MAINTAINING THE RESPONSE TO RACTOPAMINE THROUGH INTERMITTENT FEEDING

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By

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Executive Summary

The aim of this investigation was to determine the impact of intermittent Ractopamine (RAC) feeding on growth performance, feed efficiency and carcass composition of pigs when RAC supplementation begins during the late grower period. One hundred and forty four pigs (PrimeGro™ Genetics) were selected at 15 weeks of age (average weight 49.7 kg ± 0.30 kg), housed in individual pens and offered a control grower diet without RAC for 7 days. At the completion of this acclimatisation period, pigs were allocated within sex to one of 6 dietary RAC feeding strategies: Treatment 1: Control (0 ppm RAC), Treatment 2: Control diet day 0-14, 3 day break, 5 ppm RAC day 17 - 42 days (standard commercial strategy), Treatment 3: 5 ppm RAC day 0-14, 3 day break, 5ppm RAC day 17 -42, Treatment 4: 5 ppm RAC day 0-14, 5 day break, 5ppm RAC day 19 -42, Treatment 5: 5 ppm RAC day 0-14, 7 day break, 5ppm RAC day 21 -42, Treatment 6: 5 ppm RAC 0-14, 5 ppm RAC 14-42 (RAC diet continuously fed grower and finisher). Average weight at the start of the test period was 55.0 kg ± 0.61 kg. All pigs received a grower diet (either control or RAC) from day 0-14 and a finisher diet (control or RAC) from day 14 to 42. The grower diets were formulated to contain 0.65 g available lysine/MJ DE, while the finisher diets contained 0.58 g available lysine/ MJ DE. Pigs were offered their respective diets *ad libitum* for the entire experimental period.

There was no effect of dietary RAC supplementation on rate of gain, feed intake or feed conversion ratio during the initial 14 days. There were also no main effects of RAC feeding strategy on growth rate, feed intake or feed efficiency from day 17 of the experimental period (start of the standard RAC finisher feeding program). Over the entire 7 weeks of the study there were no effects ($0.72<P<1.00$) of RAC feeding strategy on any aspect of growth performance. Pooling the data for all of the groups that received a break in RAC consumption (3, 5 or 7 day break between RAC feeding) also failed to reveal any effects of RAC feeding strategy over the entire experimental period. The absence of a growth response to RAC supplementation during the initial feeding period (day 0 to 14) makes it impossible to provide an assessment on the use of intermittent RAC feeding strategies. Further research may be warranted to determine if a break 14 days after the commencement of RAC supplementation during the finisher period could improve growth performance prior to sale.

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1. Introduction

Ractopamine hydrochloride (Paylean™, Elanco Animal Health, Greenfield, IN)) is a beta adrenergic agonist (β-agonist) that is approved for use as an in feed ingredient for pigs. Ractopamine (RAC) has been widely demonstrated to improve feed efficiency and growth rates both in Australia (Dunshea *et al.* 1993a; Dunshea *et al.* 1993b; Smits and Cadogan 2003) and overseas (Schinckel *et al.* 2001). The growth response to a constant dosage of dietary RAC is not consistent over the duration of the feeding period, with the response most pronounced during the initial 2 weeks of feeding and declining thereafter due to the down regulation of β-receptors (Dunshea *et al.* 1993b; Mills 2002; Sainz *et al.* 1993; Spurlock *et al.* 1994). The most common approach to maintaining the response to dietary RAC beyond this initial feeding period is to increase the dose of Paylean in the subsequent weeks (referred to as a step-up feeding program). Studies in Australia and overseas have shown that stepping up the dietary RAC concentration to 10 or 20 ppm after an initial 14 day feeding period at 5 ppm is an effective method of maintaining or even improving the growth and feed efficiency response to RAC over the finisher period (Rikard-Bell *et al.* 2009; See *et al.* 2004).

From a commercial perspective, an increase in dietary RAC concentration during the late finisher period when feed intakes are high can be associated with an increase in feed costs. As such, alternative methods of maintaining the response to RAC during this finisher period are being investigated. One such approach is to provide a withdrawal or resting period of 3 to 7 days after the initial period of RAC feeding, followed by a secondary RAC feeding period. A preliminary study by Elanco Animal Health, Mexico suggested that finisher pigs offered 5 ppm RAC for 28 days followed by a 5 day break and then 5 ppm RAC for an additional 23 days grew faster and more efficiency over the entire 56 day experimental period than those animals offered the 5 ppm RAC diet continuously for the 56 days (Cuarón *et al.* 2004). The starting weight of the animals used in this Elanco study was 65 kg, resulting in a final weight of approx 115 kg at the end of the 56 day feeding period. This weight is higher than typical slaughter weights in Australia, and as such the use of an intermittent RAC feeding program beginning in the grower period is worth investigating. If the growth response to RAC can begin in the late grower period and be maintained through to slaughter, this strategy would provide economic benefits to producers. As such, the aim of this investigation was to assess the impact of an intermittent RAC feeding strategy on the growth performance, feed efficiency and carcass composition of pigs when RAC supplementation begins during the late grower period.

2. Methodology

Animals and treatments

One hundred and forty four pigs (72 male and 72 female, Large White x Landrace, PrimeGro™ Genetics) were selected at 15 weeks of age (average weight 49.7 kg ± 0.30 kg) from the Rivalea Research and Innovation Unit, Corowa NSW. Pigs were selected in two replicates, with the first replicate selected on the 2nd September 2009 and the second replicate selected on the 24th November 2009. Pigs were housed in individual pens and offered a control grower diet without RAC for 7 days while they acclimatized to their new environment. At the completion of this acclimatisation period, pigs were allocated within sex to one of 6 dietary RAC feeding strategies:

Treatment 1: Control (0 ppm RAC)

Treatment 2: Control diet day 0-14, 3 day break, 5 ppm RAC day 17 - 42 days (standard commercial strategy)

Treatment 3: 5 ppm RAC day 0-14, 3 day break, 5ppm RAC day 17 -42

Treatment 4: 5 ppm RAC day 0-14, 5 day break, 5ppm RAC day 19 -42

Treatment 5: 5 ppm RAC day 0-14, 7 day break, 5ppm RAC day 21 -42

Treatment 6: 5 ppm RAC 0-14, 5 ppm RAC 14-42 (RAC diet continuously fed grower and finisher)

Average weight at the beginning of the test period (day 0) was 55.0 kg ± 0.61 kg. All pigs received a grower diet (either control or RAC) from day 0-14, and the finisher diet (either control or RAC) from day 14 to 42. The grower diets were formulated to contain 0.65 g available lysine/MJ DE, while the finisher diet contained 0.58 g available lysine/ MJ DE (Table 1). All diets were formulated to contain 14 MJ digestible energy/kg diet.

