 pigs remained in each pen; and Phase 3 = at the end of the 35-d feeding trial, the remaining 11 pigs from each pen were sent to slaughter.”
Changed in line 114-118.

123 “At each marketing phase, pigs were weighed …”
Changed in line 121.

124-127 “… removed from the pen, individually tattooed, loaded onto a conventional semitrailer, and shipped XX km [X h] to a commercial pork slaughter facility.”
Added in distance and time traveled during transport in line 125.

130-131 “Pigs were held in lairage overnight with access to water only, and slaughtered in accordance with industry-accepted, humane procedures.”
Changed in line 133-134.
132 “… recorded, and 10th rib fat and LM depths were measured …”
Changed in line 135.

134 “plant-proprietary”
Changed in line 137.

136 “… using the mixed models procedure of SAS …” <or> “…using PROC MIXED of SAS …”
Changed in line 140.

137 “… Cary, NC), with pen of pigs as the experimental unit.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

141 “… the PDIF option of SAS at \( P \leq 0.05 \).”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

143-144 I really don’t see the relevance of this sentence, especially because the authors do not note that feed samples were collected nor where and how feed samples were analyzed for RAC.
We believe it is important to show that the analyzed RAC level was in fact within expectations based on diet formulations. We have not made these changes.

146-147 Please delete this sentence
Deleted.

148-162 Please merge into a single concise paragraph
Changed in lines 150-161.

149 “… compared to controls (Table 3). Across the entire 35-d feeding trial, feeding …”
Changed in line 151.

150 “… G:F (23.7%), but reduced \( (P < 0.001) \) ADFI …”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

151-152 “… compared to controls. In general, the …”
Changed in line 153.

153 Delete “For example”
Deleted

154 “… 20% improvement over controls in growth …”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.
155-157 “… for 35 d; however, Gerlemann et al. (2014) noted minor improvements of only 10.9 and 12.9% in ADG and G:F, respectively, in RAC-fed pigs over controls.”
Changed in line 157.

158-160 “… reported that growth rate and efficiency were increased 12 and 10%, respectively, by feeding 5 mg/kg RAC, whereas ADFI and G:F were increased 11 and 13%, respectively, in pigs fed 10 mg/kg RAC.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

160-162 “Moreover, Apple et al. (2007) reported only numerical reductions in ADFI when pigs were fed RAC, which is similar to the findings of the current study where overall ADFI was only reduced 3.3% (Table 3).”
Changed line 159-161.

163 “During Phase 1 (d 0 to 7), feeding …”
Changed in line 161.

164-165 “… no effect (P = 0.78) on ADFI compared to controls; yet, during Phase 2 (d 7 to 21), RAC-fed pigs had greater (P < 0.001) ADG and G:F, as well as lower …”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

166 ADFI compared to the controls (Table 3).” Please do not report F:G in the text or in Table 3
All references to F:G have been removed.

166-168 “Although feeding RAC had no (P = 0.19) effect on ADG during the last marketing phase (Phase 3), ADFI was decreased (P < 0.001) and G:F was increased (P = 0.01) over controls by feeding 7.4 mg/kg RAC.”
Changed line 164-166.

169-170 “… were greatest in Phase 1 and gradually declined …”
Changed line 168.

172 “… than 21 d (through Phase 3) resulted in similar ADG as controls (Table 3).”
Changed line 170.

173 “Compared to the control-fed pigs, feeding RAC depressed ADFI, and …”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

174 Are you sure “-2.9%” is correct, because it does not jive with results presented in Table 3? Should have been 2.9% lower. Change made in line 172.
174-175 “… for Phases 1, 2, and 3, respectively.”
Changed line 173.

176 “Similarly, the magnitude of the improvements in G:F in response to feeding RAC declined with …”
Changed line 174-175.

177 “… (37.5, 25.8, and 6.4% greater for Phases 1, 2, and 3, respectively).”
Changed line 175.

179 “… and sent to slaughter on specific days (7, 21, and 35) during the RAC-feeding period.”
Changed line 177.

181-182 “… and end weights of … than the controls at each marketing phase.”
Changed line 179-180.

182-189 “Nonetheless, feeding RAC improved the live pig performance of pigs compared to the control-fed pigs up to the end of Phase 2, similar to the results of Armstrong et al. (2004), who demonstrated the …”
Changed line 180-183.

189-190 “… on feed, and the improvements in growth performance of RAC-fed pigs waned after 20 d on feed.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

192-193 “… strategy (16, 18, and 66% of pigs sent to slaughter on d 7, 21, and 35 …”
Changed line 186.

