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The Interaction between Ractopamine Supplementation, Porcine Somatotropin and Moisture Infusion on Sensory Pork Quality

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Table of Contents

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Technical Summary

Moisture infusion is used by processors to improve pork quality, however anecdotal evidence suggests that when aged, moisture infused pork loses excess moisture which subsequently has a negative impact on its appearance, eating quality and shelf-life. Ractopamine and porcine somatotropin (pST) are used by producers pre-slaughter to improve growth performance and carcass composition. However, they have been found to have a negative impact on pork quality by altering the muscle structure or inhibiting the ageing process. It was thought that ractopamine supplementation and/or pST administration may improve the quality of moisture infused pork due to the altered muscle structure and inhibited ageing process. This experiment aimed to i) determine the interaction of the inclusion of ractopamine, pST and moisture infusion post-slaughter on sensory pork quality and; ii) examine the interaction between ageing and moisture infusion on sensory pork quality.

Ninety six crossbred (Large White x Landrace x Duroc) physically castrated pigs were used in a 4×2×2 factorial experiment to determine the effects of management strategy (control, ractopamine, pST and ractopamine and pST in combination for 28 days pre-slaughter), moisture infusion (0 and 10%) and ageing (24 hrs and 7 days) on intramuscular fat and sensory pork quality. Management strategy had no effect on the level of intramuscular fat or sensory pork quality. Moisture infusion improved the sensory pork quality measures of aroma, flavour, tenderness, juiciness, overall acceptability and quality. Ageing for 7 days improved flavour, tenderness, juiciness, overall acceptability and quality. There was an interaction between ageing and moisture infusion in that moisture-infused pork was more tender at 24 hrs post-slaughter, but had the same tenderness after 7 days of aging compared to pork that was not moisture infused.

These findings indicate that ractopamine supplementation or pST pre-slaughter did not interact with moisture infusion post-slaughter to improve the sensory quality of pork. Furthermore, the increase in moisture loss which has been anecdotally observed in aged moisture-infused pork was not observed in this study. Although both ageing and moisture infusion can be used to improve sensory pork quality, moisture infusion improved sensory pork quality to a greater degree. Therefore, moisture infusion can be effectively used by processors to improve sensory pork quality, particularly when the supply chain does not allow for sufficient ageing time.

Background to Research

The sensory characteristics of aroma, flavour, juiciness and tenderness contribute to a consumer's overall perception of pork and ultimately its eating quality (Nardone and Valfre, 1999). In Australia, tenderness accounts for 30% of consumer preference for pork (Channon et al. , 2001). Ageing pork for 4 to 7 days post-slaughter improves tenderness (decreases shear force) due to proteolysis occurring within the myofibrillar component (Channon *et al.* 2004; Faustmann, 1994; Miller, 1994; Lawrie, 1998).

A proportion of pigs are now fed diets containing ractopamine just prior to slaughter to improve growth performance and increase lean meat deposition. Based on a review of the literature, Dunshea *et al* (2005) reported that while ractopamine supplementation has no effect on either intramuscular fat content or drip loss, there is an increase in shear force. This result is supported by consumer eating quality data which indicates a decrease in tenderness (-6%) but no effect on juiciness of pork from ractopamine supplemented pigs. This increase in toughness can be attributed to the increased muscle fibre thickness in pigs that have been fed ractopamine (Aalhus *et al.* 1992). There are also

indications that pork from pigs treated with ractopamine ages more slowly due to a reduction in the amount of energy stored in the muscle post-mortem and inactivation of the proteolytic enzymes that are responsible for ageing (Guo *et al.* 2003; Lonergan *et al.* 2001).

Porcine somatotropin (pST) is used by producers to increase growth rate and decrease fat deposition. After a review of the literature, Dunshea *et* al (2005) reported that pST increased shear force (9%) and decreased drip loss. This result is supported by consumer eating quality data which indicates a decrease in tenderness (-9%) (Dikeman, 2007). The reduction in tenderness has been attributed to increased muscle fibre size, and a reduction in calcium-activated proteolysis which prevents improvements in tenderness during the ageing process (Soloman *et al.* 1990; Weikard *et al.* 1992).

