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Gen 1 & Gen 2 Electrical Stimulation Ex-Ante Value Proposition

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Contents

Abstract

This *ex-ante* study estimates the improvement in value created by electrical stimulation over no stimulation for beef and lamb carcases. It also compares the difference in value between fixed dose (Gen 1) and variable dose (Gen 2) stimulation and is based on the premise that effective variable dose stimulation could control pH decline through a much tighter carcase temperature range than fixed dose systems. Domestic retail beef carcases would be most likely to benefit from Gen 2. Domestic lamb carcase eating quality would benefit from Gen 2 but the realisable value would not be significant over Gen 1. There is limited opportunity for export beef and sheep carcases. If Gen 2 technology could reduce variance in temperature at pH6 and improve meat colour the potential value of the technology ranged between $0.00 - $1.61/head and $0.00 - $0.56/head for beef and sheep respectively as compared with $-0.57 - $1.24/head and $0.00 - $0.49/head for Gen 1 systems for beef and sheep respectively. Range in values is dependent on animal type and market destination for a range of beef and sheep supply chains. However, whilst two variable dose electrical stimulation systems (1 beef, 1 lamb) have been installed in Australia, to date no independent validation work has been done on meat quality differences relative to fixed dose stimulation. Preliminary beef trials do not indicate any significant difference of variable dose stimulation over fixed dose stimulation. Until detailed validation trials are conducted there is no evidence that Gen 2 provides any improvement in meat quality over fixed dose stimulation.

Acknowledgements

The authors thank the beef and lamb processing companies who gave of their time, skills and market knowledge across a number of in-person meetings, phone calls and e-mails to establish the value parameters supporting this report. Special acknowledgement should also be made to the MSA staff and scientists for their contribution of industry research, peer review and references to published literature on which this CBA is based.

1 Background[1]

Improving the consistency of Australian beef and lamb eating quality is one of MLA's strategic objectives. A significant source of variation in eating quality results from factors within the processing sector providing the opportunity to develop technology interventions to increase the eating quality of red meat. Electrical stimulation is one of these technologies and has been used to affect the rate of post-slaughter muscle pH decline for improvement in eating quality.

For optimum eating quality, muscles should enter rigor mortis (pH6) at a temperature range of around 18^0C. Outside this range muscle contraction can occur and is detrimental to eating quality. For example, muscle entering rigor mortis while muscle temperature is still high is more likely to heat toughen, while low muscle temperatures for pre-rigor meat increases the risk of cold shortening. There are also consequences other than decreased tenderness of rapid pH decline which could potentially impact on carcass value including reduced ageing time and changes in meat colour. Although rate of pH decline for optimum eating quality will vary from carcase to carcase the MSA pH/temperature window was developed to help optimise carcase processing for eating quality. One of the abattoir audits that MSA conducts is to determine the proportion of carcases that pass through pH6 at temperatures between 35^0C and 12^0C. Obviously there is variation about this requirement, with the MSA audit making sure the majority of carcasses comply with the window. Rather than adjusting abattoir chilling rates it is easier to manipulate the rate of pH decline *via* electrical stimulation to match the temperature decline. Generation 1 (Gen 1) stimulators deliver a fixed dose of stimulation for a fixed period but given differences in carcass resistance, fatness etc., each carcase requires different amounts of stimulation to optimise temperature at pH 6.0. Meat and Livestock Australia, MLA (MDC Donor Company) and MIRINZ/Carne Technologies developed variable dose electrical stimulation technology to improve the existing eating quality benefits gained in beef and lamb from fixed dose electrical stimulation systems. Generation 1 stimulation was modified to apply a variable stimulation input based on carcase response to an electrical test pulse. These developments resulted in a Generation 2 variable dose prototype system, otherwise known as *SmartStim*. In theory this tailored stimulation could bring all carcase pH declines through a tighter pH/temperature decline curve, reducing variability with a resultant improvement in meat quality. Furthermore, the test pulse could potentially estimate post chilling carcase grading outcomes, enabling a range of early management interventions pre-chilling.

