final report

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Beef Aitchbone and Knuckle Puller

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Executive Summary

Recent development of manual assist equipment for the semi-automation of hindquarter boning in beef has reached the final stages of commercialization. Analysis was conducted to observe the cost benefit to a plant already operating with the equipment installed on the boning room floor.

Benefits including yield gains, increasing the chain speed on the boning floor, a reduction in OH&S costs and benefits to the labour force related to a value gain of $5.17 per head. Increased costs and risk associated with the use of the equipment were calculated at $0.50 per head. This resulted in a net benefit of $4.65 per head. For a plant processing 269,000 carcasses per annum under these circumstances this resulted in a total gain of $1.22 million.

These results are specific to the plant that was surveyed and are not necessarily indicative of the gains that all most processing plants in Australia would expect to achieve. Plant specific benefits and costs have been highlighted where applicable.

Background

Northern Co-Operative Meat Company Ltd (NCMC) developed a conceptual design for a manual assist boning machine and with the assistance of Robotic Technologies (RTL) (as the engineering design developer) has delivered to industry a low cost and relatively simple hindquarter manual assist beef boning machine to assist boners in existing boning rooms to remove various leg cuts from the carcass. .
MLA assisted with partial R&D funding of the project.
The system has now been commercialised with a number of installations already in place in Australia and New Zealand.
Until this report no assessment of the cost benefits of the machine has been conducted, although the primary benefits of yield and reduced strain on the operator are obvious.
To assist in sales and further integration of the system into beef boning plants around the world, a detailed cost benefit analysis including calculations on return on investment, supported by factual evidence of these calculations is required.

Objectives

The objective of this work was to quantify the following benefits and costs of a manual assist system developed by NCMC and RTL installed in a commercial boning room.
Benefits

1. Increase in yield
2. Increase in the chain speed resulting in a reduction in boning labour
3. OH&S savings
4. Increase in the potential labour pool to fill the position

Costs - Risks:

1. Capital cost
2. Training
3. Cleaning
4. Maintenance
5. Risk of mechanical failure

6. Risk of mechanical injury to operators
7. Risk of mechanical damage to product

Methods

Early scoping work identified yield gains with the introduction of the new equipment onto the boning room floor as being the major component of this project work. The following methods section provides details on design of trials used to obtain yield data, and also on surveys conducted, and industry information sourced to quantify benefits and costs of the system.

Yield

Trials were conducted at the NCMC plant to determine the increase in yield achievable with the introduction of the Manual assist equipment manufactured by RTL for the semi-automation of hindquarter boning.

The following table shows carcass types and number of sides that were selected for measurement in the yield trial.

Table 1: Trial Design

Carcass Type	No of Sides
Yearling	10
Medium Grain Feed	12
Heavy Grain Feed	10
Total Number	**32**

- All carcasses were boned under manual operation, with the exception of one side from each different category boned using the manual assist equipment.
- Hindquarter primals boned manually were compared with the result of using the manual assist equipment, and yield differences between the two systems were observed.
- Trimming loss that was a result of poor seaming didn't occur with the use of manual assist was observed for all primals
- Current industry sales pricing were used to establish the dollar benefit by comparing the value of the trim as 95 CL as opposed to relevant primal price.

Drip Loss

It was expected that there would also be a small saving with the use of the manual assist equipment in post processing drip loss. This is due to a reduction in the amount of cut surfaces on the primal because of more accurate seaming between the different muscles during the boning process. Relevant literature was used to estimate the impact of a reduced cut surface area on the quantity of drip loss from primals. This benefit may not be directly realized by the processing plant; however in consideration of the whole supply chain a direct benefit can still be identified.

Survey Data, and other information

Information relating to HR issues, payment rates, training costs, staff turnover, specific site costs, robustness of equipment and many other important details were collected through the use of survey questionnaires and were conducted both on site, through email, and on the phone.

Several other non-primary data have been used for the development of the cost benefit model and have been referenced accordingly.

Results and discussion

Assumptions and Limitations of the cost benefit model:

Several important assumptions have needed to be included in the cost benefit analysis. Obviously many of these are assumptions will be site specific and any inferences in relation to the benefits and costs in a different application would need to be sensitive to this. The following list provides a summary of these assumptions in order of the benefits and costs that they are presented in the report.