Pigs were offered the test diets *ad libitum* for the entire experimental period. Individual live weights were recorded at entry to the facility (day -7), day 0, day 7, day 14, day 17, day 19, day 21, day 28, day 35 and day 42. Individual feed intake as estimated by feed disappearance was recorded between each of these time periods. Back fat depth at the P2 site along with leg fat depth were measured at day 0 and day 42 to assess differences in body composition. Animals were slaughtered at a commercial abattoir at the end of the 42 day test period. Individual carcass weight and carcass P2 was measured and dressing percentage subsequently calculated. All procedures undertaken in this investigation were approved by the Rivalea Animal Care and Ethics Committee (License: SPPL111).

Statistical analyses

Differences in growth performance and carcass characteristics due to the main effects of RAC feeding strategy and sex were analysed using an analyses of variance (ANOVA) for a completely randomized design. Replicate was included as a blocking factor in the analyses. Pooled data from animals receiving the same diets during a set period of time were subsequently analysed using a residual maximal likelihood (REML) mixed model analyses with the random effect of replicate and the fixed effects of RAC feeding program and sex. During the grower period (0-14 days), the growth performance data was pooled for treatments 1 and 2 as both treatment groups received the control grower diet during this time. Similarly, the data from animals allocated to treatments 3, 4, 5 and 6 were also pooled as all treatments received the RAC grower diet during this time. During the finisher period and for the entire experimental period, additional data analyses was undertaken using the pooled data set for animals allocated to treatments 3, 4, and 5 (collectively referred to as the pooled break treatment group). The individual animal was the experimental unit for all analyses. All analyses were performed using Genstat 10th Edition (Payne *et al.* 2005).

Table 1. Ingredient profile and nutrient composition of the grower and finisher diets, % of diet (as fed)

	Grower		Finisher	
	Control	RAC	Control	RAC
Ingredient, %				
Wheat	69.2	69.2	72.7	72.7
Mill mix	7.3	7.3	8.2	8.2
Soybean meal	16.0	16.0	11.0	11.0
Meatmeal	3.3	3.3	3.3	3.3
Water	1.0	1.0	1.0	1.0
Natuphos 5000	0.01	0.01	0.01	0.01
Tallow	0.9	0.9	1.4	1.4
Salt	0.2	0.2	0.2	0.2
Limestone	1.47	1.47	1.57	1.57
Synthetic lysine (L-lysine HCl)	0.25	0.25	0.25	0.25
Synthetic Dl-methionine	0.06	0.06	0.04	0.04
Synthetic threonine	0.08	0.08	0.07	0.07
Copper Proteinate	0.1	0.1	0.1	0.1
Rivalea grower premix	0.07	0.07		
Rivalea finisher premix			0.07	0.07
Rumensin	0.08	0.08	0.08	0.08
Ractopamine		0.025	0	0.025
*Estimated nutrient composition, %**				
DE, MJ/kg	14.0	14.0	14.0	14.0
Crude protein	20.96	20.96	19.29	19.29
Crude fibre	2.97	2.97	2.96	2.96
Crude fat	2.57	2.57	3.03	3.03
Total Lysine	1.06	1.06	0.95	0.95
Available lysine	0.91	0.91	0.81	0.81
Available lysine: DE (g/MJ)	0.65	0.65	0.58	0.58
Ractopamine (ppm)**	<0.3	5.0	0.1	5.0

*Nutrient value based upon Rivalea Australia Pty Ltd proprietary composition data
** Analysed by AsureQuality based on Eli Lilly method BO4372

3. Outcomes

Data for the first 2 weeks of the study were analysed to determine the effect of RAC supplementation during the late grower period (control: Treatments 1 and 2 versus RAC: Treatments 3-6). There was no effect of dietary RAC supplementation on rate of gain, feed intake or feed conversion ratio during this time (Table 2). As anticipated, boars grew at a faster rate than the gilts and were able to utilise feed for gain more effectively. There were no significant interactions between RAC supplementation and sex. Overall, animal health during the grower period was good with no deaths or removals from any of the treatment groups during this time.

Table 2. Effects of dietary RAC supplementation on growth performance of gilts and boars during the grower period (Day 0-14).

	Gilt		Boar			Significance		
	0ppm	5ppm	0ppm	5ppm	sed	RAC	Sex	RAC x Sex
	(n=24)	(n=48)	(n=24)	(n=48)				
Rate of gain (kg/d)	1.01	1.06	1.13	1.13	(0.040-0.057)	0.43	0.012	0.45
Feed intake (kg/d)	2.37	2.40	2.27	2.35	(0.057-0.080)	0.24	0.16	0.58
FCR	2.41	2.33	2.04	2.12	(0.077-0.109)	0.97	<0.001	0.25

There were no main effects of RAC feeding strategy on growth rate, feed intake or feed efficiency from day 17 of the experimental period (start of the standard RAC finisher program, Table 3). Considering the data for the pigs offered the control and standard finisher RAC feeding programs only (treatments 1 and 2), pigs offered the finisher RAC strategy grew numerically faster than the control animals during the initial 11 days of supplementation (ROG day 17-28: 1.02 and 1.11 kg/d for the control and finisher RAC feeding strategies respectively, sed 0.076, P=0.26) and tended to be more feed efficient (FCR 2.65 and 2.42 respectively, P=0.13, sed 0.151). This response to RAC diminished with time consistent with many other studies (ROG day 17-35: 1.06 and 1.08 kg/d respectively for the control and finisher RAC treatments, P=0.68, sed 0.064, FCR day 17-35: 2.64 and 2.56 respectively P=0.59, sed 0.156). There was one death during the finisher period, with the cause of death established as *Actinobacillus pleuropnemoniae* (APP). This animal had been allocated to treatment 5 (RAC grower, 7 day break, RAC finisher) and died on day 17 of the experimental period.

