# The use of ractopamine by the Australian pig industry to improve feed efficiency and lean meat production

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## Summary

Studies on the use of ractopamine as a commercial feed additive in the Australian pig industry confirm previous findings that it has the potential to improve feed efficiency and lean meat production from finishing pigs. It appears that the response to ractopamine is greater in heavier finishing pigs and it is likely that the castrate and female pigs destined for boning rooms and/or export markets are well suited to its use. Commercial implications that need to be considered before adopting its use in finishing pig diets are discussed.

**Keywords:** pigs, ractopamine, feed efficiency, leanness

## Introduction

Ractopamine as a commercial feed additive is now used in the USA and will be available to Australian pig producers in 2003. It has the potential to significantly improve feed efficiency and leanness in finishing pigs, particularly those destined for boning rooms for domestic and export markets. Production systems in the USA favour heavy castrate (barrows) and female pigs that are sold based on carcass lean indices, but in Australia most farmers produce entire males and females and these are generally sold at lighter weights. Over the last 15 years there have been many experiments and reviews by Australian and overseas scientists on the effects, efficacy and mechanisms by which ractopamine acts on tissue growth and pig performance. This paper describes how we see the potential for ractopamine in the Australian pig industry.

## Background

Ractopamine hydrochlorine (RAC) is a β–1 agonist that binds to beta–adrenergic receptor sites on muscle and adipocyte membranes (Watkins *et al.* 1990). This in turn significantly increases muscle accretion and produces small reductions in fat deposition. Ractopamine is reported to activate adenosine monophosphate (cAMP), influencing many aspects of cellular metabolism, including the increase in protein synthesis and decrease in protein degradation (Mersmann 1998; Mills 2001). Dunshea and King (1995) found adipose tissue receptors desensitise rapidly in the presence of RAC compared to other tissue, which may explain why ractopamine only has slight effects on fat deposition. The raising of cAMP levels by RAC is not the only mode of action that increases lean growth by 30 to 34%, and reports suggest that other intracellular pathways are involved (Mills 2001).

The response to ractopamine changes with the duration of feeding. Most studies have found the response peaks in the first 14 days, or 12 to 15 kg liveweight gain, and then declines (Dunshea *et al.* 1993b; Williams *et al.* 1994; Bark *et al.* 1992; Schinckel *et al.* 2001b). Only increasing the dietary level has resulted in further improvements in growth after 30 to 40 days (Schinckel *et al.* 2001b). Results from over 20 studies in North America have shown ractopamine improves daily gain from 9 to 12%, feed efficiency by approximately 15% and decreases feed intake by 5 to 6% (Schinckel *et al.* 2001a).

The optimum dietary level of ractopamine varies depending on the liveweight, sex, market destination and the duration of feeding. Schinckel *et al.* (2001a) reviewed commercial uses in the U.S. and concluded that the majority of the growth rate improvement is achieved with an inclusion level of 5 ppm RAC. Further improvements have been shown to be gained in feed efficiency, carcass fat, dressing percentage, carcass weight and lean at RAC levels of 10 to 20 ppm, especially in heavier pigs (Herr *et al.* 2001). Dunshea and Gannon (1995) concluded from their review that the response in growth performance and carcass fatness is much less in entire boars compared to females and castrates. From a meat quality view, studies so far have shown ractopamine to have little impact on pork quality including colour, marbling, firmness, and ultimate pH (McKeith and Ellis 2001).

Dunshea and King (2001) and Weldon and Armstrong (2001) reported that the pig's requirement for essential amino acids increases by approximately 30% when offered RAC supplemented diets, and current estimates of available lysine levels range between 0.80 and 1.00% or 0.60 to 0.70 g/MJ DE for females and castrated males when energy intakes were restricted.

## Commercial application of ractopamine in the USA

The USA Food and Drug Authority registered a ractopamine commercial feed additive in December 1999 for use. Although much of the research investigating RAC was conducted well before (see Dunshea and Gannon 1995; Dunshea and Walton 1995), the most economical commercial applications have only recently become available. In the USA the rate of dietary inclusion largely depends on market payment contracts for increased carcass lean yields. The rate also depends on the duration of feeding, as the muscle receptors desensitize after 14 to 18 days (Dunshea and Gannon 1995). After 35 to 42 days on a constant rate of ractopamine, pig growth performance declines and carcasses become fatter (Williams *et al.* 1994; Schinckel *et al.* 2001b). Step–up programs, where the level of ractopamine is increased every two to three weeks, was recommended by Purdue University (Herr *et al*. 2001) and appears to be the most cost–effective strategy. The most common feeding duration in the USA is over a 28 to 35 d period as a step–up program. These programs are still being assessed experimentally and economically; initial findings question the cost–effectiveness and practicability of these strategies.