The use of moisture infusion post-slaughter has been found to significantly improve the tenderness of pork (Hayes *et al.* 2006; Sheard *et al.* 1999). Moisture infusion involves the addition of water, phosphates, salt and potassium or sodium lactate to meat post-slaughter (Cannon *et al.* 1993). An important characteristic of moisture infusion is the retention of the water and other ingredients by the muscle lattice system which results in improved tenderness and juiciness of pork when cooked (Hayes *et al.*, 2006; Sheard *et al.*, 1999). However, when aged, moisture infused pork has been found to lose excess moisture which subsequently has a negative impact on the appearance, eating quality and shelf-life of pork. It was hypothesised that ractopamine supplementation and/or porcine somatotropin administration may actually improve the quality of moisture infused pork due to the altered muscle structure and inhibited ageing process. Also, there is very little information on the interaction between ageing and moisture infusion on sensory pork quality.

Objectives of Research

The main aim of this experiment was to determine the interaction of the inclusion of ractopamine and porcine somatotropin and moisture infusion post-slaughter on sensory pork quality. The interaction between ageing and moisture infusion on sensory pork quality was also examined.

Methodology

This pre-slaughter component of this experiment was conducted at the Department of Agriculture and Food Western Australia's (DAFWA) Medina Research Centre. The experimental protocol used in this study was approved by the DAFWA Animal Research Committee and by the Animal Ethics Committee and animals were handled according to the Australian code of practice for the care and use of animals for scientific purposes (NHMRC, 2004).

Experimental Design

Ninety six surgically castrated male pigs (Large White × Landrace × Duroc) were used in a 4 × 2 × 2 factorial experiment. The main treatments were:

i) Management strategy

1. Control: conventional diet for 28 days pre-slaughter
2. Ractopamine (Rac): included in conventional diet for 28 days pre-slaughter
3. pST: administered daily for 28 days pre-slaughter
4. Ractopamine + pST (Rac+pST): ractopamine included in diet for 28 days pre-slaughter and pST administered daily for 14 days pre-slaughter

ii) Moisture infusion

1. 0%
2. 10%

iii) Ageing period

1. 24 hrs
2. 7 days

The pigs were transported to Medina Research Station at approximately 57 kilograms liveweight (LW). They were housed in groups of 6 in a conventional naturally ventilated grower/finisher shed. All pigs had *ad libitum* access to feed, and water via swing drinkers. The control diet was fed from arrival until the management strategies were implemented at 68.1±1.39 kg LW, four weeks prior to slaughter (Table 1). Pigs receiving pST were given a daily dose of 5 mg porcine somatotropin (Reporcin®, Zamira, Australia) which was administered intramuscularly in the neck region using the approved gas-powered injection device. Ractopamine was included in the diet at a rate of 5 ppm. The diet specifications for the Control and Rac management strategies were 13.5 MJ DE/kg and 0.56 g Av Lys/MJ DE. The diet specifications for the pST and Rac+pST management strategies were 14.2 MJ DE/kg and 0.65 g Av Lys/MJ DE as a consequence of the higher protein and energy requirements of pST administered pigs.

At an average of 104 kg LW the pigs were individually tattooed, removed from feed overnight and transported to a commercial abattoir (approx. 90 minute transport time). The pigs were stunned using a carbon dioxide, dip-lift stunner set at 85% CO_2 for 1.8 minutes (Butina, Denmark). Exsanguination, scalding, dehairing, evisceration and chilling were performed using standard commercial procedures.

The pigs were ranked on their final liveweight with half of the pigs in each pen randomly allocated to the 10% moisture infusion treatment (Tenderboost® 100, Venturetech, Murdoch, Western Australia). Twenty four hours post-slaughter the *Longissimus* muscle was removed from both sides of the carcass and the moisture infusion treatment applied to the allocated pigs.

Intramuscular Fat Analysis

A 50 g sample of *L. thoracis* muscle, trimmed of visible fat and skin, was used to determine the percentage of intramuscular fat via the Soxhlet extraction method (Silliker Australia, Sydney).