There were no significant effects of RAC feeding program on growth performance during the finisher period when the data for the animals that received a break in RAC consumption at the end of the grower period were pooled together (Table 4). Feed efficiency was again numerically improved in the pigs offered the normal finisher RAC feeding program from day 17-28 (FCR: control- 2.65, control/finisher RAC- 2.42, Pooled break RAC- 2.63 and RAC no break - 2.53, P=0.26), with the response more pronounced in the boars than the gilts (Table 4).

Over the entire 7 weeks of the study there were no effects (0.72<P<1.00) of RAC feeding regime on any aspect of growth performance (Table 3). There were also no interactions between sex and dietary RAC except for feed intake (P=0.034) but there is little biological or commercial implications of the latter. The effects of sex were as expected except for a lower back fat in gilts, possibly because of lower carcass weights. Pooling the data for all of the groups that received a break in the RAC treatment also failed to reveal any effects of RAC feeding strategy over the entire experimental period.

Table 3. Effects of Ractopamine feeding regime on growth performance during the finisher period and over the entire experimental period (n=12 per treatment).

	Gilt						Boar									
	Con	Con/ RAC	3 d break	5 d break	7 d break	RAC	Con	Con/ RAC	3 d break	5 d break	7 d break	RAC	sed	RAC	Sex	RAC x Sex
Day 17-28																
Rate of gain (kg/d)	0.95	0.99	0.92	0.95	0.96	1.01	1.08	1.22	1.19	1.16	1.16	1.19	0.085	0.70	<0.001	0.90
Feed intake (kg/d)	2.67	2.53	2.64	2.70	2.75	2.71	2.61	2.64	2.62	2.71	2.67	2.79	0.139	0.58	0.93	0.90
FCR	2.71	2.65	2.97	2.93	2.90	2.70	2.58	2.19	2.25	2.37	2.39	2.36	0.203	0.52	<0.001	0.45
Day 17-35																
Rate of gain (kg/d)	1.07	1.02	1.05	1.02	1.06	1.18	1.04	1.15	1.14	1.08	1.10	1.17	0.081	0.30	0.19	0.76
Feed intake (kg/d)	2.77	2.57	2.72	2.83	2.82	2.76	2.63	2.79	2.71	2.78	2.83	2.83	0.131	0.51	0.71	0.52
FCR	2.63	2.62	2.60	2.77	2.67	2.36	2.66	2.49	2.45	2.77	2.65	2.46	0.203	0.19	0.71	0.96
Day 17-42																
Rate of gain (kg/d)	0.99	0.94	0.90	0.97	0.98	0.99	1.08	1.14	1.17	1.14	1.14	1.11	0.067	0.96	<0.001	0.47
Feed intake (kg/d)	2.78	2.59	2.72	2.82	2.82	2.77	2.71	2.87	2.86	2.86	2.84	2.87	0.121	0.72	0.094	0.43
FCR	2.84	2.83	3.14	2.96	2.92	2.79	2.64	2.53	2.46	2.54	2.52	2.63	0.187	0.97	<0.001	0.43
Day 0-42																
Rate of gain (kg/d)	1.00	0.94	0.94	0.98	0.97	0.99	1.07	1.13	1.15	1.11	1.12	1.10	0.053	1.00	<0.001	0.61
Feed intake (kg/d)	2.65	2.42	2.56	2.62	2.61	2.60	2.43	2.66	2.69	2.62	2.57	2.63	0.010	0.72	0.61	0.034
FCR	2.67	2.60	2.75	2.72	2.72	2.66	2.30	2.37	2.35	2.36	2.31	2.40	0.121	0.96	<0.001	0.87
Carcass weight (kg)	72.6	70.8	70.4	70.8	71.6	71.8	73.2	75.6	76.3	76.1	76.3	74.7	2.25	0.99	<0.001	0.58
Dressing %	75.8	75.4	75.1	74.7	75.5	75.1	72.4	73.2	73.5	73.9	74.1	73.0	0.86	0.86	<0.001	0.41
Carcass P2 (mm)	8.4	8.2	8.3	8.4	8.7	8.6	9.3	10.2	9.4	9.3	9.4	9.6	0.82	0.99	0.001	0.90

Table 4. Effect of Ractopamine feeding regime on growth performance during the finisher period and over the entire experimental period (data for pigs offered the 3, 5 and 7 day break have been pooled).