## Studies on ractopamine at QAF meats

We have conducted three studies on ractopamine, using the commercial feed additive Paylean® (Elanco Animal Health, MacQuarie Park NSW 2113) on a temporary registration permit from the National Registration Authority. The first study was conducted to provide data for the Australian registration of the additive. Because it was a registration trial, a high inclusion level was used (1 kg /tonne, supplying 20 ppm ractopamine) over the maximum number of days that it would be used (6 weeks).

One hundred and thirty two finishing pigs were used in the experiment conducted at the Research and Development Unit at QAF Meat Industries, Corowa, in commercial housing conditions. In a 2 x 3 factorial design, entire males, females and castrates were offered either a Control Grower Phase 4 diet (14 MJ DE/kg; 0.58 g available lysine/MJ DE) containing no ractopamine or the same specification including 1 kg additive/tonne (20 ppm ractopamine). Diets were offered *ad libitum* through electronic feeders from 18 weeks of age for 6 weeks duration. Each pen contained 22 pigs of single sex (0.65 $m^2$/pig) and dietary treatment. At 18 weeks of age, pigs were individually weighed and back fat P2 was recorded using a real–time ultrasound. Animals were allocated within sex according to liveweight and P2 to create two groups within each sex. Individual carcasses were followed through the abattoir and boning room for carcass performance and lean meat yield measurement. The four primal cuts of hind leg, foreleg, and loin and belly were

**Table 1** The overall growth performance (ADG), carcass and boned yield performance of finishing pigs offered a diet either supplemented with 20 ppm ractopamine per tonne or an unsupplemented Control for 42 days (Smits *et al.* unpublished).

| | Control | Ractopamine | *P* value | Significance |
|---|---|---|---|---|
| ADG (kg/d) | 0.732 | 0.726 | 0.802 | NS |
| ADI (kg/d) | 2.14 | 1.98 | 0.003 | ** |
| FCR (feed:weight gain) | 2.97 | 2.74 | 0.001 | ** |
| Final liveweight (kg) | 101.9 | 101.9 | 0.991 | NS |
| Carcass wt (kg) | 80.8 | 82.4 | 0.226 | NS |
| Dressing yield (%) | 79.4 | 80.9 | 0.000 | *** |
| P2 (mm) | 11.1 | 10.7 | 0.478 | NS |
| Legfat (mm) | 15.2 | 14.8 | 0.579 | NS |
| Cold carcass wt (kg) | 69.8 | 70.9 | 0.326 | NS |
| Lean yield (%) | 59.3 | 61.2 | 0.002 | ** |
| Colour | 49.5 | 49.7 | 0.601 | NS |
| pH | 5.41 | 5.50 | 0.000 | *** |
| Drip loss (%) | 1.72 | 1.56 | 0.422 | NS |

Significance of main effect differences and interaction mean values: *$P$<0.05; **$P$<0.01; ***$P$<0.001; NS not significant weighed before and after boning and rind removal and subcutaneous fat trimming as part of the boning room operation. In this experiment, all the muscles from each primal were weighed. The overall growth and carcass performance for finishing pigs over a 6 week feeding period is summarised in Table 1.

These results showed that feed efficiency and carcass leanness were significantly improved by the addition of 20 ppm ractopamine, however carcass weight and carcass P2 were not improved (Table 1). It was estimated that an extra 2 kg of lean meat was produced per carcass by the supplementation, which is a substantial reward when selling boned out, fat trimmed pork.