Two Gen 2 prototype stimulators have been installed in Australia (1 lamb and 1 beef installation). Lamb trials conducted by the manufacturer indicate improved pH declines over no-stimulation but these trials

[1] This report represents a summary of a larger report on the value proposition of Gen 1 and Gen 2 Stimulation. The full report provides details of the assumptions used and a more in depth analysis of the value proposition. A CBA model in Excel that enables meat processors to assess the value proposition of different scenarios is also available. Please contact MLA for copies of the full report and CBA model.

did not compare between Gen 1 and Gen 2. Preliminary beef trials indicate no significant difference in pH declines between Gen 2 and fixed dose stimulation. Until detailed validation trials are conducted there is no evidence that Gen 2 prototypes provide any improvement in meat quality over fixed dose stimulation.

2 Purpose

Given the outcomes from the first two prototype installations are yet to show any improvement over Gen 1, at this point in the R&D pathway a fresh look at the value proposition of variable dose stimulation is required and is the basis of this report.

3 Research Validation

This *ex-ante* cost benefit[2] study is based on the assumption that effective variable dose stimulation could control pH decline through a much tighter carcase temperature range than fixed dose systems. It assumes specifically that:

1. Controlling pH decline through a narrower temperature range than possible with Gen 1 will increase meat quality; AND
2. Technology can be built to interrogate carcase stimulation needs accurately, then apply variable stimulation to control pH decline within a narrower temperature range than possible with Gen 1; AND
3. Changes in meat quality resulting from assumption 1 and 2 above will impact on the value received along the supply chain.

This report estimates the change in value to each section of the supply chain in assumption 3 (above) on the basis that assumptions 1 and 2 are valid. It considers the different species, carcase types and markets that would impact on the potential value that could be delivered[3].

At the time of writing no Australian *'in plant'* data was available to validate Gen 2 performance relative to fixed dose stimulation. Such data is essential to confirming the projected Gen 2 benefits identified in this report.

[2] **Definition:** *Ex-ante* is Latin for "beforehand". In models where there is uncertainty that is resolved during the course of events, the *ex-antes* values (e.g. of expected gain) are those that are calculated in advance of the resolution of uncertainty.
http://economics.about.com/cs/economicsglossary/g/ex_ante.htm

[3] Values used in this report are referenced from a detailed *ex-ante* cost benefit model that was developed to estimate potential benefits on a plant by plant basis. The report supporting the CBA model explains the assumptions used in the model at a plant specific level and is included as an appendix to this document.

4 Methodology

A wide range of factors within the beef and lamb processing sectors were identified that could be impacted by Gen 1 and Gen 2 stimulation. Each potential benefit of variable dose stimulation was reviewed as to how it might impact value along the supply chain.

Where data around the impact of meat quality on market value was available, this was either applied directly or used to reference and extrapolate likely magnitude of change in value.

Three processors provided data to support assumptions around the changes in value due to meat-quality downgrades, premiums for branded beef and lamb programs, costs related to cold storage and ageing of product as well as operational procedures and costs that might reduce through improved management interventions.

Retail data around the cost of mark downs and dumps was used to estimate value changes in the retail sector.[4]

Price premiums received in the market for MSA and how those premiums were distributed along the chain were referenced from industry reports to underpin assumptions about value distribution. The marketing departments from 4 different processors provided information around the magnitude of benefit they observe in the market for branded meat products with meat quality claims.[5]

MSA willingness to pay estimates between 3, 4 and 5 star product were used to underpin pricing premium assumptions for improved eating quality for both MSA and non-MSA products.[6]

Consultation with a range of processors indicates values will vary for specific plants and supply chains.[7]

5 Estimated Value

A wide range of different benefits emanating from either the tighter pH decline curve which is theoretically possible with Gen 2 compared to Gen 1 or from using data from the test pulse used by Gen 2 have been proposed. It is important to appreciate that these are potential benefits, yet to be demonstrated in an Australian meat processing plant. The range of possible benefits distils down to three main areas of value:

[4] Percentage of total sales contributing to markdowns was referenced from non-MLA projects

[5] Two beef processors and two lamb processors validated (through in-person meetings) value assumptions made in the CBA models for their specific companies around price premiums they achieve in the market for different brand and quality premiums in both domestic and export markets.

[6] From data provided in Microsoft excel format from MSA staff.

[7] Benefits have been determined from the perspective of a 'typical' processing plant based on assumptions detailed in the CBA modelling report. It is acknowledged that considerable variation exists between processing plants that may affect the value proposition. It is recommended that plant specific data is entered into the model to determine the value proposition for an individual plant.