	Gilt				Boar					Significance		
	Con	Con/ RAC	Pooled Break	RAC	Con	Con/ RAC	Pooled Break	RAC	sed	RAC	Sex	RAC x Sex
	n=12	n=12	n=36	n=12	n=12	n=12	n=36	n=12				
Day 17-28												
Rate of gain (kg/d)	0.95	0.99	0.94	1.01	1.08	1.22	1.17	1.19	(0.051-0.087)	0.43	<0.001	0.76
Feed intake (kg/d)	2.67	2.53	2.70	2.71	2.61	2.64	2.66	2.79	(0.080-0.137)	0.40	0.91	0.71
FCR	2.72	2.65	2.93	2.70	2.58	2.19	2.34	2.36	(0.117-0.206)	0.26	<0.001	0.26
Day 17-35												
Rate of gain (kg/d)	1.07	1.02	1.05	1.18	1.04	1.15	1.11	1.17	(0.046-0.080)	0.14	0.19	0.48
Feed intake (kg/d)	2.77	2.57	2.78	2.76	2.63	2.79	2.76	2.83	(0.076-0.130)	0.43	0.70	0.25
FCR	2.63	2.62	2.68	2.36	2.66	2.49	2.63	2.46	(0.131-0.225)	0.20	0.72	0.86
Day 17-42												
Rate of gain (kg/d)	0.99	0.94	0.95	0.99	1.08	1.14	1.15	1.11	(0.039-0.066)	0.98	<0.001	0.38
Feed intake (kg/d)	2.78	2.59	2.79	2.77	2.71	2.87	2.85	2.87	(0.070-0.120)	0.47	0.089	0.23
FCR	2.84	2.83	3.00	2.79	2.64	2.53	2.50	2.63	(0.117-0.201)	0.94	<0.001	0.39
Day 0-42												
Rate of gain (kg/d)	1.00	0.94	0.96	0.99	1.07	1.13	1.13	1.10	(0.030-0.052)	0.99	<0.001	0.41
Feed intake (kg/d)	2.65	2.42	2.60	2.60	2.43	2.66	2.63	2.63	(0.057-0.099)	0.44	0.60	0.013
FCR	2.67	2.60	2.73	2.66	2.30	2.37	2.34	2.40	(0.069-0.119)	0.83	<0.001	0.61
Carcass weight (kg)	72.6	70.8	70.9	71.8	73.2	75.6	76.2	74.7	(1.28-2.22)	0.96	<0.001	0.29
Dressing %	75.8	75.4	75.1	75.1	72.4	73.2	73.8	73.0	(0.49-0.85)	0.80	<0.001	0.20
Carcass P2 (mm)	8.4	8.2	8.4	8.6	9.3	10.2	9.4	9.6	(0.47-0.81)	0.92	0.001	0.69

The influence of time on growth rate and feed intake during the experimental period is displayed in Figure 1. It was anticipated that there may have been a reduction in feed intake and therefore growth rates during the seven day period from day 14-21, during which time the pigs were individually weighed on four separate occasions (day's 14, 17, 19 and 21). The results displayed in Figure 1 do not support this hypothesis, with average feed intake and growth rate during this time actually higher that that recorded from day 7 to 14. There was however a dip in feed intake and rate of gain during the following week (day 21-28), primarily due to a reduction in feed intake of the first replicate. It is unlikely that climatic conditions impacted on this result, as the day 28 weights for replicate 1 were undertaken during early October 2009, a period of mild maximum temperatures.

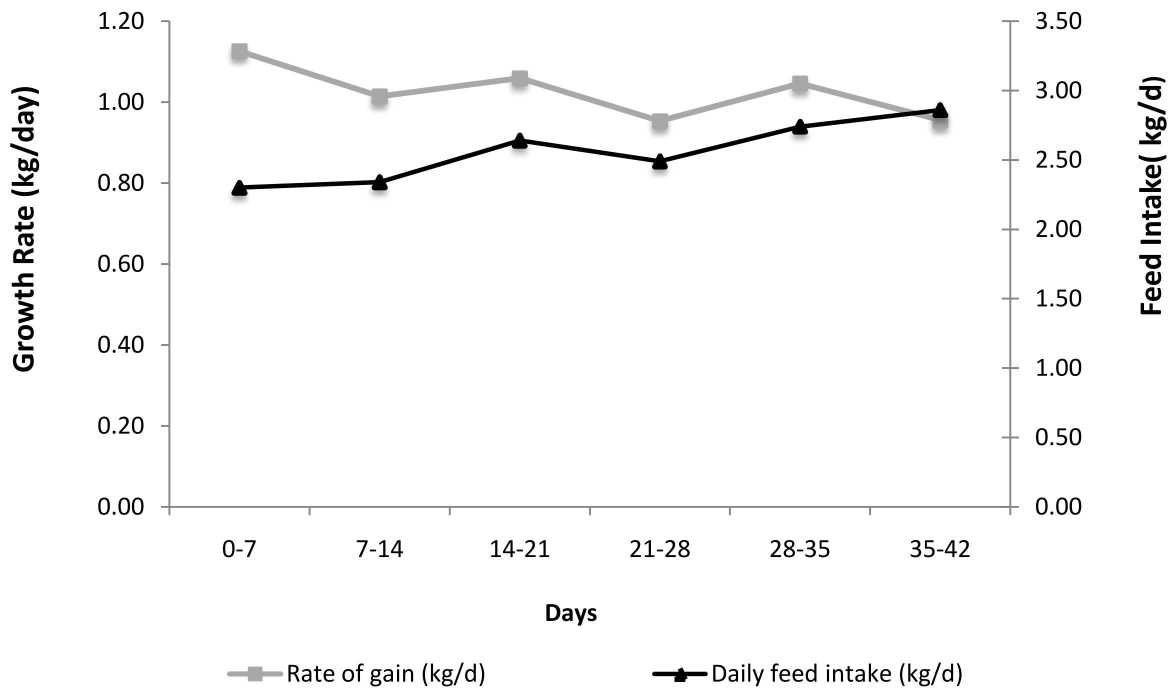

Figure 1. Influence of time on growth performance and feed intake over the experimental period.

4. Application of Research

The results from this investigation do not support the use of an intermittent RAC feeding strategy when RAC supplementation begins early (i.e. during the grower period). The lack of a significant response to RAC during the grower period was unexpected and may suggest that pigs of a lighter age and/or weight may not be as responsive to RAC as those that are older/heavier. Finisher pigs considered light upon entry to the finisher period (65 kg at 16 weeks of age) have been shown to respond to increasing concentrations of RAC in a similar manner to heavier pigs (Rikard-Bell *et al.* 2007). The start weight of the pigs in this present investigation at the commencement of RAC feeding was however 10 kg lighter (55 kg start weight) than those utilised in the investigation by Rikard-Bell (2007). Further research is required to understand the influence of age/ weight on the expression of β-receptors in growing pigs and therefore the potential for lighter weight animals to respond to dietary RAC supplementation. Preliminary gene expression analyses has been undertaken on tissue samples obtained from a separate Pork CRC research project, with the results anticipated to provide some insight into the influence of weight, sex and RAC supplementation over time on receptor expression. It is also likely that the expression of β-receptors in both skeletal muscle and adipose tissue will vary with genotype. Further research in this area is warranted to enable producers to maximise their herd's response to RAC in a consistent manner.

