AUSTRALIAN MEAT PROCESSOR CORPORATION

Milestone 2C: Value opportunity for improving beef colour at grading

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Date Submitted:	27 April 2015
Date Published:	27 April 2015
Published by:	Australian Meat Processor Corporation Limited

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1. Introduction

This project forms part of a larger research and development project that looks to research and eventually commercialise a technology for beef colour grading. The colour of beef at grading is one of the criteria that determine the value of a carcass. Beef carcasses can be downgraded because the striploin is too dark or has a high ultimate pH (refer Fig 1). Electrical stimulation (ES) can be used to increase the number of carcasses with 'ideal' colour scores (colour score <4) but application of ES can also result in deterioration in other quality traits such as sensory appeal. Research on meat colour has focused on reducing ultimate pH, through increased muscle glycogen, and also on using electrical stimulation. Although early research showed that muscle structure has a role in determining beef colour at grading, there has been little recent research. Using a novel microscopy technique, the project team has recent evidence for the role of muscle structure in determining beef colour.

Figure 1: Rib-eye steaks with darker, higher pH vs bright coloured, normal pH (5.5)

2. Objectives

The objective of the current work is to perform a cost benefit analysis of technology interventions in relation to the potential market application in order to determine the commercial viability. Specifically the project intends to:

- Understand the role of muscle structure in determining beef meat colour and
- Investigate strategies to manipulate muscle structure to improve muscle colour, through pre- or post-rigor interventions,
- Quantify the value of loss to the Australian beef industry by cattle type to establish the value opportunity
- In conjunction with the researchers, identify the share of the target market that the technology could influence
- Apply estimations of value improvement to relevant cuts and cattle types and season based on technology affect to establish likely value increase
- Develop a model that can be used to manipulate the data for sensitivity analysis to support ongoing commercialisation pathway decisions for the technology researchers

3. Methodology

Australian beef industry data collected has been used to inform a cost benefit model and analysis of the novel technology. However as the system is still currently being researched and developed, specific plant costs and benefits will need to be input by CSIRO in consultation with processors looking to uptake the new technology.

A wide range of market analysis data was made available by the client and in collaboration with MLA and MSA grading results. Most of the raw grading data was already available and easily obtained, the main work was in breaking down whole carcase grading data to the values for specific cuts affected by the grading results.

Beyond this carcase value analysis the model addressed the specific capabilities and constraints of the technology, now and in its "hoped" state. This accounts for factors like the number of different cattle types impacted by the technology and impact across the cuts in a carcase as well as the effectiveness of the interventions across these variables. Parameters for further development will need to be considered including, commercialisation, installation and commercial operation costs and relative to value generated.

Factors the model comparatively reviews include:

- Quality and Shelf Life
- Market access
- Yield implications
- Potential Labour Savings on plant
- OH&S implications
- Capital and installation costs, foot print required
- Economic Impact
- Reliability
- Maintenance Costs

The value proposition will be applied to Australian plant situations in the form of a cost benefit model that can be used to communicate the value of commercialising the technology for the Australian beef industry including the difference in value received for processors and for live cattle suppliers.

Main components of the model are:

- Costs and benefits associated with dark cutters in Australia. The method included the following
    - Obtain the occurrence of dark cutters when compared to pH in the industry.
    - Obtain values associated with dark cutters for processors and producers. Details below:
        I. Processors, the cost for each animal type was obtained from a number of sources to identify the value lost on a primal per primal basis. These values can be changed as required in the cuts sheet.

The value and weight of these cuts was then multiplied by the percentage of dark cutters in the data set obtained from AMPC.

II. A number of industry processing grids have been reviewed to assess the cost per colour score discounts imposed to producers due to dark cutters. The value per dark cutter was then multiplied by the occurrence rate of dark cutters to provide an estimated value per head processed. The cost to producers was also coupled with the percentage of animals sold on a live weight basis for processing (sale yards etc.). This provided the value per head sold by the processors.

- The final process was to identify the percentage of each animal type processed in Australia to ensure that an average value across industry was identified. Section 4.3 shows the total value of dark cutters to processors and producers.
- The discount costs for primal's and grades have been included as an input cell and thus can be changed as required during site visits.

- In addition to the changes in colour grade the following factors have also been included:
  - Variation in drip loss
  - Increased or decreased rate of heat toughening
  - Increased rate of MSA grading
  - Effect on eating quality
  - Discounting due to decreased colour stability
  - Value of additional market access
  - Reduced aging costs
- Additional operating and maintenance costs associated with the systems
  - The operating costs which can be manipulated by the user are as follows:
    - Cost of treatment to either carcases or primal affected dark cutters
    - Additional staff requirements including overhead costs, staff rate per hour, training and WH & S costs associated with increased or decreased staff requirements
    - Maintenance costs of the system
    - The costs of building chiller space if carcases need to be chilled for longer
- Cost of system which would allow for a reduction in occurrence of dark cutters in the industry
  - The cost of the system to industry has been calculated by the user electing the payback period required. This payback period then calculates the required system cost, with the incorporation of the value created and the costs associated with operating the system.

4. Dark colour meat cost benefit analysis model

This section of the report details the cells which can be manipulated by the user throughout the model to support ongoing commercialisation pathway decisions for technology researchers. For the purpose of this report, MSA industry data has been used to populate the

model. It is important to note however, that specific plant costs and benefits will need to be input by CSIRO in consultation with processors looking to uptake the new technology.

In summary, the dark colour meat costs benefit analysis model contains the following sheets:

Results sheet (yellow tabs)	Summary – Overall Model ES results Calculations
Meat colour input sheets (blue tabs)	Inputs Primal discounts Colour benefit
Plant operational input sheets (green tabs)	Chiller Costs Calculations – Labour and Throughput Constant- Equipment costs Constants-Plant Specifics

Sections 5 to 8 of the report provides the user with specific step by step instructions on how to correctly complete the model. In turn, the results can then be used to communicate the cost benefit value of commercialising the technology for the Australian beef industry at a plant level including the difference in value received for processors and for live cattle suppliers.

Table 1 shows the cells in the model which can be manipulated by the user to affect the final result produced through the model.