1. Minimising the number of carcases with pH decline curves currently at risk of some heat toughening or cold shortening. This reduction in variation would reduce variation in eating quality to improve consumer satisfaction. Over time this should return value to the industry. The success of the MSA program is an example of this value creation.
2. Increased colour and aging rate by increasing stimulation levels towards the upper end of the pH decline window.
    a. In theory a precise control of individual carcase decline curves would reduce the risk of heat toughening that would otherwise occur if attempting this with fixed dose stimulation.
    b. There is no evidence to date this level of control is possible. Furthermore;
    c. The impact of pH/temp on meat quality is a continuum, not a threshold. So as rate of pH decline increases away from optimal, the likelihood of reduced colour stability, excessive purge and store markdowns increases. Short term benefits of reduced meat colour downgrades would potentially be offset somewhere in the supply chain by reduced eating quality.
3. Data from the test-pulse has been proposed as method for obtaining information on individual carcases that would enable management intervention and even reduce grading costs by removing the need to measure ultimate pH (pH_u).
    a. The use of Gen 2 as a management intervention tool is another possible benefit but at this stage is unlikely to be possible. Even if it Gen 2 was able to provide accurate information about post chill grading prior to slaughter floor grading, generating value would be minimal and restricted to a small number of plants, based on layout, market destination and limited ability for further sorting of carcases in chillers.

Physical impacts vs. value impacts

Keeping in mind the assumptions in section 3, this study is focused on the value impacts in assumption 3, not on whether a meat science impact occurs. There is a difference between meat science impact and the resultant impact on value. For example, if the test pulse on a Gen 2 system was able to predict at the slaughter grading station some of the attributes like meat colour that would be graded the following day in the chiller that would not reduce chiller assessment costs in most beef plants. The chiller assessor measuring pH_u and meat colour also measures other things in parallel while the pH meter is stabilising prior to giving a reading. These jobs would still need to be done with little time saved.

Table 1 summarises the economic benefits attributable to Gen 1 and Gen 2 systems for beef and sheep supply chains. The table lists the areas where stimulation could impact on meat quality and cost inputs. It assumes that all areas labelled 1.1 – 2.8 could be achieved reliably with Gen 2[8]. The right hand columns indicate ("Y") if an attribute is likely to create a change in value somewhere in the supply chain. Note that some benefits are antagonistic to each other.

[8] Requires independently validated plant trials to establish if there is any significant difference between Gen 1 and Gen 2.

Table 1: Summary of potential economic benefits for Gen 1 and Gen 2 stimulation by potential attribute. Explanations for each attribute are included in the MLA supplement to the CBA model

		Beef		Sheep	
Areas of potential economic benefit		Gen1	Gen2	Gen1	Gen2
1.1	Increase MSA Compliance				
1.2	Increase eating quality - MSA		Y		
1.3	Increase eating quality - NON MSA				
1.4	Reduce Purge				
1.5	Decreased ageing time	Y	Y	Y	Y
1.6	Improved meat colour grade	Y	Y		
1.7	Colour Stability - Less markdowns				
	Possible secondary value benefits				
2.4	Predicting pHU/ Heat toughening		Y		
2.5	Reduce Carcase Grading costs				
2.6	Enable faster carcase chill			Y	Y
2.7	Market Access				Y
2.8	Warm boning enabler			Y	Y

5.1 Key messages[9]

Beef

Improved meat quality

1. No value of Gen 1 or 2 to heavy grain fed beef. Currently most plants report that pH decline relative to temperature decline is already too fast and any application of stimulation would only exacerbate this risk.
    - Abattoirs using Gen 1 with a mix of heavy and light beef require manual turn-off of ES for heavy carcases. Provided the test pulse on a Gen 2 system did not accelerate glycolysis and hence pH decline, Gen 2 technology could be turned on all the time and would eliminate the reliance on manual operator intervention and the risk of overstimulation.

2. Reduced ageing for Gen 1 and Gen 2 is only relevant for some domestic supply chains (typically retail supply, not including supplementary products[10]). Export destinations include a set period for transport and hence ageing and so would not benefit from higher stimulation levels.

[9] Benefits have been determined from the perspective of a 'typical' processing plant based on assumptions used in the Ex-Ante Stimulation CBA. The supplement to the CBA model explains each value assumption. It is acknowledged that considerable variation exists between processing plants that may affect the value proposition. It is recommended that plant specific data is entered into the model to predict the value proposition for an individual plant.