The ractopamine x sex comparisons are summarised in Table 2. The inclusion of RAC improved the feed efficiency of females and castrates by 8% and 16% respectively. The improvement in lean meat weight for the castrates was 6% higher than the controls, due to a combination of carcass leanness (as lean yield %) and a heavier carcass weight. Most of the benefits of using RAC were in a heavier, leaner hind leg and, to a less extent, the loin of females and castrates (Table 3). Unfortunately the belly, which is the hardest portion to trim as it has multiple fat layers between muscle, did not exhibit higher yields as a result of supplementation, but actual weight of the belly portion tended to be heavier from RAC compared to control carcasses. The amount of pork cut from the hind leg was the portion most increased, however it is not a preferred cut for the Japanese market.

The registration study gave some important information on the potential use of RAC for the Australian pig industry. Its use did not significantly reduce fatness at the P2 site, though it did increase carcass weight and lean yield, especially in the castrates and females where it is most likely to be used. The length of feeding is likely to have had an adverse effect on the efficacy of RAC. Dunshea *et al.* (1993a) reported that the growth response of pigs from 60–90 kg was most apparent in the first 3 weeks then diminished with time. The decrease in responsiveness over time has been reported in other studies (Wallace *et al.* 1987; Williams *et al.* 1994) and it is generally accepted that it is due to the down–regulation of receptor sites.

The next two experiments investigated the responsiveness of female finishing pigs to a step–up strategy (Herr *et al.* 2001) over a recommended feeding period of 28 days. Ractopamine concentration was either kept constant at 12 ppm, or increased every 2 weeks (5, 10, 20 ppm), or stepped–down every two weeks (20, 10, 5 ppm). These three programs were compared to an unsupplemented control. The Purdue results over the initial 28 day period showed that a step–up program gave the highest and most efficient growth response (Table 4).

We evaluated the potential of a step–up strategy over 4 weeks in female finishing pigs reaching either a market weight suitable for Singapore and the Australian bacon market (70–80 kg hot carcass weight) or the Japanese or boning room market (90–100 kg hot carcass weight).

Two hundred and forty females were used in the experiments. Pigs were housed in groups of 20 in partially slatted floor pens fitted with two electronic feeders per pen. Each pen was allocated to one of three treatments: an RAC step–up strategy, a constant amount, or an unsupplemented commercial finisher diet. The first experiment evaluated pigs over 28 days commencing at 70 kg liveweight. The levels of RAC used in Experiment 1 were 5 ppm /tonne as the constant treatment for 28 days or 5 ppm for the 0–14 day period then increased to 10 ppm/tonne for the 14–28 days period. Experiment 2 evaluated pigs commencing with

**Table 2** The growth (ADG) and carcass performance of entire males, female and castrated finishing pigs offered a diet either supplemented with 20 ppm ractopamine/tonne (RAC) or an unsupplemented Control for 42 days (Smits *et al.* unpublished).

| | Males | | Females | | Castrates | | Significance | | |
|---|---|---|---|---|---|---|---|---|---|
| | Control | RAC | Control | RAC | Control | RAC | Sex | Treat | S x T |
| W at start ( kg) | 75.3 | 74.8 | 69.7 | 70.3 | 68.8 | 70.1 ** | NS | NS | |
| ADG (kg/d) | 0.730 | 0.766 | 0.757 | 0.706 | 0.720 | 0.717 | NS | NS | NS |
| ADI (kg/d) | 1.91 | 2.12 | 2.21 | 1.92 | 2.29 | 1.93 | NS | ** | *** |
| FCR (feed:gain) | 2.69 | 2.81 | 2.94 | 2.73 | 3.21 | 2.71 | * | ** | ** |
| W 42 d (kg) | 106.0 | 107.0 | 101.5 | 99.9 | 99.0 | 100.2 | ** | NS | NS |
| Carcass wt (kg) | 83.9 | 84.5 | 81.9 | 82.6 | 77.4 | 79.4 | * | NS | NS |
| P2 (mm) | 9.9 | 9.5 | 11.0 | 10.2 | 12.3 | 12.2 | ** | NS | NS |
| Leg fat (mm) | 12.0 | 12.5 | 16.3 | 13.9 | 16.9 | 17.4 | *** | NS | NS |
| Lean yield (%) | 59.2 | 61.3 | 59.6 | 62.8 | 59.1 | 60.7 | NS | *** | NS |
| Lean wt (kg) (half carcass) | 21.1 | 21.2 | 20.8 | 20.9 | 19.1 | 20.2 | ** | NS | NS |