Table 1: Model input cells

KEY
Plant Specific INPUT (Adjustable)
Industry Wide INPUT (Adjustable)
Calculation do not change
Model Results

The following list of key tables in the report and their corresponding tabs in the model are the main areas where manipulating the data will alter the results for changing the colour score (Table 2):

Table 2: Key tables displayed in the report to change colour score results

Table in Report	Model Sheet	Cell Reference
Table 16	Colour Benefit	C6 to K18
Table 18	Inputs	K4 to AA23
Table 15	Primal Discounts	C2 to AI33
Table 5	Summary-overall Model	D28 to F35
Table 13	Inputs	K25 to M27
Table 14	Inputs	K29 to M37

5. Results sheets (yellow tabs in the model)

This section of the model is made up of three sheets including summary overall model, ES results and calculations. Results here are calculated by manipulating the data in the meat colour and plant operational input sheets in the model. Upon completion, the user is provided with the value proposition and return on investment (ROI) as it relates to the dark cutting technology in question.

5.1.Summary – Overall model

The purpose of table 3 is to provide the user with an overall cost benefit summary position as it relates to the investment into the dark cutting technology in question. It is important to note that the main take away of this table is to provide the user with the return on investment (ROI) from a fixed capital cost which considers operational costs, capital costs and associated value benefits. Points to consider include:

- 2 year payback is in most cases the accepted period by industry
- This may increase or decrease depending on significance the plant sees the cost of dark cutters being to their business

In this case, the following conclusions can be drawn from table 3:

- If the capital cost of the dark cutting system was $4,856,778;
- The expected payback period would be 0.97 years;
- With the expected NPV of the system to be $33,223,552

Table 3: Summary of benefits for the development of the Dark cutting system

SUMMARY PERFORMANCE MEASURES	
	Dark Colour Meat System
Hd / annum	8,360,000
Total Cost of Dark Cutters - Processors	$31,492,015
Total Cost of Dark Cutters - Producers	$12,031,965
Production increase with equipment	0.00%
	Avg.
Capital cost (pmt option, upfront)	$4,856,778
Gross return per head	$0.65
Total Costs per head	$0.11
Net Benefit per head	$0.54
Annual Net Benefit for the plant	$ 4,511,429
Annual Net Benefit for the ex cap	$ 4,997,107
Pay back (years)	0.97
Net Present Value of investment	$33,223,552

Note the capital costs shown in Table 3 are calculated using the number of cattle processed shown in Table 4. To allow the user to model different sized processors as well as customise the results to the plant in question, the figures highlighted in this table can be modified by manipulating the data in the constants – plants specific tab (refer table 22).

Table 4: Calculations used for determining production volume base line

Operation speeds		
	Current	Dark Colour Meat System
Carcases / min	38.19	38.19
Carcases / Statn./hr	2292	2292
Carcases / day	34833	34833
Annual days	240	240
Annual # of hd	8,360,000	8,360,000

The model drivers shown in Table 5 again have an impact the values produced in the Summary-overall results sheet. Here the user is required to input the following data:

1. **Equipment life:** the value input into this cell will impact the cost per year over the life of the system
2. **Chiller life:** the value input into this cell will impact the cost per year for the installation of additional chiller capacity
3. **Discount rate:** the interest rate paid on the total investment of the system
4. **Whole Industry:** when "Yes" is entered into this cell the model is programed to model on an industry basis but when "No" is entered the model calculates the results on a plant specific basis
5. **Plant hd/annum:** is the number of animals processed per year by an individual plant
6. **Additional chiller capacity**: indicates if the processing plants chiller capacity is at capacity and additional chillers will be required for longer chilling periods
7. **Max number of dark cutters per day:** this drives the total area of additional chiller capacity required to chill dark cutters for longer

Table 5: Model selection drivers and assumptions

Model Drivers	
Equipment Life	10 Years
Chiller Life	20 Years
Discount Rate	7%
Whole Industry (Yes) or Plant (No)	Yes
Plant hd/annum	200,000
Additional Chiller Capacity Required	Yes
Max number of dark cutters per day	

The inclusion of Table 6 into the model was to allow the user to identify the capital cost expenditure plants are willing to spend as a result of the return on investment. Manipulating

the payback cell highlighted in Table 6 (blue circle) to reflect the plants desired payback period, will consequently alter the capital investment costs.

In this case, using industry MSA data, to ensure a payback of 2 years, the maximum capital cost of the dark colour technology would need to be no more than $10,843,565.

Table 6: Capital expenditure calculator as a result of the required Return on Investment

Capital Cost (ROI What-if Calculator)	
Capital cost - Calculated	$10,843,565
Gross return per head	$0.65
Total Costs per head	$0.18
Net Benefit per head	$0.54
Annual Net Benefit for the plant	$ 4,511,429
Annual Net Benefit for the ex cap	$ 5,421,782
Payback (years)	2.00

Information displayed in Table 7 and Figure 2 is drawn from the values manipulated in the calculations sheet discussed in section 5.3. Key purpose of Table 7 is to provide the user with the value of opportunity to decreases the occurrence of dark cutters in their plants. The benefit shown here is an average benefit which could be experienced by industry but will dramatically affected by the plants location.

The key area to consider in Table 7 is that the negative producer benefit. This is a result of the processor now having to pay producers an increased value due to the reduced number of dark cutters being processed. The percentage of animals purchased through live weight sales is absorbed by the processor.

In contrast, processors will benefit as a result of decreasing the occurrence of dark cutters. However it is important to note that associated benefits will vary depending on the type of dark cutting system implemented. For example:

- Where procedures are conducted post grading such as primal injections, the value to the processor would be higher however there will limited value created up the supply chain.
- In comparison, where procedures are completed prior to grading there will be benefit obtained by both the producer and processor.