194-196 “… reductions in ADG (from 18.2 to 1.9%) and G:F (16.7 to 6.9%) with increased RAC-feeding duration.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

196-199 “… continual reductions in the magnitude of RAC-induced improvement in growth rate (30.0 to 10.8%) and efficiency (30.3 to 8.8%) when 26, 31, and 43% of the pen was strategically marketed on d 7, 2, and 35 of the last finishing period.”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

199-203 “In contrast, feeding RAC reduced ADFI, and this reduction increased in magnitude with time on RC in the present trial has not been observed in studies of similar …”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.
204-206 Please consider removing this redundant sentence
Removed.

206-207 “… results, along with others, suggest that, although RAC …”
Changed in line 198.

208 Delete “significantly”
Removed.

210-211 “… current study, ADG and ADFI of pigs was …”
Changed line 202.

212-213 “After Phase 1, ADG and ADFI were greater in both control- and …”
Changed line 203.

214-215 “… pigs during Phase 2, with the ADG of control-fed pigs being 20.0% greater in Phase 2 than Phase 1.”
Changed line 204-205.

215-216 “Interestingly, removal of the first 16% of RAC-fed pigs on d 7 did not produce a substantial …”
Changed line 205-206.

217 “… during Phase 2. Whether is was due to …”
Changed line 207.

219-222 “… performance in Phase 3 was similar to that of Phase 2, suggesting that the removal of an additional 10 pigs from each pen, and clearly increasing floor and feed space allowances, did not produce any additional improvements in growth performance of the remaining pigs, which is in agreement with …”
Changed lines 208-213.

225-226 Please consider deleting this single-sentence paragraph.
Deleted

227-229 “Pigs fed RAC were heavier \((P < 0.001)\) at the end of Phases 2 and 3, as well as across all marketing phases (Table 4).”
Changed line 215.

229-230 Replace “\((P < 0.05)\)” with “\((P < 0.01)\)” in according with the \(P\)-values reported in Table 4.
Replaced throughout the manuscript.

230 Insert a comma after “\((4.98\%)\)”
Inserted in line 218.

231 “… units), and reduced ($P < 0.001$) 10th rib fat depth …”

Changed line 222-225.

233-244 Please merge into a single concise paragraph.

Merged. New paragraph is in line 215-221.

233-235 “The observed 3.6% increase in HCW of RAC-fed pigs is within the range of report previously (Apple et al., …”

After revision above, this no longer applies.

235-236 “Moreover, the overall improvements in carcass yield, LM depth, and predicted lean content with feeding RAC are similar to a number of previously published studies …”

In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

236-237 You have 4 references listed in this citation, but JAS guidelines limit the number of references in a single citation to the 3 most relevant.

Deleted Apple et al., 2007 reference.

238-244 “Improvements in carcass yield (0.2, 0.6, and 0.9 percentage units for Phases 1, 2, and 3, respectively) and predicted lean content (0.2, 1.0, and 1.3 percentage units for Phases 1, 2, and 3, respectively) from feeding RAC increased with increase on RAC was likely due to the reduction in 10th rib fat depth in carcasses of RACfed pigs at the end of Phase 2 (4.0% less) and Phase 3 (10.4% less).”

Revised line 222-225.

245-246 “… study, RAC-inducted improvements in carcass traits increased with increasing time on feed, which concurs with the results of Hinson et al. (2012a), who reported …”

Revised line 227-230.

247-248 “… improvements in HCW, carcass yield, LM depth, and lean content, as well as decreased backfat depth, the long pigs were fed RAC.”

Revised line 229-230.

248-250 “Additionally, Gerlemann et al. (2014) reported …”

Revised line 231.

250-252 “… yield of 0.1 to 1.1 percentage units for pigs slaughtered after 7, 21, and 35 d on RAC.”

In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.
Similarly, Christianson et al. (2014) reported 0.7 percentage units greater carcass yield for…
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

Please consider deleting this redundant sentence
Removed.

“… lean content with increased RAC feeding duration (please provide citations for this particular statement).”
Added in line 237-238.

“… finishing pigs, RAC-induced responses on the carcass traits relative to those of control-fed pigs continue to…”
Revised line 238-240.

These results validate …
Changed line 242.

“… RAC on increased growth performance …”
Changed in line 242.

Moreover, results also suggested that the magnitude of the improvements in growth rate and efficiency will decrease with increasing time fed RAC, but improvements …”
In our opinion, proposed changes do not improve the clarity of the text and we have not made these changes.

Please ensure that both of these Hinson et al. (2012) references were cited in the Text
Both appear in the text.

Table 1
- Replace the row heading “Fat, Choice white grease” with “Choice white grease”
  Changed

Table 2
- Please consider changing the following row headings: “Phase 1 (d 0 to 7)”, “Days on RAC”, “Pigs slaughtered/pen, %”, “Phase 2 (d 7 to 21)”, and “Phase 3 (d 21 to 35)”
- Please delete the row “No. pigs remaining/pen on d 35” (irrelevant)
- Also, please remove the “about symbol” (~) from “25”
  Changed

Table 3
Please delete “F:G” results from the table
  Deleted

Reviewer: 2

Comments to the Author

Line 10 - This is a personal preference, but I suggest removing the words "heavy weight" from the title. Heavy weight is not defined in the introduction and the ending weight of the pigs (318 lbs) are not really heavy weight. National Pork Board recently identified heavy pigs as those weighing between 275 lbs and 400 lbs. These pigs would be considered more on the heavy end of average than heavy weight.