It is also important to identify that the dollar benefit associated with the use of equipment is related to how the technology is integrated with the existing boning operation. It is therefore not possible to conclude that other plants installing this equipment will achieve the same benefits.

All drivers are linked to the final cost benefit in the model and can be changed to observe the effect, for example, the number of head processed, interest rates for capital expenses, prices or number of manual assist units required.

Yield

Hindquarters selected for the yield trial included three different groupings. These included 10 yearlings with an average side weight of 79 kg, and no fat reading, 12 Medium grain feed steers at 141 kg a side and average P8 fat measurement of 12mm, and thirdly heave grain feed sides at 160kg average, and an average P8 fat measurement of 20mm .

Table 3 shows significant yield savings for all three carcass types measured. Yield savings were quantified as .34%, .44% and .43% respectively for Yearlings, Medium grain and heavy grain feed.

Several opportunities for yield savings were identified, these included:

Gains in yield and value occurred in two key areas.

1. Improved seaming and cut removal reduced the amount of foreign muscles left on primal that would be downgraded from primal value to trim value.

2. In some cases meat previously left on bones was recovered as trim or primal meat.

The value of these gains was costed as the difference between trim and primal value in the first case and as the difference between rendering and trim values in the second case. The prices used to revalue meat are included in Table 2. Values were then compared, giving an actual dollar savings per side in Table 3.

it should be noted that achieving approximately 2/3 of these yield benefits required optimisation of boning room procedures and as such may not be applicable to other plants without the same level of optimisation.

Table 2: Prices used for calculating yield value increase:

Item	Yearling $/kg	Medium Grain Feed $/kg	Heavy Grain Fed $/kg
Tri Tip	$5.50	$5.50	$5.50
D Rump	$8.00	$7.00	$7.00
Topside	$4.50	$4.30	$4.30
Silver side	$4.40	$4.20	$4.20
Knuckle	$4.60	$4.20	$4.20
Trim 85 cl	$3.50		
Trim 65 cl			
Rendering	$0.05		

Table 3: Yield gains observed through the use of RTL Manual assist equipment

	Trial 3	Trial 2	Trial 1
Carcass Type	Yearling	Medium Grain	Heavy Grain
Number of sides	10	12	10
Avg carcasses side weight (kg)	78	141	160
Variation in weight	3.100	7.750	9.920
Fat	N	12.160	20.400
Var in Fat %	Na	40.00%	28.00%
% Yield gain	**0.347%**	**0.448%**	**0.435%**
	$ Save	**$ Save**	**$ Save**
Total gain per side	**$1.04**	**$1.62**	**$1.90**
Total $ increase per head	$2.08	$3.23	$3.81
Average Increase per head Yield Gain			**$3.04**
Yield Gain for Plant (based on x carcasses per annum)			**$817,684**

Assumptions:

- Expected difference between moving chain and stationery lines. All manual boning was conducted on a stationary line, whilst all manual assist results were obtained on a moving chain and the yield gains observed using manual assist equipment would be higher if the manual boning had been conducted on a moving line.
- The assumption is made that the three different yield values determined in the analysis are indicative of the overall throughput in the plant during a year. The average of yield increase of $3.04 / head has been used in the expected $ dollar benefit of manual assist on yield.