Table 7: Benefits and Costs associated with the installation of the dark colour meat system

TOTAL BENEFIT		
		Dark Colour Meat System
Processors Benefits Summary		$/hd From
1.1 Colour Benefit	Producer Benefit	-$0.59
	Processor Benefit	$1.24
1.2 Other Benefits		$0.00
2. Throughput Benefit		$0.00
3. OH&S Benefit		$0.00
4. Labour Benefit		$0.00
Equipment Benefit	**Maintenance**	$0.00
	Operation	-$0.05
	Risk of failure	$0.00
	$ Benefit per head	**$0.60**
$ Annual Benefit overall plant		**$4,997,107**

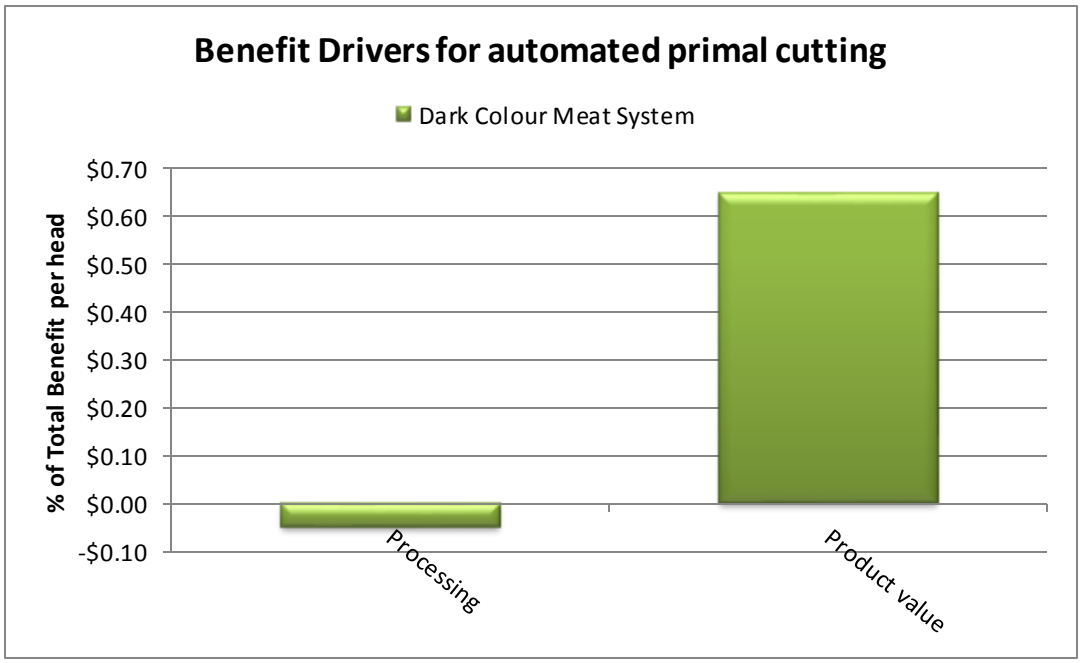

Figure 2: Broad grouping of benefits delivered by the Dark colour meat system , industry Average.

5.2.ES results

Table 8 highlights areas of opportunity which could either add or reduce value to processors as an effect of additional treatment options. These areas have been limited to low values currently as the system has not been developed. In this instance for example, the technology in question has no impact on the ageing time. The inputs sheet in the model (discussed in section 6.1) allows the user to manipulate values between the current system and any

proposed dark colour meat systems to identify where the most value for the producer, processor of through sales can be developed. Each line item in the table below has a separate set of calculations which feeds into this summary table. Refer to appendix 10.1 for a complete list of these benefit input tables.

Table 8: Value and costs associated with the development of a system to reduce the occurrence of dark cutters

Benefits	Current				Dark Colour Meat System			
Primary value benefits	Producer	Processor	Sales	Total	Producer	Processor	Sales	Total
Increase MSA compliance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Increase eating quality - MSA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Increase eating quality - NON MSA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Reduce Purge	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Decreased ageing time	$ -	$ 0.80	$ -	$ 0.80	$ -	$ 0.80	$ -	$ 0.80
Improved meat colour grade	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Colour stability - Less markdowns	NA	NA	-$ 0.42	-$ 0.42	NA	NA	-$ 0.42	-$ 0.42
Total primary	$0.00	$0.80	-$0.42	$0.38	$0.00	$0.80	-$0.42	$0.38
Possible secondary value benefits								
Reduce carcase grading costs	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Market access	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total secondary	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
NET BENEFIT					$ -	$ -	$ -	$ -

5.3. Calculations

The values presented in Table 9 is the benefit the processing sector would experience if they were to invest in dark colour meat system to reduce the occurrence of dark cutters. Note this is a results sheet not an input sheet. Rather, the values entered in Table 15 (primal discount sheet discussed in section 6.2) will affect the results in the below Table 9. The following is a brief explanation of each section of the table.

- **Total carcases graded:** total number of animals in the data set provided by MSA
- **Carcase value:** cost per carcase to the producer for dark cutters
- **Number of hd affected:** total number of animals who's meat colour improved
- **Total cost to industry:** the total benefit for the improvement in meat colour of all animals in the data set
- **Cost per hd:** cost per head across the population of animals processed
- **Percentage of each class of animal**: percentage of animals processed
- **Average Industry cost:** cost per head for total industry

Table 9: Economic benefit to the industry through reducing the occurrence of dark cutters to processors

Net Benefit of Improving Colour Grades - Processor								
	Grainfed animal	Y to PR grassfed animal	Prime beef - Grassfed	Cow	Additional Animal type 1	Additional Animal type 2	Additional Animal type 3	Additional Animal type 4
TOTAL carcases graded (MC 1A - 7)	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055
Carcase value increase ($/hd)	$ 78.73	$ 59.04	$ 68.88	$ 49.20	$ -	$ -	$ -	$ -
Number of hd affected	47,661	85,770	25,460	12,077	41,157	41,157	21,432	10,366
Total cost	$ 3,752,118	$ 5,064,161	$ 1,753,764	$ 594,202	$ -	$ -	$ -	$ -
Cost per hd	$ 1.99	$ 2.68	$ 0.93	$ 0.31	$ -	$ -	$ -	$ -
Perentage of each class of animal	10%	27%	20%	43%	0%	0%	0%	0%
Average industry cost/hd	$0.20	$0.72	$0.19	$0.14	$0.00	$0.00	$0.00	$0.00
							Net Benefit per hd	$1.24
							Total cost to industry	$ 10,394,577
							Total animals processed in Australia in 2013	8,360,000

The rows in Table 10 use the same methodology as explained above, however they highlight the value opportunity as it relates to the producer.