[10] "Supplementary product" refers to primals purchased from the wholesale market separate to a retailers primary livestock supply. These primals are likely to be aged already or from carcases with a portion of cuts destined for export where a slower ageing process is required due to sea freight transport.

3. Gen 2 benefits only – Optimise pH decline in the pH/temp window to increase eating quality, reduce purge and improve colour stability beyond that of Gen 1;

OR

Improved colour grade

4. Improve meat colour grade for both Gen 1 and Gen 2 due to overstimulation (at the expense of Gen 2 eating quality benefits in point3 above).

   Meat colour grade improvement is the largest immediate gain to processors but is at the expense of less tangible eating quality improvements

5. No reliable meat grading process savings for either technology

Sheep/lamb

1. Effective Gen 1 stimulation has resulted in a 65% reduction in cold shortening in Australian lamb significantly improving eating quality.
2. Gen 2 could increase the percentage of carcases within the pH/temperature window over Gen 1[11].
   - Gen 1 stimulation trials indicated reduction in the number of carcases cold shortening but also resulted in some carcases heat toughening as the fixed dose stimulation increased the rate of pH decline (Hopkins, 2007).
3. Gen 1 & 2 are relevant to both domestic and export product because of cold-shortening issues without stimulation.
4. Increased colour stability could occur for Gen 2[12] by preventing some carcases from being over-stimulated as sometimes occurs with fixed dose stimulation (Jacob, 2008).
5. Retailer keeps all benefits associated with improved meat quality with no value passed back up the value-chain[13],[14].

5.2 Value estimates

Figure 1 summarise all potential benefits for both beef and lamb supply chains. These benefits do not apply to all supply chains and some benefits are not additive but are alternatives or trade-offs.

[11] Requires independently validated plant trials to establish the difference in pH/temperature decline variation between Gen 1 and Gen 2.
[12] Requires independently validated plant trials to establish the difference in colour stability variation between Gen 1 and Gen 2.
[13] Lamb carcases are not individually graded so there is no differentiation on quality.
[14] Reduced purge and increased colour stability are impacted by many factors beyond the processor so retailers would be reluctant to pay a premium where processor interventions cannot be quantified

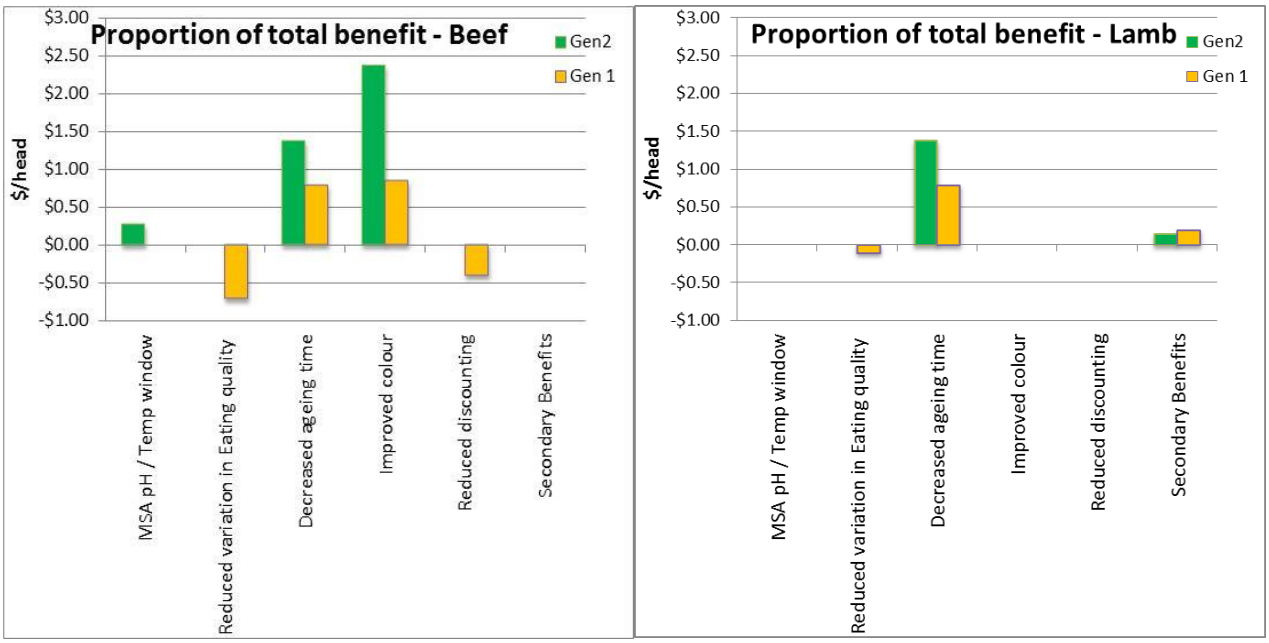

Figure 1: Comparative value Gen 1 and Gen 2 in beef and sheep relative to no stimulation for each benefit group on a per head basis