Sensory Pork Quality Assessment

A total of 320 individually wrapped and identified boneless LT steaks were used for the consumer taste panel assessment. The steaks were vacuum packed 24 hrs after slaughter and then aged for either 0 or 6 days before they were frozen (equating to an ageing period of 24 hrs and 7 days, respectively). Four pigs per treatment were randomly selected and five steaks per loin (15 mm thick) were used. The pork samples were thawed at 4°C prior to cooking for approximately 5 minutes on a flat-plate grill (Silex, Hamburg, Germany) at 190°C until a standardised degree of doneness was reached (medium to well done, internal temperature of 75°C). Each cooked steak was rested for 3 minutes before it was halved and tasted by two consumers. Ninety two consumers were used in the assessment and each consumer tasted a total of 7 samples over a 45 minute session. Consumers assessed the steaks for aroma, flavour, juiciness, tenderness, overall acceptability and quality. Assessment was conducted using a line scale where 0=dislike extremely to 100=like extremely. Quality was assessed with the following score: 1=unsatisfactory, 2=good everyday quality, 3=better then everyday quality and 4=premium quality.

Statistics

Analysis of variance (ANOVA) was used to analyse the main effects of ageing period, moisture infusion and management strategy and their interactions on sensory pork quality. Two-way analysis of variance was used to analyse the main effects of management strategy and moisture infusion on the intramuscular fat content. All analyses were conducted using Genstat 12th Edition. Least significant differences were used to determine differences between treatments.

Results

Intramuscular Fat

Intramuscular fat was not significantly different between levels of moisture infusion or management strategy (P>0.05). However, there was a trend for pigs that received ractopamine alone to have more intramuscular fat compared to the other management strategies (P=0.067; Table 1).

Sensory Pork Quality

Consumer taste panel results are presented in Tables 2 and 3. Overall, moisture infused pork had significantly better aroma (P=0.029), flavour (P<0.001), tenderness (P<0.001), juiciness (P<0.001), acceptability (P<0.001) and quality (P<0.001) compared to pork that did not receive moisture infusion. Ageing for 7 days after slaughter improved flavour (P=0.017), tenderness (P=0.003), juiciness (P=0.008), acceptability (P=0.019) and quality (P=0.010) compared to ageing for 24 hours after slaughter. Management strategy had no significant effect on the aroma, flavour, juiciness, acceptability and quality of pork (P>0.05). However, there was a trend for Rac+pST pigs to have decreased tenderness compared to the other management strategies (P=0.087).

There were several two-way interactions between the main factors that had a significant effect on sensory parameters of pork in this experiment. Moisture-infused pork was more tender at 24 hrs but had the same tenderness after 7 days of aging compared to pork that was not moisture infused (P=0.011). At 24 hrs ageing, there was a trend for Rac and pST to have lower likeness scores for flavour (P=0.053) compared to the other management strategies, however, after 7 days of ageing there was no difference between management strategies (P=0.053). There was also a tendency for pork from pST pigs to have a greater improvement in tenderness when moisture infused compared to the other management strategies (P=0.087).

Table 1: The effect of moisture infusion and management strategy on intramuscular fat content of surgically castrated pigs (n=12).

Moisture infusion (%) (MI)	0				10				SEM	P-value		
Management strategy (MS)	Control	Rac	pST	Rac + pST	Control	Rac	pST	Rac + pST		MI	MS	MIxMS
Intramuscular fat (%)	1.84	2.19	1.79	1.82	1.80	2.17	1.78	1.33	0.318	0.384	0.067	0.669

Table 2: The effect of moisture infusion, management strategy and ageing on the eating quality of the *Longissimus thoracis* muscle.

Moisture infusion (MI)	0%								10%								SED	Significance
Ageing period (AP)	24 hrs				7 days				24 hrs				7 days					
Management strategy (MS)	Control	Rac	pST	Rac + pST	Control	Rac	pST	Rac + pST	Control	Rac	pST	Rac + pST	Control	Rac	pST	Rac + pST		
Aroma[a]	72.0	67.2	69.7	69.5	70.0	69.6	66.2	66.1	71.4	74.2	69.0	71.5	71.4	71.5	69.8	77.1	4.15	MI**
Flavour[a]	65.0	57.1	52.9	61.9	64.0	68.8	63.0	59.4	70.8	67.6	68.7	69.8	72.1	72.4	74.3	69.7	4.42	MI****, AP**, APxMS*
Tenderness[a]	55.1	44.2	47.4	45.4	60.1	66.5	51.0	58.1	66.6	66.7	68.7	56.1	66.8	64.0	69.3	60.1	5.61	MI****, AP***, MS*, MIxAP**, MIxMS*
Juiciness[a]	66.6	52.7	55.5	61.7	65.7	66.5	65.1	65.2	66.5	70.2	66.5	67.7	66.6	69.3	73.3	72.7	4.90	MI****, AP***
Acceptability[a]	62.1	55.3	53.1	57.3	62.4	67.9	60.3	58.4	69.8	69.2	69.4	64.7	72.1	69.6	76.2	65.7	4.77	MI****, AP**
Quality[b]	2.20	1.95	1.85	2.02	2.32	2.50	2.10	2.15	2.67	2.57	2.63	2.33	2.67	2.62	2.72	2.52	0.190	MI****, AP***