Table 10: Economic benefit to the industry through reducing the occurrence of dark cutters to producers

Net Benefit of Improving Colour Grades - Producer								
	Grainfed animal	Y to PR grassfed animal	Prime beef - Grassfed	Cow	Additional Animal type 1	Additional Animal type 2	Additional Animal type 3	Additional Animal type 4
TOTAL carcases graded (MC 1A - 7)	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055	1,889,055
Value to producer of reduced dark cutters	$ 32.00	$ 105.77	$ 64.00	$ 32.00	$ -	$ -	$ -	$ 32.00
Number of hd affected	47,661	85,770	25,460	12,077	41,157	41,157	21,432	10,366
Total cost	$ 1,525,152	$ 9,071,848	$ 1,629,408	$ 386,448	$ -	$ -	$ -	$ 331,702
Cost per hd	$ 0.81	$ 4.80	$ 0.86	$ 0.20	$ -	$ -	$ -	$ 0.18
Perentage of each class of animal	10%	27%	20%	43%	0%	0%	0%	0%
Average industry cost/hd	$0.03	$0.47	$0.06	$0.03	$0.00	$0.00	$0.00	$0.00
							Net Benefit per hd	$0.59
							Total animals processed in Australia in 2013	8,360,000
							Total cost to industry	$ 4,972,794

6. Meat colour input sheets (blue tabs in the model)

This section of the model is made up of three sheets including inputs, primal discount and colour benefit. Upon completion, the user is provided with the cost benefit analysis as it relates to the dark cutting technology in question.

6.1. Inputs

As discussed previously in section 5.2, data input in the following tables directly impacts the values displayed in the ES results sheet.

The treatment costs section of the model allows the user to identify the costs associated with treating either carcases or primals. To do so the user is required to input data into the following cells as it relates to the plant in question:

- The cost of the injectable per litre and volume of injection per carcase. As a result of the treatments applied to carcases, an increase in the plants operating costs will be evident.
- The entire kill treated cell will prorate the cost to either the entire kill or ONLY the dark cutters within the processing facility

- In this case, the total cost/hd increase for the processor as a result of the treatment associated with the implementation of a dark colour meat system is $0.05.

Table 11: Treatment costs for dark cutters or entire kill

Treatment Costs		
	Dark Colour Meat System	
Cost of injectable per litre	$5.0	
Volume of injection per carcase	0.50	
Entire kill treated (Yes or No)	No	
Number of head treated	169,092	
Total Cost/hd increase - Processor	$	0.05

The input cells in the above Table 12 affect the cost of grading associated with the development on a new technology. Currently the table is set to 0% increase in workload for the grader. However if the new system requires carcases to have an additional grader taken, for example a second colour score, the cell circled in black will need to be modified accordingly.

If the grader had an additional 10% workload due to the change in process. This cell could need to be set to 10% causing an increase in cost per head to be shown in the cell highlighted in blue.

Table 12: Reduction in grading costs associated with grading additional animals

Reduced MSA Grading Costs		
	Current	Dark Colour Meat System
Grading	0.00%	0.00%
Full time equivalent labour cost	$65,000	
Labour saved	$0.0	$0
Total $/hd increase - Processor	$ -	$0.00

The assumptions shown in Table 13 dictate the opportunity to the Australian Beef Industry of dark cutters and the cost of dark cutters to the producers and processors due to the percentage of cattle graded using the MSA grading system.

The input cells in the below table in the model requires the following data:

- Number of carcasses processed in Australia in 2013 – in this case 8,360,000
- Percentage of MSA graded cattle – in this case 23% of animals processed were MSA graded for colour.
- Further, using this example, the processor could then pass on 23% of the cost of dark cutters to the producer. In contrast however, if carcasses weren't MSA graded, the cost of dark cutters would fall to the processor.

Table 13: Assumptions used to calculate the cost of dark cutters to the industry

Assumptions	
Number processed in Australia in 2013 *	8,360,000
Percentage of MSA graded cattle **	36%

* McRae & Thomas (2014), ** Meat Standards Australia (2014)

Table 14 requires the user to input the average carcase weights of each animal type. In turn, data input here will directly impact on the values displayed in the ES results sheet and the value per carcase for the processor.

Table 14: Average carcase weights for each class of animal

Animal Type	Average Carcase Weight
Grainfed animal	320
Y to PR grassfed animal	240
Prime beef - Grassfed	280
Cow	200
Additional Animal type 1	
Additional Animal type 2	
Additional Animal type 3	
Additional Animal type 4	

6.2. Primal discounts

The key to Table 15 is to ensure that all price discounts are included to highlight the lost value associated with each downgraded dark colour primal. Note, the colour grade in the blue cells will automatically adjust as the meat colour in the Table 18 is manipulated.

Table 15: Discounts imposed per primal to processors due to colour scores

Primal Discounts ($/kg)																
	Grainfed animal				Y to PR grassfed animal				Prime beef - Grassfed				Cow			
	Colour Change Discounts				Colour Change Discounts				Colour Change Discounts				Colour Change Discounts			
Primals	4 to 3	-	-	-	7 to 3	6 to 3	5 to 3	4 to 3	5 to 4	-	-	-	6 to 5	-	-	-
TENDERLOIN S/OFF	$4.00				$4.00	$4.00	$4.00	$4.00	$4.00				$4.00			
CUBE ROLL	$4.00				$4.00	$4.00	$4.00	$4.00	$4.00				$4.00			
STRIPLOIN 1 RIB	$1.50				$1.50	$1.50	$1.50	$1.50	$1.50				$1.50			
SHORT RIB (4 RIB)																
TOP RIBS INTERCOSTALS																
BOTTOM RIB INTERCOSTALS																
BRISKET INTERCOSTALS																
FLANK STEAK																
FLANK PLATE (Intermedius Adom.)																
D-RUMP (From full rump)	$0.50				$0.50	$0.50	$0.50	$0.50	$0.50				$0.50			
INSIDE/TOPSIDE	$0.30				$0.30	$0.30	$0.30	$0.30	$0.30				$0.30			
BRISKET SKIRT (Transverse)																
1 RIB NE BRISKET																
CHUCK ROLL 5 RIB																
TRI TIP																
NE BRISKET																
OUTSIDE																
CHUCK TENDER																
KNUCKLE	$0.50				$0.50	$0.50	$0.50	$0.50	$0.50				$0.50			
PE BRISKET DECKLE ON																
BONE OUT BLADE/CLOD																
CONICAL MUSCLE																
BACK RIBS																
FQ SHIN MEAT																
SHIN																
HEEL MUSCLE																

Please note that this table contains 8 animal types in the model and has just been reduced in size for reporting purposes.

