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Effect of dietary ractopamine supplementation on growth performance, meat quality and fecal score in finishing pigs

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Abstract

An experiment was designed to assess ractopamine supplementation on growth, meat quality and carcass, and fecal scores of pigs. The 96 crossbred pigs ([Yorkshire × Landrace] × Duroc) had an average body weight of 72.8 ± 2.5 kg. Randomized allocation was followed in the allotment of the pigs according to their body weight into 1 of 2 dietary treatments: 1) CON, basal diet and 2) RAC (ractopamine hydrochloride), CON + 1% ractopamine with 12 replication pens per treatment including equal numbers of barrows (2) and gilts (2) per pen. At the end of the experiment, the lean meat percentage was higher ($p < 0.05$) for the RAC group compared to the CON group. Dietary ractopamine supplementation did not influence ($p > 0.05$) the growth performance and fecal score throughout the experimental period. In regard to sensory evaluation, higher ($p < 0.05$) scores for color and firmness were observed in the RAC group than in the CON group. Drip loss ($p < 0.05$) was higher in the ractopamine fed diet group compared to the control diet group at day 1. Additionally, longissimus muscle was improved ($p < 0.05$) in the ractopamine treated diet group than in the control diet group. In conclusion, in the early stage, ractopamine supplementation may not influence the growth performance, but it improves the leanness in the meat of finishing pigs.

Keywords: carcass characteristics, finishing pigs, growth performance, meat quality, ractopamine

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Introduction

Research interests in pig farming have been shifted its focus among average daily gain, feed intake, conversion efficiency, carcass weight and meat quality. Now a days, lean meat has become a primary concern for meat consumers. Ractopamine, which is a beta-adrenoreceptor agonist, acts as a repartitioning agent, helps to bring lean tissue deposition in finishing pigs at market weight (Watkins et al., 1990; Crome et al., 1996). Ractopamine hydrochloride (RAC) is pharmacologically phenethanolamine. In literatures, properties and effects of ractopamine on pork meat structure and quality have been described (Anderson et al., 1987; Prince et al., 1987; Uttaro et al., 1993; Crome et al., 1996). These literatures mentioned ractopamine's function in lean meat production and improved growth performance in pig. In the long history of pig farming numerous production changes have been brought in the United States. Recent noticeable changes have been brought on genetics and management practices. Breeding for lean pig and lean meat production is one of the changed objectives that has been prompted by the consumers' demand. The increasing addition of synthetic amino acids in lower protein diets is also a management change of the recent practices. Usually, older pigs deposit more fat during their final growth of marketing weight (Gu et al., 1992; Schwab et al., 2007). Ractopamine is being used in the United States since December, 1999. In May, 2006; a range of 5 to 10 ppm of ractopamine use in the daily diet of finishing swine has been set by the Food and Drug Administration (FDA). Many studies had been conducted using ractopamine on finishing pigs. But different countries have different desired body weight for marketing of finishing pigs. Moreover, Rickard et al. (2017) reported declining effect of ractopamine in finishing pigs (over 136 kg) after 21 days of use. To elucidate the effect of ractopamine on the finishing pig marketing system in South Korea, this study was planned and performed. The objective of this study was to assess the growth performance, feed efficiency, carcass weight and meat quality response of finishing pigs to ractopamine.

Materials and Methods

Treatment and management of animals were deployed by following the standards of the animal care and use committee of Dankook university.

Experimental design, animals and housing

Population sample of 96 finishing pigs ([Yorkshire × Landrace] × Duroc) possessing an average body weight (BW) of 72.8 ± 2.5 kg were selected for this experiment. According to body weight they were divided into pens and then allotted to two (2) experimental batches in a randomized way. Each treatment had 12 replicate pens of 4 pigs (2 gilts and 2 barrows·pen^{-1}). The investigation duration was 6 weeks. Dietary treatments were designated as: 1) CON, basal diet, 2) CON + 1% ractopamine. The given diets were formulated according to NRC (2012) to meet or exceed pigs' nutrient requirements (Table 1). In a controlled house where pigs were allotted, the temperature was maintained at 24℃. Each pen had an area of 1.8 × 1.8 m^2 including self-feeder and nipple drinkers to assure ad libitum feed and water access.