Significance of main effect differences and interaction mean values: *$P$<0.05; **$P$<0.01; ***$P$<0.001; NS not significant

**Table 3** The boned yield (%) of the half carcass and meat quality of entire males, female and castrated finishing pigs offered a diet either supplemented with 20 ppm ractopamine/tonne (RAC) or an unsupplemented Control (Ctl) for 42 days (Smits *et al.* unpublished).

| | Males | | Females | | Castrates | | Significance | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ctl | RAC | Ctl | RAC | Ctl | RAC | Sex | Treat | S x T |
| Hindleg yield (%) | 59.3 | 58.8 | 55.4 | 58.0 | 53.3 | 55.6 | *** | * | NS |
| Hindleg wt (kg) | 7.0 | 6.9 | 6.3 | 6.7 | 5.7 | 6.3 | *** | * | NS |
| Foreleg yield (%) | 63.6 | 64.6 | 65.8 | 66.4 | 66.2 | 65.9 | * | NS | NS |
| Foreleg wt (kg) | 7.2 | 7.4 | 7.2 | 7.1 | 6.8 | 6.9 | *** | NS | NS |
| Belly yield (%) | 64.4 | 65.5 | 70.5 | 69.0 | 69.5 | 68.4 | *** | NS | NS |
| Belly wt (kg) | 3.4 | 3.5 | 3.7 | 3.8 | 3.5 | 3.7 | * | NS | NS |
| Loin yield (%) | 69.2 | 67.1 | 66.9 | 67.8 | 62.4 | 64.0 | *** | NS | NS |
| Loin wt (kg) | 3.5 | 3.3 | 3.5 | 3.3 | 3.0 | 3.1 | *** | NS | NS |

Significance of main effect differences and interaction mean values: *$P$<0.05; **$P$<0.01; ***$P$<0.001; NS not significant

**Table 4** Effect of differing ractopamine inclusion rates on fortnightly growth rate (ADG), feed intake (AFI), and feed efficiency (FCR) in late finishing pigs (from Herr *et al.* 2001).

| | Control | Step–down | Step–up | Constant |
|---|---|---|---|---|
| Initial weight | 72.1 | 71.9 | 72.2 | 72.1 |
| *Period 1 (days 0–14)* | | | | |
| ADG (kg/d) | $1.027^{a}$ | $1.273^{b}$ | $1.227^{b}$ | $1.286^{b}$ |
| AFI (kg/d) | $2.80^{a}$ | $2.74^{a}$ | $2.71^{a}$ | $2.76^{a}$ |
| FCR (feed:gain) | $2.78^{a}$ | $2.16^{b}$ | $2.23^{b}$ | $2.15^{b}$ |
| *Period 2 (days 14–28)* | | | | |
| ADG (kg/d) | $0.914^{a}$ | $0.968^{ab}$ | $1.073^{c}$ | $1.018^{bc}$ |
| AFI (kg/d) | $3.00^{a}$ | $2.83^{b}$ | $2.75^{b}$ | $2.88^{ab}$ |
| FCR (feed:gain) | $3.29^{a}$ | $2.94^{b}$ | $2.56^{c}$ | $2.84^{b}$ |

$^{abc}$Means in a row with different superscript differ ($P$<0.05)

a start weight of 90 kg liveweight. The RAC levels in Experiment 2 were 10 ppm/tonne for the constant treatment for 28 days, or 10 ppm/tonne for the 0–14 day period increased to 20 ppm/tonne for the step–up strategy. Both experiments were conducted over 28 days and diets were offered *ad libitum*. The pigs on the Control treatment were fed a commercial finisher diet containing 13.7 MJ DE/kg, 135 g crude protein/kg and 7.5 g lysine/kg. Animals allocated to the RAC treatments in both experiments were offered a base diet containing per kg 14.0 MJ DE, 175 g crude protein and 10 g lysine.

The growth results are summarised in Table 5. The growth performance overall was down from expectations due to the severity of the summer, however we still recorded a significant improvement in daily gain and a reduction in FCR when either constant or step–up strategy was used. The effectiveness of the step–up strategy was more pronounced in the heavier finishing pigs. The step–up strategy produced a slightly better growth response and a significantly lower FCR value in heavy females in Experiment 2. Although the two experiments were not conducted as a factorial design, it appears likely that the improved performance using the step–up strategy is more effective in the heavier finishing pig.