The magnitude of the growth and efficiency response to the standard finisher RAC feeding program was within the anticipated range for the Rivalea genotype. During the initial 11 days, growth rate increased by 8.8 % and FCR was improved by 8.7 % compared to the control animals when RAC was included in the finisher diet. Consistent with previous studies, this response diminished as the duration of RAC feeding was extended. The excellent performance of the control animals throughout the study suggests that nutrients were not limiting performance. Independent analyses of the grower and finisher diets for actual RAC concentrations confirmed that RAC was present in the diets at the required concentrations.

It is difficult to assess the effectiveness of the intermittent feeding strategy tested in this study given that there was no observable response to RAC consumption during the initial 14 day feeding period. Previous studies have indicated that finisher pigs offered 5 ppm RAC for 28 days followed by a 5 day break and then 5 ppm RAC for an additional 23 days grew faster and more efficiency over the entire 56 day experimental period than those animals offered the 5 ppm RAC diet continuously for the 56 days (Cuarón *et al.* 2004). However, in a more recent study Neill *et al.* (2010) reported similar growth rates and feed efficiency over a 56 day experimental period when finisher pigs (start weight 67-70 kg, barrows and gilts) were offered diets containing 10 ppm Ractopamine from day 35 to 56 only (normal finisher strategy) or 10 ppm Ractopamine from day 0 to 21 and again from day 35 to 56 (14 day break strategy). During the break period, rate of gain and feed efficiency both declined, however the re-feeding of RAC after the withdrawal period resulted in there being no negative impact of the withdrawal period over the entire experimental period. While producers would not implement such an intermittent strategy given that there were no improvements above the standard finisher feeding program, the authors do note that there may be an opportunity to utilize this strategy in situations where pigs are sold out at sorted weights. Under such commercial situations, light pigs that are not marketed within the initial 3- 4 weeks of sale may be moved and fed a control diet for 7- 14 days and then re-fed diets containing RAC if necessary without there being any negative effects on performance. This may provide producers with improved performance from these slower growing animals compared to a situation where they may be fed RAC continuously for a number of weeks. This conclusion would however need to be confirmed with ‘fall back’ or slow growing animals and further data obtained on the length of time required for re-feeding in order to overcome the negative impact of the withdrawal period.

5. Conclusion

The absence of a growth response to RAC during the grower period in this investigation makes it impossible to provide an assessment on the use of intermittent RAC feeding strategies. Further research may be warranted to determine if a break 14 days after the commencement of RAC supplementation during the finisher period could improve growth performance prior to sale.

6. Limitations/Risks

The absence of a response to Ractopamine supplementation during the initial 14 day grower period makes it impossible to assess the potential of an intermittent feeding strategy to improve growth performance and feed efficiency.

7. Recommendations

Given that conclusive recommendations could not be obtained from the results of this experiment, an additional study may be warranted to determine the response to an intermittent feeding strategy during the finisher period when a consistent response to Ractopamine supplementation can be obtained.

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INFLUENCE OF DIETARY VEGETABLE PROTEIN SOURCE ON THE RESPONSE TO RACTOPAMINE

2H-102

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By

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Executive Summary

The aim of this investigation was to determine if the response of finisher pigs to dietary Ractopamine (RAC) supplementation is influenced by the vegetable protein source in the diet. Three hundred and twelve female pigs (PrimeGro™ Genetics) were selected at 17 weeks of age (average weight 65.7 kg), housed in individual pens and offered a control acclimatisation diet without RAC for the initial 7 days. At the completion of this acclimatisation period, pigs were allocated to a 2 x 4 factorial experiment with the respective factors being RAC inclusion (0 or 5 ppm) and dietary vegetable protein source (soybean meal, canola meal, peas or lupins included at approximately 10 % of the diet). Diets were formulated to contain 14.0 MJ DE and 0.60 g available lysine/ MJ DE. Pigs were offered their respective diets *ad libitum* for the 21 day test period, with individual feed intake, growth rate and feed efficiency measured during this time.

There were no significant interactions between RAC inclusion and dietary vegetable protein source on any of the performance parameters measured, nor were there any main effects of dietary vegetable protein source on growth rate, feed intake or feed efficiency over the test period. Growth performance over the entire 21 day feeding period was improved with the inclusion of RAC in the diets (ROG 1.05 and 1.09 kg/d respectively for the control and RAC treatments, P=0.046). The magnitude of the growth rate improvement with RAC supplementation was greatest in the pigs offered the soybean meal diets (8.7 %), with pigs offered RAC diets containing the other vegetable protein sources increasing their rate of gain by between 0.9 and 3.8 %. There was no influence of RAC supplementation on carcass characteristics, nor were there any impacts of dietary vegetable protein source on carcass weight or P2. The results from this study do not support suggestions that dietary vegetable protein source can influence the response of finisher pigs to Ractopamine. As such, there is no evidence to suggest that the use of canola meal as the sole vegetable protein source in nutritionally adequate diets will limit the response of finisher pigs to Ractopamine.