Sampling and measurements

During this 6 week long experimental period BW and abstained feed was recorded on a pen basis. From these BW and feed record average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio (G : F) were calculated. Concluding the experiment, one pig per pen were slaughtered at a local slaughterhouse. Obtained carcasses were chilled for 24 hour at 2℃. From between 10th and 11th ribs right loin samples were taken for meat quality analysis. Before evaluating sensory meat color, marbling, and firmness score the meat samples were thawed to room temperature. Six (6) trained personnel panelist team performed the sensory evaluation of color, firmness and marbling on a basis of three-point assessment system (NPPC, 1999). Just after the subjective scores, the lightness (L*), redness (a*), and yellowness (b*) values were measured at two (2) different surfaces of each sample. For this subjective evaluation CR-410 Chromameter (Konica Minolta Sensing Inc., Osaka, Japan) was used. At the same time, pH values were taken using a pH meter for twice per sample

(Fisher Scientific, Pittsburgh, PA, USA). The water holding capacity (WHC) was calculated abiding the methods elucidated by Kauffman et al. (1986). For WHC 0.2 gm meat from each sample was cut and put in a filter paper (125-mm-diameter) at 26℃. Then the filter paper was kept under a pressure of 3 kg weight for 3 minutes. The border area of the pressed meat sample and the extended moisture area were portrayed and then measured. For area measurement MT-10S digitizing area-line sensor (M.T. Precision Co., Ltd., Tokyo, Japan) was used. For the calculation of WHC, water: meat area was estimated (a higher ratio indicates decreased WHC). The LM surface of the 10th rib was traced marked. Then, using the antecedent digitizing area-line sensor the area was measured. Drip loss was measured following the method described by Honikel (1998). From each sample approximately 4 g of meat was cut and hanged in a plastic bag. Meat weight was checked in D 1, D 3, D 5, and D 7. Meat samples (2 gm) were cooked at 80℃ in a water bath to bring the core temperature of the fillet to 72℃. After cooking, samples were weighed again and the cooking loss percentage was calculated (Albrecht et al., 2019).

From day 10 to 17 fecal samples from each pen (1 gilt and 1 barrow) were collected by rectal massaging for diarrhea score observation. Individual person took subjective diarrhea scores each day (d 10 to 17) based on the following: 1 = hard feces, 2 = well-formed feces, 3 = sloppy and soft feces, 4 = semi-liquid and unformed feces, 5 = Watery liquid feces Scores were tabulated on a pen basis just after observations of stool consistency of the pigs in the pen. The score is presented as average daily diarrhea of individual pig score.

Table 1. Compositions of the basal finishing diets (as-fed basis).

Items	CON	Ractopamine
Ingredient (%)		
Maize	65.94	64.50
Soybean Meal 44% CP	11.62	13.02
Wheat	6.00	6.00
DDGS (dried distillers grains)	4.39	4.39
Rapeseed meal	3.00	3.00
Molasses	3.50	3.50
Tallow	2.80	2.80
DCP (Di-calcium phosphate)	1.05	1.00
Limestone	0.82	0.83
L-Lysine HCl	0.25	0.29
Methionine	-	0.04
Vitamin[y]	0.20	0.20
Mineral[z]	0.10	0.10
Salt	0.30	0.30
Choline, 25%	0.03	0.03
Total	100.00	100.00
Calculated composition (%)		
ME (metabolizable energy) ($kcal \cdot kg^{-1}$)	3,262	3,264
Crude protein	14.00	14.60
Crude fat	5.78	5.75
Calcium	0.65	0.65
Total phosphorus	0.53	0.53
Available phosphorus	0.32	0.32
Lysine	0.80	0.87
Methionine	0.24	0.28

[y] Provided for each kg of complete diet: 1,103 IU vitamin D3; 11,025 IU vitamin A; 44 IU vitamin E; 4.4 mg vitamin K; 50 mg niacin; 8.3 mg riboflavin; 4 mg thiamine; 29 mg d-pantothenic; 166 mg choline; 33 μg vitamin B12.