6.3. Colour benefits

Displayed in Figure 3 are the distribution meat colour scores, percentage of carcasses graded and the correlation with pH at time of grading. The data collected from MSA graded meat currently accounts for anything with a pH less than 6 at the time the readings were taken. Note, data input in Table 16 in the colour benefits sheet of the model will correlate to this graph.

Depicted in Figure 3:-

- Carcasses with <5.67 pH achieved the optimum MSA grade of between 1A and 3
- Slightly decreased at pH levels between 5.67 and 5.7, still with a MSA grading of 1A and 3
- Non-compliant pH levels of above 5.71 graded all above 4 on the MSA meat colour graded table.

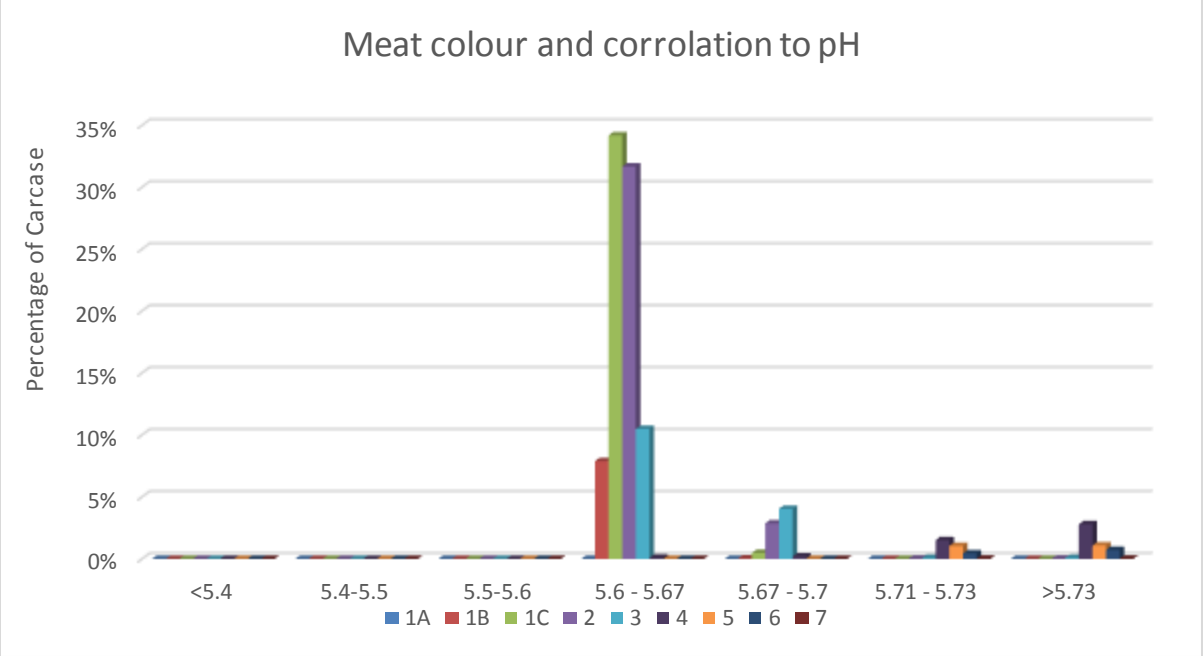

Figure 3: Distribution of animals processed in Australia during 2013, showing the correlation between Meat colour grade and pH

The full summary of all data obtained from MSA graded plants is detailed in Table 16. We received 12 months of data taken in 2013, from across Northern and Southern plants.

The summary shows that pH compliant carcasses of 5.7 or less are much more likely to have a meat grading of 1A to 3, whereas any animal's that had meat colour grading of 4 or greater had pH levels of 5.71 or higher. As a result of the findings any system to be developed should look to target pH level less than 5.67.

If the plant in question has commercial grading data, this would be input into Table 16 in the colour benefit sheet of the model.

Table 16: Number of animals by pH and meat colour processed during 2013

Overall Summary								
Meat colour	pH compliant					non pH compliant		
	<5.4	5.4-5.5	5.5-5.6	5.6 - 5.67	5.67 - 5.7	5.71 - 5.73	>5.73	N
1A				11	3	4	4	22
1B				149,210	814	8	20	150,052
1C				645,944	9,204	89	112	655,349
2				598,409	54,416	371	438	653,634
3				198,394	76,510	1,491	1,739	278,134
4				1,855	3,804	28,716	53,144	87,519
5				146	239	19,900	20,698	40,983
6				66	74	8,480	13,826	22,446
7				1	-	457	458	916
Total	-	-	-	1,594,036	145,064	59,516	90,439	1,889,055

The economic cost of grain fed dark cutters can be seen quantified in Table 17 calculates the number of animals whose colour scores will be decreased as a result of the new intervention method. This table calculates the number of grain fed animals which will have a decrease in colour grade from 4 to 3 as a result of the values entered in Table 18. There are 8 tables identical to this sheet for each of the animal types in the colour benefits sheet.

The main values which are used from this table are as follows:

- The cell highlighted by the black circle is the total number of animals which could have their meat colour ungraded as a result of parameters entered in Table 18
- The value per year should be the red circle is the estimated increase in value for this group of animals as a result of the intervention methods.