In our opinion, these were heavy weight pigs. Many producers in the present day currently market pigs between 120.2 and 133.8 kg BW. In the current study, the mean BW at the end of study was 144.6 kg BW, which is much heavier than current industry practice. In addition, the heavier live weight was by design to evaluate the responses of RAC at heavier weights. For these reasons, we wish to leave “heavy weight” in the description and title of the study.

Line 26 - It is not clear how the objective of this study differ from the objective provided in Lowe et al. (doi:10.2527/jas.201337516). Ending weights in that study were only slightly less. While the objective may be similar, we believe the primary objective of Lowe et al. was to evaluate RAC in immunological castrates, which are seldom used in the US swine industry. Furthermore, the study design is quite different. The study of Lowe et al. evaluated traditional barrows with that of immunological castrates. This study evaluated the effects of feeding RAC in heavy weight barrows and gilts. Furthermore, that study evaluated the growth performance over a longer period of time and actually weighed individual pigs to send the heaviest pigs for slaughter. The current study, we believe, provides data that producers could quickly implement, as this study used the 2 most common sexes and also represents a more realistic marketing strategy, as pigs were selected by visual appraisal vs. individual weights.

Line 50 - The experiment was well designed and well executed, as would be expected with this group of scientists, but there is nothing new or novel about the trial. In fact, the concluding remarks here are very similar to those made by Gerlemann et al. (doi:10.2527/jas.2013-6548). The greatest deficiency with this work is a lack of a novel objective and a lack of novel results.

The current study is the first study to evaluate the responses of feeding RAC to pigs of such heavy weight. With the onset of PEDv in the US in 2014, slaughter weights were setting or near record highs. The response on growth and carcass traits from feeding RAC were somewhat of an unknown at such heavy weights. In fact, this study demonstrated some of the greatest responses of any commercial RAC study, and showed much greater responses vs. those reported in Gerlemann et al.

Line 54 - Overall, the introduction does not address the issue presented in the title. The only thing new about the project is the ending weight of the pigs. Defining what ractopamine does has been published many times over. Suggest revising the introduction to address the potential issues associated with raising and marketing heavy weight pigs. The introduction lacks a
justification and a hypothesis. What new information will be garnered from reading this paper? Please define a "heavy weight" pig.

Defined heavy weight pig as >136 kg BW in line 71. While the response of RAC has been investigated previously, little information exists where RAC was fed in a controlled commercial system and certainly not in pigs of this weight. Also modified the introduction from line 70-73.

Line 84 - RAC should be Ractopamine when used at the beginning of a sentence.
Changed in line 84.

Line 91 - Suggest revising to say allotment to the study was carried out when the pigs reached approximately 152 d of age.
Currently, line 91 says that the allotment was carried out at approximately 152 d of age. Deleted BW reference from line 92.

Line 135 - This is split-plot experimental design. There 88 observations for each marketing group, but 264 (88 pens x 3 marketing events) observations for diet effects. Strong consideration should be given to reanalyzing the data prior to publication. How were the assumptions of ANOVA tested? I realize the lack of interaction between sex and diet has been established, but if the authors are testing the effects of RAC in heavy wt pigs and they are asserting that information is novel, then an assumption that there are no interactions seems inappropriate. Suggest reanalyzing as a 2x2 factorial in a split-plot. How were the assumptions of ANOVA tested?

We disagree with this evaluation. There were 88 pens, 44 complete replicates. Pen was the experimental unit and while pigs were sent for slaughter at different times, this does not constitute a split plot design as the treatment was still applied at the pen level. Furthermore, a similar study design was used in the current study as has been used and published (in JAS) in other studies (Lowe et al., Gerlemann et al., Arkfeld et al., etc.). Therefore, we have not reanalyzed this dataset.

Line 157 - On line 58 the authors state that most RAC studies were carried out in academic settings. The Apple citation provided here was written when far fewer of the commercial studies were available. If the intent is to distance this trial from an academic trial, more relevant citations should be discussed. How do these pigs compare with the surgically castrated barrows fed RAC on the Lowe study? What about the Gerlemann study? Both of those seem to be more appropriate contemporaries than the Apple meta-analysis.
Deleted Apple reference in this case and added in Gerlemann and Christianson paper references for ADFI. Change made in line 157-161.

Line 267 - JAS not requires all citations to include a doi number. Please see guide to authors for details.
Added in all doi’s.