[a] Acceptability score (line scale), 0 = dislike extremely and 100 = like extremely

[b] Quality score: 1=unsatisfactory, 2=good everyday quality, 3=better than everyday quality, 4=premium quality

*P<0.1, **P<0.05, *** P<0.01, ****P<0.001

Table 3: The effect of moisture infusion (MI), management strategy (MS) and ageing (AP) on the eating quality of the *Longissimus thoracis* muscle.

	Moisture infusion (%)		Ageing period		Management strategy				SED	Significance
	0	10	24 hrs	7 d	Con	Rac	pST	Rac+pST		
Aroma[a]	68.8	72.0	70.5	70.2	71.2	70.6	70.5	69.2	4.15	MI**
Flavour[a]	61.5	70.7	64.2	68.0	68.0	66.5	64.7	65.2	4.42	MI****, AP**, APxMS*
Tenderness[a]	53.5	64.6	56.1	62.0	61.9	60.4	59.1	54.9	5.61	MI****, AP***, MS*, MIxAP**, MIxMS*
Juiciness[a]	62.4	69.1	63.4	68.0	66.3	64.6	65.1	66.8	4.90	MI****, AP***
Acceptability[a]	59.6	69.6	62.6	66.6	66.6	65.5	64.8	61.5	4.77	MI****, AP**
Quality[b]	2.14	2.60	2.28	2.45	2.47	2.41	2.33	2.26	0.190	MI****, AP***

[a] Acceptability score (line scale), 0 = dislike extremely and 100 = like extremely

[b] Quality score: 1=unsatisfactory, 2=good everyday quality, 3=better than everyday quality, 4=premium quality

*P<0.1, **P<0.05, *** P<0.01, ****P<0.001

Discussion

The results indicate that there was no interaction between the inclusion of ractopamine or pST and moisture infusion post-slaughter on sensory pork quality. The anecdotal evidence that moisture infusion loses excess moisture when it ages was not confirmed. Moore (2009), in the objective quality associated with this experiment, also found no increase in purge or drip loss with moisture infusion at 7 days post-slaughter. Under the conditions in this experiment, ractopamine supplementation and/or porcine somatotropin administration would not influence the quality of moisture infused pork due to their effect on muscle structure and inhibited ageing process (Aalhus *et al.*, 1992; Lonergan *et al.*, 2001; Soloman *et al.*, 1990; Weikard *et al.*, 1992). It is not known if ractopamine or pST would have had an effect on moisture retention if moisture loss had been increased with moisture infusion.

The management strategies used pre-slaughter had no effect on the sensory pork quality attributes of aroma, flavour, tenderness, juiciness, overall acceptability and quality. In contrast, a meta-analysis conducted by Dunshea *et al.* (2005) found a decrease in tenderness by approximately 6% with ractopamine, while Dikeman (2007) concluded that on average pST decreases tenderness by 9%. However, in agreement with this experiment, Nurnberg and Ender (1992), Lefuacheur *et al.* (1992), and Stoller *et al.* (2003) and Rincker *et al.* (2009) also found no effect on tenderness of pST administration and ractopamine supplementation, respectively.

There were no differences in the levels of intramuscular fat between management strategies in this experiment. The pST result is supported by D'Souza and Mullan (2002) who found no significant differences in intramuscular fat levels between control and pST pigs. However, most other researchers have reported a decrease in intramuscular fat levels as pST decreases fat deposition and increases protein deposition (Dunshea, 1994). The effect of ractopamine on reducing fat deposition is small (Dunshea *et al.* 1993) and most have reported no effect on intramuscular fat levels (Stoller *et al.* 2003; Rincker *et al.* 2009), which is in agreement with the results from this experiment. Although there was no difference in intramuscular fat between management strategies, Moore (2009) found that the use of pST and Rac+pST reduced the subcutaneous backfat of these pigs.