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1. Introduction

Ractopamine hydrochloride (Paylean, Elanco Animal Health, Greenfield, IN)) is a beta adrenergic agonist (β-agonist) that is approved for use as an in feed ingredient for pigs. Ractopamine (RAC) has been widely demonstrated to improve feed efficiency and growth rates both in Australia (Dunshea *et al.* 1993a; Dunshea *et al.* 1993b; Smits and Cadogan 2003) and overseas (Schinckel *et al.* 2001), and is commonly included in commercial finisher diets across Australia. Despite this, several studies conducted at Rivalea and the Victorian Department of Primary Industries over recent years have shown an irregular performance response to the inclusion of Ractopamine in finisher diets. In such studies, the performance improvements usually observed with RAC consumption were noticeably absent. The common link across these studies appeared to be the use of canola meal as the predominant vegetable protein source in the diets. In comparison, the majority of published Ractopamine studies conducted in Australia and overseas in which the authors reported a positive response to Ractopamine utilised soybean meal as the predominant or sole vegetable protein source (Carr *et al.* 2005; See *et al.* 2004; Watkins *et al.* 1990). Following the unusual performance results from these studies, commercial nutritionists have tended to impose a maximum canola inclusion level in finisher diets containing RAC. Alternatively, some nutritionists have tried where possible to use an alternative vegetable protein source in these diets. Given that in South-Eastern Australia canola is the current vegetable protein source of choice (least cost) it is important that research is undertaken to clarify if protein source has an impact on the commercial response to metabolic modifiers. If it is found to influence the response, further studies may be required to understand why there are limitations when utilising particular protein sources. Clear guidelines could then be provided to commercial nutritionists to ensure that the maximum benefits of Ractopamine can be consistently obtained for Australian producers. As such, the aim of this study was to determine the impact of dietary vegetable protein source on the response of finisher pigs to Ractopamine.

2. Methodology

Animals and treatments

Three hundred and twelve female pigs (Large White x Landrace, PrimeGro™ Genetics) were selected at 17 weeks of age (average weight 65.7 kg ± 0.3 kg) from the Rivalea Research and Innovation Unit, Corowa NSW. Pigs were selected in three replicates, with the first replicate selected on the 19th January 2010, the second replicate on the 23rd February 2010 and the final replicate on the 30th March 2010. Pigs were housed in individual pens and offered a control acclimatisation diet for the initial 7 days. This diet contained an equal mix of all vegetable protein sources evaluated in this study (Table 1). At the completion of the acclimatisation period, pigs were allocated to a 2 x 4 factorial experiment with the respective factors being dietary Ractopamine inclusion (0 ppm or 5 ppm RAC) and dietary vegetable protein source (soybean meal, canola meal, peas or lupins included at approx 10 % of the diet). Diets were formulated to contain 14.0 MJ DE and 0.60 g available lysine/MJ DE with amino acids balanced with animal protein sources (Tables 1 and 2). Pigs were offered these test diets for a 21 day experimental period, with individual weights recorded at day 0, day 14 and day 21. Individual feed intakes were estimated from feed disappearance from day 0 to 14 and day 14 to 21. Back fat depth at the P2 site and leg fat depth were also measured at day 0 and day 21 to determine differences in body composition. Animals were slaughtered at a commercial abattoir at the end of the 21 day test period, with carcass weight and carcass P2 measured and dressing percentage subsequently calculated. All procedures undertaken in this investigation were approved by the Rivalea Animal Care and Ethics Committee (License: SPPL111).

Statistical analyses

Differences in growth performance and carcass characteristics due to the main effects of dietary RAC inclusion and dietary vegetable protein source were analysed using an analyses of variance for a randomised design. Replicate was included in the model as a blocking factor. The individual animal was utilised as the experimental unit for all analyses. All analyses were performed using Genstat 10th Edition (Payne *et al.* 2005).

Table 1. Ingredient profile and nutrient composition of the acclimatisation diet and the four experimental diets containing 0ppm Ractopamine, % of diet (as fed)

	Acclimatisation diet	Soybean meal	Canola meal	Peas	Lupins
Ingredient, %					
Wheat	49.4	42.8	57.3	35.2	43.9
Barley	19.2	25.0	13.7	25.0	22.3
Mill mix	13.0	13.2	10.0	14.2	13.0
Lupins	2.0				10.0
Soybean meal	2.0	10.0			
Canola	2.0		10.2		
Peas	2.0			10.0	
Meatmeal	3.0	1.2	1.0	8.9	3.9
Water	1.0	1.0	1.0	1.0	1.0
Natuphos 5000	0.01	0.01	0.01	0.01	0.01
Porzyme	0.02	0.02	0.02	0.02	0.02
Tallow	3.7	3.9	3.8	4.4	3.4
Salt	0.2	0.2	0.2	0.2	0.2
Limestone	1.47	1.83	1.76	0.37	1.33
Synthetic lysine (L-lysine HCl)	0.44	0.38	0.48	0.29	0.44
Synthetic Dl-methionine	0.03	0.02	0.01	0.02	0.05
Synthetic threonine	0.17	0.14	0.16	0.14	0.16
Synthetic isoleucine			0.06	0.03	0.05
Copper Proteinate	0.1	0.1	0.1	0.1	0.1
Rivalea finisher premix	0.07	0.07	0.07	0.07	0.07
Rumensin	0.08	0.08	0.08	0.08	0.08
Betaine	0.1	0.1	0.1	0.1	0.1
Ractopamine					
*Estimated nutrient composition, %**					
DE, MJ/kg	14.0	14.0	14.0	14.0	14.0
Crude protein	17.0	17.6	16.8	18.6	17.8
Crude fibre	3.9	3.9	4.4	4.1	3.7
Crude fat	5.5	5.3	5.4	6.5	5.6
Total Lysine	0.97	0.98	0.97	1.0	0.98
Available lysine	0.84	0.84	0.84	0.84	0.84
Available lysine: DE (g/MJ)	0.60	0.60	0.60	0.60	0.60
Ractopamine (ppm)**	<0.1	<0.1	<0.1	<0.1	0.3

* Nutrient value based upon Rivalea Australia Pty Ltd proprietary composition data

** Analysed by AsureQuality based on Eli Lilly method BO4372

Table 2. Ingredient profile and nutrient composition of the experimental diets containing Ractopamine, % of diet (as fed)