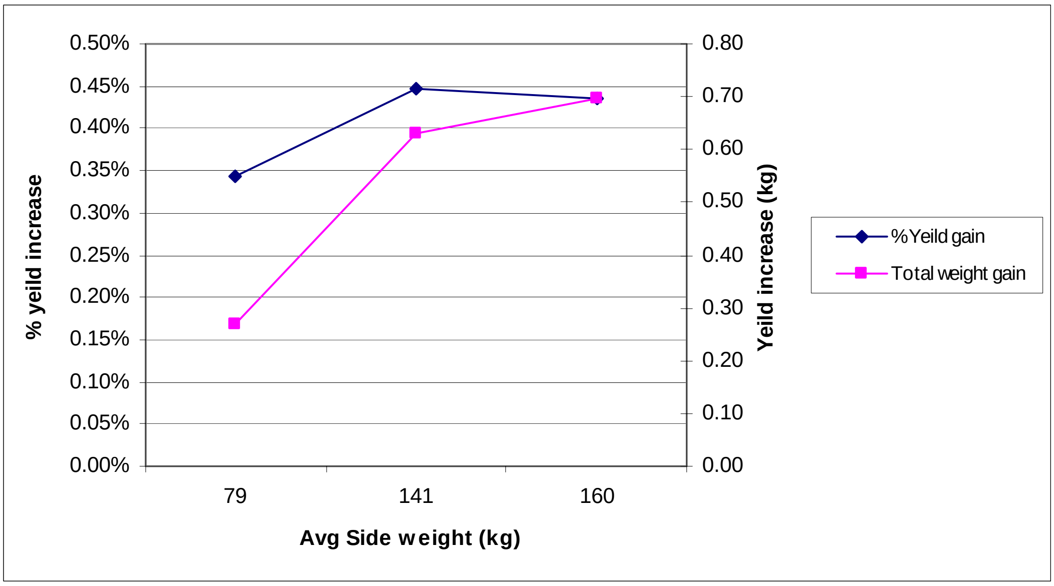

Figure 1: Comparison of the percent yield gain, and actual weight gain obtained from yearling, medium feed, and heavy feed carcass.

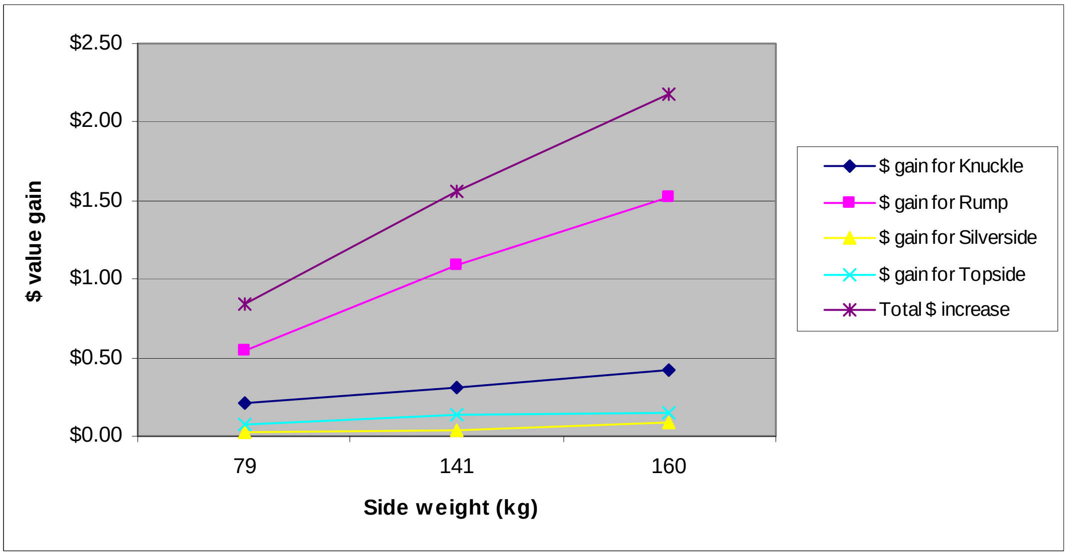

Figure 2: Comparison of yield gains obtained from different primals relative to carcass type.

Chain Speed

Chain speed was increased by 3% due to the installation of the manual assist equipment in the boning plant. This resulted in a labour saving of $1.18 per head. Source data for calculation; Previous Greenleaf Enterprises work conducted at the NCMC plant for CT scanning cost benefit (Oct 2007) – Updated Feb 2009. Increases in chain speed are impacted by many other limiting factors on a boning line. Benefits observed at this plant will not be relavant for some other plants where constraints are different.

Reduction in OH&S issues

Table 4 presents data from a number of industry sources, used to calculate the approximate upper arm injury cost associated with the manual break down of the hindquarter for each beef animal processed. Data shows the break down of injury types that relate to this specific task of manually breaking down the hindquarter. This data has been compiled by the Queensland Government and includes claims from all self insured organizations, and all organizations participating in work cover. Important assumptions made in estimating a final figure include:

- a conservative estimate of 65% of these claims being from the boning room, as opposed to the slaughter floor;
- an estimate of 60% of boning room injuries for these types of disorders are a direct result of manual boning on the chain;
- The assumption that these Queensland state wide figures are representative of the entire industry and therefore applicable to Cassino.