There have been various minimum levels of intramuscular fat proposed as necessary for optimum eating quality. Bejerholm and Barton-Gade (1986) proposed that between 2 and 3% is necessary, however, Fortin *et al.* (2005) reported that an intramuscular fat level of 1.5% was sufficient. Studies from other countries have also reported a range in the minimum intramuscular fat levels for optimum eating quality (Meisinger, 2002; Wood, 1990). With the exception of Rac supplementation where the intramuscular fat level was above 2%, the intramuscular fat levels were between 1.5 and 2%. There were no differences in sensory quality between management strategies possibly indicating that the level of at least 1.5% proposed by Fortin *et al.* (2005) is sufficient.

Moisture infusion improved all sensory pork quality measures examined. The increase in juiciness, tenderness and acceptability of moisture infused pork can possibly be attributed to the lower drip loss and cook loss compared to the control (Moore, 2009). Moisture infusion with sodium tripolyphosphates results in expansion of myofilamental lattices in meat which allows water-binding and physical entrapment of water thus increasing the water-holding capacity of the meat (Xiong, 2005). Other researchers have also found an improvement in sensory quality with moisture infusion (Hayes *et al.* 2006; Prestat *et al.* 2002; Sheard *et al.* 1999; Baublits *et al.* 2006; Walker *et al.* 2005). In contrast, some researchers have reported a lower flavour liking/intensity with infusion (Sheard *et al.*, 1999), however, this was not observed in the present study.

Ageing for 7 days also improved sensory pork quality, with the exception of aroma. Ageing pork for 7 days post-slaughter improves tenderness due to proteolysis occurring within the myofibrillar component (Channon *et al.* 2004; Faustmann, 1994; Miller, 1994; Lawrie, 1998). Ageing for longer than 7 days is unlikely to continue to improve tenderness, as Rees *et al.* (2002) predict that 90% of the change in tenderness occurs within 6.1 days post-mortem. These results are supported by Channon *et al.* (2004) although juiciness was not improved by ageing.

The majority of sensory pork quality studies with moisture infusion have only looked at one time point post-slaughter and so the interaction between ageing and moisture infusion on sensory pork quality was also examined. Moisture infusion improved tenderness at 24 hrs post-slaughter to a similar level as was seen by ageing for 7 days post-slaughter. There was no difference in tenderness between the levels of moisture infusion when aged for 7 days. This shows that moisture infusion is an effective tool to improve tenderness when the time in the chiller is not sufficient to improve tenderness.

With the exception of aroma, which was only improved by moisture infusion, both ageing for 7 days post-slaughter or moisture infusion improved all sensory pork quality attributes. Although either ageing or moisture infusion improved sensory pork quality the magnitude of these responses differed with moisture infusion consistently improving sensory pork quality above which was achieved by ageing for 7 days (Table 4). For example, moisture infusion improved tenderness by 20.7% compared to an improvement of 10.5% with ageing.

Table 4: The improvement in sensory pork quality due to ageing (24 hrs or 7 days) or moisture infusion (0 or 10%).

Improvement (%)	Ageing	Moisture infusion
Aroma	NS*	4.5
Flavour	5.92	15.0
Tenderness	10.5	20.7
Juiciness	7.26	10.7
Acceptability	6.39	16.8
Quality	7.46	21.5

*NS = ageing for 7 days did not significantly improve the aroma.

Conclusions

Ractopamine supplementation or porcine somatotropin pre-slaughter did not interact with moisture infusion post-slaughter to improve the sensory quality of pork. However, the increase in moisture loss which has been anecdotally observed in moisture-infused pork when aged was not observed in this study.

Both moisture infusion and ageing improved the sensory quality of pork. However, moisture infusion resulted in greater improvements in the eating quality traits of pork. For example, moisture infusion resulted in a tenderness 24 hrs after slaughter equivalent to ageing for 7 days post-slaughter. Therefore, moisture infusion provides an effective means to improve the quality of Australian pork, particularly when the supply chain does not allow for sufficient ageing time to improve pork sensory quality.

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