Table 17: Calculation of the number of carcases which colour grade could be changed and the economic impact on processors

Grainfed animal						
pH	Percentage changed from 4 to 3	Number of head in each meat colour				Number of hd
	From					To
Meat colour change	4	4	0	0	0	3
<5.4	100%	-	-	-	-	-
5.4-5.5	100%	-	-	-	-	-
5.5-5.6	100%	-	-	-	-	-
5.6 - 5.67	100%	1,855	-	-	-	1,855
5.67 - 5.7	100%	3,804	-	-	-	3,804
5.71 - 5.73	100%	28,716	-	-	-	28,716
>5.73	25%	13,286	-	-	-	13,286
Grand Total	3%	3%	0%	0%	0%	47,661

TOTAL carcases graded (MC 1A - 7)	1,889,055
Conversion factor within MC 4	2.5%
Conversion factor - Total Graded	2.52%

	$/head	$/year
Carcase value converting meat colour	$ 79	$ 3,752,118

Please note that the model contains 8 animal type result tables identical to Table 17 above. For the purpose of this report however only the Grainfed animal type table has been included. Refer to model for additional tables.

The values which can be manipulated to change the value opportunity and percentage change are shown in Table 18 of colour benefit sheet. This table contains four distinct sections which will vary the value of different dark colour meat systems being considered for development. They are as follows:

- **Meat colour change section (blue circle)**
  - The "From" and "To" values in this row need to be changed for each animal type. This will allow the user to identify the number of dark cutters affected as a result of the new dark colour meat systems ability to change the meat colour.
- **Percentage of types of animals (red circle)**
  - This will vary the percentage of each type of animal processed in turn affecting the value created
  - The high the quality of animals processed the greater the value to the processors for decreasing dark cutters will be.
  - The current values have been calculated using the following references:
    - ABS statistics

- **Percentage of animal's meat colour improves as a result of pH (purple circle)**
  - The seven input cells for each animal type will in turn manipulate the total number of animal's colour which will have an in meat colour score of different ultimate pH parameters.
  - These values will impact the number of animals which will be affected by the new system. As can be seen in this table 100% animals with a pH below 5.73 will have a decrease in meat colour score. However only 25% of animals with a pH greater than 5.73 will have a decrease in meat colour score.
- **Grid discounts for producers (black circle)**
  - The values in these cells impact on the opportunity to producers selling MSA graded cattle. These discounts are grid discounts which have been imposed to producers in the last 2 years.
  - These cells will impact the costs imposed to the producer and recovery of costs for the processor.
  - These cells are driving the values for the producer displayed in Table 7.
  - Where the value is displayed as $0.00 there are no grid discounts imposed for that particular colour score.

Table 18: Improvement of colour grades and cost to producers due to dark cutters

Animal Type								
	Grainfed animal		Y to PR grassfed animal		Prime beef - Grassfed		Cow	
Meat colour change	From	To	From	To	From	To	From	To
	4	3	7	3	5	4	6	5
Percentage of Population	10%		27%		20%		43%	
pH	Percetage changed from 4 to 3	Number of hd	Percetage changed from 4 to 3	Number of hd	Percetage changed from 4 to 3	Number of hd	Percetage changed from 4 to 3	Number of hd
5.3 -5.4	100%	-	100%	-	100%	-	100%	-
5.4-5.5	100%	-	100%	-	100%	-	100%	-
5.5-5.6	100%	-	100%	-	100%	-	100%	-
5.6 - 5.67	100%	1,855	100%	2,068	100%	146	100%	66
5.67 - 5.7	100%	3,804	100%	4,117	100%	239	100%	74
5.71 - 5.73	100%	28,716	100%	57,553	100%	19,900	100%	8,480
>5.73	25%	13,286	25%	22,032	25%	5,175	25%	3,457
Grand Total		47,661		85,770		25,460		12,077
Grid Discounts - Producers								
Meat Colour Grade	$/kg		$/kg		$/kg		$/kg	
4	$0.10		$0.10		$0.05		$0.00	
5	$0.60		$0.60		$0.20		$0.00	
6	$0.65		$0.65		$0.40		$0.10	
7	$0.80		$0.80		$0.40		$0.10	

Please note that this table contains 8 animal types in the Model and has just been reduced in size for reporting purposes.

7. Plant operational input sheets (green tabs in the model)

This section of the model is made up of four sheets including chiller costs, calculations – labour and throughput, constants equipment costs and constants plant specific. The data input into these sheet will drive the operational costs and plant benefit. These drivers allow the model to correctly calculate the return on investment (ROI) as it relates to the dark cutting technology in question.

7.1. Chiller costs

Table 19 in the chiller costs sheet of the model allows the user to identify the costs associated with increasing chiller space if carcases are to be chilled for longer. The reason for this inclusion is that most processing facilities have very limited opportunities to increase the time carcases are chilled for due to a limited chiller capacity.

In order for the user to calculate the additional cost per head processed Table 19 below requires the following input cells to be completed:

- **Number of chillers:** is the total number of additional chillers required if dark cutters are going to be held for longer in the chiller
- **Cycles/day:** is the number of carcase rotations per chiller per day. e.g. where carcases are left in the chiller for 24 hours the cycle/day will be 1 however is they are held for 12 hours there cycles could be 2/days
- **Chiller costs/m²:** the costs of building a square meter of chiller capacity

Table 19 allows the user to calculate the costs associated with an increase in chiller space if the intervention method requires carcases to be held for a longer period. The results displayed in the table are as follows (from the bottom of the table):

1. **Additional cost /head processed**: highlights the average costs per hd for all animal processed as a result of dark cutters being held for longer in the chiller. This cost is carried through to the capital costs model
2. **Annual depreciation:** annual depreciation of the new chiller space
3. **Annual capital costs:** the costs of the chiller per year over the number of year specified in the Summary Overall model sheet
4. **Interest rate:** is the interest rate imposed onto the costs as a result of paying off the capital costs over the life of the chiller
5. **Capital costs:** is the total capital cost investment required by the plant to hold carcases for longer

Table 19: Infrastructure and operating costs of additional chillers (Chiller Space Calculated from: (FAO, Unknown)

Chiller capital/head	Dark Colour Meat System
Number of chillers	1.0
Carcases/chiller	2,800
Cycles/day	1.0
Throughput (hd/day)	2800
Chiller cost/m2	$ 1,850
M2/chiller	2625
Capital Cost	$ 4,856,778
Interest rate	7%
Annual capital cost	$ 339,974
Annual Depreciation (20 years)	$ 242,839
Additional cost per hd processed	$ 0.58

7.2. Calculations – Labour and throughput

The labour and throughput sheet illustrated in Table 20 has been designed to demonstrate the costs associated with additional labour units. The three components of this table that requires the user to input data include:

- Salary paid to employees (rate/hour)
- Overhead costs associated with employing staff
- Cost of recruitment and training staff due to turnover

The reason that there has been 1 labour unit included currently is that the number of staff in individual processing facilities varies dramatically. The main reason that this has been included is to demonstrate increased costs where applicable.