[z] Provided for each kg of complete diet: 12 mg Cu (as $CuSO_4 \cdot 5H_2O$); 8 mg Mn (as MnO_2); 0.28 mg I (as KI); 85 mg Zn (as $ZnSO_4$); 0.15 mgSe (as $Na_2SeO_3 \cdot 5H_2O$).

Statistical analysis

All experimental data analysis was subjected to t test (SAS Inst. Inc., Cary, NC, USA). The pen was used as the experimental unit for growth performance. Meat sample of one carcass per pen was considered as a unit for meat quality analysis. In fecal scoring pen was considered as a unit where 2 pigs' fecal (1 gilt and 1 barrow) per pen were scored. A probability level of $p \leq 0.05$ was considered significant, whereas $p < 0.10$ was considered a tendency.

Results and Discussion

Currently, producers are paying more attention in low fat, lean meat production without sacrificing quality of meat. Ractopamine is a suitable feed additive for finishing pigs, which has a capability to bind muscle receptors and adipocyte membranes. It's principle function is to activate a major intracellular signaling molecule, cyclic adenosine monophosphate (cAMP) (Mersmann, 1998). This molecule acts on different phases of cellular metabolism. Mostly it increases fat degradation and protein synthesis. Subsequently, ractopamine in finishing pig diets, brought increment in ADG by 0 to 10%, ameliorate feed conversion efficiency by 5 to 15%, and reduced fat in carcass by 10 to 15% (Anderson et al., 1987). In other literatures ractopamine enhanced carcass leanness by 2 to 5% (Aalhus et al., 1990; Dunshea et al., 1993; Xiao et al., 1999).

Studies have shown that, ractopamine treated pigs responded favorably in case of higher protein percentage supplementation in the diet. Dikeman (2000) sketched variable effects of ractopamine on meat quality. In general, ractopamine has noticeable effects on most meat quality characteristics, especially on leanness, (Aalhus et al., 1992; Uttaro et al., 1993).

Growth performance

The effect of ractopamine supplementation growth parameters is shown in Table 2. We observed no significant ($p > 0.05$) difference among treatment groups for any growth characteristics during the whole investigation period. It only showed a tendency of ADG increase ($p = 0.094$) in overall phase.

RAC showed no significant effect on growth rate, feed intake, and feed to gain ratio (G/F) in this study. Previous studies conducted with RAC have shown an increase in growth rate and G/F (Anderson et al., 1987; Nelson et al., 1987; Prince et al., 1987; Watkins et al., 1989; Brustolinia et al., 2019; Trotta et al., 2019; Panisson et al., 2020). Although there was no significant effect, incorporation of RAC into the diet tended to increase ADG and improve efficiency of gain. Unexpectedly, the trend we observed for improvement in gain was somewhat lower in this study than in other studies using RAC (Anderson et al., 1987; Crenshaw et al., 1987; Hancock et al., 1987; Nelson et al., l987). While most of the studies in the literature show finishing average daily gains of 0.7 - 0.9 $kg \cdot d^{-1}$, it should be noted that a gain of over 1.0 $kg \cdot d^{-1}$ was maintained in the treatment group in this present study. It is possible that this very rapid growth may have reduced the potential benefit of RAC on feed efficiency. Mimbs et al. (2005) also did not find a difference in ADG using 10 ppm RAC. That experiment also had continuous mean ADG of over 1 kg during different periods. ADFI was not different which is usual as other studies (Watkins et al., 1989; Brustolinia et al., 2019; Trotta et al., 2019; Panisson et al., 2020).