	RAC Soybean meal	RAC Canola meal	RAC Peas	RAC Lupins
Ingredient, %				
Wheat	42.8	57.3	35.2	43.9
Barley	25.0	13.7	25.0	22.3
Mill mix	13.2	10.0	14.2	13.0
Lupins				10.0
Soybean meal	10.0			
Canola		10.2		
Peas			10.0	
Meatmeal	1.2	1.0	8.9	3.9
Water	1.0	1.0	1.0	1.0
Natuphos 5000	0.01	0.01	0.01	0.01
Porzyme	0.02	0.02	0.02	0.02
Tallow	3.9	3.8	4.4	3.4
Salt	0.2	0.2	0.2	0.2
Limestone	1.83	1.76	0.37	1.33
Lysine HCL	0.38	0.48	0.29	0.44
Dl-methionine	0.02	0.01	0.02	0.05
Threonine	0.14	0.16	0.14	0.16
Isoleucine		0.06	0.03	0.05
Copper Proteinate	0.1	0.1	0.1	0.1
Rivalea finisher premix	0.07	0.07	0.07	0.07
Rumensin	0.08	0.08	0.08	0.08
Betaine	0.1	0.1	0.1	0.1
Paylean™	0.025	0.025	0.025	0.025
*Estimated nutrient composition, %**				
DE, MJ/kg	14.0	14.0	14.0	14.0
Crude protein	17.6	16.8	18.6	17.8
Crude fibre	3.9	4.4	4.1	3.7
Crude fat	5.3	5.4	6.5	5.6
Total Lysine	0.98	0.97	1.0	0.98
Available lysine	0.84	0.84	0.84	0.84
Available lysine: DE (g/MJ)	0.60	0.60	0.60	0.60
Ractopamine (ppm)**	4.7	5.9	4.5	4.9

* Nutrient value based upon Rivalea Australia Pty Ltd proprietary composition data
** Analysed by AsureQuality based on Eli Lilly method BO4372

3. Outcomes

Growth performance

The influence of dietary vegetable protein source on the performance response of finisher pigs to RAC is displayed in Table 3. There were no significant interactions between RAC inclusion and dietary vegetable protein source on any of the performance parameters measured, nor were there any main effects of dietary vegetable protein source on growth rate, feed intake or feed efficiency over the test period. During the initial 14 day feeding period, there were no main effects of RAC supplementation on growth performance (995 and 1030 g/d respectively for the control and RAC diets, P=0.21) or feed intake (2.40 and 2.40 respectively, P=0.98), while feed efficiency tended to be improved with RAC supplementation (FCR 2.63 and 2.48 g/g respectively, P=0.10).

Growth performance over the entire 21 day feeding period was improved with the inclusion of RAC in the diets (ROG 1.05 and 1.09 kg/d respectively for the control and RAC treatments, P=0.046). The magnitude of the growth rate improvement with RAC supplementation was greatest in the pigs offered the soybean meal diets (8.7 %), with pigs offered RAC diets containing the other vegetable protein sources increasing their rate of gain by between 0.9 and 3.8 %. Final live weight was slightly heavier in the pigs offered the RAC diets although not significant (87.9 and 88.7 kg respectively for the control and RAC treatments, P=0.31). Dietary protein source did not influence live weight at the end of the test period (canola 88.4 kg, lupins 87.9 kg, peas 88.3 kg and soybean meal 88.4 kg, P=0.96). There was no influence of RAC on the change in P2 back fat depth over the 21 day test period (1.06 and 1.16 mm respectively for the control and RAC treatments, P=0.34), however leg fat depth increased with RAC (change in leg fat depth 1.57mm and 2.00mm for the control and RAC treatments respectively, P=0.003). Vegetable protein source did influence the change in P2 back fat depth over the test period (Soybean 1.14mm, Canola 0.96mm, peas 1.38mm and lupins 0.96mm, P=0.019) and the change in leg fat depth (Soybean 1.70mm, Canola 1.92mm, Peas 2.09mm and lupins 1.45mm, P=0.012), although the magnitude of the change was small across all treatment groups. There was no influence of dietary RAC inclusion on carcass characteristics, nor were there any impacts of dietary vegetable protein source on carcass weight or P2 (Table 3).

There was a significant influence of replicate on all performance parameters measured in this study. Pigs selected in the first replicate began the experimental period late January, and as such were subjected to the high summer temperatures typical of southern New South Wales at this time of year (19 days with maximum temperatures above 30^{o}C during the test period). In comparison, the second replicate had five days in which the maximum daily temperature during the test period was greater than 30^{o}C, while there were no hot days during the test period for the third replicate of pigs. Average daily feed intakes of pigs selected in this first replicate were lower than those of the second and third replicate (ADI 0-21 days; 2.21, 2.52 and 2.62 kg/d respectively for replicates one, two and three, P<0.001, sed 0.039). As such, the average available lysine intake per pig per day was 18.6, 21.2 and 22.0 g/d respectively for replicates one, two and three based on average daily feed intakes and the diets containing 8.4 g available lysine per kg diet. It is possible that at these lower feed intakes, lysine and or RAC consumption was not sufficient to enable the standard response to RAC to be obtained (Rikard-Bell, personal communication). Further data analysis was therefore undertaken using the performance data from replicates two and three only (Table 4). The growth rate and feed efficiency response to RAC inclusion was more pronounced over the entire 21 day experimental period with the exclusion of replicate one (ROG 0-21 days: 1.118 and 1.173 kg/d respectively for the control and RAC treatments groups, P=0.030, sed 0.025; FCR 0-21 days: 2.34 and 2.25 respectively, P=0.112, sed 0.058). As with the original data set, there was no significant impact of dietary vegetable protein source on any of the performance or carcass measures.

Table 3. Effect of dietary vegetable protein source on the response to Ractopamine (Paylean) over the entire study (n=39 per treatment).