Table 4: Musculoskeletal Disorders recorded from workers compensation claims made in Queensland in meat processing plants in 2006-07

Musculoskeletal Disorders

Type of injury	Number of Claims
Trauma to muscles & tendons	1,218
Trauma to joints & ligaments	534
Disease of muscle, tendon & related tissue	449
Residual soft tissue disorders due to trauma or unknown mechanisms	374
Total Number of claims	2,575
Average payment for all compensation claims	$2,889
Averaged cost of workplace injury to Qld livestock industry	$7,439,044
Assumption 1: 65% of all claims are from the boning room as slaughter floor has less strain	65.0%
Assumption 2: 60% of all boning room musculoskeletal claims will be a direct result of injury from Boners on the chain	60.0%
Total QLD cost of musculoskeletal injury as a direct result of boning on the chain	$2,901,227
Number of head processed in QLD	3,700,000
Number of beef processed in Australia	8,800,000
Musculoskeletal injury cost of boners on chain / hd processed	**$0.78**

Source data for Table:
(ABS 2005; Fletcher 2008; QLD-Government 2008)

Labor Benefits

Aside from the benefit of decreased injury rates already covered in the OH&S section above, it possible to identify two other positive impacts that the manual assist system will have on the work force. These are an increased labour pool from which staff can be drawn to do the job and greater staff retention for these skilled boner positions.

Increased labour pool.
An increased labour pool would result in reduced overtime costs. Number of boning personnel is one of the critical limiting factors for throughput in a boning room. While large numbers of staff are required to operate the floor, shortage of specifically trained boners will limit the processing capacity. As previously mentioned, due to the arduous nature and high level of skill required, this position has been limited to a very small group of potential operators. In a situation where rostered personal are absent from this job the processing capacity of the boning room will be reduced. The plant will need to run for longer to process the same amount of product through the boning room. The major impact of this is an increased cost of boning labour.

A major benefit of the manual assist system is that given the task is now open to a much larger labour pool (including smaller framed men and women), many more people can be trained to fill this position. The following analysis makes the assumption that more people are trained as boners, at least for the manual assist positions. Processing capacity should not be limited by the availability of boners with the use of manual assist.

Table 5 assumes the event of more than 5 boners not being available for work occurs 8 times in a year. With slicers and packers trained in these specific manual assist jobs it is assumed this situation should not occur, thereby saving overtime from staff shortages.

Staff Retention and Training Costs

Given the increase in job satisfaction with the introduction of the manual assist equipment, it is assumed that staff retention would improve from 50% turnover rate to 15%. While the wider reaching impact of stability in the work force is more complicated to put a dollar value on, the reduction in the amount of training required due to reduced staff turnover is quantifiable.

Furthermore, the training required for these manual assist positions is less than for manual positions. It only takes 2 to 3 hours to train a qualified boner to use the Scott's Manual assist system. The boner skills required with the manual assist system are significantly lower than the previous manual job. Now it only takes 2 to 3 days to train up a knife hand to be a manual assist machine boner compared with a minimum of two weeks for manual tasks performed by the positions. This results in a much lower cost of training.

Table 5 shows that if a training cost of $2,368 (2 weeks) is applied to manual boning methods, reduction in staff turnover will provide savings of $26,048.

Table 5: Analysis of the manual assist benefits as measured by the impact on labour force.

Increase Labour pool		
Number of events annually that through put capacity of the boning room floor will limited due available boners	8	
Number of boners needed	25	
People away	5	
% reduction in boning room capacity	0.2	
Number hours increased processing time to meet days quota	1.6	
Hourly cost of running boning room	$954.00	
Hourly cost of running boning room @ time and half	$1,431.00	
Increased processing cost per shift	$2,289.60	
Annual cost of increased labour	$18,316.80	
Cost per head		**$0.07**
Staff Retention		
	Manual	Cobotics
Cost of Training new Boner for manual operation and cobotics (2 weeks down time at Boner rates)	2368	473.6
Number of boners trained	25	50
Annual Turnover	50%	15%
Number of people being trained annual	12.5	7.5
Annual training cost for different systems	$29,600.00	$3,552.00
Difference		$26,048.00
Saving $ per head		**$0.10**
Labour benefits per head		**$0.16**
Annual labour benefit for plant		**$44,364.80**

Assumptions:
Increase to Labour pool:

- Under manual boning configuration eight events of 5 boners being absent from work will occur in a year
- The number of boners needed to operate the boning room floor under both systems is 25
- This will result a reduced processing capacity of 20%, and therefore equal in increase in processing time of 1.6hr, or $2,289 per shift.