Potential impacts on meat quality attributes and costs translate into value at different places along the various supply chains. The following tables summarise likely distribution of value if Gen 2 benefits listed are achieved. All figures compare Gen 1 to no stimulation and Gen 2 to no stimulation. The difference in value between Gen 1 and Gen 2 estimates the additional impact a Gen 2 system could have over Gen 1 if the capabilities proposed in this document could be achieved consistently.

Table 2: Light domestic beef optimised for eating quality (Gen 2 improvement over Gen 1 - $0.84/head)

Benefits	Gen 1				Gen2			
Supply Sectors included in comparison	Producer	Processor	Sales	Total	Producer	Processor	Sales	Total
MSA pH / Temp window	$0.00	$0.00	$0.00	0%	$0.00	$0.00	$0.27	100%
Reduced variation in Eating quality	$0.00	$0.00	-$0.57	100%	$0.00	$0.00	$0.00	0%
Decreased ageing time	$0.00	$0.00	$0.00	0%	$0.00	$0.00	$0.00	0%
Improved colour	$0.00	$0.00	$0.00	0%	$0.00	$0.00	$0.00	0%
Reduced discounting	NA	nc	nc	0%	NA	NA	nc	0%
Total	**$0.00**	**$0.00**	**-$0.57**	**100%**	**$0.00**	**$0.00**	**$0.27**	**100%**
	-$0.57				**$0.27**			

In Table 2 above the benefit category “Reduced variation in Eating Quality” is comprised of a number of factors including reduced purge and colour stability. The negative value for Gen 1 relates to changes in purge or drip loss at retail. Some beef carcases already close to the upper end of the pH/temp window without stimulation would be pushed closer to heat toughening with fixed dose stimulation with a slight increase in drip loss relative to no stimulation and Gen 2 variable dose stimulation.

Table 3: Light domestic beef optimised for meat colour at chiller grading (Gen 2 improvement over Gen 1 - $1.61/head)

Benefits	Gen 1				Gen2			
Supply Sectors included in comparison	Producer	Processor	Sales	Total	Producer	Processor	Sales	Total
MSA pH / Temp window	$0.00	$0.00	$0.00	0%	$0.00	$0.00	$0.00	0%
Reduced variation in Eating quality	$0.00	$0.00	$0.00	0%	$0.00	$0.00	$0.00	0%
Decreased ageing time	NA	$0.60	NA	48%	NA	$1.05	NA	37%
Improved colour	$0.06	$0.58	NA	52%	$0.18	$1.63	NA	63%
Reduced discounting	$0.00	$0.00	$0.00	0%	$0.00	$0.00	$0.00	0%
Total	**$0.06**	**$1.18**	**$0.00**	**100%**	**$0.18**	**$2.67**	**$0.00**	**100%**
	$1.24				**$2.85**			

Table 4: Domestic lamb supply chain (Gen 2 improvement over Gen 1 - $0.56/head)

Benefits	Gen 1				Gen2			
Supply Sectors included in comparison	Producer	Processor	Sales	Total	Producer	Processor	Sales	Total
MSA pH / Temp window	$0.00	$0.00	$0.00	0%	$0.00	$0.00	$0.00	0%
Reduced variation in Eating quality	$0.00	$0.00	-$0.11	-21%	$0.00	$0.00	$0.00	0%
Decreased ageing time	NA	$0.60	NA	121%	NA	$1.05	NA	100%
Improved colour	NA	NA	NA	0%	NA	NA	NA	0%
Reduced discounting	NA	nc	nc	0%	NA	NA	nc	0%
Total	**$0.00**	**$0.60**	**-$0.11**	**100%**	**$0.00**	**$1.05**	**$0.00**	**100%**
	$0.49				**$1.05**			

5.3 Trade-off between possible benefits

Not all benefits occur simultaneously. Some conflict with others as summarised in Figure 2 and impact on distribution of value. Benefits immediately achievable for processors such as lighter beef colour grade maybe detrimental to eating quality but not discounted downstream. Alternatively, benefits that improve overall eating quality and consumer satisfaction are not rewarded as part of commercial trade descriptions.