As we did not have amino acid kinetic data, we cannot ensure but assume that amino acid requirements, particularly for lysine, methionine and threonine were higher for RAC-treated pigs (Easter, 1987). Potential deficiencies in these amino acids may have affected the growth response of the pigs used in the present study.

Another noticeable finding is heavier pigs showed a positive effect of ractopamine in ADG and G/F (Rickard et al., 2017; Dalla-Costa et al., 2018). Rickard et al. (2017) and Dall-Costa et al. (2018) started ractopamine feeding at an average starting body weight of 121 kg and 92 kg respectively. Whereas, our study started early ractopamine feeding at only 72 kg average body weight. It might be a reason of no instant impact of ractopamine in ADG and G/F, with a tendency of positive growth performance which might be a significant effect on heavier pigs.

Table 2. Effect of ractopamine on growth performance in finishing pigs.

Items	CON	RAC	SEM	p-value
d 1 - 14				
ADG (g)	698	744	22	0.818
ADFI (g)	1,918	2,026	58	0.662
G/F	0.364	0.367	0.005	0.550
d 14 - 21				
ADG (g)	704	686	20	0.210
ADFI (g)	1,989	1,905	73	0.332
G/F	0.354	0.360	0.008	0.815
d 21 - 28				
ADG (g)	787	801	27	0.108
ADFI (g)	2,529	2,470	99	0.304
G/F	0.311	0.324	0.008	0.440
d 28 - 35				
ADG (g)	904	946	31	0.118
ADFI (g)	3,119	3,046	95	0.832
G/F	0.290	0.311	0.007	0.520
d 35 - 42				
ADG (g)	901	909	19	0.132
ADFI (g)	3,188	3,067	96	0.496
G/F	0.283	0.296	0.009	0.544
Overall (d 1 - 42)				
ADG (g)	731	757	16	0.094
ADFI (g)	2,136	2,196	52	0.442
G/F	0.342	0.345	0.004	0.542

12 replicate pens per treatment, (2 gilts and 2 barrows)·pen^{-1}.
CON, basal diet; RAC, CON + 1% ractopamine; SEM, standard error of the mean; ADG, average daily gain; ADFI, average daily feed intake; G/F, gain to feed ratio.

Meat quality, lean meat percentage and back fat thickness

The effect of ractopamine diet on finishing pig meat quality is exhibited in Table 3. Inclusion of ractopamine supplemented diet did not affect ($p > 0.05$) meat color. In regard to sensory evaluation color and firmness of meat were higher ($p < 0.05$) in control diet than ractopamine supplemented diet. Drip loss was higher in the ractopamine fed animal group compared to control diet at day 1. More importantly, longissimus muscle was improved ($p < 0.05$) in ractopamine treated diet than in the control diet. Color and structure scores were identical across all treatments, indicating that RAC did not produce PSE (pale, soft, exudative) or DFD (dark, firm, dry) meat. No differences were recorded in case of pH, cooking loss, WHC, L^* (lightness), a* (redness), b* (yellowness), marbling values. Similar results were reported by Dalla-Costa et al. (2018), Fernandez-duenas et al. (2008), Athayde et al. (2012) and Armstrong et al. (2004). Firmness and sensory color score were slightly lower in RAC treated group, but these were probably of no commercial significance. Drip loss was higher in ractopamine supplied group on D 1, which has not been observed in previous trials with RAC (Hinson et al., 2011; Athayde et al., 2012; Dalla-Costa et al., 2018; Brustolinia et al., 2019). But on D 3, D 5, and D 7 drip losses were similar between control and RAC groups. RAC supplementation showed an increase of the Longissimus muscle area. Kim et al. (2019), Carr et al. (2005), Armstrong et al. (2004) and Trotta et al. (2019) found similar increases in the Longissimus muscle area in their studies. Kim et al. (2019) suggested that RAC might have made enzymes associated with muscle development and muscle fiber type shift, more available in RAC supplied group.