Costs incurred specific to RTL Manual assist installation

Table 6 shows an estimation of the annual cost of the manual assist system including installation and operation in the boning room.

Capital Costs: Assume market value of the equipment at $60,000 per unit, and participating plant would require 8 units in total. Other capital costs were also required for before the equipment could be installed such as air dryer units and plumbing. Cost of capital is assumed to 7%.

Cost of training: Is calculated to show the cost has been considered, however it is also considered under staff satisfaction where difference in the cost of training is considered. For this reason the calculation of the cost is included in Table 6, however the $ cost is factored into the model in the previous section.

Cleaning costs are tied to the increase in the daily cleaning time with the installation of the equipment. Annual Maintenance costs per unit were obtained from the onsite maintenance engineer. At this stage no cost is included for mechanical break down as the operator would still be able to revert to manual boning in the specific application, however the benefits outlined in the previous sections would be lost.

Risk of mechanical injury to the operator:
When observing the machine in action the meat hooks did catch on the operator's knife belt at one point. Although no injury was inflicted this posed the question of operator injury inflicted directly by the machine. No injuries resulting from the manual assist machine have been reported at Cassino. Interviews with operators indicate there is limited risk of injury. Given the easy of controlling the system, it is appears the risk of injury resulting from the manual assist machine is less than with manual boning.

Please note MLA and Scott's Technology are in the process of conducting a separate independent ergonomic study of the system. That study will provide more details about system design and operator considerations than this report.

Product quality risks from the manual assist machine:
At this stage it is expected that any increased risk in damage to the product would be self managed by boning staff online. Therefore no direct cost associated with the installation of the equipment has been considered.

Table 6: Additional costs and risks associated with use of NCMC / RTL manual assist equipment (purple cells still need be verified).

ITEM DESCRIPTION	Calculation	Sub Cost / hd	Total Cost / hd
1. Capital cost semi-automated knuckle puller (1 unit)	$60,000.00		
Installation costs per unit (Custom Pneumatic plumbing, install brackets and mounts)	$4,000.00		
Cost of installing air dryer (one of only)	$28,000.00		
Total capital Cost (8 units)	$540,000.00		
Annual Cost of Capital (7%)	$67,500.00	$0.25	
Opportunity Cost of capital*	$0.00	$0.00	
Sub Total Capital Cost			$0.25
2. Cost of training operators for the equipment			
Number of operators requiring training each year			
Cost of Trainer hrly rate	32	256	
Trainee hrly rate	22	176	
Number or hours required for training	8		
Number of staff trained each year	10		
Cost per labour unit		432	
Total training cost		4320	
Training Cost per head			0
3. Cost cleaning the equipment			
Assumes 1/2 per machine	0.5		
Pay rate for cleaners	$29.00		
Number of cleaning shifts in year	$230.00		
Annual Cleaning Cost	$26,680.00		
Cleaning cost per head			$0.10
4. Cost of maintenance			
Annual cost per unit (includes cost of time for maintenance staff member, pneumatic components, replacement of control units)	$5,000.00		
Total Annual Cost	$40,000.00		
Cost per head			$0.15
5. Risk of mechanical failure causing a hold up on boning chain			$0.00
Boners can immediately revert to manual boning so boning can still continue until equipment is repaired. However a shortage of manual boners would result in production losses (not counted)			
6. Risk of mechanical injury to operators (hook on Scotts equipment catching operator)			$0.00
7. Any potential for negative impacts on the quality of the product.			$0.00
Total Cost of the system			**$0.50**

*Assumes no capital opportunity cost as comparing investment in this capital with alternative investment of the same capital budget.