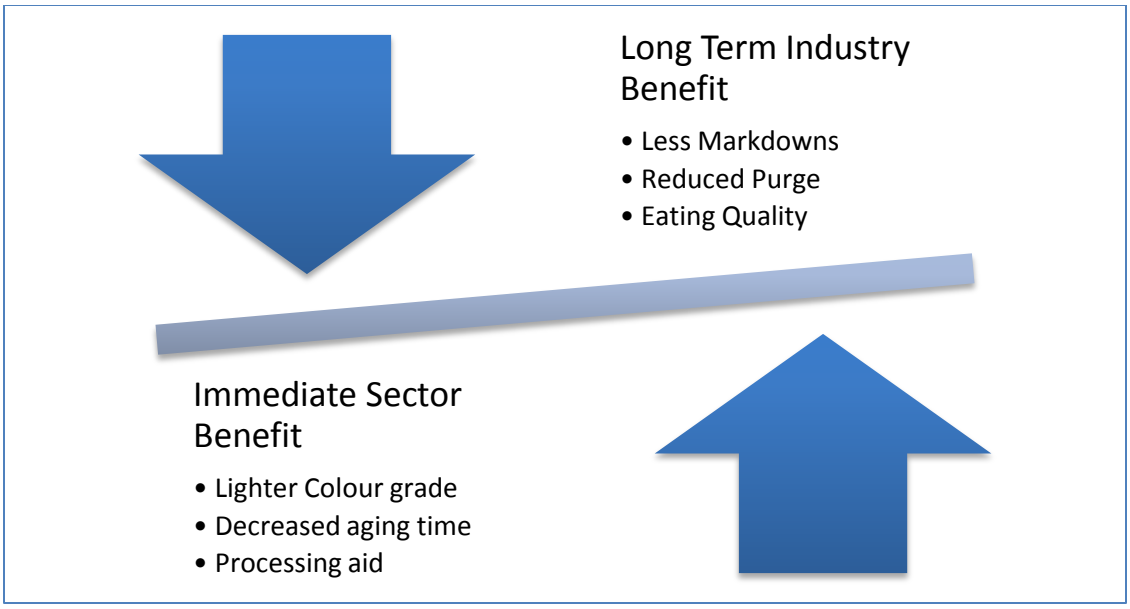

Figure 2: Trade-off between benefits across the supply chain

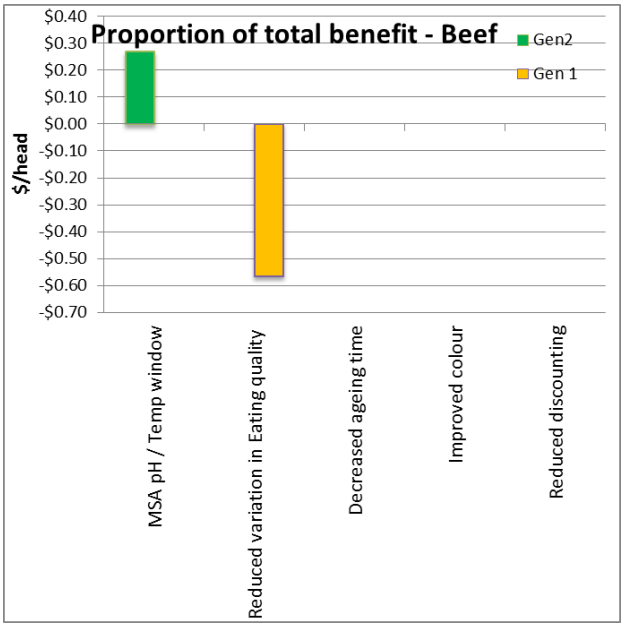

Figure 3: Longer term value of stimulation to domestic beef supply chains over the longer term when optimising for eating quality