	Soybean meal		Canola meal		Peas		Lupins			Significance		
	Control	RAC	Control	RAC	Control	RAC	Control	RAC	SED	RAC	Vegetable Protein	RAC x Vegetable Protein
Day 0-14												
Rate of gain (kg/d)	0.99	1.10	1.00	1.03	0.97	1.00	1.03	1.00	0.057	0.21	0.56	0.34
Feed intake (kg/d)	2.37	2.49	2.39	2.44	2.42	2.36	2.40	2.29	0.077	0.98	0.37	0.16
FCR	2.58	2.35	2.67	2.55	2.71	2.56	2.57	2.46	0.183	0.10	0.54	0.97
Day 0-21												
Rate of gain (kg/d)	1.03	1.12	1.05	1.09	1.07	1.08	1.06	1.09	0.041	0.046	0.99	0.63
Feed intake (kg/d)	2.42	2.52	2.43	2.50	2.46	2.45	2.46	2.38	0.064	0.48	0.74	0.18
FCR	2.43	2.31	2.34	2.39	2.37	2.41	2.41	2.26	0.121	0.48	0.92	0.54
Δ P2 day 0-21 (mm)	1.03	1.25	0.95	0.97	1.31	1.46	0.95	0.97	0.218	0.34	0.019	0.89
Δ leg fat day 0-21 (mm)	1.35	2.04	1.55	2.28	1.96	2.22	1.41	1.49	0.287	0.003	0.012	0.30
Carcass characteristics												
Carcass weight (kg)	64.7	65.7	65.1	66.0	64.8	65.7	64.5	64.8	1.19	0.20	0.77	0.96
Dressing %	74.0	73.6	74.0	74.5	73.5	74.3	73.3	73.6	0.43	0.22	0.085	0.22
Carcass P2 (mm)	8.5	8.3	8.2	8.4	8.3	8.5	8.0	7.9	0.37	0.87	0.24	0.89

Table 4. Effect of dietary vegetable protein source on the response to Ractopamine (Paylean) over the entire study (Replicates two and three only, n=26 per treatment).

	Soybean meal		Canola meal		Peas		Lupins			Significance		
	Control	RAC	Control	RAC	Control	RAC	Control	RAC	SED	RAC	Vegetable Protein	RAC x Vegetable Protein
Day 0-14												
Rate of gain (kg/d)	1.10	1.19	1.10	1.14	1.08	1.09	1.12	1.10	0.069	0.40	0.72	0.73
Feed intake (kg/d)	2.48	2.63	2.51	2.57	2.52	2.45	2.58	2.40	0.103	0.83	0.71	0.11
FCR	2.37	2.29	2.35	2.31	2.54	2.37	2.52	2.27	0.205	0.20	0.80	0.89
Day 0-21												
Rate of gain (kg/d)	1.13	1.20	1.08	1.16	1.13	1.17	1.13	1.16	0.050	0.030	0.64	0.88
Feed intake (kg/d)	2.54	2.51	2.53	2.60	2.55	2.57	2.64	2.50	0.076	0.88	0.99	0.15
FCR	2.28	2.22	2.36	2.33	2.32	2.22	2.39	2.22	0.116	0.11	0.66	0.84
Carcass characteristics												
Carcass weight (kg)	66.3	67.5	66.4	67.4	65.9	67.2	66.0	65.9	1.56	0.27	0.81	0.92
Dressing %	73.6	73.2	73.7	73.7	72.6	73.4	72.9	73.0	0.55	0.66	0.14	0.54
Carcass P2 (mm)	9.0	8.6	8.8	8.8	8.6	8.8	8.5	8.4	0.56	0.82	0.78	0.92

4. Application of Research

The results from this study do not support the hypothesis that dietary vegetable protein source influences the response of finisher pigs to Ractopamine supplementation. While there were no significant differences in the performance results across the dietary protein sources, the magnitude of the improvement in growth rate with Ractopamine was greatest when pigs were offered the soybean meal diets. In comparison, the greatest improvement in feed efficiency with Ractopamine supplementation over the entire test period was observed when pigs were offered the lupin based diet, followed by the soybean meal diet. It is likely that variation in ingredient quality and nutritional composition across batches has a much greater influence on the performance response to Ractopamine than the dietary protein source per se.

The reduced feed intakes during the summer period in this study are in line with numerous other experiments conducted with finisher pigs in this facility. The reduced response to Ractopamine supplementation during this time is a concern and further investigation may be warranted to determine how producers can consistently achieve performance improvements with Ractopamine during the summer period. Similar feed intakes were achieved during the summer replicate of another recent Pork CRC study investigating the lysine requirement of boars and gilts offered Paylean supplemented diets. In this study the results from the summer replicate were excluded from the data analyses due to the reduced lysine and Ractopamine consumption and the resulting lower than anticipated growth rates (Rikard-Bell, personal communication).

The small increase in leg fat depth with RAC supplementation in this study was not anticipated and has not be observed in other studies using finisher pigs in this facility. The increase in leg fat depth was however small, and given that there was no significant increase in P2 back fat depth over the test period nor was there any impact on carcass P2, the change in leg fat depth is of little commercial relevance.

5. Conclusion

The results from this study do not support suggestions that dietary vegetable protein source influences the response of finisher pigs to Ractopamine. As such, there is no evidence to suggest that the use of canola meal as the sole vegetable protein source in nutritionally adequate diets will limit the response of finisher pigs to Ractopamine.

6. Limitations/Risks

The results from this study have been obtained using a single batch of each of the vegetable protein sources. The quality of specific vegetable protein sources can vary within and across regions due to a number a factors including variety, climatic conditions, post harvest storage and processing conditions. Nutritionists should assess the vegetable protein sources that they have available on a case by case basis and adjust diets accordingly based on quality and nutritional composition.

7. Recommendations

The outcomes from this study suggest that dietary vegetable protein source does not influence the growth and efficiency response to dietary RAC inclusion during the finisher period. Further studies to determine the maximum inclusion rates of individual protein sources in diets containing Ractopamine do not appear warranted.

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