Total benefit

Table 7 shows the cost benefit that could be expected for a plant that is processing 269,000 head per annum. Assumptions included in the cost benefit show that 8 units would be required within the existing configuration of the boning room floor. It is also expected that the working life of the equipment would be approximately 8 years; this is based on discussions with development engineers.

The total dollar benefit of the equipment is calculated at $5.17 per head, with a total cost of $0.64 per head, giving a total gain of $4.53 per head.

Table 7: Cost Benefit analysis,

Plant Specific information	
Number of Head Being processed	269,000
Number of RTL units required	8
Life Expectancy of equipment (yrs)	8
Specific Benefit	$ Value of benefit or cost / head processed
1. Yield Gains Basic*	$1.86
1. Yield Gains Focused**	$1.18
2. 3% reduction in boning labour	$1.18
3. OH&S savings	$0.78
4. Labour benefits	$0.16
TOTAL BENEFIT / Hd	$5.17
Capital	$0.25
Training manual assist	$0.00
Cleaning	$0.10
Maintenance	$0.15
Risk of Mechanical Failure	$0.00
Risk of Mechanical injury	$0.00
Risk of Product Damage	$0.00
TOTAL COST / Hd	$0.50
Cost - Benefit / Hd	$4.65
Annual benefit for case study processing plant	$1,249,752

*Basic yield gains are those most likely to be achieved where yield is given some attention
** Focused yield gains are those that will only be achieved with very specific focus on improving and adjusting existing cutting methods

Discount rate	7.00%	
NPV	$7,403,902	
Payback	4.89	Months

Assumptions: The number of head being processed does not include veal, as the manual assist equipment is not used for boning these smaller carcasses.

Implications for Industry

Operational and production characteristics will differ from plant to plant, impacting on the benefits a plant can expect to achieve from the RTL system.

Depending on the speed of the line and the size of cattle being boned, one or two systems should be installed on each line if improvements in yield are desired. The calculations included in this report assume two systems are required per line to achieve the reported benefits. Other plants with smaller cattle and slower line speeds may only require one system per line.

The system provides the greatest benefit on larger longer fed cattle where strain on boners is greatest and hard fat issues are more prevalent. Use of the system did not appear to be beneficial to veal boning which involves much faster chain speeds. The range of machine travel along the chain mixed with reduced strain on boners limits the benefits to boners. Furthermore, the machine hook sometimes pulls through the eye of the softer veal aitch bones reducing its efficiency.

Although the yield benefits observed in this plant are large, it is possible for plants to install this system without a yield improvement. Large yield improvements are possible if the system is used as an enabling technology to assist boners in operating differently. If the system is only used to reduce the strain experienced by boners under existing boning conditions, yield benefits will be much less, and driven solely by limiting the affect boner fatigue has on yield from start to finish of the day.

The system can only be used on side boning chains and is not suitable for table boning.

Impact on livestock industry now and five years time

Results from this study (Table 7) show that this equipment has the potential to offer immediate measureable benefits to the industry. The impact of these benefits is both to the quality of the product being processed, and to the people engaged in the work.

It is anticipated that the health benefits resulting from the installation of this equipment will continue to increase over time as new generations of boners are not exposed to the debilitating impact that can occur over time within a manual boning procedure.

The successful development and application of this equipment is an important step towards the long term objectives of incorporating automation and manual assist into the boning process.

Conclusions

Installation of this equipment to change from manual boning procedure to use of power assist for removal of aitch bone and knuckles has several immediate and long term benefits for processing plants.

- Although not listed first in the analysis results, improvement to the working conditions results in a quantifiable reduction in work place injury. This not only provides an improvement in the boners working conditions but also provides a reduction to processing plant in OH&S costs previously associated with this task.
- Improving the working conditions and ease of task also leads to quantifiable benefits associated with the labour force.
- The yield gains identified in the trial work will be somewhat conservative as the manual boning occurred on chain that was moving, and fatigue of the boner was not a consideration in the trial work. These observed yield gains are also relative to the boning procedure being used.
- Ability of plants to increase the chain speed specifically due to the manual assist equipment will be dependent on other crucial limiting factors (CLF) existing within the processing system. If hindquarter breakdown is a CLF than increases in chain speed can be expected.

Relative to the benefits, the costs and risks associated with this equipment appear to be low.

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