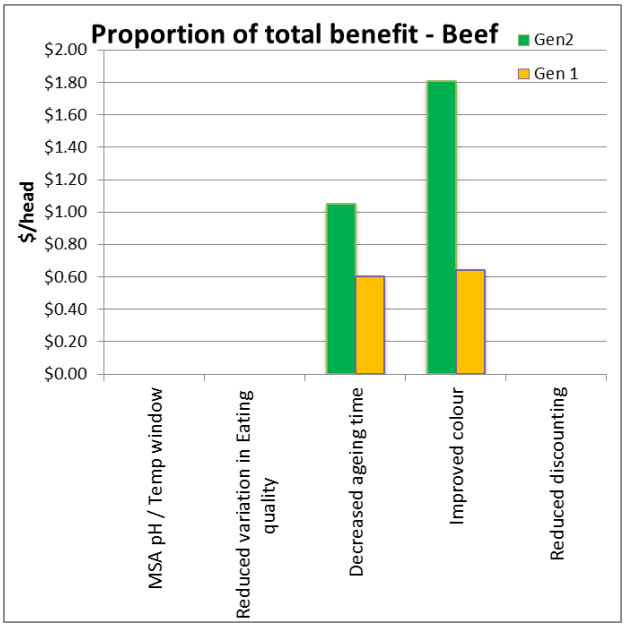

Figure 4: Short term value created in processing sector when optimising stimulation for meat colour (at the expense of eating quality)

6 Summary

- *There is no Australian in-plant data to validate the improved technical performance of Gen 2 relative to Gen 1 and the value proposition for Gen 2 should be considered as speculative until such validation is available.*
- *Even if there was a significant improvement in the meat quality factors the increase in value is not significant.*
    - *Assuming the technology was used to optimise eating quality for the end consumer the value would not be realised by the processer at this point in time.*
    - Assuming the technology was used to optimise short-term meat colour only beef processors would gain but at the downstream customers and end-users expense. Most processors are focused on consumer eating quality and longer term brand sustainability than on this sort of short term gain.
- *Any technology purported to generate short term gain at expense of consumer satisfaction should be treated with extreme caution.*
- *For any meat processor considering replacement of an old stimulator, given the length of time a stimulator will last, having the latest technology is in itself a worthwhile consideration.*
    - *The newer Gen 2 system with improved control of stimulation, the ability to monitor variation in stimulation dose and ability to turn on and off remotely makes the management and auditing of the system a genuine reason to consider over Gen 1. These types of benefits have minimal quantifiable value besides convenience and reliability.*
    - *Each processor would have to do calculations as to whether the increased capital cost and ongoing service support costs are worthwhile. A CBA modelling tool has developed by MLA to assist processors with this type of analysis*
- *The only attribute of Gen 2 that should be promoted for future R&D is the ability to control pH decline within the optimum band of the pH decline window. However, currently there is no mechanism to reward a meat processor with higher value for carcases for achieving a tighter pH decline window. MSA premiums are paid based on carcase grade but the component related pH decline is only considered on a chiller basis. So further R&D around Gen 2 stimulation in the short term would have to be on the basis of longer term improvement in consumer satisfaction given there will not be any tangible immediate cash benefit to any sector of the supply chain.*

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9 Appendix

9.1 Summary of comparisons between Gen 1 and Gen 2 technology

GEN 2 (SMARTSTIM) **PRIMARYCLAIM**

- Proposed to control the rate of pH decline across carcases in a population, thereby reducing variation in temperature at pH 6.0 resulting in improved eating quality

GEN 2 (SMARTSTIM) **DOES NOT**

- Improve tenderness of meat beyond its original aged potential
- Prevent dark cutting meat from occurring
- Improve colour stability beyond meats natural potential
- Does not do anything different to conventional stimulation except control the dose (Tailoring stimulation dose minimises the negative impacts on meat of over or under stimulation in order to optimise the beneficial outcomes)

GEN 2 (SMARTSTIM) **INTEGRATION WITH MSA**

Given stimulation and SmartStim only controls the rate of pH decline, stimulation should not be included in the MSA model as an effect. However:

- If it was proven that specific pH decline rates within the MSA pH/temp window produce different eating quality then intervention technologies enabling the optimum declines to be achieved could be accredited to provide carcase by carcase monitoring/control of pH declines in line with new eating quality parameters.
- If SmartStim was proven to deliver tight control of decline and the impact on eating quality was significant, considering SmartStim as an intervention tool may be of value.
- Significant validation research would be required for this to occur.