Table 20: Labour requirements to operate dark colour meat system

Increased throughput through the room			Current	Dark Colour Meat System
Average daily hd			34833	34833
Hd/annum			8,360,000	8,360,000
Average kg			265.00	265.00
Total Kg boned per day			9,230,833	9,230,833
Boning room cost / hour			$47	$47
Boning room cost / day			$718	$718
Labour cost \ per kg to bone			$0.00	$0.00
Labour cost \ per hd to bone			$0.02	$0.02
Labour productivity savings/ head			**$0.00**	**$0.00**
Task	**Rate / hour**	**WW Loading** 35.00%	**Number labour units per shift - Manual Process (Note - this is gross of labour savings - based on No. of**	
Supervisor	$35.00	$47.25	1	1
QA	$31.00	$41.85		
Admin	$24.00	$32.40		
Band Saw operator	$26.23	$35.41		
Ticketing	$23.10	$31.19		
Knife hand	$23.10	$31.19		
Trimmers	$23.10	$31.19		
Packer	$23.10	$31.19		
General Labour	$23.10	$31.19		
Maintenance	$19.00	$25.65		
Chiller - Carcase pushing	$16.92	$22.84		
AQIS	$22.11	$29.84		
Rail Boy	$16.92	$22.85		
		$0.00		
Total FTE's required			1.0	1.0

7.3. Constant – Equipment costs

Table 21 is used to modify the following equipment, operating and maintenance costs:

- Operational costs such as:
  - Energy consumption of the system
  - Additional training required to be given to current staff to use the system
  - Service contracts for the manufacture to install additional updates or consumables
- Maintenance cost include:
  - Upkeep of the system
  - Replacement parts
  - System overall to extend working life etc.
- The working life of the new system in the top right of the table will affect the total value which can be achieved. As the working life of the system decreases the costs per head will increase and the longer a system can operate the more animals the system will be able to process.

Table 21: Equipment, Operating and Maintenance Costs

Capital Cost	Current		Dark Colour Meat	
	Cost	Life span	Cost	Life span
Capital Cost of the equipment				10
Chiller costs			$4,856,778	10
Other Capital install				10
Total			**$4,856,778**	
Service maintenance	**Current**		**Dark Colour Meat**	
	Units	Cost	Units	Cost
Estimated - COSTS				
Electricity	2.00 KW	$0.22 /KWH	2.00 KW	$0.22 /KWH
Maintenance labour (Daily)		0.00 /Yr		0.00 /Yr
Maintenance labour (Preventative)		0.00 /Yr		0.00 /Yr
Maintenance labour (Breakdown)		0.00 /Yr		0.00 /Yr
Maintenance labour (Training)		0.00 /Yr		0.00 /Yr
Operational		**$1,605**		**$1,605**
Maintenance		**$0**		**$0**
Annual Sub Total		**$1,605**		**$1,605**
Major maintenance	**Current**		**Dark Colour Meat**	
	Total	Life span	Total	Life span
Upgrade electronics				
System overhaul				
Other				
Sub Total: Operating Expense				
Combined Total: (cap ex + operating)				
Total Annual Estimated Expenses	**Hours**	**Cost**	**Hours**	**Cost**
Expected downtime hours per year	0	0.00 /Yr	7	340.20 /Yr

7.4. Constants – Plant specifics

Table 23 provides the processing statistics for the model. As can be seen throughout the report the costs and benefits have all been calculated at a per head basis. This table allows the user to manipulate the total benefits and costs to be either plant specific or at an industry level.

The top three rows of the table are calculated from the Summary Overall model (Table 5) which drives the overall model.

The next 12 rows allow the user to input the number of hours for each shift processed, which drives the costs to process animals. Normally plants will only have shift 1 and shift 2 as can be seen where the data is currently entered but every plants hours and shifts will vary.

The annual days of operation is the only other row in this table which needs attention as it calculates the number of head processed per day.

All these cells will affect the costs and benefits per head processed and should be changed in accordance with the specific plants processing rates.

Table 22: Plant specifics

Processing room operation speeds		
	Current	Dark Colour Meat System
Carcases / min	38.19	38.19
Carcases / Statn./hr	2292	2292
Room speed	2292	2292
Weekday Hrs / Shift 1	7.60	7.60
Weekday Hrs / Shift 1 - O'time	0.00	0.00
Weekday Hrs / Shift 2	7.60	7.60
Weekday Hrs / Shift 2 - O'time	0.00	0.00
Saturday Hrs / Shift 1	0.00	0.00
Saturday Hrs / Shift 1 - O'time	0.00	0.00
Saturday Hrs / Shift 2	0.00	0.00
Saturday Hrs / Shift 2 - O'time	0.00	0.00
Sunday Hrs / Shift 1	0.00	0.00
Sunday Hrs / Shift 1 - O'time	0.00	0.00
Sunday Hrs / Shift 2	0.00	0.00
Sunday Hrs / Shift 2 - O'time	0.00	0.00
Annual days	240	240
Days per week	5	5
Weeks per year	48	48
Shifts per week - standard	10	10
Shifts per week - overtime	0	0
Avg Shifts / day - standard	2	2
Avg Shifts / day - overtime	0	0
Weekly hours - standard	76	76
Weekly hours - overtime	0	0
Annual hours - standard	3648	3648
Annual hours - overtime	0	0
Avg Daily hours - standard	15	15
Avg Daily hours - overtime	0	0
Avg Shift hours - standard	8	8
Avg Shift hours - overtime	0	0
Carcases / day	34833	34833
Annual # of hd	8,360,000	8,360,000

8. Recommendations

- A system that could be developed to allow processors to decrease the occurrence of dark cutters would have a benefit to industry.
- There would be a considerable variation in the benefit to processors, as a result of season, location and transport distances.
- The occurrence of dark cutters could be decreased, however it would only affect a specific group of carcases and would not remove all dark cutters from industry

9. References

FAO, (Unknown). Manual on meat cold store operation and management from http://www.fao.org/docrep/004/t0098e/t0098e02.htm

McRae, T., & Thomas, B. (2014). Australia cattle Industry projections, 2014. *MLA, North Sydney*.