Despite the increase in liveweight gain, the carcass weight and carcass backfat measured at the P2 site was not significantly improved by using RAC either constantly or as a step–up program in either light or heavy female finishing pigs (Table 6). In the lighter finishing pigs, the advantage of liveweight gain was not realised as carcass weight because there was a tendency for a lower dressing percentage. Whether this was a true reflection of the treatment or a non–treatment related factor is unknown. In the Purdue commercial studies studies, dressing percentage generally increased by 1.5% with RAC, and it also increased in our temporary registration permit study (Table 1). A dressing percentage was only available on half the pigs within each treatment in Experiment 2 due to a kill over 2 days, and there was no evidence of a treatment effect on dressing percentage on these animals (79.3%, 79.9% and 80.1% for Control, RAC Constant and RAC Step–up, respectively).

The lack of a reduction in backfat may have been due to the genetic leanness of these animals. In the

**Table 5** Growth performance over 28 days in female finishing pigs when fed either an unsupplemented commercial finisher diet (Control), or with ractopamine (RAC) added at a constant level or as a step–up strategy (Smits *et al.* unpublished).

| | Daily gain (kg/d) | | Feed intake (kg/d) | | FCR (feed:gain) | |
|---|---|---|---|---|---|---|
| **Starting W (kg)** | **70** | **90** | **70** | **90** | **70** | **90** |
| Control | 0.689$^{a}$ | 0.741$^{a}$ | 1.81 | 2.25$^{a}$ | 2.68$^{a}$ | 3.12$^{a}$ |
| RAC constant | 0.767$^{b}$ | 0.815$^{ab}$ | 1.84 | 2.00$^{b}$ | 2.46$^{b}$ | 2.50$^{b}$ |
| RAC step–up | 0.781$^{b}$ | 0.841$^{b}$ | 1.82 | 1.62$^{c}$ | 2.39$^{b}$ | 1.99$^{c}$ |
| SED | 0.013 | 0.016 | 0.03 | 0.05 | 0.05 | 0.07 |
| *P* value | 0.012 | 0.027 | 0.898 | 0.001 | 0.030 | 0.001 |

$^{abc}$Mean values with different superscripts within columns differ significantly ($P$<0.05)

**Table 6** The effect of using RAC over a 28 day period at either a constant level or as a step–up strategy on carcass weight and backfat P2 in light and heavy female finishing pigs (Smits *et al.* unpublished).

| | Final liveweight (kg) | | Carcass weight (kg) | | Carcass P2 (mm) | |
|---|---|---|---|---|---|---|
| **Starting W (kg)** | **70** | **90** | **70** | **90** | **70** | **90** |
| Control (no RAC) | 87.4$^{a}$ | 111.1$^{a}$ | 68.9 | 88.8 | 8.5 | 10.3 |
| RAC constant | 89.8$^{b}$ | 113.2$^{ab}$ | 70.2 | 91.0 | 8.2 | 9.8 |
| RAC step–up | 90.0$^{b}$ | 114.0$^{b}$ | 70.2 | 90.4 | 8.6 | 9.9 |
| SED | 0.8 | 0.9 | 0.7 | 0.7 | 0.2 | 0.2 |
| *P* value | 0.014 | 0.023 | 0.158 | 0.110 | 0.570 | 0.323 |

$^{abc}$Mean values with different superscripts within columns differ significantly ($P$<0.05)

heavier females, there was some evidence of a lower P2 due to the RAC treatments compared to the controls when adjusted for carcass weight ($P$ = 0.174). The magnitude of any effect on carcass P2 measurements may be small as supported by previous studies. There was little evidence of any 'tightening' of the range of P2 either, with a coefficient of variation of approximately 22% in the RAC treatments in both experiments and 21% for the Controls. Numbers may have been too small to make a clearer conclusion. There is no doubt that RAC is effective in increasing lean tissue growth, as was evident from the results of the carcasses processed in the boning room (Table 7). When used on heavy female finishing pigs, the step–up strategy tended to produce a greater quantity of trimmed lean meat from the loin and the collarbutt, a portion derived from the foreleg. The heavy carcasses from Experiment 2 were processed through the boning room and trimmed according to a Japanese specification order for one of QAF Meats customers. The trim yields of the foreleg and belly were lower than those recorded in the registration study (Table 4) across treatments due to a different trim specification.