Table 3. Effect of ractopamine on meat quality in finishing pigs.

Items	CON	RAC	SEM	p-value
Meat color				
Lightness (L*)	57.97	58.44	0.75	0.826
Redness (a*)	17.56	17.16	0.38	0.614
Yellowness (b*)	10.61	10.67	0.33	0.771
Sensory evaluation				
Color	2.02a	1.91b	0.04	0.013
Firmness	1.98a	1.89b	0.02	0.028
Marbling	2.00	2.01	0.08	0.890
Cooking loss (%)	28.64	30.01	0.73	0.902
Drip loss (%)				
D 1	5.93b	11.24a	1.59	0.044
D 3	12.88	16.86	1.26	0.629
D 5	15.29	18.02	1.17	0.955
D 7	17.70	19.15	1.21	0.709
pH	5.43	5.38	0.02	0.128
Longissimus muscle area (cm^2)	45.22b	48.91a	0.62	0.044
Water holding capacity (%)	60.22	59.25	2.47	0.432
Initial				
Lean meat percentage (%)	61.2	62.0	0.4	0.139
Back-fat thickness (mm)	9.0	8.2	0.3	0.854
Final				
Lean meat percentage (%)	54.6b	56.7a	0.5	0.002
Back-fat thickness (mm)	19.3	18.5	0.3	0.122

12 replicate meat samples for each treatment, 1 sample·pen^{-1}.

CON, basal diet; RAC, CON + 1% ractopamine; SEM, standard error the mean.

a, b: Means in the same row with different superscript differ significantly ($p < 0.05$).

Inclusion of ractopamine to the diet led to higher ($p < 0.05$) lean meat percentage than control diet at the final period of the experiment. Moreover, we did not find difference ($p > 0.05$) in backfat thickness throughout the experiment. Though backfat did not differ significantly, leanness of meat was significantly lower in ractopamine supplied group. Probably through the reduction of fat accumulation, lyposis or protein synthesis. Carr et al. (2005), Athayde et al. (2012), Fernandez-Duenas et al. (2008) and Dalla-Costa et al. (2018) have mentioned related results in their studies. In pig industry, meat quality is influenced by the fat percentage and it is an economic trait (Lim et al., 2016). Lean tissue increment in pig is more efficient as lean tissue deposition is energetically more efficient than adipose tissue (De Lange et al., 2001). Ractopamine may have increased protein synthesis as See et al. (2004) found reduced circulating plasma urea in RAC treated pigs. An increase in lyposis (Fain and García-Sáinz, 1983; Peterla and Scanes, 1990; Mersmann, 1998) and decrease of fatty acids and triacylglycerol synthesis (Mersmann, 1998) caused by ractopamine supplementation have been reported.

Fecal score

The result of ractopamine supplementation on fecal score is presented in Table 4. Ractopamine supplementation did not affect ($p > 0.05$) fecal score. Fecal score showed no difference between groups, suggesting that RAC may have no effect on fecal score or intestinal condition.

Table 4. Effect of ractopamine on fecal score in finishing pigs.

Items	CON	RAC	SEM	p-value
d 21	3.00	3.00	0.00	0.512
d 42	3.05	3.00	0.04	0.926

Fecal scoring system: 1 = hard feces, 2 = well-formed feces, 3 = sloppy and soft feces, 4 = semi-liquid and unformed feces, 5 = Watery liquid feces. 12 replicate pens per treatment, 2 pig (1 gilt and 1 barrow)·pen^{-1}.
CON, basal diet; RAC, CON + 1% ractopamine; SEM, standard error of the mean.

Conclusion

From our study, we can suggest that in early implementation of ractopamine can bring improvement in longissimus muscle and meat leanness in pig without economically affecting other meat characteristics which may be preferred by consumers and marketing channels.

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