Meat Standards Australia. (2014). Meat Standards Australia Annual Outcomes Report, 2013-2014.

10.Appendix

10.1. Inputs Sheet – Input Tables

Table 23: Product specific drivers, affects the target marks for processors

Plant Specific Drivers			
ES hardware		Current	Dark Colour Meat System
Number of head per year being boned			8,360,000
% of total carcases for quality markets			100%
Number of head for chilled quality market			8,360,000
% of cuts being aged			100.00%
Percentage of systems working at any one time.		60%	60%

Table 24: Marketing value created by the addition of the new system

Marketing			
Secure improved markets to improve product pricing		Current	Dark Colour Meat System
Current market prices (Primals)			$828.53
Improved market access price premium			0%
Improved market access pricing ($/hd)			$0.00
Improved market access pricing ($/kg)			$0.00
% of product with improved market price (as % of total)			0%
Average increase in income/kg total slaughter			$0.00
Average increase in income/hd total slaughter			$0.00
Secure service kill contracts		Current	Dark Colour Meat System
Service kill contract secured - Slaughter/boning fee ($/hd)			$ 35.00
Service kill profit ($/hd)	5.0%		$ 1.75
Service Kill volume secured (hd/week)			0
Average increase in income/hd total slaughter			$0.00

Table 25: Effect of changing carcase attributes on the value of MSA graded cattle

MSA Grading			
		Current	Dark Colour Meat System
% Graded MSA		80%	80%
$/hd increase to PRODUCER achieving MSA	$0.01 /kg		$1.20
$/hd increase to PROCESSOR achieving MSA	$0.01 /kg		$1.20
$/hd increase to RETAIL/FOODSERVICE achieving MSA	$0.00 /kg		$0.00
Percentage of heavy beef carcases stimulated		0%	
Current % of livestock heat toughening		78.0%	
Current % of livestock cold shortening		0.0%	
Current % hitting MSA pH decline window		22%	22%
Improved % of livestock heat toughening		78.0%	78.0%
Improved % of livestock cold shortening		0.0%	0.0%
New % hitting MSA pH decline window		22.00%	22.00%
Improved compliance to MSA pH decline window		0.00%	0.00%
Increase in MSA grade value			
MSA grading costs		Current	Dark Colour Meat System
Grading % of role required for pH.		0.00%	0.00%
Full Time Equivalent labour cost		$65,000	
Labour saved		$0.0	$0.0

Table 26: Industry benefits of increasing eating quality for MSA graded cattle

Industry benefit from improved EQ - MSA		Current	Dark Colour Meat System
Current average MQ4 score (3 Star)		55	
New MQ4 score (3 Star)		55	55
Improvement in MQ4 score with optimised pH decline		0	0
3 Star market value (primal basis)		$12.00	
Current average MQ4 score (4 Star)		70	
4 Star market value (Primal basis)		$15.00	
MQ4 pricing differential		$3.00	
Industry value created through improved MQ4 score		$ -	$ -
Weighted industry value (% of time technology is effective)		$ -	$ -

Table 27: Industry benefits of increasing eating quality for non - MSA graded cattle

Industry benefit from improved EQ - Non MSA		Current	Dark Colour Meat System
Calculate Processor premium as % of MSA premium (Y/N)?		N	0%
Processor branded premium $/kg (MSA %)			$0.000
Processor branded premium (% on unbranded & primal $/kg)			$ 0.26
% of MSA premium			1376.5%
PROCESSOR branded premium ($/kg & $/hd)		$0.264 /kg	$33.14 /hd
Calculate Consumer premium as % of MSA premium (Y/N)?		N	4%
Consumer branded premium $/kg (% of MSA premium)			$0.000
Consumer branded premium $/kg (% of primal $/kg)		1%	$ 0.09
% of MSA premium			0.0%
CONSUMER branded premium ($/kg & $/hd)		$0.089 /kg	$11.19 /hd

Table 28: Additional processing costs and benefits associated the addition of the new system

Impact on Product			
Retail sales as % of total sales volume			60.00%
Improvement in colour stability		Current	Dark Colour Meat System
Current level of discounting at retail			8.00%
New level of discounting with ES		9.00%	9.00%
Amount price is discounted by			20.00%
Kg/carcase of cuts affected by colour			63.8
PROCESSING AID - Weekly audit costs		Current	Dark Colour Meat System
Auditing hours per week to ensure effective treatment	1.00		
Full Time Equivalent labour cost/hr & Cost/week	$28.50	$28.50	$0.00
New hours after automated monitoring		1.00	0.50
Labour saved annually		$0.0	$741.0
Labour saving/hd		$0.000	$0.000
PROCESSING AID - Reduced purge		Current	Dark Colour Meat System
Current Level of purge			3.00%
Reduced drip loss with treatment			3.00%
Current Level of purge w/ heat toughening			3.00%
PROCESSING AID - Reduced		Current	Dark Colour Meat System
Convert portion of carcases from cold to warm boning			0.00%

Table 29: Costs associated with aging meat for shorter or longer periods due to a variation in meat quality

Plants Costs			
Reduced aging storage		Current	Dark Colour Meat System
Cold Storage Costs (Pallet/week)		$12.00	
Kilograms/pallet		792	
Cold Storage $/kg/day		$0.002	
Current number of days storage		14	
New requirement for ageing		10	10
Saving		4	4

Table 30: Australia customer response to MSA grades and the corresponding affect the new system can have on meat quality

Australian consumer WTP responses for MSA grades (Sydney, Nov 2008 to Jan 2009)			
		Current	Dark Colour Meat System
Average $/Kg		$6.00	$12.00
$/Kg Diff to 3*		-$6.00	$0.00
% Diff to 3*		50.0%	0.0%
MQ4 Low		30	46
MQ4 High		45	63
2400 Consumers			
Consumer willingness to pay relative to MSA 3-Star		50%	
Points per grade		15.00	17.00