As in the registration experiment, we recorded a significant increase in lean yield content and lean meat cut from the hind leg (Table 7). In Experiment 2 we also recorded a significant effect of RAC on lean meat yield from the loin. This may have been due to the carcass being heavier than those put through the boning room in the registration study and could indicate that the effectiveness of RAC in increasing lean yield is more likely to occur in the heavier export–weight carcasses for females and castrates. We recorded a significant increase in the amount of lean meat produced from the hind leg, as collarbutt and as loin, but as for the registration experiment there was not a significant increase in trimmed belly weight portion. Using digital imaging analysis, the proportion of subcutaneous fat in the belly averaged 36% in the Controls and 32% and 33% in the Constant and Step–up treatments, respectively. However the intermuscular fatness (between the muscle layers) was considerably less in both the RAC treatments (8.6%) compared to the Controls (11.7%). By the use of the digital image assessment, we concluded that bellies from pigs offered supplemented diets are likely to have a leaner visual appearance compared to pigs offered a control diet. This is an important marketing trait.

## Summary of outcomes from experimental results

The results conducted at QAF Meats showed that the inclusion of RAC in diets offered to finisher pigs of a modern lean genotype significantly improved feed efficiency by 15% and increased leanness in the carcass by 5%. The effects on carcass weight were not significant but the positive trends were consistent in all three studies; the order of carcass weight gain was approximately + 1.5–2.0 kg hot standard carcass weight. The response to RAC in terms of feed efficiency and carcass weight gain was greater when used in heavy finishers. The response is also likely to be more effective in females and castrates where protein deposition potential is lower compared to entire males. Although we have not conducted an experiment using 5 ppm RAC or a step–up strategy of 10–20 ppm RAC in castrates, we are confident that the benefits of supplementation may be even more apparent than recorded for females given other published results (Dunshea *et al.* 1993b; Williams *et al.* 1994).

We did not record a significant reduction in carcass P2 in our experiments. Schinckel *et al.* (2003) reported that offering castrates a step–up series of diets significantly reduced last rib backfat from 15.4 mm in unsupplemented controls to 12.7 mm in heavy carcasses (96 kg and 89 kg respectively). Herr *et al.* (2001, 2000) also reported that the addition of RAC to diets fed to late–finishing pigs significantly reduced 10$^{th}$ rib backfat thickness by 15–20%. These studies were conducted on very fat pigs, where the controls were 17–20 mm at 113 kg carcass weights. The lack of a significant and substantial reduction in backfat P2 in our studies may indicate that unless the control carcasses are fat (i.e. >14 mm) a reduction in fatness as measured at the P2 site could be small. Ractopamine works by increasing protein gain in muscle, rather than a reduction in fat deposition. For this reason, the greatest gains will be realised when the carcass are fully boned out and trimmed, rather than from a carcass weight and P2 selling matrix.

The results support those of Herr *et al.* (2001) that step–up feeding of ractopamine increases its efficacy. As with other authors (Dunshea and Gannon 1995; Schinckel *et al.* 2001b), we conclude that optimising the ractopamine response will depend on dose rate, age/ liveweight of the animal and duration of feeding. A greater response to ractopamine may be limited if down–regulation of the stimuli due to de–sensitisation of receptor sites cannot be overcome. There are commercial considerations, such as feed management in silos and selling strategies where pigs are sold at different ages, that may also restrict the ability to optimise the efficacy of ractopamine by adjusting diet concentrations and feeding durations.

## Commercial implications for the adoption of ractopamine feed additive

The studies conducted at QAF Meats have confirmed that the use of RAC in finishing pigs results in an improved feed efficiency and a better boning yield particularly from the hind leg and loin. However there is less evidence that its use will lead to a heavier carcass weight and a carcass with a lower P2 compared to un–supplemented controls. Fine–tuning the addition in commercial piggeries will be needed to maximise returns. The studies have indicated that the adoption of a step–up strategy is likely to produce a better response to RAC in finishing pigs destined for the heavy carcass export market, but feeding a diet with a constant 5 ppm per tonne for the lighter Singapore and domestic market will be simpler to manage and equally as effective in improving feed efficiency and growth. These outcomes will be dependant on the sex and genotype of the pig. One of the major costs associated with the use of RAC is the level of dietary protein and energy required to maximise the efficacy of treatment. On current recommendations of 0.60–0.70 g available lysine/MJ DE, the base diet cost excluding the cost of RAC is currently $30–$40/tonne more expensive than the normal finishing pigs or pre–sale diet fed during the last 4 weeks of growth. This year, feed prices are at record high levels and any adoption of RAC has to be very carefully considered as to the net return. Herr *et al.* (2000) reported that a phase–feeding program whereby dietary protein is reduced according to the animal's lean deposition curve improved net return. In Australia, the ability to fine–tune dietary protein levels

**Table 7** The effect of feeding a constant 10 ppm ractopamine and a 10–20 ppm step–up program on mean lean yield of loin, ham, shoulder and belly for a Japan customer specification (Smits *et al.* unpublished).

| | Control | RAC Constant 10 ppm | RAC Step–up 10–20 ppm | SED | *P* value |
|---|---|---|---|---|---|
| Hindleg yield (%) | 50.3$^a$ | 53.1$^b$ | 52.8$^b$ | 0.3 | 0.001 |
| Hindleg wt (kg) | 6.23$^a$ | 6.64$^b$ | 6.79$^b$ | 0.06 | 0.001 |
| Foreleg yield (%) | 16.7 | 20.1 | 17.8 | 0.9 | 0.323 |
| Collarbutt wt (kg) | 1.87$^a$ | 1.95$^{ab}$ | 2.05$^b$ | 0.02 | 0.005 |
| Belly yield (%) | 57.2 | 58.2 | 57.8 | 0.3 | 0.364 |
| Belly wt (kg) | 3.17 | 3.19 | 3.33 | 0.04 | 0.163 |
| Loin yield (%) | 63.8$^a$ | 65.9$^b$ | 65.4$^b$ | 0.3 | 0.019 |
| Loin wt (kg) | 3.80$^a$ | 3.94$^{ab}$ | 4.14$^b$ | 0.05 | 0.011 |

$^{abc}$Mean values with different superscripts within columns differ significantly ($P$<0.05) as phase–feeding is made easy through the use of AUSPIG (Smits and Mullan 1995). At QAF Meats, we are currently evaluating the dietary protein requirement for our own lean genotype under different rates of RAC inclusion and feeding strategies.

The cost–benefit of using any growth modifier needs to be calculated according to the market the pigs are sold, the ease of diet management and the cost of the diet. There are costs associated with the use of RAC that include:

- cost of the base diet need to optimise the response to ractopamine;
- inclusion rate in the diet;
- adoption of a constant or step–wise phase–feeding program;
- duration of feeding;
- other management issues (e.g. silo management, early marketing).

The income received for pigs treated with RAC will depend on the market by which pigs are sold. The price received will depend on:

- sex of the pig marketed;
- liveweight (if sold by liveweight);
- carcass weight and P2;
- premium for carcass lean yield;
- integrated boning room benefits.

Thus the profitability of using RAC will depend on the magnitude of the costs over the returns. This will be determined by the effect on:

- FCR;
- carcass weight (or liveweight only if sold on liveweight basis);
- carcass P2 or other indicator used by the buyer as an estimate of leanness;
- boning room yield efficiencies if part of an integrated business.

## Conclusions

The option of using ractopamine in the Australian pig industry will be available this year. The QAF Meats studies conducted as part of the registration of the commercial feed additive Paylean® in Australia and to evaluate the options for different feeding strategies have confirmed overseas results that it is effective in producing efficient lean tissue deposition. Whether or not RAC will be effective in significantly reducing carcass P2 remains unclear. With its widespread adoption the Australian pig industry must deal with the customer perceptions in treated pork products from overseas and domestically. Although there is no evidence of residues in the meat when animals are slaughtered according to the withhold periods, public reaction may still be an influential factor in the decision to use RAC, or for some markets to accept treated pigs. The adoption of the technology by pig producers in Australia will be individual, and producers, feed suppliers and consultants will have to make continuing profitability evaluations.

## Acknowledgement

The authors acknowledge the funding from Elanco Animal Health Australia for the experiments described in this paper.

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